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A NEW EMPIRICALLY WEIGHTED
MONETARY AGGREGATE FOR THE U.S.

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Abstract

This paper utilises an approach to long run modelling proposed by Pesaran, Shin and
Smith (2001) to develop an empirically weighted broad monetary aggregate for the
U.S., and to demonstrate the advantages of this type of aggregate from a monetary
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approach to deal with periods of significant financial innovation and money demand
instability, such as the "missing money" episodes of the early/mid 1970s (with respect
to M1) and the early/mid 1990s (with respect to M2).

Keywords: Monetary aggregation; Monetary aggregates; Monetary policy; Leading
indicators.

JEL Categories: E41, E52, E58.

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1. Introduction

This paper utilises an approach to long run modelling proposed by Pesaran, Shin and Smith (2001) to develop an empirically weighted broad monetary aggregate for the U.S., and to demonstrate the advantages of this type of aggregate from a monetary policy perspective. In particular, the paper examines the ability of this type of approach to deal with periods of significant financial innovation and money demand instability, such as the “missing money” episodes of the early/mid 1970s (with respect to M1) and the early/mid 1990s (with respect to M2).

The formal targeting of monetary aggregates was introduced in many countries, including the U.S. and the U.K., during the early to mid 1970s. Monetary targets became particularly important at this time as the discipline of the Bretton Woods regime had been removed and some guiding principle for monetary policy was required. A key requirement for monetary aggregates to provide a useful role in guiding monetary policy, however, is that they should be stably related to the objectives of policy, such as inflation or nominal income growth. In this context, the U.S. has exhibited periodic evidence of significant money demand instability. Most notably, these have been Goldfeld’s (1976) case of the “missing M1” in 1973/74 and the “missing M2” episode of the early 1990s (Feldstein and Stock, 1996). In both cases the aggregate in question experienced a significant velocity increase and, as a consequence, previously established and apparently stable money demand relationships began to seriously overpredict the growth in these aggregates.

The “missing M1” episode in 1973/74, together with subsequent evidence that M2 was more predictable than M1, led many economists to use M2 as an indicator of nominal activity. Hence, during the 1980s, M2 became the primary intermediate target of monetary policy. Furthermore, the primacy of M2 appeared to be well supported by the available empirical evidence. Feldstein and Stock (1994), for example, established that the rate of change of M2 was a statistically significant predictor of the rate of change of nominal GDP over the period 1959–92. Furthermore, M2 remained statistically significant when short term-interest rates were added to the relationship. Subsequent research, such as Miyao (1996) and Estrella and Mishkin (1997), however, cast doubt on the robustness of this result. Carlson et al (2000), for example, summarise the current situation by arguing that “……the promising empirical conclusions of Feldstein and Stock (1994) that established predictive content for M2 in a vector error correction setting do not seem to find support in data that extend through the mid–1990s” (page 346).

The key factor behind the breakdown in the M2 relation appears to have been the substitution away from time deposits and into mutual funds, and particularly stock
and bond mutual funds, in the low interest rate environment of the early 1990s. Although the definition of M2 has been expanded by the Federal Reserve in the past to include MMMFs and MDAs, for example, a number of analysts (Duca, 1993; Darin and Hetzel, 1994; Orphanides, Reid and Small, 1994) have advocated that M2 should be expanded further to include these stock and bond mutual funds (M2+). Significantly, these studies typically utilise the simple sum aggregation approach in which all component assets are given equal and constant weights over time. This approach does not seem consistent, however, with the accumulating evidence of a significant shift in wealth holders preferences in the early 1990s. Carlson et al (2000), for example, add to the empirical evidence which accumulated during the 1990s by suggesting that the instability was associated with a permanent upward shift in M2 velocity between 1990 and 1994. Furthermore, they argue that “….our results support the hypothesis that households permanently reallocated a portion of their wealth from time deposits to mutual funds” (page 381). Clearly, simple sum aggregation is not able to take account of these changes in preferences. More significantly, however, simple sum aggregation cannot take account of any changes in the relationship between component assets and nominal income over time.

Although Carlson et al (2000) do manage to re-establish a stable money demand relationship for MZM and M2M through the 1990s, this is only possible by specifically accounting for the financial innovation which occurred in the early 1990s. Specifically, a linear shift variable is incorporated over the period 1990 to 1994. While this is an interesting result, it is of limited use to policy makers in the sense that this type of evidence is only available ex-post, often with a considerable time lag. In other words, it is only with the benefit of hindsight that a particular period of instability can be rationalised in terms of financial innovation, permanent velocity shifts, etc. In contrast, policy making is an ongoing process conducted in real time, and policy makers need to be assured that movements in a variable such as M2 contains reliable information content in respect of policy objectives. In response to the evident problems with M2 in the early 1990s, for example, the FOMC downgraded its role and no single variable has subsequently taken its place.

What is required is a monetary aggregate that can endogenously respond to changes in wealth holder preferences, possibly caused by financial innovations, which impinge upon the information content of monetary aggregates or their sub-components. A possible theoretical solution to this problem is to employ the Divisia aggregation procedure, advocated by Barnett (1980, 1982), and adopted by many central banks around the world. This type of weighted monetary aggregate allows the composition of the aggregate to respond to financial innovations which impact on relative rates of return. Specifically, the component asset weights are derived as
monetary expenditure shares which, in turn, are influenced by relative interest rates captured by the user costs or rental prices of the assets. While a number of studies have produced evidence of stable broad money demand relationships using Divisia aggregation (Belongia and Chalfont, 1989, for the U.S., Belongia and Chrystal, 1992; Drake and Chrystal, 1994, 1997, for the U.K.), the application of the Divisia index number methodology to the missing M2 episode of the early 1990s is problematic. Although an established methodology does exist (Barnett, Jensen and Liu, 1997) for incorporating risky assets, such as stock and bond mutual funds, into Divisia monetary aggregates, the risk adjustments implied by the CCAPM methodology employed tend to be relatively small. As is well established in the “equity premium puzzle” literature (see Mehra and Prescott, 1985, and Drake et al, 1999), the large risk adjustments implied by the typical equity premiums cannot be produced in the absence of unreasonably high coefficients of relative risk aversion.

