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Foreign Holdings of Dollars and Information Value of US Monetary Aggregates.

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DISCUSSION PAPER

Foreign Holdings of Dollars and Information Value of US Monetary Aggregates*

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Abstract

Recent empirical research has found that the strong short-term relationship between US monetary aggregates and macroeconomic fundamentals, as outlined in the classical study of M. Friedman and Schwartz, mostly disappeared since the early 1980s. In the light of B. Friedman and Kuttner (1992) information value approach we reevaluate the vanishing relationship between US monetary aggregates and macroeconomic fundamentals. By using the official US data constructed by Porter and Judson (1996) we find that the currency component of M1 corrected for the foreign holdings of dollars contains valuable information on US macroeconomic fundamentals, such as nominal and real income, as well as inflation. This correction for monetary aggregates is required because the rate of foreign holdings in total money creation is large and unstable. The statistical evidence provided in this paper suggests that the Friedman and Schwartz's stylized facts can be reestablished once the focus of analysis is back on the domestic monetary aggregates.

JEL Classification: E3, E4, E5.

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

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1. Introduction

In the literature there is a broad consensus on the long-term neutrality of money. Conventional monetary theory argues on the one hand for a one-to-one relationship between price levels and monetary growth. On the other hand, monetary changes are believed not to have permanent effects on the output growth. However, empirically the same argument does not seem to hold for short-term relationships between money and macroeconomic fundamentals. In other words, monetary disturbances can have substantial implications on macroeconomic fundamentals, such as nominal and real output, and inflation. Therefore, on the side of both economic policy and research, short-term monetary non-neutrality has always received large attention as the monetary policymaker may possibly affect real economic activity by manipulating monetary instruments. [1]

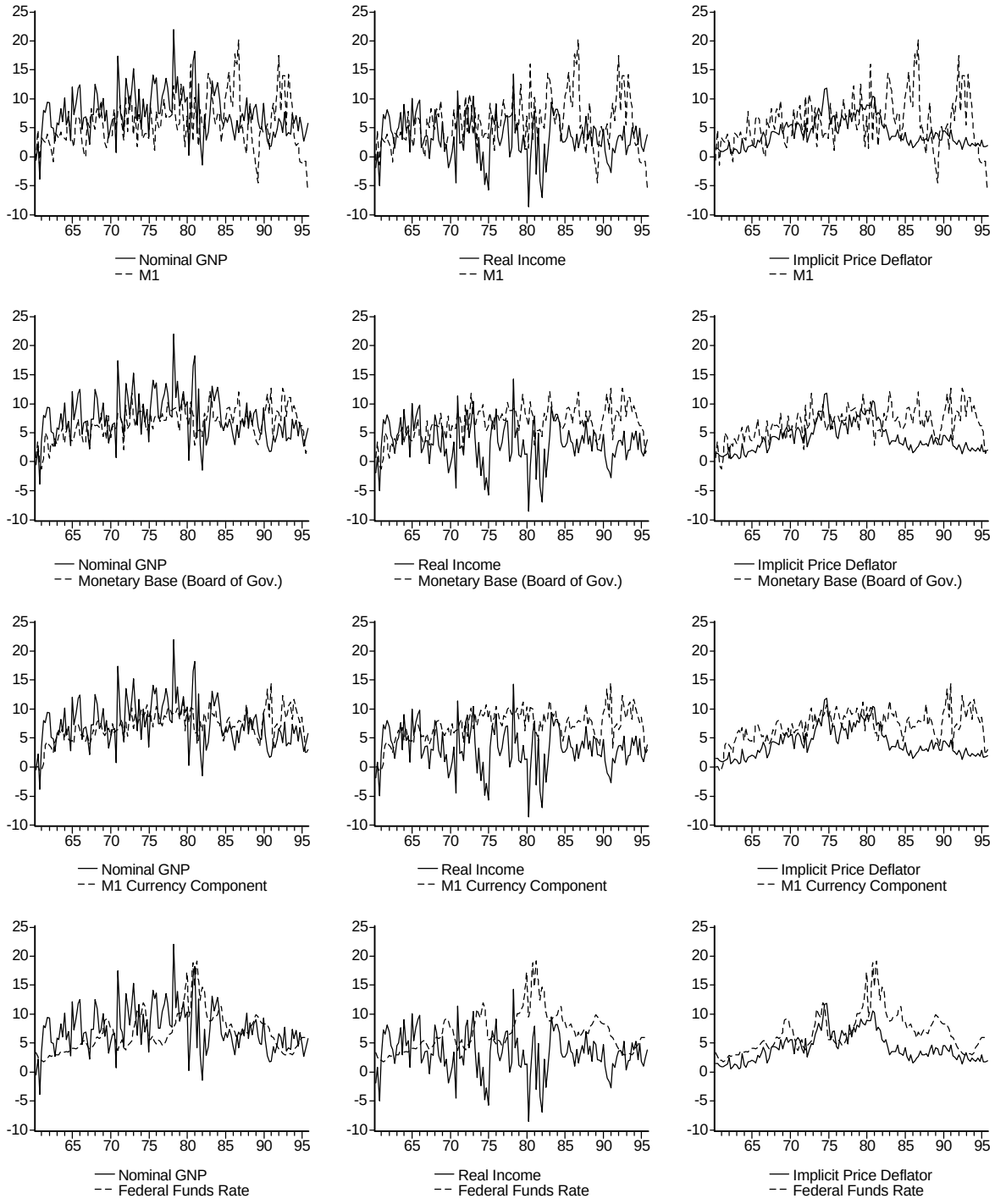
For decades, the classic work of M. Friedman and Schwartz (1963) has been the benchmark for those who wanted to assess the impact of monetary policy on macroeconomic variables in the United States. They found over the period of nearly one hundred years (1867-1960) a strong short-run positive correlation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

Recent empirical research provides somewhat puzzling evidence on these relationships. The influential study by B. Friedman and Kuttner (1992) provides statistical evidence for the case that after around 1982 the relationship between the changes in the monetary aggregates and macroeconomic fundamentals collapses and therefore the information content of monetary aggregates vanishes. Furthermore, they show that the short-term interest rates contain valuable lead-information on the macroeconomic fundamentals. [2]

In Figure 1 we plot nominal and real income, and inflation together with a sample of monetary variables.[3] It is apparent that movements in these macroeconomic fundamentals are disconnected from the movements of monetary aggregates in recent periods. Monetary aggregates exhibit a substantial increase in their volatilities whereas output and price series stabilize after the beginning of eighties. On the other hand, movements of the short-term interest rates represented by the Federal funds rate closely correspond to those of macroeconomic fundamentals.

[1] See for example Lucas (1996).
[2] See also Bernanke and Blinder (1992), Friedman and Kuttner (1996), and Friedman (1998) on this.
[3] Monetary aggregates, nominal and real income, and inflation are expressed as the percentage growth rate in annual terms while the Federal funds rate is expressed in levels. For the detailed data descriptions refer to Appendix A.2.

Figure 1



Not surprisingly, the change in the statistical pattern between the monetary aggregates and macroeconomic fundamentals led to a major shift in policy and research focus. This vanishing relationship made several scholars confident about the consistency of the Federal Reserve's focus on the interest rate policies, rather than targeting monetary aggregates. Consequently, current monetary

research concentrates on the short-term interest rates such as the US Federal funds rate in analyzing the US monetary policies.[4]

In the literature several potential explanations for the apparent collapse of this relationship have been provided.[5] It has been argued that the increasingly complex nature of financial markets, the increasing integration of the world economy and also changes in the underlying characteristics of macroeconomic conditions play a role in this context. In this paper we will propose an alternative explanation for the breakdown in the relationship between macroeconomic fundamentals and monetary aggregates.

We argue that part of the apparent lack of a relationship between the macroeconomic fundamentals and monetary aggregates is due to the presence of substantial and unstable foreign holdings of the US dollars, which are largely unaccounted for. The international currency feature of the US dollars generates a substantial noise in the domestic monetary data series. One should correct for it when the focus of analysis is on the link between the domestic fundamentals and monetary aggregates. For this purpose we use the official foreign flows data provided by Porter and Judson (1996).[6]

We put our research question explicitly on the establishment of statistical relationships between these variables. As we will explain below, a reliable statistical connection between macroeconomic fundamentals and monetary variables constitutes a first essential criterion in evaluating the usefulness of monetary variables in making monetary policy. The presence of large and unstable foreign demand for US currency might severely bias the interpretation of the statistical relationships between macroeconomic variables and US monetary aggregates. Therefore, the crucial question that arises is to what extent the correction of the US monetary aggregates for the foreign holdings affects the stylized facts on monetary aggregates and macroeconomic variables.

For the purpose of analysis we use the information value approach outlined in Friedman and Kuttner (1992). The information value approach allows us to address the issue on whether there is some reliable relationship between income, prices, and money, or other potential instruments, such as interest rates. Since the seminal work of Poole (1970) it is well known that in a frictionless economy money supply and interest rate policies would be equivalent. However, in an economic environment with large uncertainties and real and nominal rigidities this instrument equivalence tends to disappear. Therefore, comparing the informational contribution of monetary aggregates to future movements of prices and output provides an interesting insight in the choice of policy indicators and instruments. In this respect a reliable statistical connection between the monetary aggregates and movements of prices

[4] See for example Taylor (1999) where all papers focus on the Federal funds rate.
[5] See Walsh (1998) and references given therein.
[6] This dataset has been subject to studies by Jefferson (1998) in calculating seigniorage income of the United States and Jefferson (2000) in assessing McCallum type of monetary policy rules for US nominal income.

and output provides a first essential test of their usefulness. If the fluctuations in a monetary variable have no implications for subsequent movements of prices and output, this variable should be considered neither as an information indicator nor as a policy instrument. Only after a statistical relationship between certain monetary variables is established, can the usefulness of these variables as potential indicators, intermediate targets, or instruments be assessed[7]. It is therefore substantial 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 words (1992, p. 474):

As long as movements in money do contain information about future movements in income beyond what is already contained in movements in income 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.

In this paper, we provide evidence suggesting that the Friedman and Schwartz's stylized facts on the close correlation between monetary aggregates and future movements in the macroeconomic variables can be reestablished once the focus of analysis is back on the domestic monetary aggregates. We find that the monetary aggregates corrected for the foreign holdings of dollar contain valuable statistical information with respect to movements of nominal and real output, and inflation.[8]

Our paper is organized as follows. Section 2 provides intuition behind the relevance of the monetary aggregates corrected for the foreign holdings of US dollars and presents the data generated by Porter and Judson (1996). In Section 3, we reevaluate the usefulness of potential monetary instruments of the US Federal Reserve as the information variables. For that purpose, in line with

[7] By considering their relative performance, measurement timing and accuracy, and maybe most importantly the controllability of the potential instruments.

