RESERVE REQUIREMENTS AND THE INDICATOR PROERTIES OF MONETARY AGGREGATES

by

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January, 1992

Abstract

Targeting of broadly based monetary aggregates, such as M2, continues to play an important role in U.S. monetary policy. Yet the average reserve requirement on M2 assets has fallen dramatically in recent years, a trend which may hamper the ability of the central bank to control such large aggregates. This paper explores the controllability and information content of monetary aggregates in a simple, flexible-price macroeconomic model, with specific attention to the role played by reserve ratios.

It is found that although reserve ratios influence the conditional expectations of both the price level and real output, they do not influence the *variance* of these variables conditioned on observations of nominal monetary aggregates. The best indicator of real income is a deposit aggregate whose income elasticities differ the most from the income elasticity of currency while, in general, a deposit aggregate with a very low income elasticity is the best indicator of the aggregate price level. These results suggest that broad monetary aggregates such as M2 may be better indicators of the price level while narrow aggregates such as M1 may be better indicators of real income. Finally it is shown that the factors which make deposits more controllable by the central bank are often incompatible with the factors that make these aggregates good indicators of real income and prices.

1 Introduction

Over the past decade there have been several changes in the focus of U.S. monetary policy which has shifted attention to monetary aggregates containing many assets without any reserve requirements. Due to the instability of the velocity of M1, the narrow monetary aggregate consisting of currency and reservable checking accounts, in the mid 1980s the Federal Reserve began targeting M2, a far broader aggregate including virtually all other bank liabilities plus money market mutual funds. In December, 1990, due to sharply declining profits of large commercial banks, the Federal Reserve removed all reserve requirements on non-transactions deposits, leaving every asset in M2 which is not already in M1 without any reserve requirement. As a result of this action and trends in monetary demands, the reserve ratio on M2 has fallen from 6.54% in 1960 to 1.51% in 1990, the lowest effective reserve ratio on that aggregate since the establishment of the Federal Reserve System in 1913.

Despite the decline in reserve ratios and numerous doubts about the stability of the velocity of M2, the importance of targeting monetary aggregates has persisted, if not grown in the 1990s. Recently several members of the Federal Open Market Committee (FOMC) have noted the potential of the money supply data to signal important changes in income and prices. Roger Guffey, former president of the Federal Reserve Bank of Kansas City and member of the FOMC, stated in August, 1991, "I don't think there is any member of the [FOMC] who doesn't place some weight on the money numbers. It varies from those who feel [the figures] have *important informational content*, to those who feel it has less."[1]

There is a long, and often confusing literature describing the role of monetary aggregates as targets and indicators of monetary policy.[2] Much of that literature debated whether the money supply itself was the important instrument of monetary policy or only an (imperfect) indicator of the stance of policy, which may be more effectively pursued through controlling other variables, particularly interest rates. Later, general equilibrium models were developed

[1]Quoted from "Fed Cuts Key Interest Rate by Quarter Point, to 5 1/2%," by Alan Murray, *Wall Street Journal*, August 7, 1991, page A3, emphasis added.

[2]See Brunner (1969), Brunner and Meltzer (1967) for early work, and well as the attempts of Tobin (1969), and Cagan (1982) to clarify some of these issues.

which demonstrated the equivalence of interest rate and money supply targeting and showed that the rule governing monetary stabilization depended on all the parameters of the model, particularly the interest elasticity of demand for money and goods and the nature of shocks which influenced the system.[3] Later work, reflecting the growing influence of rational expectations, noted that if economic agents conditioned their expectations on the rate of interest, monetary policy was ineffective in reducing the variance of the underlying real variables in the economy.[4]

Early models of reserve requirements concentrated on the stabilizing effect of reserves on the economy.[5] These results were later extended by Horrigan (1989) who showed that a rule which varied bank reserves according to the rate of interest was ineffective at lowering the conditional variance of the unobservable variables as long as agents conditioned their expectations on the rate of interest. In these models the informational content of the rate of interest was sufficient to negate any real effect of monetary policy.