An alternative approach proposed by Feldstein and Stock (1996) is to produce empirically weighted monetary aggregates. Feldstein and Stock argue that “our objective is to develop a procedure that automatically adjusts the composition of the monetary aggregate in a way that makes the resulting measure of the money stock a stable leading indicator of nominal GDP and potentially a useful control instrument for altering nominal GDP” (page 5). Feldstein and Stock (1996) employ two alternative methodologies to produce the empirically weighted monetary aggregates. The first is a switching regression methodology which attaches weights of either one or zero to monetary aggregate subcomponents and in which the switch dates are established on the basis of the ability of the aggregate to forecast GDP growth. The second is a time varying parameter model in which the component weights evolve over time so as to produce an aggregate with a stable predictive relationship to nominal GDP.

In contrast, we produce empirically weighted monetary aggregates based upon a new approach to testing for the existence of a linear long run relationship when the orders of integration in, or the form of cointegration between, the underlying regressors are not known with certainty. Hence, in contrast to Feldstein and Stock (1996), the component weights derived at any point in time are drawn from the cointegrating relationship between the component assets and nominal GDP. Furthermore, by using this approach in a recursive fashion we are able to analyse how the “optimal” weights evolve over time. This is particularly useful in respect of informing the debate over particular episodes of money demand instability.

Hence, we focus initially on a sample period running from 1960:2 to 1977.4 in order to re-examine the missing M1 period of the early/mid 1970s. Subsequently, we utilise the full sample period and focus, in particular, on the missing M2 period of the
early 1990s. As our aim is to produce an empirically weighted monetary aggregate that is useful to policy makers making decisions in real time, we focus particularly on the out-of-sample properties of the new monetary aggregates.

The remainder of this paper is structured as follows. Section 2 outlines the PSS technique and the derivation of the empirically weighted monetary aggregate. Section 3 then discusses the empirical results. Section 4 concludes.

2. Constructing a Weighted Monetary Aggregate for the U.S.

The data set used to construct an empirically determined weighted monetary aggregate contains quarterly observations from 1960.2 to 2001.2 on the logarithms of nominal GDP at factor cost, denoted \( y_t \), and five monetary components:

- \( x_{1t} \): M1 (currency, demand deposits, other checkable deposits)
- \( x_{2t} \): Savings and Money Market Deposit Accounts plus small denomination Time Deposits (Approx M2 (excluding retail MMMFs) – M1)
- \( x_{3t} \): Retail MMMFs
- \( x_{4t} \): Large denomination Time Deposits, Repurchase Agreements, Eurodollar deposits and Institutional MMMFs (Approx M3 – (\( x_1 \) to \( x_3 \)))
- \( x_{5t} \): Stock and Bond Mutual Funds

The levels of the five aggregates are shown in Figure 1. Readily apparent is the enormous growth in the \( x_5 \) component (stock and bond mutual funds) from the early 1990s. This is typically argued to be responsible for the “missing M2 puzzle” of the time, and we can see the corresponding decline in the broad money components of M2 from the decline in \( x_2 \) between 1991 and 1995. A similar decline is also evident in \( x_4 \), which corresponds to the broad M3 money components. In contrast to the growth in stock and bond mutual funds, MMMFs have exhibited more modest growth dating from the early 1980s, as evidenced by the profile of \( x_3 \).

The approach taken to construct the weighted aggregate is that proposed by Pesaran, Shin and Smith (2001), henceforth PSS, and has been used successfully in respect of U.K. monetary aggregates in Drake and Mills (2001). We thus begin by considering the following vector autoregressive model of order \( p \) (VAR(\( p \))) in the vector of variables \( z_t = (y_t, x_t')' \), where \( x_t = (x_{1t}, \ldots, x_{5t})' \) is the vector of monetary components:
\[ z_t = b + ct + \sum_{i=1}^{p} \Phi_i z_{t-i} + \varepsilon_t, \quad (1) \]

where \( b \) and \( c \) are vectors of intercepts and trend coefficients and \( \Phi_i, \quad i = 1, 2, \ldots, p, \) are matrices of coefficients. We assume that the roots of

\[ \left| I_t - \sum_{i=1}^{p} \Phi_i z^i \right| = 0 \]

are outside the unit circle \( |z|=1 \) or satisfy \( z = 1 \), so that the elements of \( z_t \) are permitted to be either \( I(0), \) \( I(1) \) or cointegrated. The *unrestricted vector error correction form* of (1) is given by

\[ \Delta z_t = b + ct + \Pi z_{t-1} + \sum_{i=1}^{n-1} \Gamma_i \Delta z_{t-1} + \varepsilon_t, \quad (2) \]

where

\[ \Pi = \left( I_t - \sum_{i=1}^{p} \Phi_i \right) \]

and

\[ \Gamma_i = -\sum_{j=i+1}^{p} \Phi_j, \quad i = 1, \ldots, p-1 \]

are matrices containing the long-run multipliers and the short-run dynamic coefficients, respectively.

Given the partition \( z_t = (y_t, x'_t) \), we define the conformable partitions \( \varepsilon_t = (\varepsilon_{z, t}, \varepsilon'_{z, t}) \) and

\[ b = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}, \quad c = \begin{bmatrix} c_1 \\ c_2 \end{bmatrix}, \quad \Pi = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix}, \quad \Gamma_i = \begin{bmatrix} \gamma_{11,i} & \gamma_{12,i} \\ \gamma_{21,i} & \gamma_{22,i} \end{bmatrix} \]

and make the standard assumption that \( \varepsilon_t = (\varepsilon_{z, t}, \varepsilon'_{z, t}) \) follows a multivariate i.i.d. process having mean zero, non-singular covariance matrix

\[ \Sigma_{\varepsilon} = \begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \Sigma_{22} \end{bmatrix}, \]

and finite fourth moments. We also assume that \( \pi_{21} = 0 \), which ensures that there exists at most one (non-degenerate) long-run relationship between \( y_t \) and \( x_t \), irrespective of the level of integration of the \( x_t \) process.

