Does Money Matter?
An Empirical Investigation

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Abstract: This paper uses a simultaneous-equations model of the new consensus macroeconomic model to examine whether the inclusion of the money stock in the aggregate demand function improves the statistical fit of the model. The results indicate that the consensus model is accurate for the U.S. in that the inclusion of money does not increase the predictive power of the model. However, the results reveal that the estimated coefficients are more robust when money is included as an instrumental variable in the simultaneous equations consensus model.

JEL classifications are: C30; C52; and E32.

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1. Introduction

One of the oldest issues in macroeconomics is the potential effect of changes in the stock of money on the real sector. The principles of dichotomy and monetary neutrality attribute no real effects to changes in the stock of money in the long run. As far as the short-run effects of monetary injection are concerned, following the traditional Keynesian model's emphasis on fiscal policy as a countercyclical tool, it is suggested that money simply does not matter. The importance or lack thereof of money was the focal point of the Keynesian-monetarist debate in the 1960s, which reached its pinnacle with the development of the St. Louis Equation. This new development purported to show empirically that money had a larger impact on nominal GDP than fiscal policy variables.

In the early 1970s, the new classical model emerged in the forefront of macroeconomic debate. It argued that only surprise changes in money stock could have real effects in the short run. This was followed by the new Keynesian macroeconomics, which demonstrated that in the presence of nominal or real rigidities the stock of money could have real effects. The early versions of the real business cycle (RBC) models, which appeared in the 1980s simply excluded money altogether, but more recent RBC models do include money as an input into "transactions technology."[1]

[1] Two alternative methods of including transaction technology in the RBC models include the cash-in-advance constraint and the shopping-time technology. Regarding the latter, one can include money in the RBC model by specifying the time needed to carry out transactions as a negative function of the quantity of money in hand (King and Plosser, 1984; Kydland, 1989.) Alternatively, one can specify the household production technology so as to include both physical output and money (Huh, 1990,) while the cash-in-advance constraint incorporates money into the model by requiring payment of money when making transactions.

The latest development in modeling the macro economy, dubbed the new "consensus" model, does not include the money stock at all (Arestis and Sawyer, 2003; Clarida, Gali, and Gertler, 1999; Fuhrer and Moore, 1995; Rotemberg and Woodford, 1997; Taylor, 1993, 1999).[2] The rationale is that central banks no longer target monetary aggregates but rather follow some sort of interest rate rule.[3] With this in mind, the new macro models incorporate monetary policy in terms of a Taylor-like operating rule that expresses the interest rate as a function of a number of nominal and real variables, most notably output and inflation, to the exclusion of the stock of money.[4]

Although money growth and inflation are positively correlated, this relationship is only significant in the long term. In fact, over periods of a few years, money supply and inflation can move in separate directions. Furthermore, the relationship between money supply and other aggregate variables depends on the stability of velocity. In the U.S., the velocity of money has been subject to large and unpredictable changes. These characteristics support the Federal Reserve's decision to no longer target money stock. Variations in interest rates, output, and prices still capture the importance of money stock but adding money stock to a model as a separate variable does not add new information. In the words of Kahn and Benolkin (2007, p. 30) "[a]s long as reliable statistics on inflation are available and observable on a timely basis, there is no benefit from tracking the money supply."

[2] It should be pointed out that the consensus does not appear to be all encompassing, as there are some prominent dissenters (e.g., Meltzer, 1999).
[3] See Romer (2000, pp. 155-156) for a discussion of nominal versus real interest rate rules.
[4] For a critical view of the Taylor Rule see Hetzel (2000).

Meyer (2001) points out that while in the new consensus model output, the interest rate, and inflation are determined without the use of an LM curve, the model does allow for the addition of a money demand equation. But this new equation would simply identify the money stock needed to be supplied by the Federal Reserve given that the Fed follows a Taylor-like rule. Meyer goes on to state that "[p]ersonally, I do not believe that there is a direct effect of money on aggregate demand. But I may be biased. My view is based in part on my own research. I tested and rejected the hypothesis of such a direct effect in my dissertation."

The foregoing discussion of alternative views of the role of money in the economy reveals that, semantics aside, there is no consensus in the profession regarding the effect of changes in the money stock. An implication of this is that the issue may be settled empirically. Indeed, some of the competing hypotheses regarding the manner in which the stock of money can exert a causal effect on the economy in the consensus model have been tested empirically (Bernanke, Gertler, and Gilchrist, 1998; Dotsey *et al.*, 2000; Hendry, 1995; Laidler, 1999). However, much of the available evidence is for different countries and different time periods. Moreover, as Arestis and Sawyer (2003, p. 125) state, "The empirical evidence on [some of] these views of money … is deficient." This provides the underlying motivation for the present study.