Most of the above literature assumed a homogeneous monetary aggregate, such as outside money, under complete control of the central bank. Yet empirical evidence suggested that most of the correlation between money and real income were due to the endogenous response of inside money to changes in the real economy.[6] These results indicated that the monetary aggregates could play an informational role even if there was no causal link between money and real income.

This paper explores the information content and controllability of these monetary aggregates in a simple flexible price macroeconomic model, with specific attention paid to the role of reserve requirements in imparting this information. It is found that, in general, the nominal money supply does yield significant information about unobservable variables in the economy, such as real output and the price level, and that the conditional expectations of these variables is dependent of the reserve ratios. The variance of these conditional estimates

[3]See B. Friedman (1975) and Poole (1970).

[4]See Canzoneri, Henderson and Rogoff (1983), Dotsey and King (1983), and Siegel (1983).

[5]See Kaminow (1977), Siegel (1981), and Baltensperger (1982).

[6]See King and Plosser (1984). The inside money response has become an important element in "real business cycle" models.

is, however, *independent* of the reserve ratio, but is dependent on the *relative* income elasticities of the demands of the monetary aggregates as well as the unexplained shifts in currency and deposit demand. It is also determined that the factors which improve monetary control are the very factors which often worsen the information content of the monetary aggregates.

The plan of this paper is as follows. Section 2 develops a disaggregated flexible-price macro model, deriving the equilibrium expressions for the price level and the nominal money supply. Section 3 derives and analyzes the estimates of the unobservable variables conditional on observing the nominal money supply. Section 4 discusses some caveats and extensions to the model and Section 5 offers some concluding comments.

2 A Disaggregated Flexible-Price Macro Model

The economy consists of two monetary assets: high-powered money, which is fiat money issued by the government, and "deposits," which aggregate a set of short-term liabilities issued by banks or other financial institutions. These deposits may or may not possess transaction characteristics. High-powered money which is held by the public and used for transactions is called currency, and that held by the banks is termed reserves.

The public's real demands for currency and deposits are functions of a set of contemporaneous and lagged observable variables, denoted by z_t, such as the rate of interest, deposit rates, etc., and of contemporaneously non-observable variables, denoted by y_t, such as real output. To allow for lagged adjustment of currency and deposit demand, z_t may include lagged real demands for these assets.

The real demands for currency and deposits are homogeneous of degree zero in the aggregate price level and are subject to non-observable random shocks ε_t^c and ε_t^d. Specifically, these demand functions are expressed in log-linear form as:

$$c_t^d = c_z z_t + c_y y_t + \varepsilon_t^c \tag{1}$$

$$d_t^d = d_z z_t + d_y y_t + \varepsilon_t^d \tag{2}$$

where c_t^d and d_t^d are, respectively, the real demand for log currency and log deposits at time

t, c_y and d_y are the respective income elasticities of currency and deposits, y_t is the log of real output, and d_z and c_z are known parameters.

The supply of nominal high-powered money is assumed exogenous and under complete control of the central bank. Financial and depository institutions demand reserves, either by statutory requirements, or as a desire to facilitate the transactions qualities of the liabilities that they issue. It is assumed that reserves are demanded as a fraction, r, of deposits issued, where r may be a function of observable variables such as the rate of interest.[7]

The real demand for high-powered money is the sum of the real demand for currency and the real demand for reserves, the latter being the product of the reserve ratio and the public's demand for deposits. In log form the real demand for high-powered money, h_t^d, can be expressed as

$$h_t^d = \log(\hat{c}_t^d + r\hat{d}_t^d) \,, \tag{3}$$

where $\hat{c}_t^d$ and $\hat{d}_t^d$ represent the real arithmetic demands for currency and deposits.

The aggregate price level is determined by equating the supply and demand for nominal high-powered money. This equilibrium can be expressed as

$$H_t^s(z_t) = p_t + h_t^d \,, \tag{4}$$

where H_t^s is the log of the supply of nominal high-powered money which is a function of the observable variables, z_t, and p_t is the log of the price level. In order to solve explicitly for the price level in terms of monetary demands, (3) is linearized so that h_t^d can be approximated as a weighted average of currency and deposit demands,

$$h_t^d \approx \beta c_t^d + (1-\beta) d_t^d \tag{5}$$

where

$$0 \leq \beta(r) = \frac{\hat{c}_t^d}{(\hat{c}_t^d + r\hat{d}_t^d)} \leq 1 \,.$$

The coefficient β is the ratio of currency to total high-powered money and is an explicit function of the reserve ratio r, so that $\beta'(r) < 0$.