With this assumption and the partitioning given above, (2) can be written in terms of the *dependent* variable \( y_t \) and the *forcing* variables \( x_t \) as
\[ \Delta y_t = b_1 + c_1 t + \pi_{11} y_{t-1} + \pi_{12} x_{t-1} + \sum_{i=1}^{p-1} \gamma_{11, i} \Delta y_{t-i} + \sum_{i=1}^{p-1} \gamma_{12, i} \Delta x_{t-i} + \epsilon_{1t} \quad (3) \]

\[ \Delta x_t = b_2 + c_2 t + \Pi_{22} x_{t-1} + \sum_{i=1}^{p-1} \gamma_{21, i} \Delta y_{t-i} + \sum_{i=1}^{p-1} \Gamma_{22, i} \Delta x_{t-i} + \epsilon_{2t} \quad (4) \]

The contemporaneous correlation between \( \epsilon_{1t} \) and \( \epsilon_{2t} \) can be characterised by the regression

\[ \epsilon_{1t} = \omega \epsilon_{2t} + \xi_t \quad (5) \]

where \( \omega = \Sigma_{22}^{-1} \sigma_{21} \), \( \{ \epsilon_t \} \) is an i.i.d. \( (0, \sigma_\xi^2) \) process with \( \sigma_\xi^2 = \sigma_{11} - \sigma_{12} \Sigma_{22} \sigma_{21} \), and the \( \{ \xi_t \} \) and \( \{ \epsilon_{2t} \} \) processes are uncorrelated by construction. Substituting (4) and (5) into (3) yields

\[ \Delta y_t = a_0 + a_1 t + \phi y_{t-1} + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \varphi_{12,i} \Delta x_{t-i} + \xi_t \quad (6) \]

where

\[ a_0 \equiv b_1 - \omega' b_2, \quad a_1 \equiv c_1 - \omega' c_2, \quad \phi \equiv \pi_{11}, \quad \delta' \equiv \gamma_{12} - \Pi_{22} \omega \]

\[ \psi_i \equiv \gamma_{11, i} - \omega' \gamma_{21, i}, \quad \varphi_0 \equiv \omega', \quad \varphi_i \equiv \gamma_{12, i} - \omega' \Gamma_{22, i} \]

It follows from (6) that, if \( \phi \neq 0 \) and \( \delta \neq 0 \), there exists a long-run relationship between the levels of \( y_t \) and \( x_t \), given by

\[ y_t = \theta_0 + \theta_1 t + \theta' x_t + \nu_t \quad (7) \]

where \( \theta_0 \equiv -a_0 / \phi, \quad \theta_1 \equiv -a_1 / \phi, \quad \theta \equiv -\delta / \phi \) is the vector of long-run response parameters and \( \{ \nu_t \} \) is a mean zero stationary process. If \( \phi < 0 \) then this long run relationship is \emph{stable} and (6) can be written in the error correction model (ECM) form

\[ \Delta y_t = a_0 + a_1 t + \phi (y_{t-1} - \theta' x_{t-1}) + \sum_{i=1}^{p-1} \psi_i \Delta y_{t-i} + \sum_{i=0}^{p-1} \varphi_{12,i} \Delta x_{t-i} + \xi_t \quad (8) \]

If \( \phi = 0 \) in (8) then no long-run relationship exists between \( y_t \) and \( x_t \). However, a test for \( \phi = 0 \) runs into the difficulty that the long-run parameter vector \( \theta \) is no longer identified under this null, being present only under the alternative hypothesis. Consequently, PSS test for the absence of a long-run relationship, and avoid the lack of identifiability of \( \theta \), by examining the joint null hypothesis \( \phi = 0 \) \emph{and} \( \delta = 0 \) in the unrestricted ECM (6). Note that it is then possible for the long-run relationship to be \emph{degenerate}, in that \( \phi \neq 0 \) but \( \delta = 0 \), in which case the long-run relationship involves only \( y_t \) and possibly a linear trend.
PSS consider the conventional Wald statistic of the null $\phi = 0$, $\delta = 0$ and show that its asymptotic distribution involves the non-standard unit root distribution and depends on both the dimension and cointegration rank ($0 \leq r \leq k$) of the forcing variables $x_t$. This cointegration rank is the rank of the matrix $\Pi_{22}$ appearing in (4). PSS obtain this asymptotic distribution in two polar cases: (i) when $\Pi_{22}$ is of full rank, in which case $x_t$ is an $I(0)$ vector process, and (ii) when the $x_t$ process is not mutually cointegrated ($r = 0$ and $\Pi_{22} = 0$) and hence is an $I(1)$ process. They point out that the critical values obtained from stochastically simulating these two distributions must provide lower and upper critical value bounds for all possible classifications of the forcing variables into $I(0)$, $I(1)$ and cointegrated processes. A bounds procedure to test for the existence of a long-run relationship within the unrestricted ECM (6) is thus as follows. If the Wald (or related $F$-) statistic falls below the lower critical value bound, then the null $\phi = 0$, $\delta = 0$ is not rejected, irrespective of the order of integration or cointegration rank of the variables. Similarly, if the statistics are greater than their upper critical value bounds, the null is rejected and we conclude that there is a long-run relationship between $y_t$ and $x_t$. If the statistics fall within the bounds, inference is inconclusive and detailed information about the integration-cointegration properties of the variables is then necessary in order to proceed further. It is the fact that we may be able to make firm inferences without this information, and thus avoid the severe pre-testing problems usually involved in this type of analysis, that makes this procedure attractive in applied situations. PSS provide critical values for alternative values of $k$ under various situations. The two that are relevant here are Case 1: $a_o \neq 0, a_i = 0$ (with an intercept but no trend in (6)), and Case 2: $a_o \neq 0, a_i \neq 0$ (with both an intercept and a trend in (6)).