In this paper we examine whether the inclusion of the money stock in an otherwise consensus macro model improves the predictive power of the model. The results suggest that the consensus model is accurate for the U.S. economy since the mid 1980s, at least compared to models where money enters through the standard LM equation or through the aggregate demand equation. However, the results reveal that the estimated coefficients are more robust when money is included as an instrumental variable in the simultaneous equations consensus model. These results are generally consistent with those found by Dotsey *et al.* (2000).

The next section presents the basic consensus macro model. Section 3 presents the data and describes the findings. The final section summarizes this work and offers some concluding thoughts.

2. The Consensus Macro Model

The basic version of the consensus macro model includes an output (aggregate demand) equation, an inflation equation (the Phillips Curve), and a nominal interest rate equation (monetary policy rule).[5] The critical feature of the model is the fact that monetary policy is represented by the nominal interest rate expressed as a function of a number of nominal and real variables to the exclusion of the stock of money. A simple version of the consensus macro model can be specified as follows:

Aggregate Demand: $$\mathbf{y^g_t = \alpha_0 + \alpha_1 y^g_{t-1} + \alpha_2 y^g_{t+1} - \alpha_3 [R_t - {}_tp_{t+1}] + \varepsilon_1} \quad (1)$$

Phillips Curve: $$\mathbf{p_t = \beta_1 y^g_t + \beta_2 p_{t-1} + \beta_3\, {}_tp_{t+1} + \varepsilon_2} \quad (2)$$

Monetary Policy (Taylor) Rule: $$\mathbf{R_t = r^e + {}_tp_{t+1} + \lambda_1 y^g_{t-1} + \lambda_2 (p_t - p^T) + \lambda_3 R_{t-1} + \varepsilon_3} \quad (3)$$

where: $\mathbf{y^g_t}$ = output gap (actual output less trend or potential output)

[5] As Arestis (2007) points out, additional equations may be added to the model to represent the functions of an open economy. These equations would account for exchange rates, current account positions, and money stock. However, Arestis states that the addition of a money stock equation adds little to the model thus money stock should be treated as a residual in the sense that it does not affect the other variables in the model. This is because the stock of money is created by the banking system to meet the demand for money.

$\mathbf{R_t}$	=	nominal interest rate
$\mathbf{p_t}$	=	inflation rate
$\mathbf{{}_tp_{t+1}}$	=	expected inflation
$\mathbf{r^e}$	=	equilibrium real rate of interest
$\mathbf{p^T}$	=	target inflation rate
$\boldsymbol{\varepsilon_1, \varepsilon_2, \varepsilon_3}$	=	random shocks

Note that while the model incorporates the IS curve--the aggregate demand equation expresses output as a negative function of the real rate of interest--it does not include the typical, upward sloping LM curve found in the traditional Hicks-Hansen type IS-LM models. This is because the model does not incorporate the money market whose equilibrium gives rise to the LM curve. Instead, it includes an interest-rate operating rule, which may be viewed as a horizontal line that shifts up and down in response to changes in the rate of interest set forth by the monetary authority.[6]

While the consensus model does not include the stock of money, several attempts have been made to extend it to include money. One approach has been to introduce a money demand function that would equal the stock of money in equilibrium as in the standard LM equation (Meyer, 2001).

Alternatively, one can incorporate the money stock not only through the LM equation but also directly through the aggregate demand equation (McCallum, 2001a, 2001b). Another option is to assign an "active" role to the stock of money (bank deposits) and treat it as an endogenous variable that depends on the non-bank public's demand for loans (Laidler, 1999).

[6] Romer (2000) calls this horizontal line the MP curve (for monetary policy), which resembles the perfectly flat LM curve of the standard IS-LM model under the Keynesian extreme case of liquidity trap.

The final way in which the stock of money has been incorporated in the consensus model is through credit market frictions whereby the stock of money is endogenous and is determined by the demand for money (Bernanke, Gertler, and Gilchrist, 1998; Bernanke and Gertler, 1999).

In the next section we estimate an empirical counterpart of the above model. Using this as our benchmark, we re-estimate the model while including a monetary aggregate in all three equations to see whether the inclusion of money improves the predictive power of the model.