[7]Since deposits may constitute a heterogeneous set, r should be interpreted as a weighted average of the reserve ratio on each individual asset.

Substituting Eqs. (1) and (2) into (5) yields the following expression for the price level,

$$p_t = H_t^s - h_z z_t - h_y y_t - \varepsilon_t^h \tag{6}$$

where

$$h_z = \beta c_z + (1-\beta) d_z \,, \quad h_y = \beta c_y + (1-\beta) d_y \,, \quad \varepsilon_t^h = \beta \varepsilon_t^c + (1-\beta)\varepsilon_t^d \,. \tag{7}$$

Under the assumption of constant returns in the banking industry, the quantity of deposits supplied by banks is determined by the demand. The log of nominal deposits, D_t, is defined as

$$D_t \equiv d_t + p_t \,. \tag{8}$$

Substituting Eqs. (6) and (2) into (8), yields the following expression for the log of nominal deposits,

$$D_t = H_t^s + \beta \left\{ (d_z - c_z) z_t + (d_y - c_y) y_t + \varepsilon_t^d - \varepsilon_t^c \right\} \,. \tag{9}$$

Since high-powered money and z_t are known by economic agents, unexplained movements in the nominal deposit supply occur only if there are changes in the relative real demands for deposits or currency, induced by changes in income, or unexplained monetary shocks.[8] Changes in the relative demands for currency and deposits can occur if income changes and the elasticities of deposit and currency demand differ or there are differences in the monetary shocks, ε_t^c and ε_t^d.[9] Equiproportional changes in the real demands for currency and deposits change the price level in the opposite direction, and by the same proportion, leaving the nominal value of both currency and deposits unchanged.

Since high-powered money is the sum of currency plus deposits times a known reserve ratio, knowledge of *either* (1) nominal currency, (2) nominal deposits, or (3) their sum (defined as the nominal money supply), implies the values of the other two.[10] Since there is

[8] I use the term "unexplained" to refer to changes induced by the unobservable variables y_t and ε_t^d and ε_t^c. "Unanticipated" changes in D_t could also result from unanticipated changes in z_t which, because they are observable, could be included in any policy rule.

[9] This is why money multiplier analysis can be expressed in terms of the *ratios* of demands for monetary assets. For a more detailed exposition, see Santomero and Siegel (1982).

[10] When $r = 1$, money is equal to high-powered money and has no independent informational role.

no independent information imparted by the knowledge of currency and deposits separately, for simplicity we shall examine the indicator properties of nominal deposits, which currently comprises well over 90% of M2.

3 Indicator Properties of Nominal Deposits

It is assumed that economic agents obtain data on the monetary aggregates *prior* to obtaining data on the unobservable variables such as real income and the price level. This assumption corresponds to the fact that money supply figures are released with a ten-day lag, while aggregate price level data are released with at least a one month lag and economy-wide information about real output is made available even later than that.

The conditional expectations of unexplained changes real output, $\tilde{y}_t$, and the price level, $\tilde{p}_t$, given the values of all known variables, z_t, and the observation of the nominal deposit supply, D_0, are[11]

$$E(\tilde{y}_t|\widetilde{D}_t = D_0) = \frac{(d_y - c_y)\sigma_y^2}{\beta\left[(d_y - c_y)^2\sigma_y^2 + \sigma_m^2\right]} D_0 \tag{10}$$

$$E(\tilde{p}_t|\widetilde{D}_t = D_0) = \frac{-h_y(d_y - c_y)\sigma_y^2 - \sigma_{hm}}{\beta\left[(d_y - c_y)^2\sigma_y^2 + \sigma_m^2\right]} D_0 \,, \tag{11}$$

where

$$\begin{aligned} \sigma_m^2 &= \mathrm{var}\,(\varepsilon_t^d - \varepsilon_t^c) = \sigma_d^2 - 2\sigma_{cd} + \sigma_c^2 \,, \\ \sigma_{mh} &= \mathrm{cov}\,(\varepsilon_t^d - \varepsilon_t^c, \varepsilon_t^h) = (1-\beta)\sigma_d^2 - \beta\sigma_c^2 + (2\beta - 1)\sigma_{cd} \,. \end{aligned} \tag{12}$$