PSS show that this testing procedure is consistent and that the approach is applicable in quite general situations. For example, equation (6) can be regarded as an autoregressive distributed lag model in $y_t$ and $x_t$, having all lag orders equal to $p$. Differential lag lengths can be used without affecting the asymptotic distribution of the test statistic.
3. Empirical Results

3.1 The Missing M1 Episode

Our first exercise is to consider the period up to the end of 1977. During this period, the aggregate underlying \( x_3 \) was either zero, or almost so, and hence is excluded from the analysis. Thus we focus on using \( x_{1t}, x_{2t} \), and \( x_{4t} \), so that \( k = 3 \) and attention is initially concentrated on the period up to the end of 1972, i.e., before the episode of the missing M1.

In implementing the PSS approach, our first task is to check that the assumptions required for attention to focus solely on equation (6) are satisfied. One underlying assumption, implicit in the discussion above, is that the maximal order of integration of the \( \{x_t\} \) process is unity. Unit root tests of the individual series making up \( \{\Delta x_t\} \) show that a unit root is rejected at the 5% level in each case. A second assumption, explicitly discussed above, is that \( \pi_{21} = 0 \) in (the partitioned form of) the unrestricted vector error correction (2).

Estimation of this equation with \( p \) set equal to 5 produced \( t \)-statistics on the coefficients of \( y_{t-1} \) in the equations for \( \Delta x_{it}, \ i = 1,2,4, \) of 0.27, -0.22, and 0.46, thus producing no evidence against the null hypothesis \( \pi_{21} = 0 \). A setting of \( p = 5 \) was thought to be an appropriate trade-off between the need to account for any seasonal fluctuations and the degrees of freedom available given the length and dimension of \( z_t \). Having thus ascertained that the conditions required for (6) to be considered in isolation are satisfied, the following parsimonious specification of this equation was eventually arrived at:

\[
\Delta y_t = 0.088 - 0.291 y_{t-1} + 0.274 x_{1,t-1} + 0.074 x_{2,t-1} + 0.013 x_{4,t-1} \\
+ 0.184 \Delta y_{t-1} - 0.172 \Delta y_{t-2} - 0.176 \Delta y_{t-4} \\
- 0.064 \Delta x_{1,t-2} + 0.124 \Delta x_{1,t-3} \\
- 0.518 \Delta x_{2,t-2} + 0.235 \Delta x_{2,t-3} + 0.018 \Delta x_{4,t-2}
\]

Sample: 1960:2 - 1972:4 \( R^2 = 0.774 \)  \( \bar{\sigma}_e = 0.00516 \)  
\( AUTO(4) = 0.29[0.88] \)  \( NORM = 2.75[0.34] \)  \( ARCH(1) = 0.01[0.93] \)  
\( HET = 1.50[0.16] \)  \( RESET(1) = 0.13[0.72] \)
The standard diagnostic checks (prob-values are shown in brackets) indicate no evidence of misspecification.

The Wald statistic for testing whether there exists a long run relationship between \( y_t \) and \( x_t \) produces an \( F \)-statistic of 20.32. This is well beyond the 1% significance level upper bound in both Cases 1 and 2: with three regressors these upper bounds are 5.61 and 5.23, respectively (note that the trend was found to be insignificant and hence has been omitted from the chosen specification). We must therefore conclude that such a long run relationship certainly exists and, given our estimates, the long run relationship (7) is

\[
y_t = 0.09 + \hat{\phi}_t = 0.09 + 1.24(0.76x_{1,t} + 0.20x_{2,t} + 0.04x_{4,t})
\]

Having thus demonstrated that a long-run relationship exists between nominal income and these monetary components up to 1972, we now use this model to investigate M1 instability around the missing money period. We first investigate the stability in the component weights over time by estimating the model above recursively up to end-1972. Thereafter, the weights are derived using the model established on the ‘full’ sample of data up to 1972. Hence, this permits a genuine out of sample analysis of the empirically weighted aggregate over the missing M1 period of 1973/74.

It is clear from Figure 2 that the recursive weights are reasonably stable prior to 1970. More significantly, the optimal monetary aggregate (based on the relationship with nominal income) would have a weight on \( x_1 \) (M1 assets) of around 0.85 to 0.9, and relatively low weights on both \( x_2 \) and \( x_4 \). Hence, it is perhaps not surprising that the standard Goldfeld money demand specification, which focused on M1, performed well prior to the early 1970s. It is clear, however, that from 1970 the implied optimal weight on \( x_1 \) begins to decline while that on \( x_2 \) begins to increase. This trend continues in the out-of-sample period and begins to accelerate from late 1973, so that by 1977 the implied optimal weights are around 0.5 on both \( x_1 \) and \( x_2 \). This is highly suggestive as this is precisely the time when the standard Goldfeld model began to seriously overpredict M1 growth.

In order to illustrate this missing M1 episode, we estimate a standard Goldfeld partial adjustment model for M1 up to end-1972. (Goldfeld-type models using both M1 and ‘composite M3’ are reported in Appendix A). Figure 3 clearly shows that the model fits the data very well prior to 1972:4, while the out-of-sample evidence shows that the model progressively over-predicted M1 growth after 1973. Subsequent studies have attempted to explain the missing M1 puzzle in terms of problems with the partial adjustment model (inadequate dynamic specification) and the impact of
inflation and financial innovation. Our results suggest that the instability can be explained very simply by a failure to adequately account for the switch out of M1 assets and into M2 assets, which may have been prompted by the impact of high inflation and high nominal interest rates on the zero yielding M1 assets. This conjecture is confirmed by fitting a Goldfeld demand function to $\hat{\alpha} \mathbf{x}$, up to end-1972 and forecasting out-of-sample until end-1977. Figure 4 illustrates quite clearly that the optimally weighted aggregate based on $x_1$, $x_2$, and $x_4$ (approximately M3) produces a good fit based on the standard Goldfeld model, both within and out-of-sample. It should be noted, however, that unlike the M1 specification, the significant coefficient on prices in the context of a real money demand equation for weighted M3 suggests, not surprisingly, that there is some mis-specification inherent in the simple Goldfeld type partial adjustment model.