3. Empirical Analysis

3.a) Data

We estimate the model described above (Equations 1-3) using monthly data covering the period 1985:01-2009:03. The use of monthly data necessitates two changes in the model above. First, the output gap must be defined based on measures of real income as opposed to real GDP, which is not available on a monthly basis. Second, the one-period leads and lags of the variables in the theoretical model may need to be extended in the empirical model when using high-frequency data. Regarding the first issue, we define the output gap (**GAP**) as real disposable income in billions of 2000 chained dollars minus its long-term trend. The lag and lead of the gap (**GAPLAG** and **GAPLEAD**) are specified in terms of their three-month moving averages. As for the second modification, we express all lags and leads in terms of three-month moving averages of the corresponding variables. This allows, for example, inflation to respond to not only its previous month value and output gap (in Equation 2) but also to the moving average of the past three months' values of these variables. Therefore, the reaction of inflation to a one-time output or inflation shock is muted by assuming economic agents respond to a more gradual change in the trends of these variables.

The real interest rate is constructed as the ten-year government bond rate minus a measure of expected inflation (**EXPINFL_M**). For the latter, we use the inflation rate expected over the next 12 months from the University of Michigan survey of consumers. As is the case with the output gap, the lagged real rate used in Equation 1 (**RLONG_LAG**) is expressed as the three-month moving average of the contemporaneous and previous two months' values of this rate.

In addition to the variables entering equation 1, we also empirically test whether the inclusion of some money aggregate into this aggregate-demand equation would improve its statistical performance. For that purpose, we use the Federal Reserve Bank of St. Louis adjusted monetary base. Theoretically, only the unanticipated component of money should enter the aggregate demand equation. Empirically, we measure the unanticipated money as the actual or observed growth of the monetary aggregate minus the expected value of this rate. For the latter, we use the approach use in Barro (1977, 1978) by regressing actual money growth (**MBASEGR**) on a series of explanatory variables and using the residuals form this regression as unanticipated money growth (**UAMBASEGR**). The explanatory variables used in this regression are **GAPLAG**, the lagged value of the three-month moving average of inflation (**INFLLAG**), the lag of actual money growth, a variable representing tight credit conditions defined as the nominal long-term interest rate minus the nominal short term rate (**NLONG-NSHORT**) lagged one period, and two dummy variables. **DUM2000** represents the extra liquidity provided by the Federal Reserve in response to the anticipation of the Millennium; it equals one for September 1999 to January 2000. **DUM2008** represents the extra liquidity provided by the Federal Reserve during the current liquidity crisis; it equals one for September 2007 to March 2009. The results from estimating the money growth equation, which are not reported here to conserve space, include a high adjusted R-squared (97%) with all coefficients significant at the 10% level or better except for **GAPLAG** and **DUM2000** which are significant at the 20% level.[7]

In Equation 2, the inflation rate (**INFL**) is the year-over-year percentage change in the CPI for all consumers. The year-to-year specification is utilized in order to be consistent with the manner in which the expected inflation measure (**EXPINFL_M**) is defined. Other explanatory variables in Equation 2 are the three-month moving averages (contemporaneous and previous two months) of the output gap (**GAPLAG**) and lagged inflation (**INFLLAG**).

We estimate the Taylor Rule in Equation 3 by regressing the effective Federal Funds Rate (**NSHORT**) on the contemporaneous real interest rate (**RLONG**), expected inflation (**EXPINFL_M**), lag of GDP gap (**GAPLAG**), deviation of the actual inflation from "target" inflation, and the three-month moving average of the nominal Federal Funds Rate (**NSHORTLAG**). The latter is included to represent the gradual approach to switching from one target Federal Funds Rate to another. The target inflation rate is calculated similar to the long-term trend of income in the output gap with the use of the Hodrick-Prescott filter. The lagged value of the "target" or trend inflation is subtracted from the three-month moving

[7] The results are available from the authors upon request.

average of actual inflation to generate the deviations (**INFLDEV**). Variable descriptions and data sources are reported in Table 1.

3.b) Results

We estimate our empirical counterpart of the model in Equations 1-3 using 2SLS, correcting for autocorrelation that was present in Equations 2 and 3. Lagged values of several regressors as well as predetermined variables were added to the instrument list, which includes: **GAPLAG**, **INFLLAG**, **NSHORTLAG**, **EXPINFL_M**, **RLONG_LAG**, **UAMBASEGR**, and the lags of **RLONG**, **INFLDEV**, **GAPLAG**, **INFLLAG**, **NSHORTLAG**, and **EXPINFL_M**. The estimation period is from 1985:01 through 2009:03. Results are found in Table 2.