The expectations of income and the price level, conditioned on the observation of nominal deposits, are explicitly dependent on β and hence on the reserve ratio, r, the income elasticities of deposits and currency, and the variance-covariance matrix of monetary shocks.[12]

[11] These expressions are derived assuming the shocks are normally distributed. In that case $E(\tilde{y}|\tilde{x} = x_0) = [\mathrm{cov}\,(\tilde{x}, \tilde{y})/\mathrm{var}\,(\tilde{x})] \cdot x_0$.

[12] Although Eqs. (10) and (11) are predicated on observing nominal deposits, it can be shown that identical expressions hold for expectations conditioned on the nominal money supply (currency plus deposits) where the β in the above equations is replaced by $\alpha - \beta > 0$, where α is the currency to money ratio.

Since the denominator of (10) and (11) is positive, as long as $d_y > c_y$, unexplained changes in nominal deposits will be positively correlated with real income, while if $d_y < c_y$, the correlation will be negative. This occurs because if real output expands, there will be a relative shift from currency to deposits if $d_y > c_y$. If $d_y < c_y$ then a rise in income induces a relative shift to currency, causing nominal deposits to decline and inducing a negative correlation between real output and nominal deposits.

Unexplained changes of nominal deposits are ambiguous signals of price level changes. If $d_y > c_y$, then the price level will be negatively correlated with unexplained changes in nominal deposits induced by changes in income alone. This is due to the fact that an upward shift in real income increases the demand for real high-powered money and hence lowers the equilibrium price level. However, the nature of the shocks to the monetary demands, which influence the sign of σ_{hm}, complicate the picture. An upward shock to deposit demand, if reserve requirements are positive, will increase both nominal deposits (by Eq. 9) and lower the price level (by Eq. 11). In contrast, an upward shock to currency demand will lower both nominal deposits and the price level. If reserve requirements are zero, shocks to deposit demand will not influence the price level and shocks to currency demand will induce a positive correlation between the price level and nominal deposits. Hence the correlation between nominal deposits and the price level is ambiguous and depends on reserve levels.

Although the conditional expectations are firmly dependent on the reserve ratio, such is not the case of the *variance* of the estimate of the unexplained changes in the variables p_t and y_t. The conditional variance of these unexplained changes are:

$$\text{var}\,(\tilde{y}_t|D_0) = \frac{\sigma_y^2\sigma_m^2}{(d_y - c_y)^2\sigma_y^2 + \sigma_m^2} \tag{13}$$

$$\text{var}\,(\tilde{p}_t|D_0) = \frac{\sigma_y^2\left[d_y^2\sigma_c^2 + c_y^2\sigma_d^2 - 2\,d_y c_y \sigma_{cd}\right] + \sigma_c^2\sigma_d^2(1-\rho_{cd}^2)}{(d_y - c_y)^2\sigma_y^2 + \sigma_m^2}\,. \tag{14}$$

Eqs. (13) and (14) indicate that the conditional variances of both real income and the price level are explicitly *independent* of the reserve ratio r.[13] This is in contrast to the

[13]It is possible that the reserve ratio, by acting as a tax on deposits, will alter the income elasticities and

unconditional variances of the price level, which, from Eq. (6) is clearly dependent on r through the terms β, h_y and ε_t^h. Eq. (13) is less than the unconditional variance $\tilde{\sigma}_y$ (except if $d_y = c_y$) and falls as the difference between the income elasticities grows. This is because unexplained movements in the deposit multiplier yield information about the level of aggregate real income only if the income elasticities of currency and deposits differ.

The expression for the conditional variance of the price level is more complicated than that of real income. Even when $d_y = c_y$, the variance of the price level conditional on the nominal deposit supply is strictly less than the unconditional variance, in contrast to the case for real income. This is because observation of nominal money improves the conditional estimate of the monetary shocks ε_t^d and ε_t^c which influence the price level, but not of real income.