It is interesting to note from Figure 2 that $x_4$ has a weight that is relatively low and stable for most of the sample period. Hence, the optimal weighted monetary aggregate would be composed, in the main, of M2 assets. Furthermore, as the weights on $x_1$ and $x_2$ converge towards 0.5 after 1973, the weight on $x_4$ trends towards zero. Figure 5 illustrates that this is also the case when stock and bond mutual funds ($x_5$) are included in the model (the estimated model is shown in Appendix B). Although the decline in the $x_1$ weight and the increase in the $x_2$ weight occurs slightly later than in Figure 2, both $x_4$ and $x_5$ trend towards a weight of zero after 1974.

Again, this is a significant result from a policy perspective as it explains the favourable empirical results obtained for simple sum M2 and the evolution of M2 as the primary intermediate target variable by the 1980s. More specifically, the use of a simple sum monetary aggregate that accorded equal weights (of unity) to both M1 and (M2 – M1) assets, but a weight of zero to any broader monetary assets, accords reasonably well with the optimal weighting scheme implied by our analysis. Hence, since this optimal weighting scheme is derived from the implied nominal income relationship, it would be expected that the M2 aggregate would perform well both empirically and in a policy context. In essence, given the almost zero weight on $x_4$, this is illustrated very clearly by the out-of-sample performance of the weighted aggregate (effectively M2) shown in Figure 4.

Clearly, however, the continued success of simple sum M2 as a key monetary policy variable through the 1980s and 1990s would depend crucially on two factors. Firstly, the stability and equality of the weights on $x_1$ and $x_2$. If the optimal weights were to deviate significantly from the weights of 0.5 evident in the late 1970s, then the simple sum M2 aggregate (which imposes equal weights of unity on all components) would be expected to increasingly diverge from the optimal aggregate.
It should also be noted that if either $x_1$ or $x_2$ were to exhibit periods of very rapid growth, this would produce excessive growth in simple sum M2 (relative to the optimally weighted aggregate) by virtue of the weights of unity on both these component assets. A case in point is the very rapid growth in M2 as a result of the significant increase in the $x_2$ component after 1983. This is discussed further subsequently.

Secondly, if the implied optimal weights on assets such as $x_4$ and $x_5$ were to increase over time, then the M2 aggregate would again be expected to diverge increasingly from the optimal aggregate over time. As was stressed previously, a particularly serious episode of M2 instability occurred during the early 1990s. Hence, in the next section we utilise the full sample period of 1960.2 to 2001.2 and focus, in particular, on the out-of-sample properties of the model post 1990.

### 3.2 Full Sample Results

Due to the fact that money market mutual fund (MMMF) data is only available from 1973, and that MMMF holdings do not begin to exhibit rapid growth until the 1980s, we combine MMMFs with the $x_2$ assets to form the aggregate $x_{23} = x_2 + x_3$ (in levels). As emphasised previously, we are particularly interested to examine the period of M2 instability in the early 1990s, known as the period of "missing M2". This has been largely attributed to the substitution away from M2 assets and into mutual funds, particularly stock and bond mutual funds, in the low interest rate environment of the early 1990s. Hence, we first examine the recursively estimated weights from a model estimated up to the end of 1989 in order that the estimated weights during the 1990s are genuine out-of-sample recursive weights.

The long-run equation was developed using the techniques outlined earlier. After the underlying assumptions required for the approach to be used were found to be satisfied, the Wald statistic for testing whether there exists a long run relationship between $y_t$ and $x_t$ produced an $F$-statistic of 7.00. This is again well beyond the 1% significance level upper bound in both Cases 1 and 2: with $k = 4$ these upper bounds are 5.06 and 4.92, respectively (note that the trend was found to be insignificant and is excluded from the specification shown below)
$$\Delta y_t = 0.124 + 0.095 \Delta y_{t-1} + 0.198 \Delta y_{t-2} - 0.122 y_{t-1}$$
$$\begin{pmatrix} 
(0.027) & (0.075) & (0.077) & (0.028) 
\end{pmatrix}$$

$$+ 0.056 x_{1,t-1} + 0.074 x_{23,t-1} + 0.004 x_{4,t-1} - 0.007 x_{5,t-1}$$
$$\begin{pmatrix} 
(0.026) & (0.024) & (0.004) & (0.003) 
\end{pmatrix}$$

$$- 0.046 \Delta x_{1,t-4} + 0.017 \Delta x_{5,t-2} + \text{dummies}$$
$$\begin{pmatrix} 
(0.028) & (0.009) 
\end{pmatrix}$$

Sample: 1960:2 - 1989:4  
$$R^2 = 0.518 \quad \hat{\sigma}_y = 0.00736$$

$$AUTO(4) = 0.89[0.47] \quad NORM = 2.36[0.31] \quad ARCH(1) = 0.24[0.62]$$

$$HET = 1.26[0.22] \quad RESET(1) = 1.54[0.22]$$

Three dummy variables are included to deal with outlying residuals in 1978.2, 1980.4 and 1982.1. After their inclusion the standard diagnostic checks (prob-values are shown in brackets) indicate no evidence of misspecification. We therefore conclude that a long run relationship certainly exists and, given our estimates, the long run relationship (7) is

$$y_t = 0.12 + \hat{\theta}x_t = 0.12 + 1.05(0.44x_{1,t} + 0.58x_{23,t} + 0.03x_{4,t} - 0.05x_{5,t})$$

As before, this specification was estimated recursively and the calculated weights are shown in Figure 6 (note that the presence of the dummies only allows the recursions to be estimated after 1982). The in-sample recursive weights confirm the trend decrease in the $x_1$ weight and the trend increase in the $x_2$ weight ($x_{23}$ weight in this case) that was apparent from the early 1970s in Figures 2 and 5. From 1987 until 1992, however, these weights are relatively stable at around 0.4 and 0.6 respectively. With respect to $x_4$ and $x_5$, the implied weights are both close to zero, with the weight on $x_4$ being slightly positive and that on $x_5$ slightly negative. From the perspective of the late 1980s/early 1990s, therefore, there was no strong rationale for the inclusion of either broad M3 monetary assets ($x_4$) or stock and bond mutual funds ($x_5$) in official monetary aggregates. Similarly, these results confirm the evidence presented earlier in the sense that M2 would be expected to outperform M1 given the increased weight on $x_{23}$ and the decreased weight on $x_1$ implied by the long run nominal income relationship.