The results for Equation 1 when no monetary aggregate is present in the model (column 1) are predominately as hypothesized. The estimate associated with **RLONG_LAG** is negative, as expected, but statistically significant only at the 20% level. Interestingly, the coefficient estimate on **GAPLEAD** is substantially larger (and significantly different) than that of **GAPLAG**, which is not statistically significantly different from. When unanticipated money growth (**UAMBASEGR**) is included in Equation 1 (column 2) as well as the instrument list (similar to the four-equation model in Arestis and Sawyer, 2003) the adjusted-R^2 does not change markedly. The other estimated coefficients in the model with unanticipated money are unaffected. The most relevant finding thus far is the fact that unexpected money growth does exert an independent influence on aggregate demand.

As was indicated earlier, the measure of unanticipated money growth (**UAMBASEGR**) is added to the model to test whether its inclusion improves the statistical fit of the model. The estimation results for Equations 2 and 3 are not greatly affected by the inclusion of monetary aggregate in Equation 1, the only noticeable change being in the list of instruments.[8] For example, consider the results for Equation 2 shown in Table 2 for the model without and with the monetary aggregate variable present (columns 3 and 4, respectively).[9] The adjusted-R^2 equals 0.99 without or with the monetary aggregate included in the instrument list. Moreover, the estimated coefficients on **EXPINFL_M** and the three-month moving average of **INFL** are statistically significantly different from zero and identical in both regression equations. The three month moving average of **GAP**, although identical in both regression equations, is not statistically significantly different from zero. It is interesting to note that with or without money present in the model, in Equation 2 the estimated coefficient on **INFLLAG** is many times larger than the coefficient of **EXPINFL_M**, and the sum of the coefficients is not significantly different from one (for either period), a result that is expected theoretically. Similarly, the estimated coefficients, as well as the coefficient of determination in Equation 3 are virtually identical whether a monetary aggregate is or is not

[8] Since money stock is not directly introduced into Equation 2 or 3 the only noticeable change is the list of instruments is inclusion of the monetary aggregate.

[9] We estimated versions of Equations 2 and 3 that contained an intercept term. This did not affect the significance of any of the estimated coefficients in Equation 2. Likewise, the coefficient of determination and the standard error of the equation did not improve. Nor did the inclusion of an intercept term affect the significance of the coefficients when money stock was excluded from Equation 2. We also found that inclusion of an intercept term in Equation 3 has little effect on the results. In particular, the estimated coefficients on GAPLAG, RLONG, and NSHORTLAG retained their original significance while the coefficient associated with EXPINFL_M became significant at the 5% level and the coefficient on INFLDEV was no longer significant at the 20% level. Overall, the inclusion of an intercept term did not improve the adjusted R^2 or standard error of Equation 3.

included in the model. These findings suggest that on statistical grounds the inclusion of a monetary variable in the model is not warranted.

3.c) Sensitivity Analysis

In order to examine the sensitivity of the results to the specification of the monetary aggregate, we re-estimated the model using the actual as opposed to the unanticipated growth of the monetary base. The estimated coefficient on the actual monetary growth rate was not statistically significantly different from zero, the coefficient estimates of the other variables in the model were not materially affected, and the adjusted R-square was essentially the same as that of the model with no monetary aggregate.

We also considered the effect of using data with a lower frequency. We estimated Equations 1-3 using quarterly instead of monthly data. All variables corresponded to those described above with the following exceptions: the output gap based on real GDP replaced the gap constructed from real disposable personal income; and the lagged and lead values of the variables were defined as the one quarter-lag rather than a three-month moving average. Using these data, we found that the addition of the monetary aggregate variable to Equation 1 and to the instrument list resulted in no noticeable change in any of the estimates. Moreover, the estimated coefficient on the money variable in the aggregate demand equation was statistically insignificant (p-value in excess of 0.70).

It may be argued that Equation 3, which is a set rule, may be subject to no error and thus would not need to be estimated as a regression equation. To account for this, we re-estimated the model as a two-equation system (Equations 1 and 2) treating Equation 3 as an identity and obtained results that were not substantially different from those reported in Table 2. Next, we included both the actual and anticipated (predicted) values of money growth rate in the model. In no case was the estimated coefficient on the actual or anticipated money growth statistically significant at conventional levels.