[8] To our knowledge, there is only one study in the literature, Jefferson (2000), that attempts to take into consideration the foreign holdings in assessing monetary policy actions of the US Federal Reserve. However, his assessment differs substantially from ours in at least four respects, in the sense of research question, methodology, data coverage and construction of the corrected monetary aggregate. First, our starting point is that there is no research consensus on the form of the short-run relationships between macroeconomic fundamentals and monetary variables. Therefore, our research question is explicitly on the statistical relationships between these variables while Jefferson focuses on an ad hoc macroeconomic relationship implied by the McCallum monetary base rule. Second, to address our research question, we use a general methodology aiming to avoid causality, exogeneity or controllability matters via focusing on a statistical exercise based on the information value approach. Third, Jefferson focuses on the nominal income, whereas our coverage is on nominal and real income, and inflation, hence on a wider array of macroeconomic fundamentals that play a crucial role in the US monetary policymaking. Finally, Jefferson's correction for the foreign holdings is based on measures of US monetary base, which we believe, is much less accurate than a correction based on the currency component of M1. Monetary base measures estimated by the Federal Reserve Bank of St. Louis and Board of Governors of the Federal Reserve System, respectively, differ substantially from each other whereas the currency component of M1 is a result of a simple accountancy. All these aspects will be explained in detail in the following sections.

Friedman and Kuttner (1992), we make use of the information value approach based on the Granger causality tests and implied impact responses. In Section 4 we construct a new monetary aggregate (the currency component of M1 corrected for the foreign holdings) and apply the methodology used in Section 3 to evaluate its information content. In Section 5 we conduct vector autoregression analysis and provide results for the variance decompositions. Section 6 concludes.

2. Foreign Holdings of US Dollar

The US Dollar is the most important international currency. Citizens, central banks, private 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 tool to immunize citizens' income from domestic nominal and real shocks. It is even used in daily transactions.[9]

There is a research consensus that the central banks are mainly interested in stabilizing the major macroeconomic fundamentals such as income and inflation. Now, suppose that a large amount of national currency is in the hands of foreign residents outside the borders. If there were no competing international currencies that can substitute these holdings or no obvious shifts in the preferences of the foreigners to walk away from that currency, the domestic stabilization objectives would not be endangered. Under these circumstances any rational central bank would like to satisfy the currency demands outside the borders in order to generate seigniorage income.[10]

Beyond seigniorage concerns, monetary policymakers and 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. Recently, several studies have focused on this issue. [11] 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 use their median flow estimate of the quarterly flows of US dollars abroad for the sample period 1977:1-

[9] 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)

[10] 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).

[11] See for example Feige (1996), Doyle (2000), and Anderson and Rasche (2000).

1995:4, which sums up to the annual median flows data given in Porter and Judson (1996). Their estimates are now incorporated into the revised official *Flow of Funds Statistics* of the Board of Governors of the Federal Reserve System (1996).[12]

Porter and Judson estimate the flows of US dollars abroad employing seven methodologies. Authors then proceed to construct a median series of the foreign holdings. On the left hand-side of Figure 2 we present quarterly median flow estimates of US dollars abroad. On the right side, we present the ratio of changes in the foreign holdings abroad to the total change in the currency component of M1 (calculated as 100×[flows abroad/change in M1 currency component]).

Figure 2

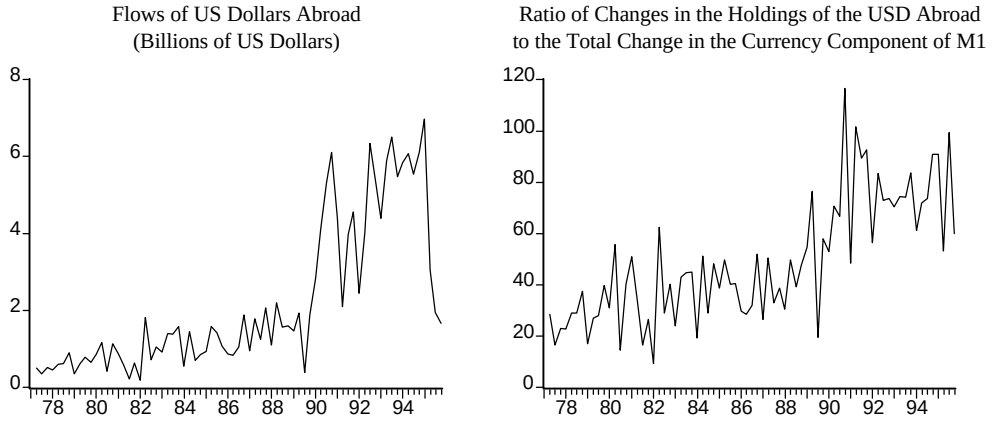


Figure 2 shows that the flows of US dollars abroad were increasing in an unstable way over the period 1977:1-1995:4. As we observe, the flows of US currency abroad are much higher in the nineties as compared to the previous decade.[13]

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 the domestic money.[14] On the other hand, if the ratio of foreign flows to changes of the currency

[12] See also US Treasury (2000) and Allison and Pianalto (1997).

[13] 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.

[14] 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.

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.[15]

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 rising. On an annual basis, the share of foreign flows to change of the currency component of M1 steadily increased from around 20 percent in 1977 to around 75 percent in 1995. Not surprisingly, Porter and Judson (1996) report that almost 90 percent of the variance of currency changes can be explained by the changes in the foreign holdings of dollars.

In Section 4, we use this official data on the foreign flows of US dollars in assessing the role of domestic monetary aggregates in macroeconomic fundamentals.[16]

3. Information Value Approach Revisited

In the introduction we have already provided our motivation as to why our focus is on the information value approach. Therefore, we will be brief here. The information value approach as suggested by Sims (1972) and Friedman and Kuttner (1992) allows us to evaluate a reliable statistical relationship between major macroeconomic fundamentals and monetary or other potential instruments such as interest rates without having to focus on issues related to exogeneity, causality, and the likes.

In this section, we will describe our data and replicate the analysis of Friedman and Kuttner (1992). We will use the same variables they suggest. Moreover, we will consider some new, potentially useful, monetary indicators for slightly different time periods in order to make use of more

[15] See for example, Orphanides (1998), who assesses information value of the monetary aggregates in the presence of noise.

[16] In this footnote we discuss some important features of the Porter and Judson's data. First, the median is constructed with the use of seven independent methodologies. Two out of these seven methodologies, "money demand" and "signal extraction", contain measures that are based on outliers from the prespecified relationship and therefore are likely to be endogenous with respect to market forces. Other five measures are exogenous, at least from the point of view of the citizens, firms, and the policymakers in the Unites States. The two potentially endogenous methods do not appear as the median (only a single observation of money demand method appears as the median on annual basis). This is very important as one could argue that the frequent presence of the endogenous methods could turn the foreign flows data spurious. Secondly, the presence of two endogenous methods can critically affect the flow estimate if the results of the two endogenous methods are not on the opposite sides of the median. We can make a preliminary assessment of the importance of this argument only using annual data, as we do not dispose of quarterly data of the seven methodologies. Therefore, on the annual data we remove the two endogenous methods and calculate a new median series. The simple correlation between the original median series and the one constructed with the use of five exogenous methods is 0.997 and the level difference between them is very small (see Appendix A.1). Hence, we conclude that the inclusion of the two endogenous methodologies into the process of constructing the median flow data is not likely to affect the original median series in a significant way. Finally, one needs to know the initial foreign holdings of US dollars in our sample period. Porter and Judson assumed that around 50 percent of the M1 currency component were held outside the US borders in 1977:1. In Section 4 we explain how we tackle this issue.

recent data.[17] Then, in Section 4 we will compare the statistical performance of the financial variables from the Friedman and Kuttner's work with the statistical performance of our new proposed financial indicator variable, being the currency component of M1 corrected for the foreign holdings.

3.1. Data

Our quarterly data covers the time period 1960:2-1995:4. To asses the structural break in the Friedman-Schwartz's hypothesis in the early 1980's we will also split the sample into the sub-periods of 1960:2-1978:1 and 1978:2-1995:4 and provide our results for these time periods.[18]

We will study the following macroeconomic fundamentals (in natural log differences): nominal income represented by the nominal GNP, real income represented by the real GNP and inflation represented by the GNP deflator.[19]

In line with Friedman and Kuttner we select two categories of financial variables to assess the fluctuations of the macroeconomic variables we consider. The first category of financial variables consists of changes (in natural log differences) in the monetary aggregates and are selected as follows: M1 ($\Delta\ln(M1)$), M2 ($\Delta\ln(M2)$), M1 currency component ($\Delta\ln(M1CUR)$), monetary base measures calculated by the Board of Governors of the Federal Reserve System ($\Delta\ln(BGbase)$) and calculated by the Federal Reserve Bank of St. Louis ($\Delta\ln(SLbase)$). The second category of financial variables consists of short-term interest rates specified as the changes in the Federal funds rate ($\Delta FUNDS$), 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).

Other potentially useful indicator variables that may help predict future macroeconomic fluctuations, which are made use of in the paper, are real and nominal changes in federal expenditures (in natural log differences). They serve as proxies for the US fiscal policy stance. All series we consider above fulfill stationarity properties.[20]

In Section 4 we will incorporate a new financial variable, the currency component of M1 corrected for the foreign holdings ($\Delta\ln(M1CUR\text{-}revised)$), and compare its informational content with the informational content of the standard, aforementioned financial variables.

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[17] More precisely, in comparison to Friedman and Kuttner (1992) we exclude credit and six-month interest spread from the analysis and instead introduce the Federal funds rate and St. Louis adjusted monetary base.

[18] As it will become clear in the subsequent sections our choice of the sub-periods is motivated by the availability of the foreign flows data covering the period 1977:1-1995:4. Detailed data descriptions and source references are tabulated in Appendix A.2.

[19] Data in the log difference form are multiplied by 400 to obtain annual percentage growth rates.

[20] Both Dickey-Fuller and Phillips-Perron tests reject the null hypothesis of unit root for all the mentioned series' specifications.

3.2. Nominal Income: Granger Causality Tests and Impact Responses

Our two-variable autoregressive specification for nominal income changes (Δy) follows exactly Friedman and Kuttner, based on Sims (1972):

$$\Delta y_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta y_{t-i} + \sum_{i=1}^{4} \delta_i \Delta m_{t-i} + v_t \tag{1}$$

where Δy and Δm are the growth rate of nominal income (the one-quarter log difference of nominal 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. The α, β, and δ are the coefficients to be estimated and v is a disturbance term.

We also specify a three-variable system including the term for government spending $\sum_{i=1}^{4} \gamma_i \Delta g_{t-i}$, where Δg is the change in the fiscal variable (the one-quarter log difference of nominal federal spending in annual terms), and re-estimate equation 1. The γ is the coefficient that captures the effect of fiscal expansion on the variable of interest.

F- and χ-square statistics for tests across different time periods are reported in Table 1. The null hypothesis is that all coefficients on the lagged financial variables, considered individually, in the two-variable nominal income specification (nominal income, financial variable) are zero.

Firstly, we focus on the overall time span 1960:2-1995:4. In line with the findings of Friedman and Kuttner, we do find evidence of significant information value for almost all financial variables. Friedman-Schwartz's hypothesis holds irrespective of the monetary indicator[21] we choose. F- and χ-square statistics for the period 1960:2-1995:4 show that the Federal funds rate, the 3-month commercial paper rate, the 3-month Treasury bill rate, the spread between the two rates, and M2 are all significant at the 1% level. M1 is significant at the 5% level. Finally, narrow monetary aggregates, such as the two monetary base measures and the currency component of M1, do not contain significant information for nominal income over the whole period. Therefore, we can conclude that during the 1960:2-1995:4 period as a whole, financial variables perform quite well in providing information about the future fluctuations in nominal income.

