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Domestic Money and US Output and Inflation

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Abstract: Recent empirical research found that the strong short-term relationship between monetary aggregates and US real output and inflation, as outlined in the classical study by M. Friedman and Schwartz, mostly disappeared since the early 1980s. In the light of the B. Friedman and Kuttner (1992) information value approach, we reevaluate the vanishing relationship between US monetary aggregates and these macroeconomic fundamentals by taking into account the international currency feature of the US dollar. In practice, by using official US data for foreign flows constructed by Porter and Judson (1996) we find that domestic money (currency component of M1 corrected for the foreign holdings of dollars) contains valuable information about future movements of US real output and inflation. Statistical evidence here provided thus suggests that the Friedman and Schwartz's stylized facts can be reestablished once the focus of analysis is back on the domestic monetary aggregates.

Keywords: Foreign holdings, US monetary aggregates, information value, Friedman-Schwartz's evidence.

JEL classification: E3, E4, E5.

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1. Introduction

One of the longstanding empirical problems in macroeconomics has been whether money has a significant and stable relationship with aggregate output and inflation. For decades, the classic work by M. Friedman and Schwartz (1963) has been the benchmark for those who wanted to assess the impact of monetary policy on macroeconomic variables in the United States. They found over a period of nearly one hundred years (1867-1960) a strong short-run positive correlation between the money growth rate and real economic activity in the US. They argued firmly that for the US higher growth in monetary aggregates led to higher output growth (above the trend) and higher inflation.

Recent empirical research, instead, provides somewhat puzzling evidence on the aforementioned relationships[1]. In their influential study, B. Friedman and Kuttner (1992) report some in-sample statistical evidence suggesting that after around 1982 the relationship between the changes in the monetary aggregates and aggregate output collapsed. On the other hand, short-term interest rates were documented to contain valuable lead-information on nominal and real output. Remarkably, recent literature suggests that monetary aggregates as well as short-term interest rates are very poor indicators for US inflation over the last two decades.

The change in the statistical pattern between monetary aggregates and macroeconomic fundamentals led to a major shift both in policy and research focus. A vanishing relationship between money and output gave scholars confidence in the consistency of the Federal Reserve's focus on the interest rate policies. Consequently, current monetary research concentrates on short-term interest rates, such as the US Federal funds rate, in analyzing US monetary policies.[2]

[1] See for example Bernanke and Blinder (1992), Friedman and Kuttner (1992, 1996), Feldstein and Stock (1994), Friedman (1998), Walsh (1998).

[2] See for example Taylor (1999) where most of the papers focus on the Federal funds rate. See also Friedman (2000).

In this paper it is argued that the international currency feature of the US dollars generates substantial noise when monetary aggregates are used to assess domestic macroeconomic conditions. The crucial question that arises here is the extent by which correcting the US monetary aggregates for the foreign holdings component affects the stylized facts on monetary aggregates and macroeconomic variables. Jefferson (2000) provides a quantitative assessment of the importance of accounting for foreign holdings of US currency for the nominal income in the context of McCallum monetary base rule for the period 1981:1-1995:4. He finds that the foreign holdings corrected monetary base has more exploratory power for changes in nominal income than when the total base is used. In this paper, we focus on two other key macroeconomic fundamentals, real output and inflation. We use US official data for foreign flows that were constructed by Porter and Judson (1996) for the period 1965:1-1998:2 to correct the monetary aggregates for US dollars held abroad. We find that in part the apparent lack of a significant relationship between monetary aggregates on one side and US real output and inflation on the other is due to the presence of substantial and unstable foreign holdings of the US dollar, which are largely unaccounted for.

Our research is hereby explicitly centered on establishing statistical relationships between these variables. Since the seminal work of Poole (1970) it is well known that only in a frictionless economy money supply and interest rate policies would be equivalent. However, in an economy characterized by large uncertainties and real and nominal rigidities such instrumental equivalence tends to disappear. A reliable statistical connection between monetary aggregates and movements in prices and output thus provides a first essential test of their usefulness. If fluctuations in a monetary variable have no implications for subsequent movements in prices and output, that variable should neither be considered an information indicator nor be taken as a policy instrument. Only after a certain statistical relationship between certain monetary variables is established, the usefulness of these variables as potential indicators, intermediate targets, or instruments can be assessed.

For the purpose of analysis we rely on the information value approach introduced by Sims (1972, 1980). The information value approach allows us to address the issue on whether there is some reliable relationship between output, prices, and money, or other potential instruments, such as interest rates. It is important to stress that the information value approach, as a first test of statistical connection between certain variables, is immune to questions of causality, exogeneity or controllability of potential instruments. In Friedman and Kuttner's own words (1992, p. 474):

As long as movements in money do contain information about future movements in output beyond what is already contained in movements in output itself, monetary policy can exploit that information by responding to observed money growth regardless of whether the information it contains reflects true causation, reverse causation based on anticipations, or mutual causation by some independent but unobserved influence.

Although the most common method of identifying potentially useful predictors is to rely on in-sample Granger causality tests and variance decompositions, considered alone these provide no assurance that the identified relationships are stable. As emphasized by Stock and Watson (2001) in-sample statistical evidence should be complemented by formal tests to investigate whether the potentially useful predictors are stably related to the variable under investigation.

Evidence provided in this paper suggests that the Friedman and Schwartz's stylized facts on the close correlation between monetary aggregates and future fluctuations in real output and inflation can potentially be reestablished once the focus of analysis is set back on the "domestic money". The domestic monetary aggregate, i.e. monetary aggregate corrected for the foreign holdings of US dollars, contains significant information for US real output and inflation.

The paper is organized as follows. Section 2 provides the intuition behind the relevance of the monetary aggregates corrected for the foreign holdings of US dollars and presents the official data constructed by Porter and Judson (1996). Section 3 presents the entire dataset used in the paper. Section 4 reevaluates the usefulness of domestic money and several other financial indicators as information variables in light of Granger causality tests. Section 5 presents stability tests. Section 6 assesses the information content of domestic money and other monetary aggregates in the presence of Federal Funds rate. Section 7 discusses results of a vector autoregression exercise and corresponding variance decompositions. Finally, Section 8 concludes.

2. Foreign Holdings of US Dollar

The US Dollar is the most important international currency. Private individuals, central banks, commercial banks and firms in foreign countries use significant amounts of US dollars. US dollars are used for international trade purposes and central bank interventions. Furthermore, in most developing countries the dollar is seen as an investment opportunity to immunize citizens' output from domestic nominal and real shocks. It is even used in daily transactions.[3]

There is a research consensus that the central banks are mainly interested in stabilizing macroeconomic fundamentals such as output and inflation. Now, suppose that a large amount of national currency is in the hands of foreign residents outside of the borders. If there were no competing international currencies that could substitute these holdings or no obvious shifts in the preferences of foreigners to walk away from that currency, domestic stabilization objectives would

[3] Note that currently several countries adopt monetary regimes in the form of currency boards that tie their hands to the US dollar reserves at their central banks (e.g. Argentina, Hong Kong, Lithuania) or choose to directly replace its domestic currency by the US dollar (e.g. Panama, Ecuador, El Salvador)

not be endangered. Under such set of circumstances any rational central bank would like to satisfy the currency demands outside the borders to generate seigniorage output.[4]

Beyond seigniorage concerns, monetary policymakers and market analysts would like to know the amount and flow dynamics of currency abroad in order to be able to assess its implications on the state of the domestic monetary and real economic environment. If the currency flows abroad are large, unstable and unaccounted for, the interpretation of the domestic monetary conditions might be severely complicated and even turn out to be spurious.

The crucial question concerns the measurement of foreign holdings. Several studies have recently focused on this issue. [5] In this paper we will use foreign holdings data constructed by Porter and Judson (1996) that are now official figures of the US Federal Reserve. More precisely we will refer to the estimate based on the shipment proxy method for the sample period 1965:1-1998:2, which is now incorporated into the revised official *Flow of Funds Statistics* of the Board of Governors of the Federal Reserve System.[6] This method is based on the net shipments of $100 notes from the Federal Reserve New York City Cash Office. Hence, the process of estimation of flows of US dollars abroad is clearly exogenous from US economic conditions.[7]

[Insert Figure 1]

[4] Based on the estimates of foreign holdings by Porter and Judson (1996), Obstfeld and Rogoff (1996) and Jefferson (1998) have calculated that the amount of seigniorage revenues obtained by the US Fed is between 20 and 30 billion dollars per year. See also Rogoff (1998).
[5] See for example Feige (1996), Doyle (2000), and Anderson and Rasche (2000).
[6] See also US Treasury (2000) and Allison and Pianalto (1997).
[7] See, Porter and Judson (1996) and Judson and Porter (2001), on this.

On the left hand-side of Figure 1 we present the flow estimate of US dollars abroad at an annual frequency. On the right hand-side, we present the ratio of changes in the foreign holdings abroad to the total change in the currency component of M1 on an annual basis (calculated as 100×[flows abroad/change in M1 currency component]). As we observe, the flows of US dollars abroad were increasing in an unstable way over the period 1965-1998. The flows of US currency abroad are much higher in the nineties as compared to the previous decade.[8]

However, what really matters is the ratio of foreign flows to changes of the currency component of M1. If this ratio were constant over time, the lack of correction for foreign flows would not affect the relevance of the total monetary aggregate. In other words, in this case the percentage change in the total money in circulation would exactly be equal to the percentage change in domestic money.[9] On the other hand, if the ratio of foreign flows to changes of the currency component of M1 is large and unstable, the use of the uncorrected money growth rates in assessing domestic economic conditions will very likely lead to spurious evidence. Therefore, the right hand figure provides us with very interesting visual evidence. It indicates that the ratio of foreign flows to changes of the currency component of M1 is large, unstable, and steadily increasing.

To assess empirically the importance of foreign holdings of the US dollars, a "corrected" monetary aggregate must be newly constructed. We opt to correct M1 currency component for foreign holdings in order to obtain a realistic measure of the US domestic narrow money supply. It is

[8] Porter and Judson (1996) explain the very strong increase in the foreign holdings of US dollar in the nineties by the Westward opening of the Eastern European countries and Russia and instability in the Latin American economies. Recent estimates show that in Russia the level of US dollar holdings is about 60 billion dollars (See US Treasury, 2000). These holdings mainly reflect efforts by residents of some countries with high financial instability to substitute a more stable dollar for their own currency and therefore are not necessarily linked to the US domestic conditions. In any case, the reason as to why there is so high global consumption of US dollars is irrelevant for our research. As we have explained in the introductory section, our methodology is immune to endogeneity or causality matters.

[9] In this case, the share of currency in circulation abroad in the total currency in circulation would also be constant and equal to the ratio of foreign flows to changes of the total currency component of M1.

a simple monetary aggregate not based on estimations so that its amount is determined and precisely known by the monetary authority. Not surprisingly, Porter and Judson (1996) study this aggregate in assessing the relevance of foreign holdings of the US dollar.[10]

We calculate domestic money (Md_t - foreign holdings corrected currency component of M1) as follows:

$$Md_t = M1CUR_t - FH_t \tag{1}$$

where $M1CUR_t$ is the level of currency component of M1 at time t (measured quarterly in billions of dollars) and FH_t is the level of holdings of the dollars outside of the United States at time t (measured quarterly in billions of dollars).