Under the assumption of independence of the monetary shocks ($\sigma_{cd} = 0$), the conditional variance of the price level, Eq. (14), is minimized for a value of d_y as close to zero as possible, while the conditional variance for real income is minimized when d_y is a far from c_y as possible. Since the broad monetary aggregates may have less "transaction" sensitivity than the narrow aggregates, and hence a lower d_y, the analysis here suggests that the broad aggregates may be better signals of the underlying price level than of changes in real income. On the other hand, if transactions accounts have a higher income elasticity than currency, then the narrow monetary aggregates, such as transactions accounts in M1, will be better signals of changes in real income.

The variance of unexplained changes in the supply of nominal deposits can, from Eq. (9), be derived as

$$\sigma_D^2 = \beta^2 \left[(d_y - c_y)^2 \sigma_y^2 + \sigma_m^2 \right] . \tag{15}$$

This term is in the denominator of the expressions for the conditional variances, Eqs. (13) and (14), multiplied by β^2. Many of the very factors that decrease the variance of unexplained movements in the nominal monetary aggregates will increase the variance of the unexplained movements in the price level and income. In particular, as β is an inverse function of the

hence indirectly influence the conditional variance of the estimates. If interest were paid on reserves, this effect would be mitigated. See Section 4 below.

reserve ratio, lowering r increases the variability of nominal deposits (and the money supply) but has no influence on the conditional variances. Furthermore, as d_y approaches c_y, the variance of the deposit supply declines but the conditional variance of real income increases. Hence factors which improve monetary control may be detrimental to the indicator properties of the monetary aggregates.

4 Caveats and Extensions

As with any macroeconomic model purporting to be useful for policy purposes, one should recall that the parameters of the system may not be invariant to changes in the policy instruments. Specifically, lower reserve requirements may increase the deposit rate. To the extent that deposit rates influence the interest elasticities of demand for currency and deposits (embedded in c_z and d_z), this extension will not change any of the conclusions found above since d_z and c_z do not appear in equations (13) and (14). However, to the extent that reserve ratios influence the *income* elasticity of deposits, d_y, or the variance-covariance matrix of the unexplained shocks to the system, then reserve ratios may influence the conditional expectations of income and prices. It is not inconceivable, for example, that higher deposit rates may make deposits more of a portfolio asset which responds more to changes in wealth, reducing the "transactions" or income elasticity of demand.

The model developed in this paper considers a price-clearing economy with shocks to transactions assets and aggregate supply. An alternative specification might model shocks to aggregate *demand* in an economy in which prices do not clear the goods market in each period. Eq. (6) would still hold, except p_t would be fixed and, in conjunction with an equation representing output demand (an "IS" curve), determine the equilibrium level of output, y_t. It is likely that reserves ratios would influence the information content of deposits in this case because the dichotomization between the real and nominal sectors is not nearly as strong as in the flexible price model. The analysis presented in this paper provides the framework for examining the information content of monetary variables in either framework.

5 Conclusions

It is shown that in a simple flexible-price macro model, observations of monetary aggregates may reveal significant information about the state of such unobservable aggregate variables as the price level and real income. Since monetary statistics are released many weeks before data on the overall economy, the revelation of such information may be important to both private agents and policymakers in forecasting the path of these economic variables.

Although reserve ratios influence the conditional expectations of both the price level and real output, they do not influence the variance of these variables conditioned on nominal deposits or the money supply. The conditional variances of output and the price level are influenced by the difference in the income elasticities of currency and deposit demand and the variance-covariance structure of the shocks to the demands for the monetary assets.

The best indicator of real income is a deposit aggregate whose income elasticity differs the most from that of currency. In general, the criteria for the best indicator of the aggregate price level is a deposit aggregate with a very low income elasticity. If one assumes that the income elasticity of currency is low relative to that of checking deposits, which comprise 70% of M1, then the narrow monetary aggregates may be better signals of changes in real income while broader, less transactions related deposits may be better signals of the price level. Finally it is shown that the factors which make the changes in nominal deposits more predictable are often incompatible with the factors that make the aggregates good indicators of the important underlying variables in the economy.

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