In the sub-period 1960:2-1978:1 we find highly significant information value of all financial variables, including the monetary base and the currency component of M1 that did not perform well over the entire sample period 1960:2-1995:4 (at the 5% significance level). Therefore, we note that

[21] We use the expressions 'financial variable', 'potential instrument', and 'monetary indicator' interchangeably throughout the text.

during the 1960's and the 1970's all potential indicator variables contain useful information about the future fluctuations in the nominal income.

Table 1: F-statistics and χ-Square Statistics[22] for Financial Variable in Nominal-Income Equation: Two-Variable System (Nominal Income, Financial Variable)

	1960:2-1995:4		1960:2-1978:1		1978:2-1995:4	
Variable	F-statistic	χ-square	F-statistic	χ-square	F-statistic	χ-square
$\Delta FUNDS$	5.666695 (0.000303)*** [23]	22.66678 (0.000148)***	3.986848 (0.006028)***	15.94739 (0.003091)***	5.176937 (0.001156)***	20.70775 (0.000362)***
Δr_p	4.610866 (0.001611)***	18.44346 (0.001011)***	3.534077 (0.011517)**	14.13631 (0.006872)***	5.671646 (0.000590)***	22.68658 (0.000146)***
Δr_b	3.959400 (0.004539)***	15.83760 (0.003245)***	3.694278 (0.009153)***	14.77711 (0.005187)***	5.008687 (0.001456)***	20.03475 (0.000492)***
$r_p - r_b$	5.087624 (0.000756)***	20.35050 (0.000426)***	5.192764 (0.001114)***	20.77106 (0.000352)***	2.225777 (0.076394)*	8.903109 (0.063567)*
$\Delta \ln(M1)$	3.208880 (0.014944)**	12.83552 (0.012108)**	5.673111 (0.000578)***	22.69245 (0.000146)***	2.037357 (0.100064)	8.149429 (0.086255)*
$\Delta \ln(M2)$	5.470311 (0.000413)***	21.88124 (0.000212)***	6.641203 (0.000159)***	26.56481 (0.000024)***	1.361232 (0.257700)	5.444929 (0.244613)
$\Delta \ln(BGbase)$	1.438693 (0.224655)	5.754774 (0.218226)	3.309973 (0.015901)**	13.23989 (0.010161)**	1.483369 (0.218091)	5.933476 (0.204172)
$\Delta \ln(SLbase)$	0.924142 (0.451985)	3.696568 (0.448625)	4.263137 (0.004073)***	17.05255 (0.001888)***	1.271376 (0.290869)	5.085505 (0.278636)
$\Delta \ln(M1CUR)$	0.802186 (0.525827)	3.208744 (0.523520)	2.907774 (0.028430)**	11.63109 (0.020316)**	0.548864 (0.700513)	2.195456 (0.699861)

In the last two columns of Table 1 we provide statistics for the sub-period 1978:2-1995:4. We note here that the Friedman-Kuttner's evidence is strongly confirmed. Only χ-square statistics of M1 displays some significance at the 10% level. All other monetary aggregates are highly insignificant. However, financial variables as represented by the short-term interest rates are highly significant. This makes them valuable information variables for the recent past (with the notable exception of interest rate spread, which is only significant at the 10% level). This evidence corroborates the Friedman and Kuttner's account of the 'structural break' in the Friedman-Schwartz's stylized facts during the 1980's.[24]

Secondly, we repeat the same analysis for the three-variable specifications where the fiscal variable is included in the systems (for the nominal income, fiscal variable and the relevant financial

[22] The results of the Granger causality tests for alternative financial variables reported throughout Tables 1 to 4 represent the F- and χ-square statistics, for tests across different time periods, of the null hypothesis that all of the coefficients on the lagged financial variables considered individually in the autoregressive specifications are zero.

[23] Throughout the paper (*) denotes significance at 10% level (**) denotes significance at 5% level (***) denotes significance at 1% level.

[24] Note that in October 1982 Federal Reserve has publicly stated that it started to pay less attention on the money growth targets. See e.g. B. Friedman (2000).

variable). In principle, the inclusion of the fiscal variable does not affect the results of the two-variable systems.[25]

Finally, in order to assess the impact of financial variables on the macroeconomic fundamentals in question, we show throughout Appendix A.3.a the impact responses of the macroeconomic fundamentals w.r.t. a one unit shock[26] in the financial variable (two-variable specifications). Inclusion of the fiscal variable does not affect the results in any significant way. To be able to compare[27] across periods, we plot impact responses for two sub-periods in one figure. The solid line corresponds to the response of nominal income in the first period (1960:2-1978:1), whereas dashed line corresponds to the second period (1978:2-1995:4).

Clearly, in the first period, nominal income responds more strongly to a change in any financial variable when compared to the second period. Therefore, we note that the nominal income in the US became less responsive w.r.t. monetary policy changes in the recent past. In both periods the nominal income responses w.r.t. monetary expansions are in the right direction. For the interest rates, particularly in the case of the Federal funds rate and the 3-month Treasury bill, the initial responses (first quarter) seem to be in the order of a price puzzle. However, in the consecutive periods this tendency reverses in both sub-periods.

In addition, we compare the impact responses of nominal income within the same category of financial variables (monetary aggregates versus interest rates). In the case of monetary aggregates, the first period nominal income responses are around the order of one half, being roughly the same size across monetary aggregates. The responses strongly decline in the second period. In the case of interest rates, the response of nominal income seems to vary strongly across the financial variables. However, we note that the first period impact responses largely dominate the second period impact responses. In line with the findings of Friedman and Kuttner we find a much stronger impact of the paper-bill spread on nominal income as compared to other short-term interest rate measures, including the Federal funds rate.

[25] In our paper the inclusion of the fiscal variable to all specifications we consider does not affect in any significant way the results of the systems with no fiscal variable. Therefore, for the purpose of brevity, we do not present the results for the specifications including the fiscal variable. The detailed results are available upon the request.

[26] One unit shock represents one- percent increase in the growth rate of the monetary aggregate and one- percent change in the level of the interest rate measure on the annual basis. Note that it is not possible to make a comparison across monetary indicators categories (i.e. monetary aggregates vis-à-vis short-term interest rates) of the impact responses of the nominal income. The 'unit' change in the instrument does not necessarily lead to a comparable amount of impact

[27] Note that it is not possible to make a comparison across monetary indicators categories (i.e. monetary aggregates vis-à-vis short-term interest rates) of the impact responses of the nominal income. The 'unit' change in the instrument does not necessarily lead to a comparable amount of impact.

3.3 Real Income: Granger Causality Tests and Impact Responses

Here, we present analogous results for the real income. In line with Friedman-Kuttner we estimate a four-variable system (real income, price deflator, fiscal variable and financial variable) and a three-variable system where we drop the fiscal variable. The three-variable specification takes the following form:

$$\Delta y_t = \alpha + \sum_{i=1}^{4} \beta_i \Delta y_{t-i} + \sum_{i=1}^{4} \lambda_i \Delta p_{t-i} + \sum_{i=1}^{4} \delta_i \Delta m_{t-i} + v_t \qquad (2)$$

where now Δy, Δp, and Δm are the growth rate of real income (the one-quarter log difference of real GNP in annual terms), inflation (the one-quarter log difference 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. In a similar manner to the nominal income specification we also consider the real income system with the fiscal variable term $\sum_{i=1}^{4} \gamma_i \Delta g_{t-i}$ included, where Δg represents the growth rate in the fiscal variable (the one quarter-log difference of real federal spending in annual terms).

F- and χ-square statistics for the three-variable real income specifications (fiscal variable excluded) are reported in Table 2. These statistics represent the tests of the null hypothesis that all coefficients of the financial variables considered individually in the real income system are zero.

Table 2: F-Statistics and χ-Square Statistics for Financial Variable in Real-Income Equation: Three-Variable System (Real Income, Price Index, Financial Variable)

	1960:2-1995:4		1960:2-1978:1		1978:2-1995:4	
Variable	F-statistic	χ-square	F-statistic	χ-square	F-statistic	χ-square
$\Delta FUNDS$	5.634354 (0.000325)***	22.53742 (0.000157)***	4.117421 (0.005215)***	16.46968 (0.002450)***	5.309023 (0.001032)***	21.23609 (0.000284)***
Δr_p	4.084382 (0.003758)***	16.33753 (0.002598)***	4.090057 (0.005419)***	16.36023 (0.002572)***	6.044643 (0.000390)***	24.17857 (0.000074)***
Δr_b	3.250694 (0.014074)**	13.00278 (0.011262)**	3.041743 (0.023944)**	12.16697 (0.016152)**	5.210087 (0.001179)***	20.84035 (0.000341)***
$r_p - r_b$	4.520596 (0.001883)***	18.08238 (0.001189)***	5.029732 (0.001480)***	20.11893 (0.000473)***	1.508177 (0.211699)	6.032707 (0.196719)
$\Delta \ln(M1)$	2.284067 (0.063732)*	9.136269 (0.057782)*	2.218744 (0.077820)*	8.874975 (0.064302)*	2.368954 (0.063000)*	9.475815 (0.050247)*
$\Delta \ln(M2)$	5.140914 (0.000707)***	20.56365 (0.000386)***	5.065581 (0.001410)***	20.26232 (0.000443)***	1.593732 (0.188166)	6.374927 (0.172844)
$\Delta \ln(BGbase)$	1.140483 (0.340422)	4.561932 (0.335267)	1.407005 (0.242807)	5.628019 (0.228704)	1.218718 (0.312790)	4.874873 (0.300379)
$\Delta \ln(SLbase)$	0.393226 (0.813201)	1.572903 (0.813654)	1.783512 (0.144212)	7.134049 (0.128972)	1.539902 (0.202670)	6.159607 (0.187542)
$\Delta \ln(M1CUR)$	0.311910 (0.869599)	1.247640 (0.870194)	1.691095 (0.164126)	6.764381 (0.148876)	0.255735 (0.905008)	1.022939 (0.906298)

As apparent from Table 2, we obtain very similar results as reported by Friedman and Kuttner. Over the entire sample period all short term interest rate measures and broader monetary aggregates (M1 and especially M2) denote significance, ranging from the 1% level to the 10% level. Narrow monetary aggregates reveal strikingly strong insignificance. The results are very similar over the subsample 1960:2-1978:1. Therefore, we find evidence for the Friedman-Schwartz's account of close correlation between the real income and monetary changes from the beginning of the 1960's until around the 1970's.

When we estimate equation (2) over the more recent sub-sample 1978:2-1995:4 we do not find any significant information generated by monetary aggregates in helping to predict the future swings in real income changes. The only exception is the change in M1, which is significant at the 10% level. All interest rate variables, except the paper-bill spread[28], perform very well during the 1980's and the early 1990's as information variables. Like the exercise with the nominal income, the four-variable specifications yield very similar results as the three-variable specifications.

Finally, we assess the impact responses over the two sub-samples (presented throughout Appendix A.3b). We present only the three-variable specifications, as the four-variable systems do not yield any significantly different results. In the first sub-period (indicated by the solid line) we obtain a systematically stronger response of real income w.r.t. a one unit change in the financial variable in question as compared to the second period (indicated by the dashed line). In the first period, changes in the monetary aggregates have a more or less similar impact on real income with the right sign[29]. In the second period this impact diminishes strongly, supporting the Friedman-Kuttner findings (albeit being statistically insignificant). The impact response of real income w.r.t. interest rate changes, while being significant in most of the cases, declines in the second period as well.