The data for flows of US dollars abroad covers the sample period 1965:1-1998:2. In order to subtract accumulated flows of US dollars abroad from the total level of M1 currency component, the amount of foreign holdings of US dollars in 1964:4 must be known. However, there is no official data on the amount of foreign holdings in 1964:4. As the stock estimate of domestic money given by (1) is conditional on the selected initial benchmark, throughout the paper we will always report statistical evidence for alternative assumptions on the initial level of US dollar stock abroad. For this purpose we assume five different initial foreign holdings levels in 1964:4 (ranging from 0% to 40% of

[10] In principle all monetary aggregates can be corrected for the foreign holdings noise. However, we focus on the currency component of M1. The reasons can be formulated as follows. Firstly, all money measures beyond the narrow definitions of monetary aggregates contain dynamics arising from the financial sector and are typically multiplied by market forces. A correction of such aggregates is extremely difficult. Secondly, other narrow monetary aggregates represented by monetary base measures are also not considered here. The reason is simply that monetary base figures are results of estimations rather than simple accountancy. Even in the US there is no consensus on the right measure of the monetary base. Two well-known measures, the Board of Governors' monetary base and the Federal Reserve of St. Louis monetary base differ considerably from each other.

the total M1 currency component, at 10% intervals). This will enable us to assess the robustness of our results with respect to various assumed levels of foreign holdings in 1964:4. [11]

[Insert Figure 2]

Left-hand side of Figure 2 shows the stock of foreign holdings for different initial level assumptions for 1964:4 (ranging from 0% to 40%). While the right hand side of Figure 2 displays quarterly growth of domestic currency for alternative assumptions on the initial level of the foreign holdings (ranging from 0% to 40%) for the period 1965:2-1998:2. As we observe after the beginning of the 1980's the small discrepancy in growth rates due to the initial level assumption diminishes and we obtain nearly a single series for the domestic money growth rate irrespective of this assumption.

3. Data

The quarterly data covers the time period 1965:1-1998:2.[12] We will study the following macroeconomic fundamentals (in natural log differences): real output represented by real GNP and inflation represented by the GNP deflator.[13] In line with Friedman and Kuttner (1992) we select two categories of financial variables to assess the fluctuations of the macroeconomic variables we

[11] As noted by Anderson and Rasche (2000) the assumption of 40% of the total M1 currency component being held abroad in the sixties is highly implausible. As an example in 1960 the 40% of the total M1 currency component equals the sum of all $100 and $50 notes plus about one-half of $20 notes in circulation at that time (see Banking and Monetary Statistics 1941-1970). Therefore, the assumption of 40% of the total M1 currency component being held abroad in 1964:4 may be treated as a maximum threshold for the amount of foreign holdings in 1964:4 while the 0% assumption constitutes the natural minimum level.

[12] Detailed data descriptions and source references are tabulated in Appendix.

[13] The series in the log difference form are multiplied by 400 to obtain annual percentage growth rates.

consider. The first category of financial variables consists of changes (in natural log differences) in the monetary aggregates and are selected as follows: M1 (Δln(M1)), M2 (Δln(M2)), M1 currency component (Δln(M1CUR)), monetary base measures calculated by the Board of Governors of the Federal Reserve System (Δln(BGbase)) and calculated by the Federal Reserve Bank of St. Louis (Δln(SLbase)), and domestic money (Δln(Md)) . The second category of financial variables consists of short-term interest rates specified as the changes in the Federal funds rate (ΔFUNDS), changes in the interest rate on the 3-month commercial paper r_p (Δr_p) and on the 3-month Treasury bill r_b (Δr_b), and the spread between the two 3-month interest rates (r_p-r_b)[14]. All series we consider above fulfill stationarity properties.[15]

4. Granger Causality Tests

This section presents the Granger causality tests for alternative financial variables in the real output and inflation regressions. The question of stability of the investigated relationships is taken up next.

The autoregressive specification for real output changes and inflation follows exactly Friedman and Kuttner (1992) based on Sims (1972). The three-variable specification for real output changes (*Dy*) is given by:

$$\Delta y_t = a + \sum_{i=1}^{4} b_i \Delta y_{t-i} + \sum_{i=1}^{4} l_i \Delta p_{t-i} + \sum_{i=1}^{4} d_i \Delta m_{t-i} + v_t \qquad (2)$$

where *Dy*, *Dp*, and *Dm* are the growth rates of real output (one-quarter log differences of real GNP

[14] The data on the 3-month commercial paper and therefore on the interest rate spread is available from 1971:2.
[15] Both Dickey-Fuller and Phillips-Perron tests reject the null hypothesis of unit root for all the mentioned series' specifications.

in annual terms), inflation (one-quarter log differences of GNP deflator in annual terms), and the change in the financial variable we will use (the one-quarter growth rate of the monetary aggregate or the one-quarter difference of the short-term interest rate measure in annual terms), respectively.

The three-variable specification for inflation takes the following form:

$$\Delta p_t = a + \sum_{i=1}^{4} b_i \Delta p_{t-i} + \sum_{i=1}^{4} l_i \Delta y_{t-i} + \sum_{i=1}^{4} d_i \Delta m_{t-i} + v_t \qquad (3)$$

where now *Dp*, *Dy*, and *Dm* are inflation (the one-quarter log difference of GNP deflator in annual terms), the growth rate of real output (the one-quarter log difference of real GNP in annual terms), and the change in the financial variable we will use (the one-quarter growth rate of the monetary aggregate or the one-quarter difference of the short-term interest rate measure in annual terms), respectively.

Table 1 presents the Granger causality χ-square statistics[16] and their p-values for the equations (2) and (3) computed with White (1980) heteroskedasticity consistent standard errors[17]. The null hypothesis is that all coefficients on the lagged financial variables, considered individually, in the autoregressive specifications are zero. The table presents results for the time period 1966:2-1998:2 and for the time period 1980:1-1998:2. The former covers the entire period of the available data for foreign flows of US dollars[18]. The latter corresponds to the last two decades during which

[16] The Granger causality test statistics based on the F-statistics yield very similar p-values to those based on the χ-square statistics. Note also that the inclusion of a fiscal variable do not affect any of the results reported throughout the paper.

[17] The White's test for heteroskedasticity rejected the non-constancy of the residual variance for almost all-financial variables in the specifications (2) and (3). Therefore, throughout the paper the White heteroskedasticity consistent standard errors are used to derive the corresponding χ-square statistics of the Granger causality tests. Moreover, the relative performance of alternative financial variables in terms of the heteroskedasticity consistent Granger causality statistics is very similar to those based on the statistics computed with unadjusted OLS residuals. Finally, we note that the Ljung-Box Q-statistics does not reject the null hypothesis that there is no autocorrelation in the residuals of the equations (2) to (3) for all financial variables considered.

[18] In the paper we do not consider the most recent available data for foreign flows. As reported by Judson and Porter (2001) domestic currency demand surged because of the Y2K effect, which introduces a large anomaly in the foreign flows figures.

the relationship between monetary aggregates and macroeconomic fundamentals were documented to fail.

[Insert Table 1]

Real Output: Firstly, we focus on the overall time span 1966:2-1998:2. Over the entire sample period 1966:2-1998:2 the short-term interest rate measures denote high significance in the real output equation. The Board of Governors monetary base is significant at the 5% level and M2 is significant at the 1%, whereas the other standard monetary aggregates exhibit no significant predictive content. The new indicator variable, domestic money, that is the M1 currency component corrected for the foreign holdings, is highly significant in the output equation.

In the period 1980:1-1998:2, all short-term interest rates display a high predictive content for the real output. Similar to the entire sample period, we find that M2 is significant although now at the 5% level. Other standard monetary aggregates, including Board of Governors monetary base, exhibit no significant predictive content for the output movements in the sample period 1980:1-1998:2. Evidence reported in Table 1 confirms Friedman and Kuttner study (1992) indicating the collapse of the information content of monetary aggregates after the 1980's. In contrast to the poor performance of the narrow monetary aggregates in the recent period, the new indicator variable, domestic money, contains highly significant predictive content for the real output (at the 1% level).

Inflation: Now, we turn our attention to US inflation. Over the entire sample period 1966:2-1998:2 we find very few financial variables containing significant information value for future fluctuations in the inflation rate, corroborating the results of Friedman and Kuttner (1992). Federal funds rate contains significant information at the 10% level. Among the standard monetary aggregates, only the Board of Governors monetary base is significant (at the 10% level). On the other hand, domestic money for various assumptions on the initial level contains significant information for future fluctuations in inflation (at the 5% level).

In the period 1980:1-1998:2, none of the financial indicators, be it short term interest rates or standard monetary aggregates, contain significant predictive content for US inflation. In contrast to the poor performance of all the standard financial variables over the period of recent two decades, domestic money is highly significant in the inflation equation (at the 1% level).

5. Stability Tests

In order to be able to make valid inferences based on the estimated Granger causality specifications the relationships should be stable over time. Therefore, it is of particular importance to investigate whether the financial variables characterized by the significant Granger causality statistics are stably related to output and inflation movements.

To analyze the stability of the output and inflation relationships we conduct several exercises based on: 1) recursive p-values, 2) rolling regressions p-values, 3) formal coefficient stability tests, and 4) out-of-sample forecasting exercise.

Recursive p-values. First, we graphically explore the stability of p-values. For this purpose we present series of p-values of Granger causality statistics for the coefficients of financial variables obtained from recursive estimations for real output and inflation. Two recursive estimations are considered. In the first exercise the endpoint of the entire sample period (1998:2) is held fixed, while in the second one the beginning of the entire sample period (1966:2) remains unchanged. The signal content of financial variables is related to the stability and precision of the various coefficient estimates of the financial variables.

Figures 3a and 4a display recursive p-values for the Granger causality tests for real output and inflation over the sample periods ending in 1998:2 for alternative financial variables and domestic money with different assumptions on the initial level. The first p-value plotted in each graph of the figures gives the Granger causality tests statistics for the sample period 1966:2-1998:2, and the subsequent p-values refer to the reduced samples 1966:3-1998:2, 1966:4-1998:2, and so on with the last value corresponding to the sample period 1988:2-1998:2.

Figures 3b and 4b present the recursive p-values of the coefficients of the financial variables for Granger causality tests of real output and inflation, respectively, over the sample periods starting at 1966:2. The first p-value plotted in the figures displays the Granger causality tests statistics for the sample period 1966:2-1976:2, and the subsequent p-values refer to the expanded samples 1966:2-1976:3, 1966:2-1976:4, and so on with the last value corresponding to the entire sample period 1966:2-1998:2. The two dashed lines correspond to the 5% and 10% significance level.[19]

[Insert Figures 3a and 3b]

Figures 3a and 3b represent the p-values for real output. Figure 3a shows that domestic money contains significant and stable information in explaining US real output for the entire series of estimations with starting point ranging from 1966:2 to 1988:2 and the sample endpoint 1998:2 held fixed. This result holds for alternative initial level assumptions. All the other narrow monetary aggregates perform very poorly when compared to domestic money. Even the Federal Funds rate

[19] In the recursive regressions the minimum sample period equals 10 years.

and the 3-month Treasury bill perform badly when earlier periods up to 1983 are excluded from the estimations.