Turning now to the "missing money" period after 1991, however, it is clear from Figure 6 that considerable instability is apparent in the optimal monetary aggregate component weights after 1992. Specifically, the implied weight on $x_1$ increases substantially to around 0.7 between 1992 and 1996. This may well reflect
the gradual impact of the low inflation/low interest rate environment of the early 1990s on the willingness of wealth holders to hold M1 balances and use these for transactions. Indeed, in Figure 1 we can see the sharp increase in $x_1$ balances between 1991 and 1995. Hence, this period may represent the opposite scenario to that of the Goldfeld missing money episode in which wealth holders had switched away from M1 due to the impact of high inflation and high interest rates in the mid 1970s.

Conversely, the implied optimal weight on $x_{23}$ declines from 0.6 to around 0.2 by 1998, and this decline is mirrored by an increase in the weight on $x_4$ from just over zero in 1992 to around 0.3 by the end of the sample, broadly equivalent to the weight on $x_{23}$. Perhaps more significantly, however, the implied optimal weight on $x_5$ remains remarkably stable and slightly negative throughout the so-called “missing M2” period. Furthermore, although the weight increases somewhat after 1996, the implied optimal weight is only just positive by the end of the sample.

These results have important policy implications. Firstly, they confirm that simple sum M2 would be expected to perform poorly during and after the missing money episode in the context of money demand and velocity instability. As mentioned above, the increase in the optimal weight on $x_1$ balances probably reflects the increased willingness of wealth holders to hold M1 balances and utilise them for transactions/nominal spending. This would tend to be naturally reflected in a decline in the optimal weight on $x_{23}$ given the substitution between $x_1$ and $x_{23}$ assets in respect of transactions balances, and the fact that the recursively estimated optimal weights are derived from a long run nominal income relationship. This substitution would not be adequately reflected by simple sum M2, however, given the equal weights of unity applied to both $x_1$ and $x_{23}$. At the same time, however, the low interest rate environment of the early 1990s encouraged those individuals holding broad M2 monetary components ($x_{23}$) on the basis of an “asset motive” to substitute them for higher yielding assets such as stock and bond mutual funds. This asset motive hypothesis is supported by the fact that the recursively estimated weights on $x_5$ do not increase significantly, either during the missing money episode, or subsequently. Hence, the substantial substitution out of M2 balances and into stock and bond mutual funds was not significant from the perspective of transactions balances and subsequent nominal spending.

In summary, therefore, the problems of M2 instability and unreliability (in a policy context) during the “missing M2” episode cannot simply be attributed to the rapid shift into stock and bond mutual funds ($x_5$ assets) from the early 1990s. This will undoubtedly have created problems for policy makers in the context of M2 providing misleading signals regarding future nominal income growth and inflation.
In the terminology of Estrella and Mishkin (1997), official simple sum M2 at this time will have been characterised by a low signal to noise ratio. Nevertheless, our results make it quite clear that the appropriate policy response was not to redefine M2 to include the \( x_5 \) assets. While the shift from M2 to \( x_5 \) assets was substantial, our results suggest that this had little significance in the context of future spending (nominal income) and inflation. Hence, had US policy makers at the time shifted their attention away from M2 towards a so-called M2+ aggregate (including stock and bond mutual funds), the growth in this aggregate would have overstated potential future inflationary pressures as most of the growth appears to be associated with an asset motive rather than a transactions motive. This is evidenced by the stable and low (slightly negative) weight on \( x_5 \) assets throughout the period of rapid growth from the early 1990s.

An important point to reiterate from a monetary policy perspective, therefore, is that the results reported in Figure 6 are genuinely forward looking. The PSS model was estimated up to end-1989, and the recursively estimated weights are post-sample weights thereafter. Hence, in the context of real time policy making, this type of technique could provide valuable ongoing information regarding the information content of monetary aggregates and components during periods of financial innovation and turbulence. The results would have confirmed, quarter by quarter, that the rapid shift into stock and mutual funds was not in itself a cause for concern, but that the weights accorded to \( x_1 \) and \( x_{23} \) should have been increased and decreased respectively. The results would also have suggested that consideration be given to monitoring M3 (including \( x_4 \) assets) as well as the optimally weighted M2. As emphasised previously, Carlson et al (2000) do manage to re-establish a stable money demand relationship for MZM and M2M through the 1990s by specifically accounting, ex post, for the financial innovation that occurred in the early 1990s. In a policy context, however, these financial innovations persuaded the FOMC to downgrade the role of M2 in 1993.

Finally, having established the optimal monetary weights in an out of sample context, it is interesting to analyse the implied recursive weights when the PSS model is estimated over the full sample period, 1960:2 to 2001:2 (this model is reported in Appendix C). It is clear from Figure 7 that the trends in the optimal weights are broadly consistent with those observed in Figure 6, although the variability in the weights is somewhat less pronounced. Nevertheless, we again see the period of relative stability in the late 1980s/early 1990s, followed by the subsequent increase in the implied weight on \( x_1 \) and the decrease in the weight on \( x_{23} \). Interestingly, Figure 7 confirms that the most substantial variations in the optimal weights did not take place until after 1994. This, combined with the very small and slightly negative
weights on $x_4$ and $x_5$, suggests that M2 would have provided a reasonable leading indicator of nominal spending/inflation for much of the missing money period of the early 1990s. This is confirmed in Figure 8, where the growth in M2 and the optimally weighted monetary aggregate are broadly equivalent in the early 1990s, but diverge significantly after the mid 1990s, with M2 exhibiting much faster growth than the optimally weighted aggregate. It is also interesting to note that the growth rates of M2 and the optimally weighted aggregates diverge considerably over the period 1982 to 1987, with the former exhibiting much higher annualised growth rates, particularly during 1992/1993.