3.4. Inflation: Granger Causality Tests and Impact Responses

Finally, we estimate a three-variable system for inflation (inflation, real income, and a financial variable) and a four-variable system where we add the fiscal variable term $\sum_{i=1}^{4}\gamma_i \Delta g_{t-i}$ (Δg represents the one quarter-log difference of real federal spending in annual terms). The three-variable specification for inflation takes the following form:

$$\Delta p_t = \alpha + \sum_{i=1}^{4}\beta_i \Delta p_{t-i} + \sum_{i=1}^{4}\lambda_i \Delta y_{t-i} + \sum_{i=1}^{4}\delta_i \Delta m_{t-i} + v_t \qquad (3)$$

[28] See also the study by Hess and Porter (1993) that finds no relationship between the paper-bill spread and real output.
[29] Meaning a monetary expansion is positively correlated with the real income.

where now Δp, Δy, and Δm are inflation (the one-quarter log difference of GNP deflator in annual terms), the growth rate of real income (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 3: F-Statistics and χ-Square Statistics for Financial Variable in Price Equation: Three-Variable System (Price Index, Real Income, Financial Variable)

	1960:2-1995:4		1960:2-1978:1		1978:2-1995:4	
Variable	F-statistic	χ-square	F-statistic	χ-square	F-statistic	χ-square
$\Delta FUNDS$	2.927962 (0.023399)**	11.71185 (0.019628)**	3.318811 (0.016120)**	13.27524 (0.010006)**	1.247610 (0.301049)	4.990439 (0.288280)
Δr_p	2.242292 (0.067954)*	8.969169 (0.061875)*	2.614987 (0.044132)**	10.45995 (0.033353)**	1.100635 (0.364982)	4.402541 (0.354261)
Δr_b	2.038513 (0.092727)*	8.154050 (0.086095)*	1.483528 (0.218728)	5.934113 (0.204123)	1.412899 (0.241105)	5.651596 (0.226722)
$r_p - r_b$	0.626101 (0.644714)	2.504404 (0.643847)	1.049695 (0.389499)	4.198782 (0.379772)	1.373863 (0.254198)	5.495453 (0.240129)
$\Delta \ln(M1)$	0.469855 (0.757773)	1.879418 (0.757925)	1.114646 (0.358247)	4.458584 (0.347487)	0.344370 (0.846866)	1.377480 (0.848100)
$\Delta \ln(M2)$	0.554659 (0.695964)	2.218635 (0.695619)	0.946814 (0.443483)	3.787258 (0.435562)	0.262329 (0.900926)	1.049318 (0.902228)
$\Delta \ln(BGbase)$	1.788965 (0.134888)	7.155862 (0.127877)	2.728165 (0.037522)**	10.91266 (0.027563)**	1.666332 (0.170145)	6.665326 (0.154667)
$\Delta \ln(SLbase)$	0.726403 (0.575446)	2.905613 (0.573743)	1.658144 (0.171838)	6.632576 (0.156626)	0.958218 (0.437362)	3.832872 (0.429096)
$\Delta \ln(M1CUR)$	1.050041 (0.384093)	4.200165 (0.379594)	0.848426 (0.500283)	3.393706 (0.494224)	1.061314 (0.383914)	4.245258 (0.373830)

Table 3 reports F- and χ-square statistics for the three-variable specifications (price deflator, real income, and financial variable). These statistics represent the tests of the null hypothesis that all the coefficients of the financial variables considered individually in the inflation specification are zero. Again, the corresponding statistics of the four-variable specifications are very similar to those of the three-variable ones.

Over the whole sample period 1960:2-1995:4 we find very few financial variables containing information value for future fluctuations in the inflation rate. This corroborates results reported in Friedman and Kuttner. The only variables that contain significant information are the Federal funds rate (at the 5% level) and interest rates on the 3-month commercial paper and on the Treasury bill (at the 10% level).

The same observation holds true for first sub-sample (1960:2-1978:1) where somewhat curiously, next to the Funds rate and the commercial paper rate, the monetary base calculated by the Federal Reserve turns out to be significant (at the 5% level).

However, in the second period (1978:2-1995:4) none of the financial variables, including the Federal funds rate, are significant handing support to the findings of Friedman and Kuttner. No indicator variable, being either an interest rate or monetary aggregate, contains useful information in assessing future fluctuations in the inflation rate.

Finally, throughout Appendix A.3.c we look at the impact responses of inflation w.r.t. financial variables in two sub-samples. We again present only the three-variable specifications as the four-variable specifications yield very similar results.

We note, in line with the literature, that the US inflation process is rigid as compared to nominal or real income adjustment with respect to changes in the monetary indicators. We observe that monetary aggregates trigger very little response on inflation even in the earlier period. In the latter period this little impact diminishes even further. Inflation response w.r.t. short-term interest changes is also small in size when compared with nominal and real income responses to interest rate changes. More interestingly, several financial variables trigger an initial price puzzle for the US economy. Inflation responds initially with a hike to an increase in the interest rates. Price puzzle is also present for some monetary aggregates, such as M2 and currency component of M1. However, this tends to vanish in the following quarters.

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

As a next step we provide a further analysis of the information content of the financial variables in the light of Granger causality tests. In particular we will assess whether the monetary aggregates contain any significant information value in the presence of the short-term interest rate in nominal and real income and inflation specifications. We focus on the Federal funds rate as a short-term interest rate as this variable is used for the public announcements of the monetary policy stance in the US. If we find a significant information provision by the monetary aggregates next to the Federal funds rate we can conclude that these variables may be of use for policymakers in predicting the swings in macroeconomic variables.

Our results, displayed in Appendix A.4, are very striking. In the case of nominal income, irrespective of the specification with or without the fiscal variable, in the first sub-sample (1960:2-1978:1), all monetary aggregates contain significant information value in the presence of the Federal

Funds rate[30]. However, in the second sub-sample (1978:2-1995:4) there is no single standard monetary aggregate containing statistically significant information value next to the Federal funds rate. We observe similar results in the case of real income and inflation.[31]

In sum, the evidence from the Granger causality tests for the standard monetary variables are in line with the findings of Friedman and Kuttner (1992). Before the eighties monetary aggregates contain valuable information about critical US macroeconomic fundamentals. These relationships seem to disappear however after this time period. In other words, the Friedman-Schwartz's empirical account of strong correlation between changes in the monetary aggregates and major macroeconomic fundamentals seem to vanish in the last two decades. Short-term interest rates on the other hand generally provide significant additional information on the future developments of macroeconomic fundamentals (with the exception of inflation) irrespective of the time spans considered. Evidence provided in this section is very well summarized by B. Friedman (2000, p. 15):

At some point in the 1980's [...] the relationship between money and either output or inflation in the United States simply disappeared. Observed fluctuations in money no longer conveyed information about future movements of either macroeconomic variable. [...] As a result, the Federal Reserve once again sets the federal funds rate with an eye directly on output and the implications of output for inflation.

In this section we did not state anything new as compared to the previous research. In the following section we will propose a new financial indicator variable, the currency component of M1 corrected for the foreign holdings (M1CUR-revised), which contains useful information about the future fluctuations in US macroeconomic fundamentals in recent periods.

4. Foreign Holdings of US Dollar and Information Value of Monetary Aggregates

Having outlined the well-known stylized facts on the behavioral relationship between macroeconomic fundamentals and financial variables we turn our attention to the argument we have sketched in Section 2. As long as foreign consumption of the domestic currency does not affect the country specific stabilization objectives, one can argue that there is no reason as to why the central bank should decline foreign demands for its currency. However, when unstable and large foreign

[30] Being significant at the 1% level in the case of M1 and at the 5% level in the case of other monetary aggregates.

consumption of the US dollars is not filtered out from the monetary aggregates over which the monetary authority possesses control, these monetary aggregates are likely to contain large noise component. Therefore, we argue that one should deduce this noise from the monetary aggregates to obtain a more accurate account of the relationship between the monetary aggregates and macroeconomic fundamentals.

To assess empirically the importance of the foreign holdings of the US dollars, a new "corrected" monetary aggregate must be constructed. Consequently, we calculate the foreign holdings corrected M1 currency component (*M1CURrev*) in order to obtain a realistic measure of the US domestic narrow money supply. It is a simple monetary aggregate not based on estimations and 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.[32]

We formulate the foreign holdings corrected currency component of M1, ($M1CURrev_t$) as follows:

$$M1CURrev_t = M1CUR_t - FH_t \qquad (4)$$

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 the border 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 1977:1-1995:4. In order to subtract accumulated flows of US dollars abroad from the total level of M1 currency component, the amount of foreign holdings in 1977:1 must be known. As mentioned in Footnote 16, Porter and Judson assume an initial level of the US dollars held abroad to be in the order of 50% of the total M1 currency component. In order to address robustness of our results with respect to this assumption we assume six different initial foreign holdings levels in 1977:1 (ranging from 0% to 50% of the M1 currency component, at 10% intervals).[33] Then we proceed by re-examining the Granger causality tests performed in Section 3 for the new foreign holdings corrected monetary aggregate.

In Table 4 we present F- and χ-square statistics for the null hypothesis that all of the coefficients on the lagged currency component of M1 corrected for the foreign holdings with initial

[31] In Appendix A.4 we do not display the systems with the fiscal variable as they yield very similar results to the systems that do not incorporate the fiscal variable.

[32] 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.

alternative assumptions considered individually are zero in the nominal and real income and inflation equations. We display the results for the systems without the fiscal variable. Again, the systems including the fiscal variable yield very similar results to those without the fiscal variable.

Table 4: F-Statistics and χ-Square Statistics for Revised M1 in Circulation:
Systems without Fiscal Variable (Period: 1978:2-1995:4)

Specification	Nominal Income Equation 2-Variable Specification		Real Income Equation 3-Variable Specification		Price Equation 3-Variable Specification	
Variable	F-statistic	χ-square	F-statistic	χ-square	F-statistic	χ-square
$\Delta\ln(M1CURrev)$ original data 50% abroad in 1977:1	5.251279 (0.001044)***	21.00512 (0.000316)***	3.968567 (0.006491)***	15.87427 (0.003193)***	1.945787 (0.114975)	7.783148 (0.099853)*
$\Delta\ln(M1CURrev)$ 40% abroad in 1977:1	4.782799 (0.001990)***	19.13120 (0.000741)***	3.589957 (0.011056)**	14.35983 (0.006231)***	1.782410 (0.144692)	7.129642 (0.129194)
$\Delta\ln(M1CURrev)$ 30% abroad in 1977:1	4.362798 (0.003578)***	17.45119 (0.001579)***	3.275969 (0.017254)**	13.10387 (0.010779)**	1.652764 (0.173384)	6.611056 (0.157926)
$\Delta\ln(M1CURrev)$ 20% abroad in 1977:1	3.987923 (0.006074)***	15.95169 (0.003085)***	3.013610 (0.025073)**	12.05444 (0.016951)**	1.548840 (0.200191)	6.195359 (0.185026)
$\Delta\ln(M1CURrev)$ 10% abroad in 1977:1	3.656794 (0.009733)***	14.62718 (0.005540)***	2.793782 (0.034323)**	11.17513 (0.024665)**	1.464922 (0.224613)	5.859690 (0.209875)
$\Delta\ln(M1CURrev)$ 0% abroad in 1977:1	3.365737 (0.014769)**	13.46295 (0.009222)***	2.608282 (0.044749)**	10.43313 (0.033731)**	1.396346 (0.246580)	5.585384 (0.232325)

4.1. Nominal Income

The first column in Table 4 presents the results for nominal income. In a two-variable system, the financial variable $\Delta\ln(M1CUR-revised)$ (the one-quarter log difference of the currency component of M1 corrected for the foreign holdings in annual terms) is highly significant (at the 1% level).[34] As we observe, the foreign holdings adjusted currency component of M1 contains valuable information on the future fluctuations in the US nominal income for the 1978:2-1995:4 period. Furthermore, different levels of initial foreign holdings do not affect our results in a statistically significant way. In Appendix A.3.a we present impact responses of nominal income w.r.t. a one unit change in the M1CUR-revised with different hypotheses about the initial level of US dollar foreign holdings. Varying degrees of initial values of foreign holdings do not affect the size of the impact in a substantial way. We also note that the sign of the impact is consistent with the standard monetary theories.[35] Interestingly, the magnitude of the nominal income impact responses to a one-unit change in

[33] See Anderson and Rasche (2000) for a discussion of this assumption.
[34] Note that the Federal funds rate and the interest rates on commercial papers and Treasury bills were very strongly significant too.
[35] A monetary expansion is positively correlated with the nominal income.

the M1CUR-revised for the sample period 1978:2-1995:4 resembles the order of those of the monetary aggregates in the period 1960:2-1978:1.