Figure 3b shows significant relationship between real output and all interest rate measures for all estimations when sample size is extended (having 1966:2 fixed). Domestic money on the other hand contains significant information on the US real output when estimations capture quarters beyond 1982:1. In other words, we find that when 1960's and 1970's are always included in-sample a significant relationship between real output and domestic money is established after the inclusion of the observations as of 1982. These results hold irrespectively of the initial level assumption. Among the standard monetary aggregates, M2 contains valuable information over the entire sequence of estimations whereas the Board of Governors monetary base displays significant information when observations as of 1982:1 are included. Other measures of monetary aggregates perform very poorly violating the case of Friedman and Schwartz.

[Insert Figures 4a and 4b]

Figures 4a and 4b display the corresponding p-values of the coefficients of financial variables for US inflation. Figure 4a shows clear evidence of significant information content of domestic money for almost all recursive estimations conducted (where the 1998:2 sample endpoint is fixed). This result holds irrespective of the assumption on the initial level of foreign holdings. In contrast, all standard financial variables considered including the Federal Funds rate display insignificant relationship with US inflation in most of the estimations.

Figure 4b indicates that when we fix the beginning of the sample to be equal 1966:2 and add observations consecutively, domestic money only contains significant information when the sample captures observations from the late 1990's onwards. We note that the standard monetary aggregates perform poorly in explaining inflation with the exception of the Board of Governors adjusted monetary base. We also note that the Federal Funds rate contains significant information in most of the periods after 1982.

Rolling regressions p-values (15 years window). In addition, we display the p-values of the coefficients for financial variables obtained from the rolling regressions with 15 years windows when both the beginning and the endpoint of the estimation sample change. Figures 5 and 6 display p-values of the Granger causality statistics for the coefficients for financial variables for real output and inflation, respectively, obtained from the rolling regressions with 15 years window. Therefore, the first p-value corresponds to the 1966:2-1981:1 estimation period and the last one to 1983:3-1998:2 estimation period.

[Insert Figure 5]

In the case of real output reported p-values from rolling regressions give support to the evidence provided in Table 1. Domestic money displays significant information content for the sample periods ending beyond the early eighties. In contrast, all the standard monetary aggregates, except M1 and M2, exhibit an insignificant relationship with real output. Figure 5 indicates that the interest rates contain significant information content to explain real output.

[Insert Figure 6]

Figure 6 displays an insignificant relationship between the standard monetary aggregates and inflation in nearly all regressions. The only exception is the Board of Governors adjusted monetary base, which has a significant inflation Granger causality statistics up to the periods ending in the early nineties. Also the Federal Funds rate and the 3-month Treasury bill contain significant information for inflation till the end of the eighties. On the other hand, domestic money has significant predictive content for inflation when the second half of the 1990's is included, and this holds afterwards.

Formal Stability Tests: Next, in order to assess formally the stability of the coefficients of the Granger causality specifications we perform the full sample stability tests. Three types of tests are considered. The Quandt (1960) likelihood ratio (QLR) statistic, in Wald form (sup-Wald), the mean Wald statistic (Hansen (1992), Andrews and Ploberger (1994)), and the Andrews and Ploberger (1994) exponential average Wald statistic. Following Stock and Watson (2001), we derive these statistics from the recursive Wald tests with White (1980) heteroskedasticity standard errors for changes in the constant term and four autoregressive coefficients of the financial variable. The 30% symmetric trimming is used that allows testing for a breakpoint in the interval of 1976:1-1988:4. The results of the stability tests are displayed in Table 2.

[Insert Table 2]

For real output there is the evidence against the null of parameter stability for most of the standard financial variables. Only in the case of M2 and the St. Louis adjusted monetary base, the null of no single breakpoint is not rejected. In contrast to the poor performance of standard financial variables, there is no evidence against the stability of the relationship between real output and domestic money. Domestic money also displays one of the smallest Wald statistics among all financial variables considered together with the monetary base of the Federal Reserve Bank of St. Louis.

In the case of inflation, we reject the null of stability for the coefficients of both monetary base measures and M1 currency component. The hypothesis of coefficients stability for domestic money is not rejected for various initial level assumptions, the only exception being domestic money with 0% initial level assumption where sup-Wald and exp-Wald indicate the rejection of the stability at the 5% significance level.

Out-of-sample forecasting. In Table 3 we present the root mean squared errors (RMSE) results for the one step ahead out of sample predictions. We split the entire sample period in two equal parts of sixteen years (64 versus 65 observations). Therefore, the first initial estimation is performed for the 1966:2-1982:1 period. Then we expand our sample by adding recursively subsequent observations. We make one-quarter ahead predictions for the real output and inflation. The predictions are made for the quarters ranging from 1982:2 till 1998:2.

[Insert Table 3]

As it emerges from Table 3, in the case of real output domestic money displays the smallest RMSE among monetary aggregates. In the case of inflation domestic money shows the smallest RMSE among all financial variables considered. The strong performance of domestic money is not affected by the alternative assumptions concerning the level of foreign holdings in 1964:4.

We conclude this section by stating that the results presented in the Granger Causality tests and subsequent in-sample and out-of-sample stability tests do not reject the hypothesis of significant and stable information content of domestic money in explaining US real output and inflation fluctuations.

6. Performance of Monetary Aggregates in the Presence of the Federal Funds Rate

As a next step we provide a further analysis on the information content of the financial variables in the light of Granger causality tests. We will assess whether the monetary aggregates contain any significant information value in the presence of the short-term interest rate in real output and inflation specifications. We reestimate the Granger causality specifications (2) to (3) for monetary aggregates including the short-term interest rate with four lags. We choose the Federal funds rate as short-term interest rate. This variable is used for the public announcements of the monetary policy stance in the US. Results are shown in Table 4.

[Insert Table 4]

Real Output: In the entire sample period, 1966:2-1998:2, when the Federal Funds rate is included only the monetary base measure of Board of Governor's performs well in explaining real output (at the 5%). All other standard monetary aggregates perform very poorly. In the second sub-sample (1980:1-1998:2) domestic money is significant in the presence of Federal Funds rate (at the 1%) as well as the Board of Governor's monetary base (at the 5%). The other standard monetary aggregates display no significance.

Inflation: For the entire sample only the Board of Governor's monetary base and domestic money contain statistically significant information value next to the Federal funds rate (at the 10% and the 5%, respectively). In the second sample (1980:1-1998:2) the Board of Governor's monetary base is significant at the 10% level and domestic money at the 1% level. All other monetary aggregates do not contain any significant information next to the Federal Funds rate. The alternative assumptions on the initial level of foreign holdings do not affect any of these results.

7. Vector Autoregressions

The reported statistical significance of domestic money in the Granger causality specifications is not the only criterion in assessing the information value of this monetary aggregate. Another important criterion used in the information value approach is the ability of a given financial variable to account for the forecast error variance of real output and inflation over a certain horizon.

Following Friedman and Kuttner (1992) we investigate the magnitude of predictive content of financial variables using the methodology provided by Sims (1980). More specifically, we estimate unconstrained VAR representations for real output and inflation in which we include the alternative financial variables one at a time. We use four lags for each variable considered in the unrestricted VAR. Therefore, each right-hand side representation of real output and inflation, which constitutes a given autoregressive system, is identical to the corresponding right-hand side of the Granger causality specification.

Tables 5 and 6 display the share of the variance of real output and inflation, with the approximate 90-percent confidence bounds, attributed to the alternating financial variables included in the VAR representations. In our estimations ordering does not affect results in a significant manner due to the low correlation among the residuals of the estimated VAR specifications. For the sake of consistency with the Granger causality tests we consider two sub-samples. The first period ranges from 1966:2 to 1998:2 and the second period from 1980:1 to 1998:2. We focus our attention on the four, eight and twelve quarters forecast horizons.

[Insert Table 5]

Real Output: Table 5 presents forecast error variance decompositions for real output. In the 1966:2-1998:2 period, the percentage of variance attributed to domestic money is higher than the percentage of variance attributed to all monetary aggregates, except for M2. The shares of real output forecast error variance attributed to domestic money and their approximate standard errors are similar across the different assumptions concerning the initial level of foreign holdings. The ratios of real output variance attributed to domestic money relative to the approximate standard errors are also larger from the corresponding ratios for other narrow monetary aggregates. In the entire sample period, 1966:2-1998:2, the forecast error variance of real output attributed to monetary aggregates is lower than the corresponding variance decomposition attributed to interest rates. The only exception is M2 that has a higher percentage of variance attributed than the 3-month Treasury bill. The Federal funds rate, the 3-month Treasury bill and M2 account for a statistically significant share of forecast error variance of real output.

In the recent sub-sample, 1980:1-1998:2, M2 and domestic money are the only monetary aggregates that account for a statistically significant share of real output variance at some forecast horizons (at the 10% level). M2 and domestic money perform similarly in terms of the percentage of real output variance attributed over the recent sample period. They strongly outperform the other monetary aggregates under consideration. The percentages of real output forecast error variance attributed to domestic money and their approximate standard errors are very similar across the different assumptions concerning the initial level of foreign holdings. In the 1980:1-1998:2 sample period, all shares of real output forecast error variance attributed to the interest rates are statistically significant (with the notable exception of spread). The Federal funds rate, the 3-month Treasury bill and the 3-month commercial paper do account for a larger share of real output forecast error variance than the monetary aggregates do.

[Insert Table 6]

Inflation: Table 6 presents analogous forecast error variance decompositions for inflation. In the entire sample period, 1966:2-1998:2 all interest rates, as well as standard monetary aggregates, perform rather poorly. The shares of inflation forecast error variance attributed to the standard financial variables are insignificant at all forecast horizons and in most cases very small. In contrast to the poor performance of the standard financial variables, domestic money accounts for a substantial percentage of the inflation forecast error variance over the entire sample period. The share of the inflation forecast error variance attributed to domestic money is also significant at twelve quarters.

In the 1980:1-1998:2 period, the performance of the short-term interest rate measures and the standard monetary aggregates is similar to their performance over the entire sample period. Again, the shares of inflation forecast error variance attributed to standard financial variables are insignificant at all forecast horizons and in most cases very small. Similar to the entire sample period, domestic money accounts albeit not significantly for a substantial part of the forecast error variance decomposition for inflation. As in the case of real output forecast error variance decomposition, the shares of inflation forecast error variance attributed to domestic money and their approximate standard errors are very similar across the different assumptions on the initial level of foreign holdings.