The evidence provided in Figure 7 confirms that there is no strong rationale for expanding M2 to include $x_5$ assets, as in the so-called M2+ aggregate, given the consistently low, and slightly negative, optimal weights on $x_5$ in the recursively estimated long run income relationship. Furthermore, Figures 9 and 10 indicate that, had policy-makers focused on an aggregate such as M2+ during the missing M2 episode, this aggregate would have provided highly misleading signals in respect of subsequent inflationary pressures in the U.S. economy. In order to take some account of the lags inherent in the monetary transmission mechanism, we plot the growth rates of these monetary aggregates lagged 8 quarters against current inflation. Figure 9 illustrates that the correspondence between U.S. inflation and prior weighted money growth is generally very good, particularly during the 1970s and 1990s. In contrast, Figure 10 indicates very clearly that M2+ significantly overestimated U.S. inflationary pressure during the so-called missing M2 period of the early 1990s. As we have seen, M2 would have proved to be a more reliable monetary indicator at that time. Furthermore, M2+ continued to overestimate future nominal spending and inflationary pressure in the U.S. throughout the 1990s.

It is also interesting to note that prior M2+ growth would have provided extremely misleading monetary policy signals over the period 1984 to 1989. This is also a feature we noted in respect of M2 growth over the corresponding period in Figure 8 (1982 to 1987). Although optimally weighted money also seems to overstate the inflationary pressures in the mid 1980s somewhat, the leading indicator properties appear to be good in terms of signalling a shift from declining to rising inflation. Furthermore, as alluded to previously, the annualised growth rates of weighted money over the period 1982 to 1987 were much lower than either M2 or M2+, and much lower than the peaks associated with the 1970s. Indeed, in the period 1982/83, the growth rate of weighted money was not much higher than exhibited in the previous few years. This contrasts with the dramatic growth spikes exhibited by M2+ and M2. With respect to the latter, Barnett (1997) suggests that the highly misleading policy
signals generated by simple sum M2 during 1982/83 were, in large part, responsible for the decline of monetarism.

A possible explanation for the apparent overstatement of future inflationary pressures by optimally weighted money in the early to mid 1980s is that the recovery from the very severe recession of the early 1980s produced a period of above trend growth. Hence, given that the monetary component weights are derived from a nominal income relationship, the relatively strong growth in weighted money would be manifested in a relatively strong subsequent growth in the real income component of nominal income, and rather less in the growth of prices, than would be the case when the economy was exhibiting trend growth. From a monetary policy perspective, however, the leading indicator properties of the optimally weighted aggregate, combined with continually updated forecasts for the real economy, should have provided a reasonable indicator of future inflationary pressures at the time.

Finally, it is interesting to note from Figure 7 that the full-sample model produces a much more moderate increase in the implied weight on $x_4$ to that suggested in Figure 6. It must be recognised, however, that the latter represents out-of-sample weights derived over more than a decade. In this context, therefore, the comparability of the general trends, if not the magnitudes, of the weights is remarkable. Furthermore, if this technique were used in a genuine policy making context, the long run model would be continually updated in order to provide sequentially updated recursive weights, rather than using the same long run model to provide recursive weights up to 11 years ahead. Hence, in reality we would expect there to be less discrepancy through time between these two sets of recursive weights than is evident in the contrast between the weights in Figures 6 and 7.

4. Summary and Conclusions

This paper uses an innovative approach to long run modelling in order to develop new empirically weighted monetary aggregates for the U.S. The empirical results shed important new light on two periods of severe monetary instability in the U.S., the “missing money puzzles” of the early/mid 1970s and the early/mid 1990s. With respect to the former “Goldfeld missing M1” episode, the initial success of the Goldfeld partial adjustment type money demand function is easily explained by the dominant optimal weight associated with M1 balances, and the relative stability of the optimal weights prior to 1973. Similarly, the subsequent period of money demand instability can be rationalised in terms of the significant decline in the implied optimal weight associated with M1 balances ($x_1$) and the corresponding increase in the
optimal weight accorded to M2 balances, as reflected in the implied recursive weights on $x_2$.

In retrospect, the Goldfeld missing M1 puzzle has been attributed to a combination of financial innovations associated with the inflationary environment of the 1970s, and inadequacies inherent in the simplistic dynamic econometric specification of the partial adjustment model. With respect to the former, these can typically only be taken into account with the benefit of hindsight, which is clearly of very limited use from a monetary policy perspective. In contrast, the results presented in this paper demonstrate that the use of the PSS technique can produce constantly updated optimal weights that respond endogenously to the financial innovations and changes in preferences that may modify the relationship between monetary assets and policy variables such as nominal income and inflation. Figure 4, for example, indicates that this approach produces a reasonably good out-of-sample prediction for weighted money over the period 1972 to 1977, even without the benefit of a sophisticated dynamic econometric specification. This contrasts with the significant over-prediction of M1 balances using the traditional Goldfeld specification evident in Figure 3.

Turning now to the “missing M2” episode of the early 1990s, this was a further period of money demand instability in respect of an aggregate that had previously appeared to be highly stable and valuable in a policy context. Again, the deterioration in the performance of the aggregate has been attributed to financial innovation and changes in wealth holder preferences, this time associated with the low interest rate environment of the early 1990s and the rapid growth of stock and bond mutual funds. While there clearly was a considerable substitution away from broad M2 assets ($x_{23}$) and into stock and bond mutual funds ($x_3$) in the early to mid 1990s, our results clearly show that this shift had little implication in respect of future nominal spending (income), as evidenced by the low and relatively stable optimal weight accorded to $x_5$ in both Figures 6 and 7. Hence, there is little rationale for broadening the M2 aggregate to include stock and bond mutual funds, as in M2+. Rather, the recursively estimated weights evident in Figures 6 and 7 indicate that the fundamental problem with the M2 aggregate after the early/mid 1990s relates to the constant and equal weights applied to the components of the simple sum M2 aggregate. Our results suggest that the optimal weight on $x_1$ was increasing in the early/mid 1990s while the optimal weight on $x_{23}$ was decreasing. Hence, it is not surprising that the information content of the official simple sum M2 aggregate tended to deteriorate during the 1990s.