4.2. Real Income

The second column in Table 4 presents our results for real income. As we observe, the foreign holdings adjusted currency component of M1 with the original 50% assumption significantly contributes (at the 1% level) to the information on the future changes in US real income.[36] Six different thresholds do not affect this result in a significant way. Figures in Appendix A.3.b show impact responses of real income w.r.t. a unit change in the monetary aggregate. We observe that the impact responses follow each other very closely for different assumptions on the initial level of foreign holdings. The impact responses indicate that real income is positively associated with the change in the monetary aggregate. Further, responses for the period 1978:2-1995:4 behave in a similar manner as did the other monetary aggregates during the periods where the Friedman-Schwartz's hypothesis was in effect (i.e. period 1960:2-1978:1).

4.3. Inflation

The third column in Table 4 shows the results for inflation. As discussed in Section 3, none of the financial variables contains any significant information on the future movements of inflation. Irrespective of the inclusion of the fiscal variable, the foreign holdings correction improves significantly (χ-square statistics is significant at the 10% level) the performance of the currency component of M1 for the original assumption of around 50% initial holdings of US dollars. For other initial levels we observe that p-values of the F- and χ-square statistics are much smaller in comparison to other monetary aggregates[37] albeit not significant. Impact responses are presented in Appendix A.3.c. We do not observe a price puzzle, i.e. an initial decline in prices with respect to a one unit monetary expansion. Finally, alternative assumptions about the level of the initial foreign holdings do not affect the results in a significant way. The impacts of a one-unit change in the corrected M1 currency component on inflation resemble the impact responses of inflation vis-à-vis other monetary aggregates during the period 1960:2-1978:1.

[36] Together with the aforementioned short term interest rates (see Section 3)
[37] With the notable exception of the Board of Governors' adjusted monetary base that has lower p-values assigned than $\Delta \ln(M1CURrev)$ for 0%, 10%, and 20% of initial holdings.

4.4. Corrected Money in the Presence of the Federal Funds Rate

In line with Section 3.5 here we will assess the additional information value of the corrected currency component of M1 in the presence of Federal Funds rate for nominal and real income and inflation specifications.

Table 5: F-Statistics and χ-Square Statistics for Federal Funds Rate and Revised M1 in Circulation, Systems without Fiscal Variable (Period 1978:2-1995:4)

Specification	Nominal Income Equation 3-Variable Specification		Real Income Equation 4-Variable Specification		Price Equation 4-Variable Specification	
Variable	F-statistic	χ-square	F-statistic	χ-square	F-statistic	χ-square
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (around 50% abroad in 1977:1)						
$\Delta FUNDS$	4.138970 (0.005117)***	16.55588 (0.002357)***	4.108519 (0.005595)***	16.43407 (0.002489)***	1.385849 (0.251122)	5.543394 (0.235941)
$\Delta \ln(M1CURrev)$ original data 50% abroad in 1977:1	4.205985 (0.004661)***	16.82394 (0.002091)***	2.916968 (0.029467)**	11.66787 (0.020000)**	2.045819 (0.100869)	8.183277 (0.085091)*
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (40% abroad in 1977:1)						
$\Delta FUNDS$	4.161468 (0.004959)***	16.64587 (0.002264)***	4.176880 (0.005095)***	16.70752 (0.002203)***	1.356810 (0.261111)	5.427239 (0.246200)
$\Delta \ln(M1CURrev)$ 40% abroad in 1977:1	3.805749 (0.008157)***	15.22300 (0.004260)***	2.642846 (0.043409)**	10.57138 (0.031828)**	1.861358 (0.130619)	7.445433 (0.114140)
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (30% abroad in 1977:1)						
$\Delta FUNDS$	4.182451 (0.004816)***	16.72980 (0.002181)***	4.233664 (0.004714)***	16.93466 (0.001990)***	1.330301 (0.270542)	5.321203 (0.255899)
$\Delta \ln(M1CURrev)$ 30% abroad in 1977:1	3.446844 (0.013538)**	13.78737 (0.008006)***	2.413609 (0.060035)*	9.654438 (0.046669)**	1.711855 (0.160807)	6.847419 (0.144175)
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (20% abroad in 1977:1)						
$\Delta FUNDS$	4.202939 (0.004681)***	16.81176 (0.002103)***	4.283384 (0.004404)***	17.13354 (0.001821)***	1.306815 (0.279154)	5.227259 (0.264764)
$\Delta \ln(M1CURrev)$ 20% abroad in 1977:1	3.127439 (0.021317)**	12.50976 (0.013937)**	2.222697 (0.078624)*	8.890786 (0.063888)*	1.590049 (0.190222)	6.360195 (0.173815)
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (10% abroad in 1977:1)						
$\Delta FUNDS$	4.223225 (0.004551)***	16.89290 (0.002028)***	4.327750 (0.004146)***	17.31100 (0.001682)***	1.286374 (0.286848)	5.145494 (0.272692)
$\Delta \ln(M1CURrev)$ 10% abroad in 1977:1	2.846716 (0.031822)**	11.38687 (0.022544)**	2.064081 (0.098313)*	8.256322 (0.082627)*	1.490422 (0.217978)	5.961686 (0.202028)
Federal Funds Rate with Currency Component of M1 Corrected for the Foreign Holdings (0% abroad in 1977:1)						
$\Delta FUNDS$	4.243294 (0.004426)***	16.97318 (0.001956)***	4.367714 (0.003926)***	17.47086 (0.001565)***	1.268674 (0.293662)	5.074697 (0.279719)
$\Delta \ln(M1CURrev)$ 0% abroad in 1977:1	2.601472 (0.045187)**	10.40589 (0.034118)**	1.931649 (0.118393)	7.726595 (0.102123)	1.408165 (0.243683)	5.632659 (0.228312)

In Table 5 (fiscal variable excluded) we present F- and χ-square statistics for the foreign holdings adjusted currency component of M1 for the period 1978:2-1995:4. Table 5 displays the joint significance tests for the coefficients of the corrected M1 currency component with alternative initial level assumptions next to significance tests for the coefficients of the Federal funds rate in the corresponding autoregressive specification. Equivalent specifications including the fiscal variable do not yield significantly different results.

In the case of nominal and real income (at varying levels of initial foreign holdings of currency) we find significant informational contribution of corrected money to future movements in nominal and real income (together with the Federal funds rate). Similar to the previous Granger causality tests, the currency component of M1 corrected for the foreign holdings based on the original series provided by Porter and Judson (with the assumption of 50% initial level of foreign holdings in the total level of US dollars in circulation) contains statistically significant information contribution when used to explain future movements of the inflation rate.

Overall our new monetary aggregate specification does not comply with recent evidence. If not corrected for foreign holdings, currency component of M1 seems to be very noisy. Granger causality tests point to a significant information value of the currency component of M1 when we filter out the foreign holdings noise. Results presented in Section 4 suggest that we should be cautious in interpreting the vanishing role of monetary aggregates in predicting future movements in the macroeconomic fundamentals in the US when there is large noise contained in the monetary figures. It is essential to stress that the results of the performed Granger causality tests are robust to eventual corrections for potential heteroskedasticity in the residuals.[38] The results are also reasonably robust with respect to the choice of the data samples.[39]

5. Vector Autoregressions

The reported statistical significance of the US M1 currency component corrected for the foreign holdings of dollars based on the Granger causality tests is not the only criterion in assessing the information value of this monetary aggregate. Another important criterion used in the information

[38] More precisely, we investigated the potential presence of the heteroskedasticity in the residuals with the use of the White's test. Then, whenever some evidence was found of heteroskedasticity, we applied the White heteroskedasticity consistent standard errors to derive the corresponding F- and χ-square statistics of the Granger causality tests. Overall evidence of the relative performance of alternative financial variables based on the tests performed with the adjusted residuals is very similar to those based on the unadjusted OLS residuals. However, given that our sample size is relatively small, this evidence should be interpreted cautiously, as both the tests and the adjustments are only asymptotically valid.

[39] As we have already explained, our sub-sample selection is determined by the availability of the foreign holdings data. Generally, the results are reasonably robust when the estimations are performed for shorter periods of the second sample.

value approach is the ability of a given financial variable to account for the forecast error variance of nominal and real income as well as inflation over a certain horizon. As Friedman (1998, p. 12) puts it:

Most basically, asking the yes-no question of whether money has <u>any</u> predictive content with respect to output or prices is not the same as asking <u>how</u> <u>much</u> predictive content money has.

Following Friedman (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 nominal and real income, and inflation (for two alternative specifications: with and without the fiscal variable) in which we include, successively, the alternative financial variables considered before. We use four lags for each variable considered in the unrestricted VAR. Therefore, each right-hand side representation of nominal and real income, and inflation that constitutes a given autoregressive system is identical to the corresponding right-hand side of the Granger causality specification as discussed in Sections 3 and 4.

By using forecast error variance decompositions, we first evaluate the informational contribution of standard financial variables in helping to predict future movements of income and prices. Then we proceed in comparing the relative predictive performance of the monetary variables vis-à-vis the M1 currency component corrected for the foreign holdings of US dollars.

5.1 Friedman and Kuttner Revisited

Tables 6a-c display the part of the variance of nominal and real income, and inflation with the 95-percent confidence bounds attributed to the successive financial variables in the VAR representations (without fiscal variable).[40] For the sake of consistency with the Granger causality tests presented in Sections 3 and 4 we consider two sub-samples. The first period ranges from 1960:2 to 1978:1 and the second period from 1978:2 to 1995:4. The latter period corresponds to the period for which we have data on foreign holdings of US dollars. We focus our attention on the four, eight and twelve quarters forecast horizons.

[40] More precisely, the ranges given throughout Tables 6a to 6c indicate approximate 95-percent confidence intervals (± two times standard error) computed by Monte Carlo simulation with 500 rounds. The numbers displayed in the table are rounded to the closest integer.