To highlight the performance of domestic money compared to the standard financial variables we present graphical representation of the attributed percentages of forecast error variances for real output and inflation (up to twelve quarters forecast horizon). Figure 7 presents the shares of forecast error variances for real output attributed to interest rates, domestic money and the standard monetary aggregates, for both entire sample period and the recent sample period. Analogously, Figure 8 presents the shares of forecast error variances for inflation attributed to interest rates, domestic money and the standard monetary aggregates for both sample periods. [20]

[Insert Figure 7]

As Figure 7 indicates, in both sample periods domestic money strongly outperforms other narrow monetary aggregates for real output at longer forecast horizons. M2 outperforms domestic money for real output over the entire sample period, whilst the performances of both variables are similar in the 1980:1-1998:2 period. In both sample periods the short-term interest rates have higher attributed share of the variance of real output than domestic money (with the exception of spread over the 1980:1-1998:2 period).

[Insert Figure 8]

As Figure 8 shows, in both sample periods, domestic money accounts for the highest share of attributed inflation forecast error variance over longer horizons compared to the standard financial

[20] Note that all results for domestic money hold irrespective of the alternative initial level assumptions (see Tables 5 and 6).

variables. Figures 7 and 8 clearly show that the performance of domestic money is very similar across the different assumptions on the initial foreign holdings.

For the sake of completeness, Figure 9 shows the impulse responses of real output and inflation to one standard deviation of domestic money. The impulse responses are generated from the corresponding unrestricted VAR systems. We present only the impulse responses for the 0% initial level assumption. Alternative assumptions on the initial level of foreign holdings do not affect the impulse responses in a substantial way. Again, we focus on the two sample periods, 1966:2-1998:2 and 1980:1-1998:2. As we have already mentioned, the ordering of variables is of negligible importance.

[Insert Figure 9]

Figure 9 indicates that the impulse responses of real output to domestic money are very similar across both sample periods. The same holds for the impulse responses of inflation. Figure 9 shows that the impulse responses of real income to domestic money in both sample periods are positive at most forecast horizons, albeit not significantly different from zero[21]. The corresponding impulse responses of inflation are positive in both sample periods, except in the second quarter. The response of inflation to domestic money is also significantly larger from zero (at the 5% level) at longer horizons in the 1966:2-1998:2 sample period.

[21] The exception being the positive response of real output to one standard deviation of domestic money in the second quarter which is significantly different from zero in the 1980:1-1998:2 period.

8. Concluding Remarks

In this paper we reevaluate the well-known evidence on the vanishing information content of US monetary aggregates in explaining fluctuations in real output and inflation. The official data constructed by Porter and Judson indicates that foreign flows of US dollars constitute a large and unstable part of total new money creation. We argue that this noise should be filtered out before undertaking an analysis of the US macroeconomic stance based on the monetary aggregates.

The monetary aggregate corrected for foreign holdings of US dollars generally performs much better than any standard monetary aggregate. The Granger causality tests point to significant information content of domestic money for real output and inflation. Moreover, several statistical tests do not reject the stability of the relationship between domestic money and US real output and inflation. The forecast error variance decompositions provide evidence for the substantial and significant contribution of domestic money to the variances of real output and inflation.

These findings can be interpreted as providing support to the M. Friedman-Schwartz's stylized facts on the close relationship between monetary aggregates and macroeconomic fundamentals and can potentially be exploited by monetary policymakers. Of course a practical use of the corrected monetary aggregates in actual monetary policymaking would strongly rely on the accuracy and the timeliness of measurement of the flows of currency abroad.

References:

Allison, T.E. and R.S. Pianalto (1997) "The Issuance of Series-1996 $100 Federal Reserve Notes: Goals, Strategies, and Likely Results" *Federal Reserve Bulletin*, Vol. **83**, no.7, July: 557-564.

Anderson, R., and R. Rasche, (2000), The Domestic Adjusted Monetary Base, Federal Bank of St. Louis Working Paper, 2000-002.

Andrews, D.W.K., (1993), Tests for Parameter Instability and Structural Change with Unknown Change Point, *Econometrica*, Vol. **61**, pp. 821-56.

Andrews, D.W.K., and Ploberger, W., (1994), Optimal Tests When a Nuisance Parameter Is Present Only under the Alternative, *Econometrica*, Vol. **62**, pp. 1383-1414.

Bernanke, B.S., and A.S. Blinder, (1992), The Federal Funds Rate and the Channels of Monetary Transmissions, *American Economic Review*, Vol. **82**, no. 4 (September), pp. 901-21.

Board of Governors of the Federal Reserve System, (1976), *Banking and Monetary Statistics 1941-1970*, Board of Governors of the Federal Reserve System, Washington, 1168 p.

Doyle, B. M., (2000), 'Here Dollars, Dollars…'- Estimating Currency Demand and Worldwide Currency Substitution, The Federal Reserve Board, International Finance Discussion Paper Series, 2000-657.

Federal Reserve Statistical Release, (1996), Flow of Funds Accounts of the United States, December 11, http://www.federalreserve.gov/releases/Z1/19961211/z1r-1.pdf

Feige, E.L., (1996), Overseas Holdings of US. Currency and the Underground Economy, in S. Pozo (ed.), *Exploring the Underground Economy*, W.E. Upjohn Institute for Employment Research, Kalamazoo, Michigan, pp. 5-62.

Feldstein, M. and J.H. Stock (1994), "The Use of a Monetary Aggregate to Target Nominal GDP," in N.G. Mankiw (ed.), *Monetary Polic*y. Chicago: University of Chicago Press for the NBER, 7-70.

Friedman, B.M., (2000), The Role of Interest Rates in Federal Reserve Policymaking, NBER Working Paper No. 8047.

Friedman, B.M., (1998), The Rise and Fall of Money Growth Targets as Guidelines for U.S. Monetary Policy, NBER Working Paper No. 5465.

Friedman, B.M., and K.N. Kuttner (1996), A Price Target for US Monetary Policy? Lessons from the Experience with Money Growth Targets, *Brookings Papers on Economic Activity*, No. **1**, pp. 77-146.

Friedman, B.M., and K.N. Kuttner (1992), Money, Income, Prices and Interest Rates, *American Economic Review*, Vol. **82**, pp. 472-492.

Friedman, M., and A. Schwartz (1963), *A Monetary History of the United States: 1867-1960*, Princeton University Press, (Princeton NJ), 860p.

Hansen, B.E., (1992), Tests for Parameter Instability in Regressions with I(1) Processes, *Journal of Business and Economic Statistics*, Vol. **10**, pp. 321-336.

Jefferson, P.N., (1998), Seigniorage Payments for the Use of the Dollar, 1977-1995, *Economics Letters*, Vol. **58**, pp. 225-230.

Jefferson, P.N., (2000), Home Base and Monetary Base Rules: Elementary Evidence from the 1980s and 1990s, *Journal of Economics and Business*, Vol. **52**, pp. 161-180.

Judson R.A., and Porter R.D., (2001), Overseas Holdings of Dollars: What Do We Know, forthcoming in *Wirtschaftspolitische Blätter*.

Obstfeld, M. and K. Rogoff (1996), *Foundations of International Macroeconomics*, MIT Press, (Cambridge, Mss.), 804p.

Poole, W., (1970), Optimal Choice of Monetary Policy Instrument in a Simple Stochastic Macro Model, *Quarterly Journal of Economics*, Vol. **84**, pp. 197-216.

Porter, R. D. and R.A. Judson (1996), The Location of US Currency: How Much is Abroad?, *Federal Reserve Bulletin*, pp.883-903.

Quandt, R.E. (1960), "Tests of the Hypothesis that a Linear Regression Obeys Two Separate Regimes," *Journal of the American Statistical Association*, Vol. **55**, 324 –330.

Rogoff, K., (1998), Blessing or Curse? Foreign and Underground Demand for Euro Notes, *Economic Policy*, Vol. **26**, pp. 263-290.

Sims, C. A., (1972), Money, Income, and Causality, *American Economic Review*, Vol. **62**, pp. 540-552.

Sims, C. A., (1980), Comparison of Interwar and Postwar Business Cycles, *American Economic Review*, Vol. **70**, pp. 250-277.

Stock, J. H., and Watson, M. W., (2001), Forecasting Output and Inflation: The Role of Asset Prices, NBER Working Paper No. 8180.

Taylor, J. B., (1999), *Monetary Policy Rules,* The University of Chicago Press (Chicago and London), 447p.

United States Treasury Department (2000), The Use and Counterfeiting United States Currency Abroad, http://www.federalreserve.gov/boarddocs/RptCongress/counterfeit.pdf

Walsh, C. E., (1998), *Monetary Theory and Policy*, The MIT Press (Cambridge, Mss.), 528p.

White, H., (1980), A Heteroskedasticity-Consistent Covariance Matrix and a Direct Test for Heteroskedasticity, *Econometrica*, Vol. **48**, pp. 817-38.

Appendix

Board of Governors' Adjusted Monetary Base
Billions of Dollars Seasonally Adjusted.
Source: Federal Reserve Board of Governors (H.3 Release).

Commercial Paper Rate 3-Month-
Percentage Points at Annual Rate.
Source: Federal Reserve Board of Governors (H.15 Release).

Currency Component of Money Stock-
Seasonally Adjusted Billions of Dollars.
Source: Federal Reserve Board of Governors (H.6 Release).

Federal Funds Rate-
Percentage Points at Annual Rate.
Source: Federal Reserve Board of Governors.

Implicit Price Deflator Gross National Product-
Seasonally Adjusted 1996=100.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

M1 Money Stock-
Seasonally Adjusted Billions of Dollars.
Source: Federal Reserve Board of Governors (H.6 Release).

M2 Money Stock-
Seasonally Adjusted Billions of Dollars.
Source: Federal Reserve Board of Governors (H.6 Release).

Real Gross National Product-
Billions of Chained 1996 Dollars Seasonally Adjusted Annual Rate.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

St. Louis Adjusted Monetary Base-
Billions of Dollars Seasonally Adjusted.
Source: Federal Reserve Bank of St. Louis.

Treasury Bill Rate 3-Month-
Percentage Points at Annual Rate.
Source: Federal Reserve Board of Governors (H.15 Release).