From a policy perspective, the difficulty with a period such as the “missing M2” episode is that the official simple sum aggregate is likely to provide extremely
noisy signals in respect of policy variables such as nominal income and inflation. For example, the M2 aggregate itself would exhibit a sharp reduction in growth associated with the switch into stock and bond mutual funds, whereas the redefined M2+ type aggregate would exhibit much more rapid growth, as it includes stock and bond mutual funds. Hence, the fundamental problem at a time of significant financial innovation is that the relationship between key monetary aggregates (assets) and the economy is clearly changing, but it is not apparent at the time how the relationship is changing. This is graphically illustrated in Figure 10 by the misleading inflationary signals provided by M2+ throughout the 1990s. It is not surprising, therefore, that the FOMC downgraded the status of M2 as a policy variable after 1993, given the uncertainty associated with the monetary signals being provided.

The results presented in this paper, however, suggest that the application of the PSS technique can produce an optimally weighted monetary aggregate that can help policy makers to interpret the, often confusing, signals coming from the growth of monetary aggregates and their components. Furthermore, our results support the pre-eminence of the M2 component assets in the U.S., and suggest that there is currently no strong rationale for shifting to an aggregate such as M3 or M2+. However, the fundamental message of this paper is that financial innovations and changes in preferences do occur through time. Hence, it is imperative that monetary aggregates are constructed using the optimal monetary component weights and that these are monitored and updated on an ongoing basis to ensure that the aggregate continues to provide valuable forward looking information in respect of the formulation of monetary policy.

References


Figure 1. Monetary components (levels).

Figure 2. Recursively estimated ‘optimal’ weights, $x_1$, $x_2$, and $x_4$ (to end-1977).
Figure 3. Actual and Predicted Real M1 using a 'Goldfeld' demand for money function.

Figure 4. Actual and predicted $\theta$, from a Goldfeld demand function.
Figure 5. Recursively estimated optimal weights, $x_1, x_2, x_4$ and $x_5$ (to end-1977).

Figure 6. Recursively estimated ‘optimal’ weights, $x_1, x_{23}, x_4$ and $x_5$ (to 2001.2).
Figure 7. Recursively estimated ‘optimal’ weights, $x_1, x_2, x_3, x_4$ and $x_5$ (estimated to 2001.2).

Figure 8. Annual growth rates of M2 and Optimally weighted money.
Figure 9. Annual inflation and annual growth of optimally weighted money lagged 8 quarters.

Figure 10. Annual inflation and annual growth of M2+ lagged 8 quarters.
Appendix A

(a) Goldfeld model for M1

\[ \log(\text{Real M1})_t = 0.900 + 0.104 \log(\text{Output})_t - 0.088 \log(\text{Price})_t, \]
\[ (0.476) \quad (0.039) \quad (0.054) \]
\[ - 0.019 \log(\text{Long interest rate})_t + 0.743 \log(\text{Real M1})_{t-1}, \]
\[ (0.011) \quad (0.115) \]

Sample period 1959.2 - 1972.4

(b) Goldfeld Model for composite M2

\[ \log(\text{Real Composite M2})_t = 0.257 \log(\text{Output})_t + 0.288 \log(\text{Price})_t, \]
\[ (0.069) \quad (0.126) \]
\[ - 0.205 \log(\text{Long interest rate})_t + 0.395 \log((\text{Real Composite M2})_{t-1}, \]
\[ (0.090) \quad (0.154) \]

Sample period: 1967.1 - 1972.4

Appendix B

Model containing \( x_5 \)

\[ \Delta y_t = 0.175 - 0.327 y_{t-1} + 0.295 x_{1,t-1} + 0.061 x_{2,t-1} + 0.012 x_{4,t-1} + 0.035 x_{5,t-1}, \]
\[ (0.056) \quad (0.078) \quad (0.093) \quad (0.047) \quad (0.008) \quad (0.011) \]
\[ + 0.252 \Delta y_{t-1} - 0.214 \Delta y_{t-3} - 0.136 \Delta y_{t-4}, \]
\[ (0.0100) \quad (0.106) \quad (0.092) \]
\[ - 0.117 \Delta x_{1,t-1} - 0.160 \Delta x_{1,t-2} - 0.088 \Delta x_{1,t-4}, \]
\[ (0.061) \quad (0.054) \quad (0.051) \]
\[ - 0.418 \Delta x_{2,t-2} + 0.303 \Delta x_{2,t-3} + 0.027 \Delta x_{4,t-2} - 0.040 \Delta x_{5,t-1} - 0.026 \Delta x_{5,t-3}, \]
\[ (0.107) \quad (0.123) \quad (0.008) \quad (0.013) \quad (0.013) \]

Sample period: 1960.2 - 1972.4 \( R^2 = 0.830 \) \( \hat{\sigma}_\varepsilon = 0.00473 \)

\[ AUTO(4) = 1.18[0.34] \quad NORM = 1.33[0.51] \quad ARCH(1) = 0.38[0.54] \]
\[ HET = 0.90[0.62] \quad RESET(1) = 0.01[0.91] \]
Appendix C

Model estimated over the full sample period.

\[ \Delta y_t = 0.344 + 0.0010 \tau + 0.096 \Delta y_{t-1} + 0.191 \Delta y_{t-2} - 0.107 \Delta y_{t-3} \]
\[ - 0.099 y_{t-1} + 0.037 x_{1,t-1} + 0.020 x_{23,t-1} + 0.005 x_{4,t-1} - 0.007 x_{5,t-1} \]
\[ + 0.154 \Delta x_{23,t-2} + 0.025 \Delta x_{5,t-2} + dummies \]

Sample period: 1960.2 - 2001.2 \( R^2 = 0.539 \) \( \hat{\sigma}_\varepsilon = 0.00669 \)

\( AUTO(4) = 0.87[0.49] \) \( NORM = 2.20[0.33] \) \( ARCH(1) = 0.06[0.81] \)

\( HET = 1.49[0.08] \) \( RESET(1) = 1.68[0.20] \)