Table 6.a: Variance Decomposition of Nominal Income Generated from Unrestricted Two-Variable VAR Specification (Nominal Income, Financial Variable)

Horizon	$\Delta FUNDS$	Δr_b	Δr_p	$r_p - r_b$	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(M1CUR)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$
Sample Period 1960:2-1978:1									
4	10±13	3±9	9±14	12±16	25±18	27±18	10±13	11±13	18±15
8	22±19	17±19	20±22	22±18	26±19	32±21	13±15	14±14	21±17
12	23±21	19±21	21±23	23±19	27±21	32±21	14±16	15±16	21±19
Sample Period 1978:2-1995:4									
4	12±15	12±14	17±16	8±12	10±15	5±12	3±12	5±13	4±11
8	14±15	15±14	19±16	9±14	13±21	11±18	7±19	13±22	10±19
12	15±16	15±15	20±17	9±15	14±24	14±22	7±21	14±25	11±22

Ranges indicate approximate 95-percent confidence intervals computed via Monte Carlo simulations with 500 rounds.
Ordering: Nominal Income, Financial Variable.

Table 6.a shows forecast error variance decompositions of nominal income for successive monetary variables. It shows an obvious deterioration in the information content of the standard monetary aggregates in explaining the forecast error variance of the nominal income across time periods. During the eighties and the early nineties the percentage of nominal income variance attributed to monetary aggregates sharply decreases for all standard monetary aggregates irrespective of the forecast horizon we consider. Moreover, as this sharp decline in the variance attributable to monetary aggregates is not accompanied by a similar decline in the confidence bounds, the variance portions attributed to monetary aggregates are highly insignificant. Note that in the earlier period 1960:2-1978:1 the variance portions attributed to all standard monetary variables are significant over most of the forecast horizons we consider.

Contrary to monetary aggregates, we observe that the percentage of variance of nominal income due to changes in all short-term interest rates (except the interest spread) is higher over the period 1978:2-1995:4 at four quarters. At eight and twelve quarters, the part of forecast error variance attributed to interest rates decreases in the second sample. However, it is important to note that this decline is much more moderate in comparison to the stark deterioration in the performance of the monetary aggregates. Moreover, we find that in the 1960:2-1978:1 period nominal income variances attributed to interest rates changes are significant over most of the forecast horizons. Over the 1978:2-1995:4 period only the variances due to the commercial paper at all quarters we consider and the Treasury bill rate at four and eight quarters are significant.

Finally, we note that the percentage of forecast variance error decompositions for nominal income tend to be higher for monetary aggregates in the 1960:2-1978:1 period, while in the 1978:2-1995:4 period the overall performance of interest rates is far better than those of monetary aggregates.

Table 6.b: Variance Decomposition of Real Income Generated from Unrestricted Three-Variable VAR Specification (Real Income, Price Index, Financial Variable)

Horizon	$\Delta FUNDS$	Δr_b	Δr_p	$r_p - r_b$	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(M1CUR)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$
Sample Period 1960:2-1978:1									
4	13±14	3±8	9±12	14±14	10±13	19±15	8±12	5±10	8±12
8	20±16	15±15	18±15	21±16	12±15	21±16	8±13	6±11	8±13
12	20±16	15±16	18±16	22±17	12±15	22±17	8±13	6±11	8±13
Sample Period 1978:2-1995:4									
4	13±14	13±15	17±16	6±11	10±14	8±13	1±8	4±11	3±8
8	16±13	16±14	20±15	7±13	11±16	9±14	2±12	8±16	8±13
12	16±13	17±15	20±16	7±13	11±18	10±16	3±13	8±17	8±13

Ranges indicate approximate 95-percent confidence intervals computed via Monte Carlo simulations with 500 rounds.
Ordering: Real Income, Price Index, Financial Variable.

Table 6.b presents analogous forecast error variance decompositions for real income. Here, we observe that in the 1978:2-1995:4 period the forecast error variance of real income due to monetary aggregates is generally lower as compared to the 1960:2-1978:1 period. The only exception is the Board of Governors' adjusted monetary base that has a higher percentage of variance attributed to at eight and twelve quarters in the 1978:2-1995:4 period. Particularly, for the M1 currency component and M2 there is very strong deterioration in the percentage of variance attributed. Overall, the forecast error variances attributable to monetary aggregates worsen over time. Furthermore, it is important to stress that none of the forecast error variances of real income attributed to monetary aggregates is significant in the latter period, whilst in the former period portions of real income variance due to changes in M2 are significant.

As concerns interest rates, we find in general that the percentage of variances of real income due to the Treasury bill rate and the commercial paper rate are higher in the 1978:2-1995:4 period compared to the 1960:2-1978:1 period. Interestingly, part of variance attributed to spread is substantially lower in the second sample. The performance of the Federal funds rate is similar at four quarters across both samples, while at eight and twelve quarters it slightly deteriorates in the 1978:2-1995:4 period. In the 1960:2-1978:1 period the percentage of forecast error variance for real income is significant for all interest rate measures at most of eight and twelve quarters horizons. With the exception of the spread, the same observation holds true for the 1978:2-1995:4 period.

In sum, we observe that similar to the findings for the nominal income, the relative performance of interest rates as compared to monetary aggregates improves substantially over time. Our results for nominal and real income forecast error variance decompositions are similar to those reported by Friedman and Kuttner (1992). We observe that the pattern of changes in the percentage of variance in nominal and real output attributed to monetary aggregates mimics the changes over time in the statistical significance of these variables in the Granger causality specifications presented in

Section 3. More precisely, we find that the deterioration in the significance is generally accompanied by a decline in the percentage of variance attributed.

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

Sample Period 1960:2-1978:1									
Horizon	$\Delta FUNDS$	Δr_b	Δr_p	$r_p - r_b$	$\Delta \ln(M1)$	$\Delta \ln(M2)$	$\Delta \ln(M1CUR)$	$\Delta \ln(BGbase)$	$\Delta \ln(SLbase)$
4	19±18	11±16	15±18	3±10	6±13	3±9	2±8	9±14	8±13
8	20±22	12±19	16±21	5±16	15±21	3±9	6±15	21±21	17±20
12	18±22	12±20	15±22	5±19	19±25	3±11	10±21	28±26	23±25
Sample Period 1978:2-1995:4									
4	2±6	2±7	2±6	2±8	1±8	0±6	8±14	12±19	4±10
8	2±7	2±8	2±9	2±11	6±19	1±10	10±21	24±32	10±23
12	1±9	1±10	2±11	4±17	11±29	4±17	11±24	33±40	17±32

Ranges indicate approximate 95-percent confidence intervals computed via Monte Carlo simulations with 500 rounds.
Ordering: Price Index, Real Income, Financial Variable.

In addition to Friedman and Kuttner (1992), we present in Table 6.c the forecast error decompositions for inflation. All monetary variables, including interest rates, perform rather poorly. In the 1960:2-1978:1 period, there is significant attribution of percentage of forecast error variance in inflation only to the Federal funds rate at four quarters and to the Board of Governors' monetary base at eight and twelve quarters. This is even worse for the 1978:2-1995:4 period. Irrespective of the monetary variable there is no single statistically significant result in any of the horizons we consider. This evidence corroborates the results from the Granger causality specifications we have presented in Section 3.

Finally, it is interesting to note that percentage of inflation variance due to interest rates decreases sharply in the second period. For monetary measures, we observe mixed evidence with some sharp and moderate decreases for some aggregates at certain forecast horizons and some increases for the others. However, as we have already stressed none of the measures are statistically significant in the latter period.

So far we have presented the forecast error variance decomposition for nominal and real income and inflation in the VAR specifications without the fiscal variable. Similarly to the Granger causality tests, the presence of the fiscal variable does not affect our results in any significant way.

A final remark concerns the well-known ordering issue in VAR specifications. In our estimations ordering does not affect our results in a significant manner due to the low correlation among the residuals of the estimated VAR specifications.

5.2. Foreign Holdings of US Dollar and Vector Autoregressions

Now we turn our attention to the corresponding forecast error variance decomposition for nominal and real income and inflation due to M1 currency component corrected for the foreign holdings of US dollars. Table 7 displays the part of variance decomposition of output and inflation due to M1 currency component corrected with different thresholds of initial foreign holdings (for the systems without fiscal variable). Our sample covers only the 1978:2-1995:4 period.

Table 7

Horizon	$\Delta\ln(M1CURrev)$ original data, 50% abroad in 1977:1	$\Delta\ln(M1CURrev)$ 40% abroad in 1977:1	$\Delta\ln(M1CURrev)$ 30% abroad in 1977:1	$\Delta\ln(M1CURrev)$ 20% abroad in 1977:1	$\Delta\ln(M1CURrev)$ 10% abroad in 1977:1	$\Delta\ln(M1CURrev)$ 0% abroad in 1977:1
Variance Decomposition of Nominal Income Generated from Unrestricted Three-Variable VAR Specification (Nominal Income, Financial Variable)						
4	16±15	17±15	17±17	17±16	17±18	17±17
8	25±16	27±18	27±21	28±21	28±21	27±21
12	28±19	30±20	31±24	31±24	31±25	30±24
Variance Decomposition of Real Income Generated from Unrestricted Three-Variable VAR Specification (Real Income, Price Index, Financial Variable)						
4	15±16	15±15	14±16	14±16	14±16	13±17
8	17±16	18±16	17±16	17±17	17±17	16±20
12	18±17	18±16	17±17	17±18	17±18	16±21
Variance Decomposition of Prices Generated from Unrestricted Three-Variable VAR Specification (Price Index, Real Income, Financial Variable)						
4	3±10	4±11	4±11	4±12	4±10	4±10
8	25±26	25±26	25±27	24±29	24±27	23±25
12	43±33	43±34	42±34	41±37	40±36	38±34

Ranges indicate approximate 95-percent confidence intervals computed via Monte Carlo simulations with 500 rounds.
Ordering Nominal Income System: Nominal Income, Financial Variable.
Ordering Real Income System: Real Income, Price Index, Financial Variable.
Ordering Price System: Price Index, Real Income, Financial Variable.

Table 7 indicates that the percentage of variance in nominal income due to the currency component of M1 corrected for the foreign holdings is substantial and significant for all assumed initial holdings and over all horizons except one case: $\Delta\ln(M1CURrev)$ "10% abroad in 1977:1" at four quarters.

The percentage of variance decomposition of real income due to the corrected monetary aggregate is substantial and significant at all quarters for the original Porter-Judson official data assuming that at the beginning of 1977 about 50% of US currency was held abroad. The same holds for the 40% and 30% assumed initial foreign holdings of US dollars in 1977. For the 20% and 10% initial foreign holdings, the percentage of attributed variance in real income is significant at eight quarters. The percentage of attributed variance in real income is not significant for the 0% initial holdings.

Overall, we find that the substantial part of variance in nominal and real income is attributed to the corrected monetary aggregate. This evidence mimics the high significance of the currency component of M1 corrected for the foreign holdings in the Granger causality specifications reported in Section 4.

In the case of inflation forecast error variance decomposition, we find that the portion attributable to M1 currency component is substantial and significant for all assumed initial holdings of US dollars at twelve quarters. Interestingly, a substantial part of variance in the deflator attributed to the corrected money and its significance mimics evidence of significance of the corrected money in the Granger causality tests provided in Section 4. It is important to stress that M1 currency component corrected for the foreign holdings is the only measure characterized by a significant percentage of attributed variance in price changes and some evidence of significance in the Granger specification for inflation.