Table 1: Granger Causality χ-Square Statistics
(OLS Estimates, White Heteroskedasticity Consistent Standard Errors)

	Real Output Equation		Inflation Equation	
	1966:2-1998:2	1980:1-1998:2	1966:2-1998:2	1980:1-1998:2
Variable	χ-square	χ-square	χ-square	χ-square
$\Delta FUNDS$	28.84286 (0.000008)	39.36052 (0.000000)	9.352853 (0.052860)	6.445799 (0.168238)
Δr_b	24.43848 (0.000065)	39.94051 (0.000000)	5.966437 (0.201669)	4.387136 (0.356141)
Δr_p	-	52.47893 (0.000000)	-	4.489214 (0.343828)
$r_p - r_b$	-	11.82214 (0.018724)	-	6.389728 (0.171872)
$\Delta \ln(M1)$	6.928698 (0.139705)	7.114144 (0.129978)	3.455659 (0.484652)	2.851797 (0.582925)
$\Delta \ln(M2)$	21.12358 (0.000299)	11.64785 (0.020171)	3.892092 (0.420806)	1.426054 (0.839654)
$\Delta \ln(BGbase)$	9.760294 (0.044665)	7.676764 (0.104163)	8.576152 (0.072612)	5.469987 (0.242380)
$\Delta \ln(SLbase)$	1.826524 (0.767626)	4.921732 (0.295423)	4.194390 (0.380337)	3.697528 (0.448486)
$\Delta \ln(M1CUR)$	1.489010 (0.828586)	2.322797 (0.676622)	4.994994 (0.287812)	3.691597 (0.449349)
$\Delta \ln(Md)$ 0%	14.27928 (0.006455)	17.38809 (0.001625)	10.76417 (0.029346)	13.47751 (0.009164)
$\Delta \ln(Md)$ 10%	14.35017 (0.006257)	17.59659 (0.001479)	11.02827 (0.026248)	13.49298 (0.009102)
$\Delta \ln(Md)$ 20%	13.97355 (0.007380)	17.81686 (0.001340)	11.15852 (0.024839)	13.51025 (0.009034)
$\Delta \ln(Md)$ 30%	13.00635 (0.011245)	18.04993 (0.001207)	11.10573 (0.025401)	13.52972 (0.008958)
$\Delta \ln(Md)$ 40%	11.41293 (0.022295)	18.29691 (0.001080)	10.83205 (0.028518)	13.55188 (0.008872)

(p-values in the parentheses)

Table 2: Tests for Structural Change (30% Symmetric Trimming)

	Real Output Equation			Inflation Equation		
	Test Statistics			Test Statistics		
Variable	Sup-Wald	mean-Wald	exp-Wald	sup-Wald	mean-Wald	exp-Wald
$\Delta FUNDS$	34.76***	9.27*	13.43***	11.73	6.45	3.95
Δr_b	17.76**	7.83	6.84**	9.32	4.40	3.09
$\Delta \ln(M1)$	16.64**	10.25**	6.43**	8.66	6.18	3.26
$\Delta \ln(M2)$	11.40	7.24	4.32	6.44	3.82	2.15
$\Delta \ln(BGbase)$	14.49	5.98	5.18*	27.62***	15.90***	11.22***
$\Delta \ln(SLbase)$	9.26	4.64	2.91	15.52*	9.31*	6.21**
$\Delta \ln(M1CUR)$	16.38*	6.76	5.95**	23.92***	9.83**	8.58***
$\Delta \ln(Md)$ 0%	10.89	4.81	3.75	17.00**	6.60	6.14**
$\Delta \ln(Md)$ 10%	9.01	4.10	3.02	14.30	5.90	4.87
$\Delta \ln(Md)$ 20%	6.92	3.29	2.25	11.32	5.21	3.71
$\Delta \ln(Md)$ 30%	4.77	2.45	1.50	8.99	4.61	2.87
$\Delta \ln(Md)$ 40%	2.98	1.77	0.94	8.57	4.16	2.44

Tests are significant at the * 10 percent; ** 5 percent; *** 1 percent. Critical values for the sup-Wald statistics are tabulated in Andrews (1993). Critical values for the mean-Wald and the exponential average Wald statistics are tabulated in Andrews and Ploberger (1994).

Table 3: Root Mean Squared Errors
Predictions for: 1982:02-1998:02

Real Output Equation											
$\Delta FUNDS$	Δr_b	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(M1CUR)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$	$\Delta \ln(Md)$ 0%	$\Delta \ln(Md)$ 10%	$\Delta \ln(Md)$ 20%	$\Delta \ln(Md)$ 30%	$\Delta \ln(Md)$ 40%
2.17	2.18	2.96	2.64	2.69	2.65	2.96	2.51	2.45	2.40	2.35	2.31
Inflation Equation											
$\Delta FUNDS$	Δr_b	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(M1CUR)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$	$\Delta \ln(Md)$ 0%	$\Delta \ln(Md)$ 10%	$\Delta \ln(Md)$ 20%	$\Delta \ln(Md)$ 30%	$\Delta \ln(Md)$ 40%
0.85	0.84	0.92	0.88	1.10	0.99	0.95	0.83	0.81	0.80	0.78	0.77

Table 4: Granger Causality χ-Square Statistics for Federal Funds Rate and Monetary Aggregates
(OLS Estimates, White Heteroskedasticity Consistent Standard Errors)

	Real Output Equation		Inflation Equation	
	1966:2-1998:2	1980:1-1998:2	1966:2-1998:2	1980:1-1998:2
Variable	χ-square	χ-square	χ-square	χ-square
Federal Funds Rate and M1				
$\Delta FUNDS$	18.66693	22.90209	9.948711	5.405581
	(0.000914)	(0.000132)	(0.041301)	(0.248154)
$\Delta \ln(M1)$	3.159784	1.821602	5.159749	2.188591
	(0.531451)	(0.768528)	(0.271295)	(0.701119)
Federal Funds Rate and M2				
$\Delta FUNDS$	18.80918	30.84188	10.14454	6.534240
	(0.000857)	(0.000003)	(0.038062)	(0.162646)
$\Delta \ln(M2)$	7.358368	3.560157	2.800534	1.900377
	(0.118119)	(0.468790)	(0.591741)	(0.754076)
Federal Funds Rate with Board of Governors Adjusted Monetary Base				
$\Delta FUNDS$	34.91312	46.06670	8.989997	9.308933
	(0.000000)	(0.000000)	(0.061350)	(0.053825)
$\Delta \ln(BGbase)$	12.37524	12.32018	8.644409	8.561085
	(0.014768)	(0.015123)	(0.070629)	(0.073057)
Federal Funds Rate with St. Louis Adjusted Monetary Base				
$\Delta FUNDS$	28.67370	40.20532	9.389901	7.461269
	(0.000009)	(0.000000)	(0.052059)	(0.113429)
$\Delta \ln(SLbase)$	1.853332	4.909598	5.808221	4.120885
	(0.762712)	(0.296700)	(0.213936)	(0.389893)
Federal Funds Rate with Currency Component of M1				
$\Delta FUNDS$	31.07105	38.65617	9.958946	10.03888
	(0.000003)	(0.000000)	(0.041125)	(0.039778)
$\Delta \ln(M1CUR)$	5.596242	3.806031	7.051204	6.166276
	(0.231398)	(0.432893)	(0.133207)	(0.187070)
Federal Funds Rate with Domestic Money (0% abroad in 1964)				
$\Delta FUNDS$	20.28859	32.08980	10.91824	7.823919
	(0.000438)	(0.000002)	(0.027498)	(0.098245)
$\Delta \ln(Md)$ 0%	6.178123	20.43179	11.93701	14.71767
	(0.186235)	(0.000410)	(0.017826)	(0.005324)
Federal Funds Rate with Domestic Money (10% abroad in 1964)				
$\Delta FUNDS$	19.86904	31.76610	11.34941	7.897198
	(0.000530)	(0.000002)	(0.022905)	(0.095417)
$\Delta \ln(Md)$ 10%	6.029259	20.51635	12.45732	14.78394
	(0.196974)	(0.000395)	(0.014256)	(0.005171)
Federal Funds Rate with Domestic Money (20% abroad in 1964)				
$\Delta FUNDS$	19.60472	31.42516	11.80824	7.975001
	(0.000598)	(0.000003)	(0.018836)	(0.092498)
$\Delta \ln(Md)$ 20%	5.759516	20.60283	12.83993	14.85542
	(0.217842)	(0.000380)	(0.012085)	(0.005011)
Federal Funds Rate with Domestic Money (30% abroad in 1964)				
$\Delta FUNDS$	19.60297	31.06568	12.22423	8.057761
	(0.000598)	(0.000003)	(0.015759)	(0.089485)
$\Delta \ln(Md)$ 30%	5.351874	20.69073	12.99882	14.93288
	(0.253060)	(0.000365)	(0.011282)	(0.004842)
Federal Funds Rate with Domestic Money (40% abroad in 1964)				
$\Delta FUNDS$	19.98162	30.68622	12.49207	8.145966
	(0.000504)	(0.000004)	(0.014044)	(0.086375)
$\Delta \ln(Md)$ 40%	4.812614	20.77935	12.85098	15.01723
	(0.307070)	(0.000350)	(0.012027)	(0.004666)

(p-values in the parentheses)

Table 5: Variance Decomposition of Real Output Generated from Unrestricted Three-Variable VAR Specification (Real Output, Price Index, Financial Variable)

Horizon (quarters)	$\Delta FUNDS$	Δr_b	Δr_p	$r_p - r_b$	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$	$\Delta \ln(M1CUR)$	$\Delta \ln(Md)$ 0%	$\Delta \ln(Md)$ 10%	$\Delta \ln(Md)$ 20%	$\Delta \ln(Md)$ 30%	$\Delta \ln(Md)$ 40%
Sample 1966:2-1998:2														
4	15[±9]	9[±8]	-	-	4[±6]	11[±9]	3[±5]	0[±3]	0[±3]	4[±6]	4[±6]	4[±6]	3[±6]	3[±5]
8	15[±9]	9[±8]	-	-	4[±6]	12[±9]	3[±6]	1[±5]	1[±5]	7[±8]	7[±8]	6[±8]	6[±8]	5[±7]
12	15[±9]	9[±8]	-	-	4[±7]	12[±9]	3[±6]	1[±5]	1[±5]	7[±8]	7[±8]	7[±8]	6[±8]	5[±7]
Sample 1980:1-1998:2														
4	19[±12]	22[±15]	26[±14]	8[±9]	6[±9]	11[±11]	6[±9]	3[±7]	1[±6]	6[±9]	6[±9]	6[±9]	6[±9]	7[±9]
8	22[±11]	24[±13]	28[±12]	11[±11]	6[±9]	11[±11]	6[±9]	5[±9]	2[±8]	10[±11]	11[±11]	11[±11]	11[±11]	11[±11]
12	22[±11]	24[±13]	27[±12]	11[±11]	6[±10]	11[±12]	6[±9]	6[±10]	2[±9]	11[±11]	11[±12]	11[±12]	12[±12]	12[±11]

Ranges indicate approximate 90-percent confidence intervals computed via Monte Carlo simulations with 5000 rounds.

Ordering: Real Output, Inflation, Financial Variable.