Finally, we replaced the real long-run interest rate in the aggregate demand equation with the short-term real interest rate to tie it to Equation 3 of the system where the nominal short-term rate is the dependent variable. This did not improve the adjusted R-squared or standard error of the regression. However, the coefficient on the short-run real interest rate in Equation 1 turned out to be significant at the 10% level whereas the real long-term interest rate is significant at the 20% level. This result holds with and without the inclusion of the monetary growth variable

4. Summary

In this paper we used a simple simultaneous-equations model of the new consensus macroeconomic model to examine whether the inclusion of the money stock improves the statistical fit of the model. We introduced money through the aggregate demand equation and found that the consensus model is accurate for the U.S. economy in that the inclusion of money does not increase the predictive power of the model. This is consistent with the finding by McCallum (2001a, p. 157) that, while macro models that do not include money may be mis-specified, “the quantitative significance of this misspecification seems to be very small.”

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Table 1
Variable Names, Variable Definitions and Data Sources

Variable Name	Variable Definition	Source
GAP	Real disposable personal income - the long-term trend of real disposable personal income (from Hodrick-Prescott filter), billions of 2000 chained $	Bureau of Economic Analysis and authors constructed
GAPLAG	Three-month moving average of the lags of GAP	Constructed by Authors
GAPLEAD	Three-month moving average of the leads of GAP	Constructed by Authors
NLONG	10-year government bond rate, %	Board of Governors
NSHORT	Effective Federal Funds rate, %	Board of Governors
EXPINFL_M	Survey of consumers expected rate of inflation over the next 12 months, %	University of Michigan Survey Research Center
RLONG	**NOMLONG – EXPINFL_M**	Constructed by Authors
RLONG_LAG	Three-month moving average of the current, one-month and two-month **REALONG**	Constructed by Authors
INFL	Year over year rate of change in the CPI all items, %	Bureau of Labor Statistics and author constructed
INFLLAG	Three-month moving average of the lag INFL	Constructed by Authors
DUM2000	Dummy variable that is 1 for the period from 1999:09 through 2000:01 and is 0 otherwise	Constructed by Authors
DUM2008	Dummy variable that is 1 for the period from 2007:09 through 2008:03 and is 0 otherwise	Constructed by Authors
MBASEGR	Year over year growth of the adjusted monetary base, %	Federal Reserve Bank of St. Louis and author constructed
UAMBASEGR	Unexpected money growth; the residuals from a regression of **MBASEGR** on **GAPLAG**, **INFLLAG**, the lag of (**NOMLONG-NOMSHORT**), **DUM2000** and lags of the dependent	Constructed by Authors
NSHORTLAG	The three-month moving average of **NOMSHORT**	Constructed by Authors
INFLDEV	The lagged valued of the difference between **INFL** and the long-term trend of inflation (from Hodrick-Prescott filter), %	Constructed by Authors

Table 2

Two-Stage Least Squares Estimates of the Equations 1-3
(Absolute Values of t-statistics in Parentheses)
1985.01-2009.03

Regressors	Equation 1 GDP Gap		Equation 2 Inflation		Equation 3 Nominal Interest Rate
	(1) Without Money	(2) With Money	(3) Without Money	(4) With Money	Same w/ and W/O Money
GAPLAG	0.114	0.121			0.0004***
	(1.02)	(1.10)			(1.50)
GAPLEAD	1.563*	1.548*			
	(9.20)	(9.20)			
RLONG_LAG	-2.22***	-2.157***			
	(1.37)	(1.35)			
UAMBASEGR		3.457			
		(.49)			
GAPLAG(1)			-0.001	-0.001	
			(0.97)	(0.97)	
INFLLAG			0.822*	0.822*	
			(18.5)	(18.5)	
EXPINFL_M			0.186*	0.186*	0.20
			(4.16)	(4.16)	(0.95)
RLONG					0.055*
					(2.31)
INFLDEV					0.038***
					(1.32)
NSHORTLAG					0.951*
					(40.71)
INTERCEPT	7.371	7.208			
	(1.23)	(1.21)			
Adjusted R^2	0.343	0.345	0.993†	0.993†	0.999†
S.E.E.	47.83	47.49	0.254	0.254	0.135
Rho			0.64	0.64	0.727
			(12.06)	(12.07)	(16.01)

*, **, and *** represent statistical significance at the 20%, 10%, and 5% levels, respectively.
†Based on the sum of squared deviations from zero.