To compare directly the performance of alternative financial variables with corrected money we present plots of percentages of variances attributed to them up to the twelve quarters forecast horizon.[41] Figure 3 compares the percentage of forecast variance of nominal and real income and inflation attributed to M1 currency corrected with different initial holdings, M1 currency corrected versus other monetary aggregates, and M1 currency corrected versus interest rates, in a row.

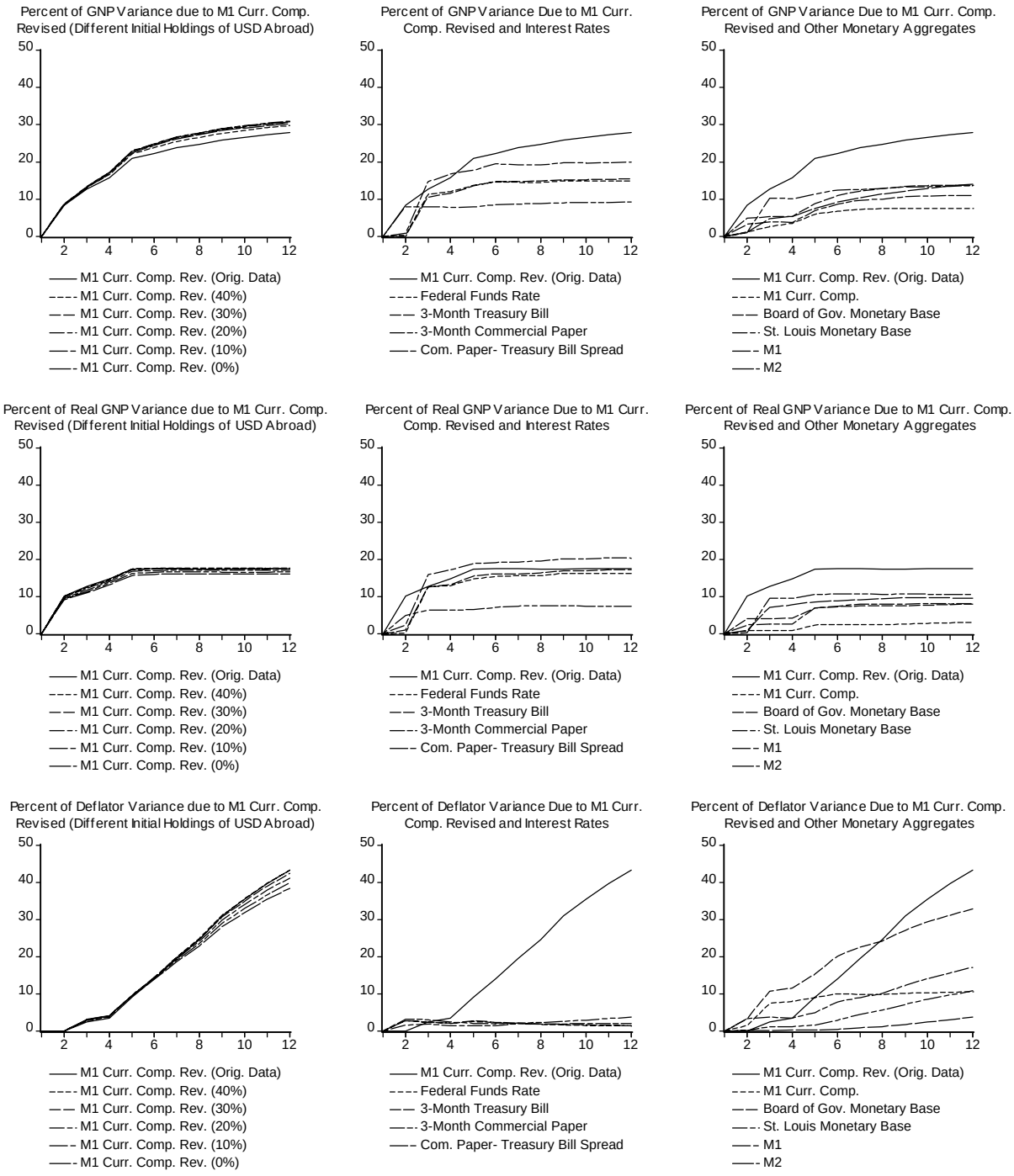
The evidence from Figure 3 is revealing. The M1 currency component corrected for foreign holdings strongly outperforms other monetary aggregates in terms of the percentage of attributed forecast error variance of nominal and real income at all forecast horizons considered. For the decomposition of inflation, the corrected money outperforms strongly other monetary aggregates over longer horizons. It is also important to remember that the M1 currency component corrected is the only measure whose attributed percentage of variance in inflation displays significance at some quarters.

For the nominal income the performance of the corrected money is stronger than those of interest rates over longer horizons and similar over shorter ones. For the real output case, the shape and magnitude of the percentage of variance attributed are very similar. For the inflation case, the corrected money strongly outperforms all short-term interest rates including the Federal funds rate. We note that alternative assumptions concerning initial foreign holdings of US dollars do not affect the forecast error variance decompositions in a significant way.

[41] The variance decompositions displayed in Figure 3 are generated from the systems with no fiscal variable included.

Figure 3

Percent of Forecast Error Variance Decomposition of
Nominal and Real Income and Prices Due to Alternative
Financial Variables (Fiscal Variable Excluded)



The analogous percentages of variance decompositions due to corrected money generated by the systems with fiscal variables do not significantly affect the results reported in Table 6a-c and Figure 3 and therefore are not presented. We also remark that the ordering of variables does not

significantly affect the results for variance decompositions due to M1 currency component corrected for foreign holdings. [42]

As a last exercise, we present, throughout Appendix A.5a-c, the impulse responses of nominal and real income, and inflation to one standard deviation of the financial variables generated from the corresponding unrestricted VAR systems (without the fiscal variable).[43] Again, we focus on the two sample periods, 1960:2-1978:1 and 1978:2-1995:4. As we have already mentioned, the ordering of variables is of negligible importance.

As we observe, the impulse responses of nominal and real income and inflation to one standard deviation in the Federal funds rate, the 3-month Treasury bill, and the 3-month commercial paper are remarkably similar within a sample period. Across periods, however, there are significant differences in impulse responses due to interest rates.

We observe that the responses of nominal and real income with respect to standard monetary aggregates tend to decline in the magnitude during the period of 1978:1-1995:4 as compared with the period 1960:2-1978:1. Interestingly, the size of the responses of nominal and real income with respect to the currency component of M1 corrected for the foreign holdings in the period 1978:2-1995:4 is closer to responses due to the standard monetary aggregates in the period 1960:2-1978:1 rather than to those in the period 1978:2-1995:4. The responses of inflation with respect to monetary aggregates are remarkably similar in the period 1978:2-1995:4.

Finally, we note that the impulse responses of nominal and real income, and inflation to one standard deviation in the currency component of M1 corrected for the foreign holdings are positive. They are also remarkably significant for inflation and nominal income. It is of interest to note that the impulse responses of inflation and nominal income are generally not significant for the other monetary aggregates. We also find that the response of real income to one standard deviation in the currency component of M1 corrected for the foreign holdings is significant in the second quarter after the shock. Therefore, an increase in the currency component of M1 corrected for the foreign holdings leads to a significant increase in nominal and real income, and inflation.

Again, we find that alternative assumptions concerning initial level of the foreign holdings of US dollars do not affect the impulse responses in any significant way.

[42] Similar to other variables, the relative irrelevance of ordering results from the low correlation among the residuals of the estimated VAR specifications.

[43] The impulse responses of the systems with the fiscal variable included are very similar and therefore we do not report them.

6. Concluding Remarks

In this paper we reevaluate the well-known evidence of the vanishing information content of US monetary aggregates in explaining fluctuations in macroeconomic fundamentals. The official data constructed by Porter and Judson (1996) indicate that the foreign holdings of US dollars are large and unstable. Therefore, they severely complicate the account of domestic monetary aggregates. We argue that this noise should be filtered out before undertaking any analysis of the US macroeconomic stance based on the monetary aggregates.

We provide a new monetary aggregate, the currency component of M1 corrected for the foreign holdings of US dollars, which contains useful information about nominal and real income, as well as inflation. Contrary to the conventional wisdom on the vanishing role of monetary aggregates, our Granger causality tests point to the significant information value of the adequately corrected money in helping to predict future movements of the macroeconomic fundamentals. Moreover, the forecast error variance decompositions indicate the substantial and significant contribution of the currency component of M1 corrected for the foreign holdings to the variances of nominal and real income, and inflation.

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

Finally, apart from the short-term policy relevance, the evidence provided in this paper suggests that if the leading role of US dollar as an international currency will be challenged by long-term adverse shifts in the preferences of the foreign holders, the US Federal Reserve may face serious obstacles in the conduct of monetary policy to stabilize the US macroeconomic environment.

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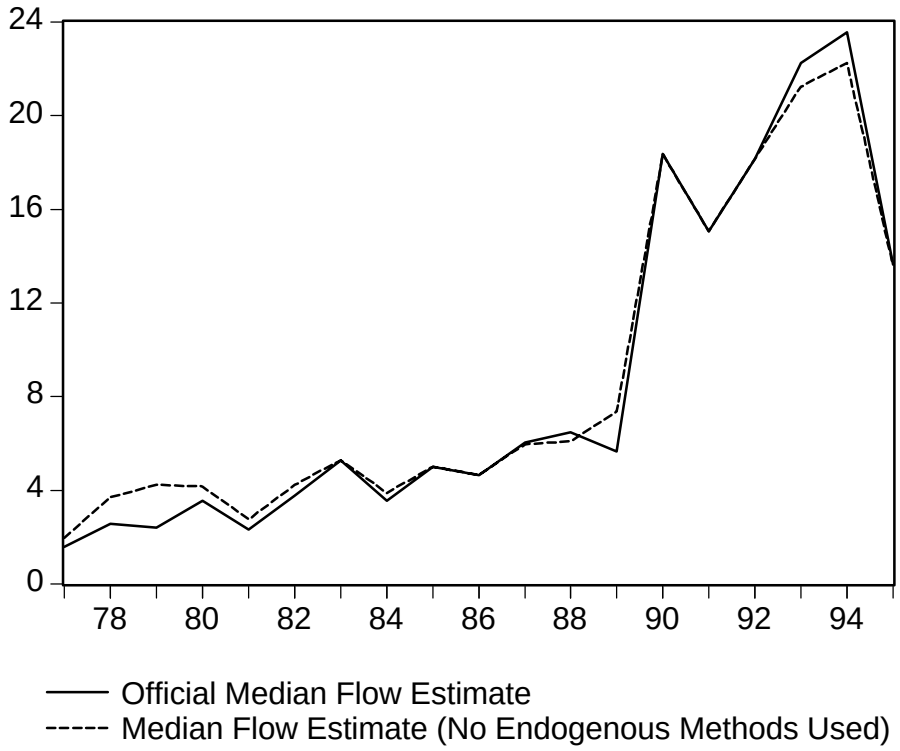
Appendix A.1
Comparison between the Official Median Flow Estimate and the Median Flow Estimate Constructed with No Use of the Potentially Endogenous Methods
(Annual Flows of US Dollars Abroad, Billions of USD)