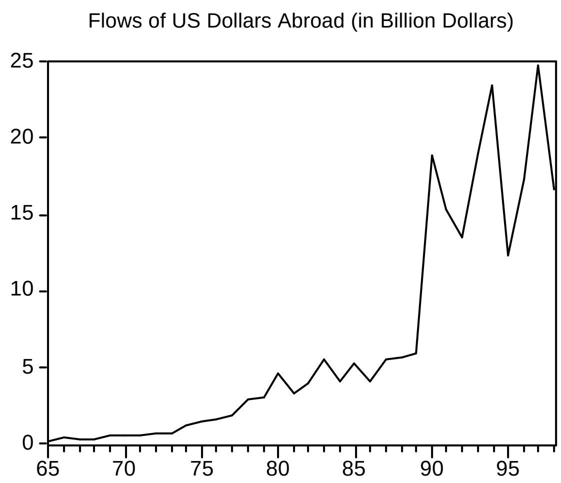
Table 6: Variance Decomposition of Prices Generated from Unrestricted
Three-Variable VAR Specification (Prices, Real Output, Financial Variable)

Horizon (quarters)	$\Delta FUND$	Δr_b	Δr_p	$r_p - r_b$	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$	$\Delta \ln(M1CUR)$	$\Delta \ln(Md)$ 0%	$\Delta \ln(Md)$ 10%	$\Delta \ln(Md)$ 20%	$\Delta \ln(Md)$ 30%	$\Delta \ln(Md)$ 40%
Sample 1966:2-1998:2														
4	6[±7]	3[±5]	-	-	2[±5]	1[±3]	6[±8]	3[±6]	2[±5]	4[±7]	5[±7]	5[±7]	5[±7]	5[±7]
8	5[±7]	2[±5]	-	-	4[±10]	3[±7]	8[±12]	5[±10]	1[±6]	13[±14]	14[±15]	15[±15]	16[±15]	15[±15]
12	4[±6]	2[±5]	-	-	7[±14]	7[±12]	11[±16]	7[±14]	1[±8]	22[±20]	23[±21]	25[±21]	26[±22]	26[±21]
Sample 1980:1-1998:2														
4	2[±5]	1[±5]	1[±5]	2[±5]	0[±4]	0[±5]	5[±9]	2[±7]	3[±8]	2[±6]	2[±6]	2[±5]	2[±5]	2[±5]
8	2[±7]	2[±8]	2[±6]	1[±9]	2[±10]	1[±8]	11[±17]	5[±13]	4[±12]	13[±18]	13[±17]	13[±17]	13[±18]	13[±18]
12	2[±8]	2[±9]	1[±7]	1[±11]	5[±17]	3[±14]	15[±23]	8[±20]	4[±14]	24[±25]	24[±25]	24[±25]	24[±25]	24[±25]

Ordering: Ranges indicate approximate 90-percent confidence intervals computed via Monte Carlo simulations with 5000 rounds.

Ordering: Inflation, Real Output, Financial Variable.

Figure 1


Flows of US Dollars Abroad (in Billion Dollars)
25
20
15
10
5
0
65
70
75
80
85
90
95

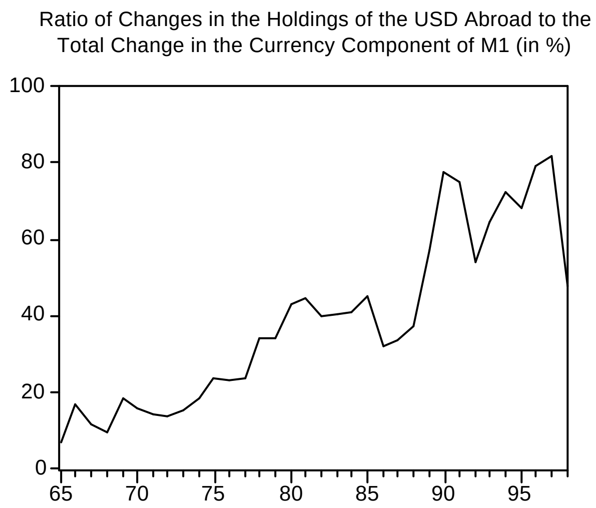
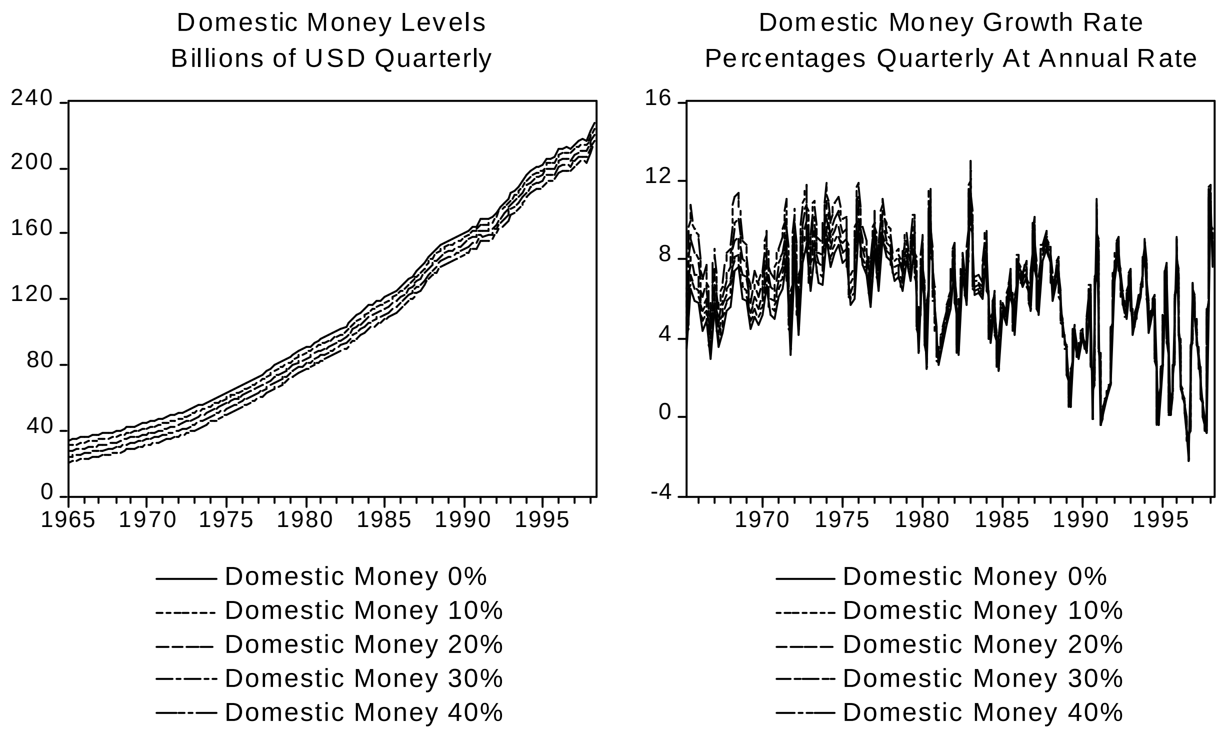

Ratio of Changes in the Holdings of the USD Abroad to the Total Change in the Currency Component of M1 (in %)
100
80
60
40
20
0
65
70
75
80
85
90
95

Figure 2



Note: Domestic Money 0% stands for M1 currency component corrected for the foreign holdings with an initial level assumption of 0% of foreign holdings in 1964:4, Domestic Money 10% stands for M1 currency component corrected for the foreign holdings with an initial level assumption of 10% of foreign holdings in 1964:4 period, etc.

Figure 3a

P-Values: Real Output Granger Causality Statistics
Samples: 1966:2-1998:2, 1966:3-1998:2, 1966:4-1998:2, 1967:1-1998:2...1988:2-1998:2

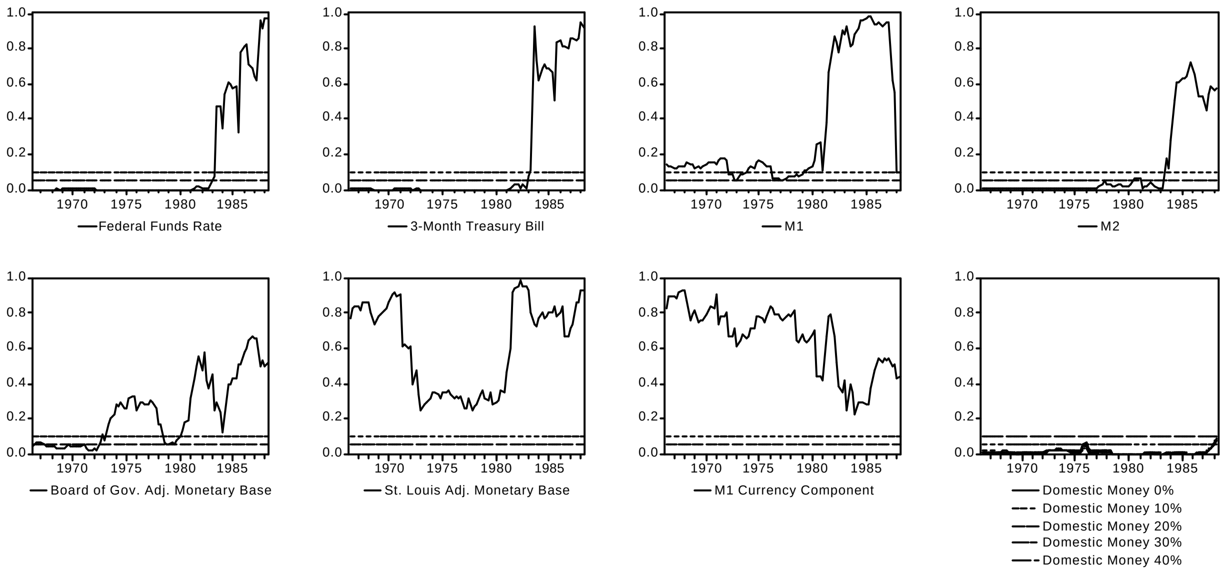
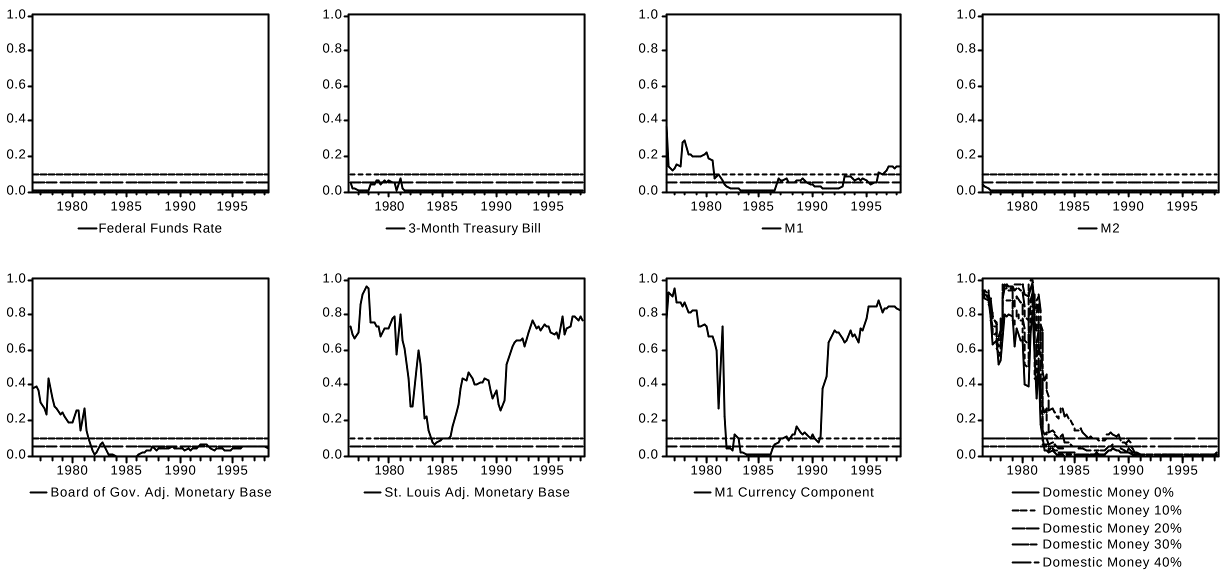


Figure 3b

P-Values: Real Output Granger Causality Statistics
Samples: 1966:2-1976:2, 1966:2-1976:3, 1966:2-1976:4, 1966:2-1977:1...1966:2-1998:2



Note: Dashed straight lines indicate %5 and %10 significance levels for p-values.

Figure 4a

P-Values: Inflation Granger Causality Statistics
Samples: 1966:2-1998:2, 1966:3-1998:2, 1966:4-1998:2, 1967:1-1998:2...1988:2-1998:2

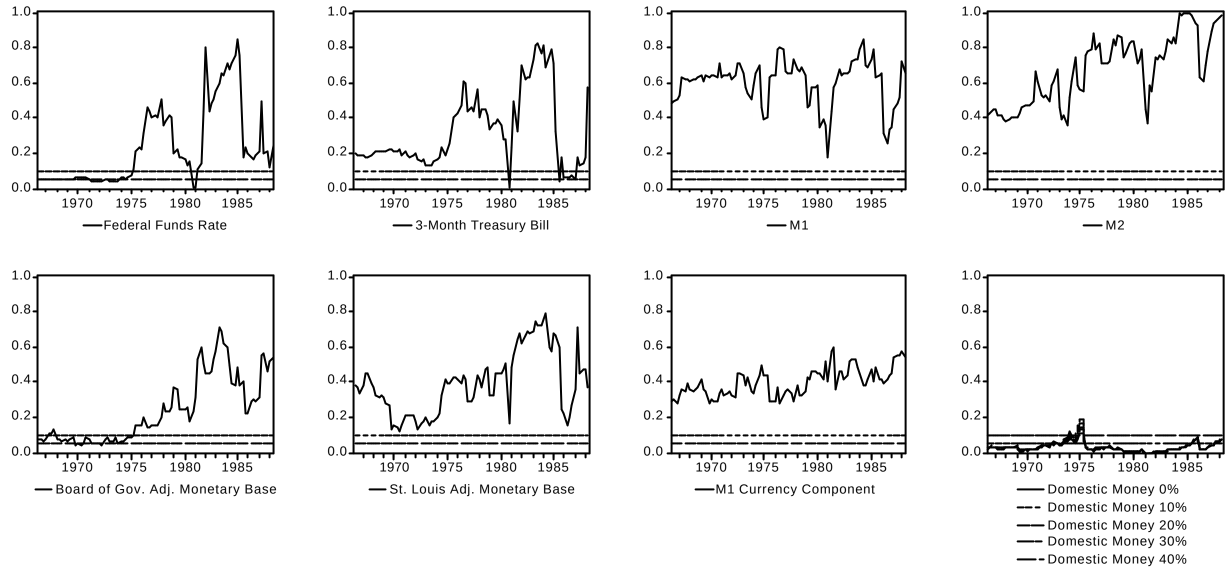
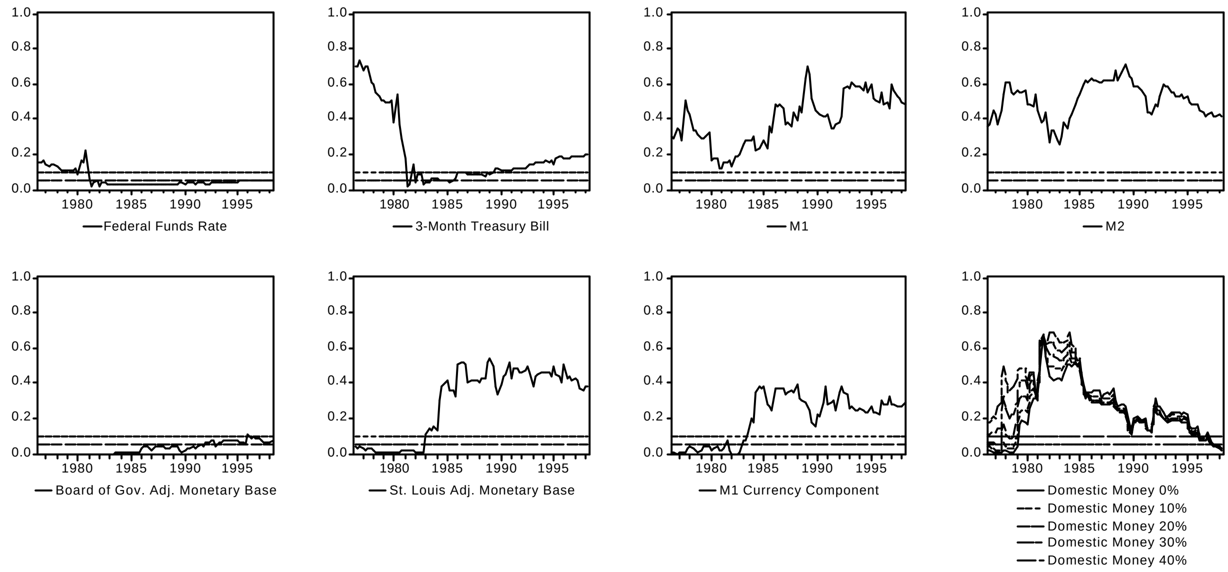


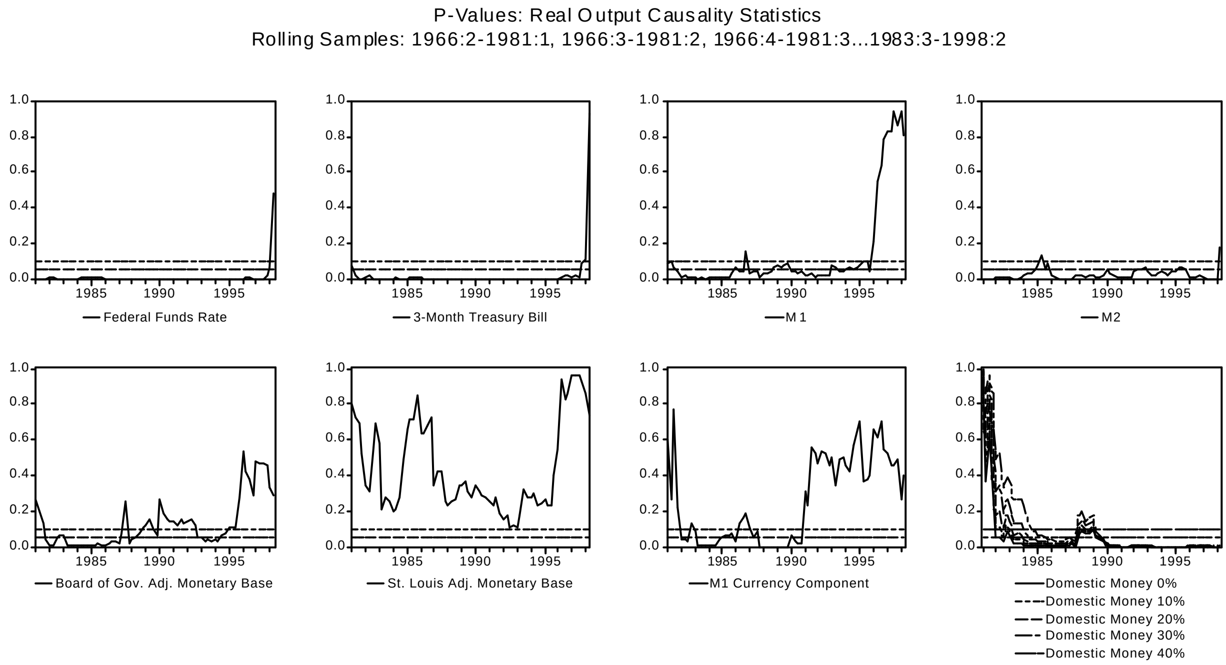
Figure 4b

P-Values: Inflation Granger Causality Statistics
Samples: 1966:2-1976:2, 1966:2-1976:3, 1966:2-1976:4, 1966:2-1977:1...1966:2-1998:2



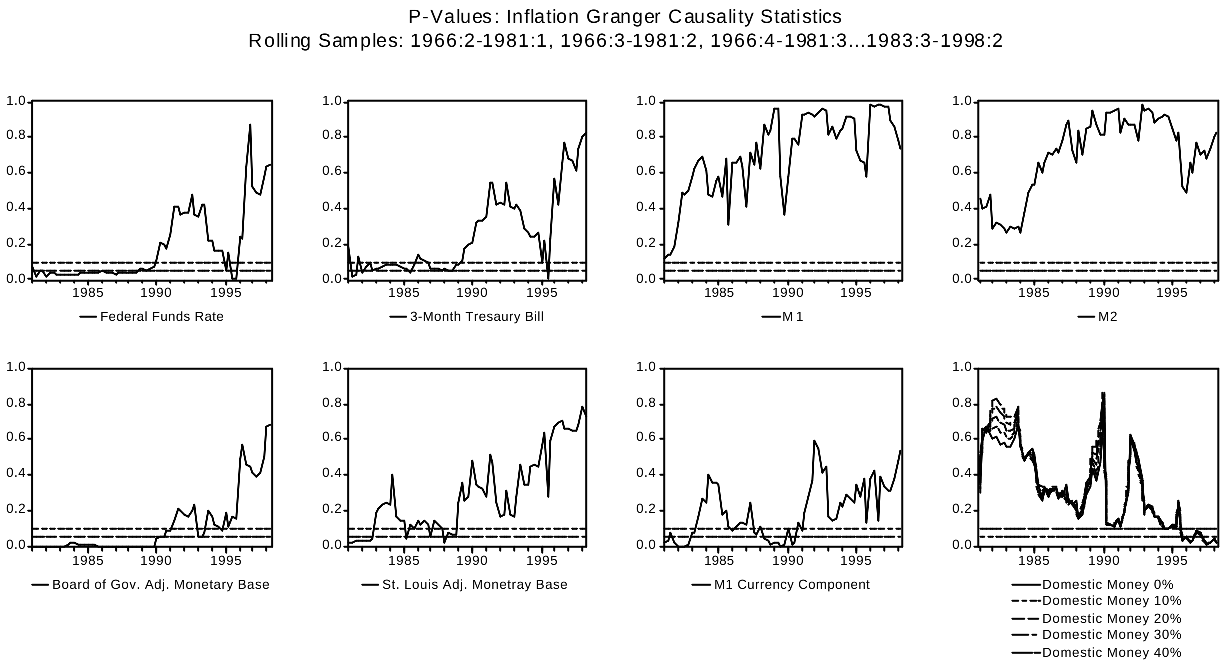
Note: Dashed straight lines indicate %5 and %10 significance levels for p-values.

Figure 5



Note: Dashed straight lines indicate %5 and %10 significance levels for p-values.

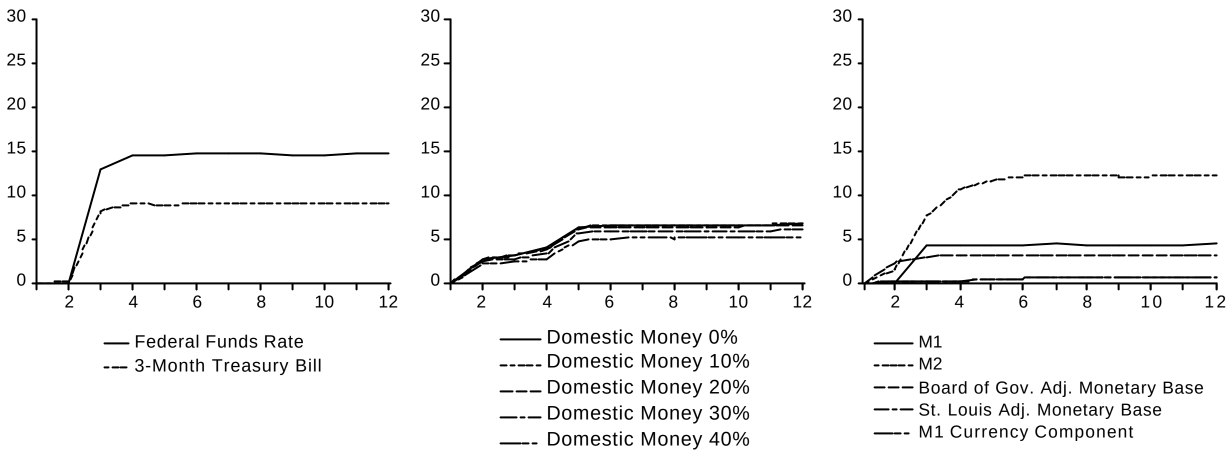
Figure 6



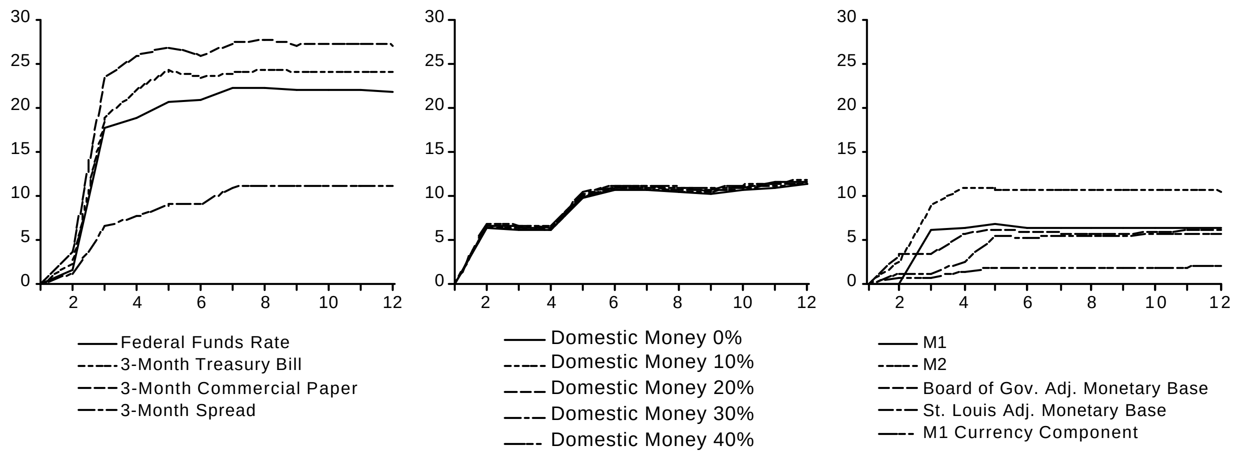
Note: Dashed straight lines indicate %5 and %10 significance levels for p-values.

Figure 7

Real Output Forecast Error Variance Decomposition
Sample: 1966:2-1998:2



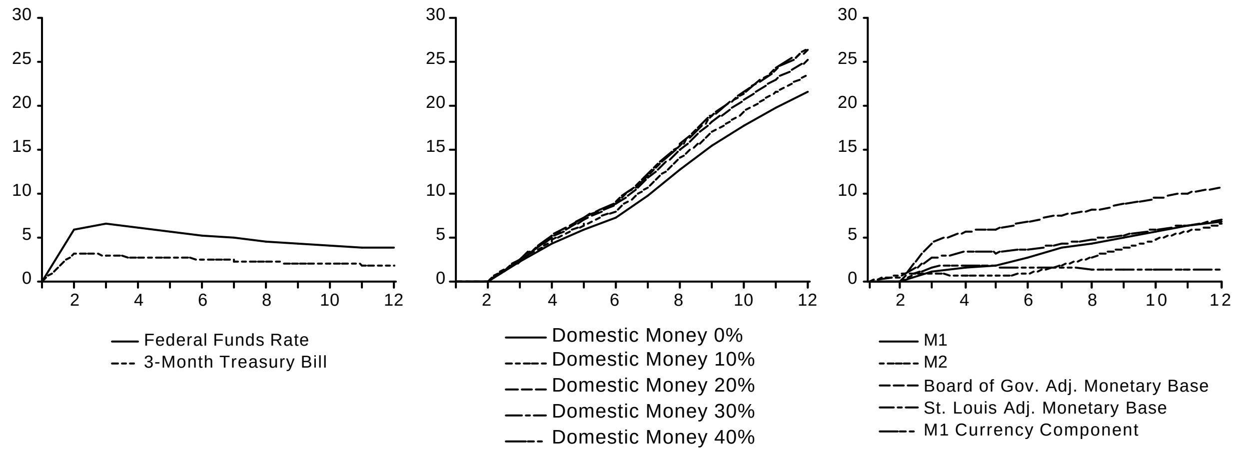
Real Output Forecast Error Variance Decomposition
Sample: 1980:1-1998:2



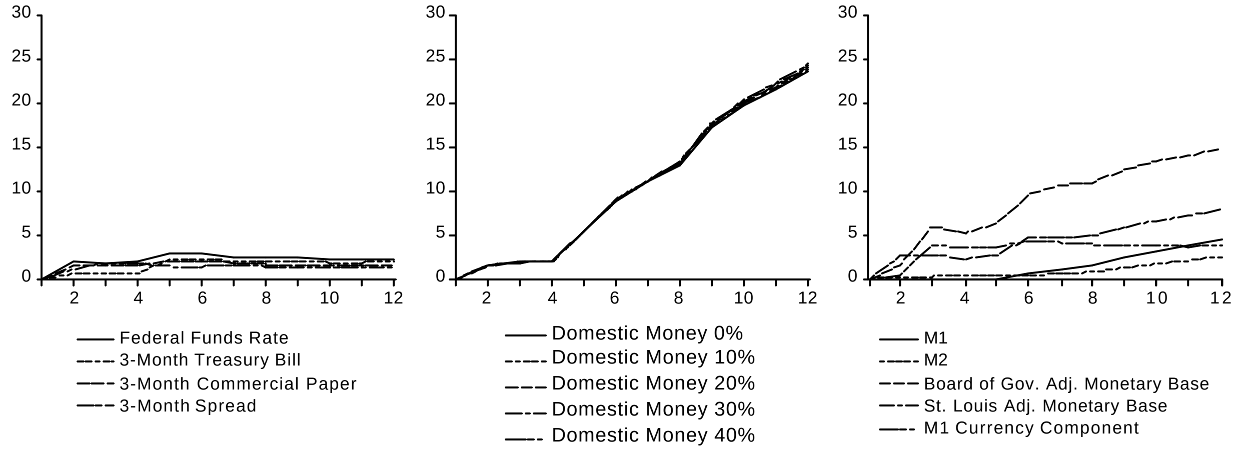
Ordering: Real Output, Inflation, Financial Variable.

Figure 8

Inflation Forecast Error Variance Decomposition
Sample: 1966:2-1998:2

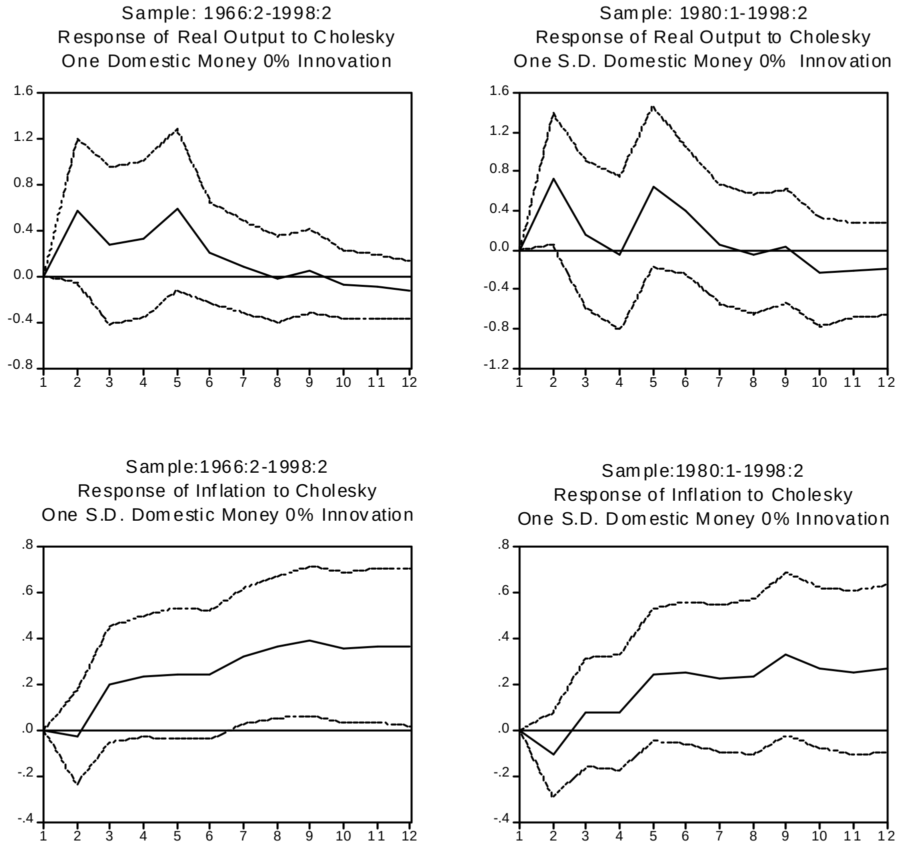


Inflation Forecast Error Variance Decomposition
Sample: 1980:1-1998:2



Ordering: Inflation, Real Output, Financial Variable.

Figure 9



Ranges indicate approximate 95-percent confidence intervals computed via Monte Carlo simulations with 5000 rounds.

Ordering Real Output Equation: Real Output, Inflation, Financial Variable

Ordering Inflation Equation: Inflation, Real Output, Financial Variable.

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