Appendix A.2
The Data

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.
Dealer-Placed Unsecured, Short-Term Negotiable Promissary Notes Issued By Companies with AA Bond Ratings and Sold to Investors. Unweighted Average of Offering Rates Reported Each Business Day to the Federal Reserve Bank of New York.
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 Consumption Expenditures & Gross Investment -
Billions of Dollars Seasonally Adjusted Annual Rate.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

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

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 Federal Consumption Expenditures & Gross Investment-
Billions of Chained 1996 Dollars Seasonally Adjusted Annual Rate.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

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

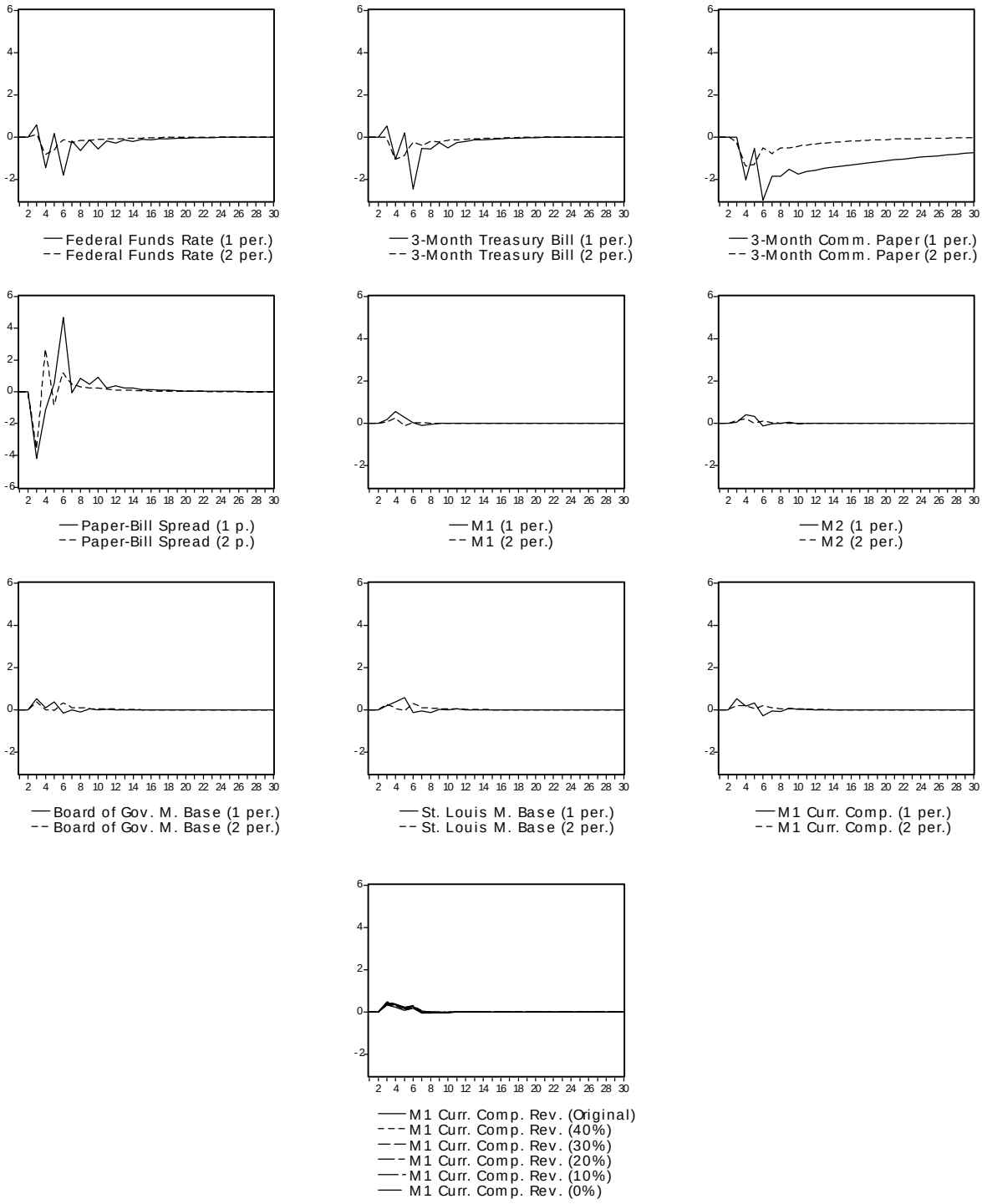
St. Louis Adjusted Monetary Base-
Billions of Dollars Seasonally Adjusted.
Source: Federal Reserve Bank of St. Louis.

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

Appendix A.3
Impact Responses of Macroeconomic Fundamentals to One Unit Shock in the Financial Variable (Granger Causality Specifications)

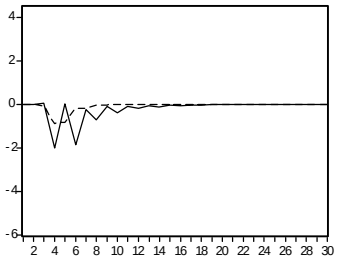
A.3a. Nominal Income

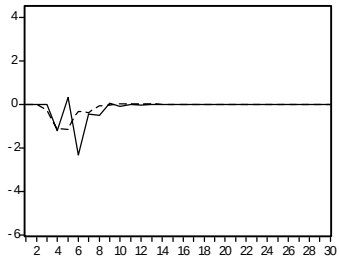
Impact of One Unit Increase of the Financial Variable
over One Quarter Period on Nominal GNP (2-Variable System)

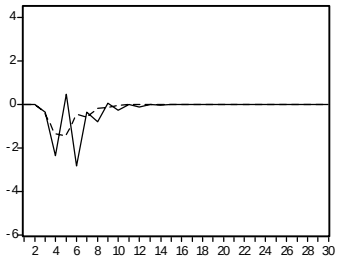


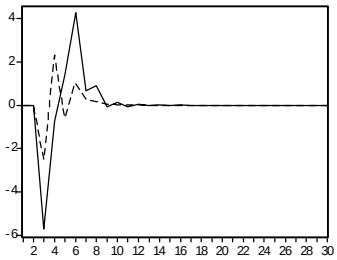
A.3b. Real Income

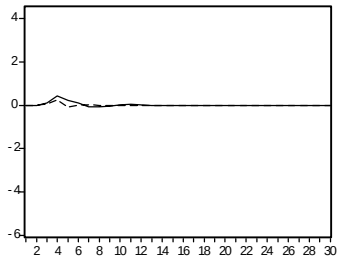
Impact of One Unit Increase of the Financial Variable
over One Quarter Period on Real GNP (3-Variable System)

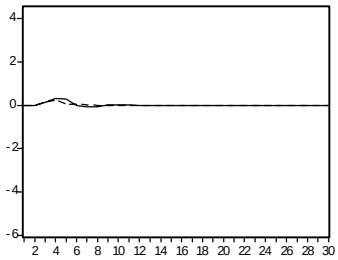


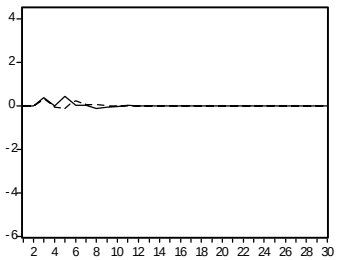


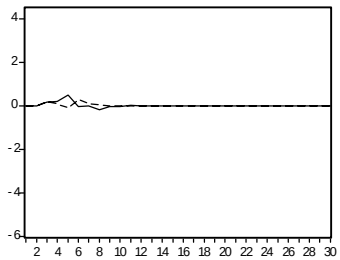


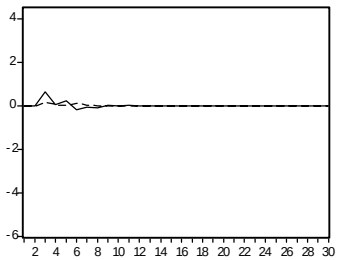


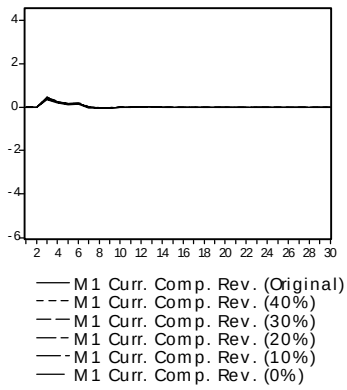






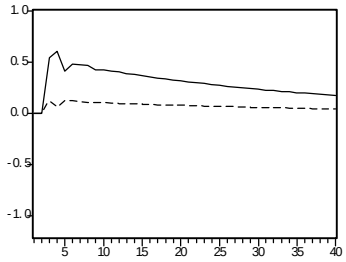


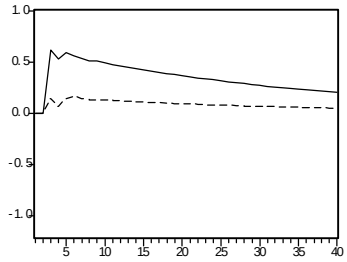


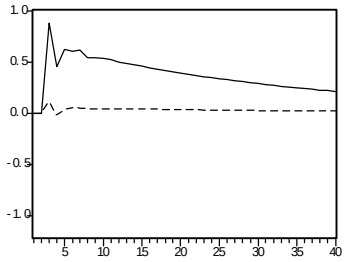


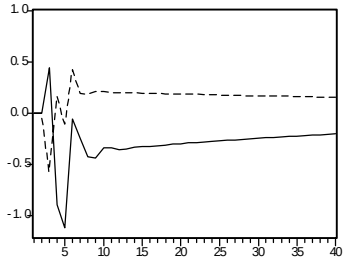
A.3c. Inflation

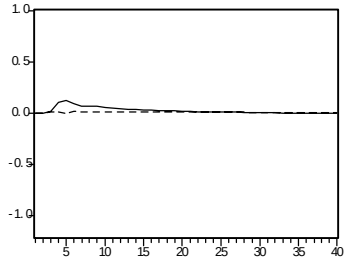
Impact of One Unit Increase of the Financial Variable
over One Quarter Period on Inflation (3-Variable System)

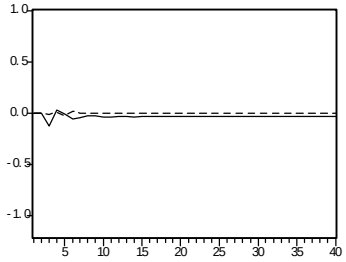


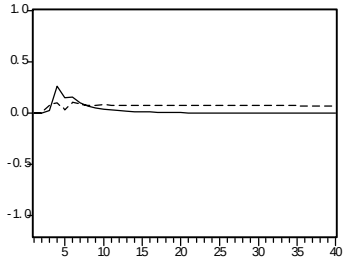


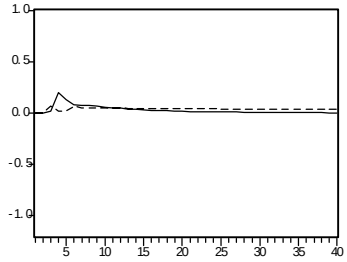


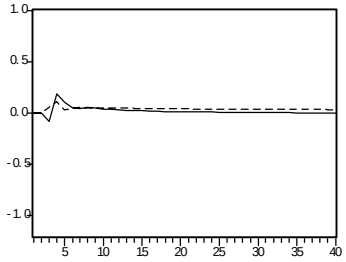


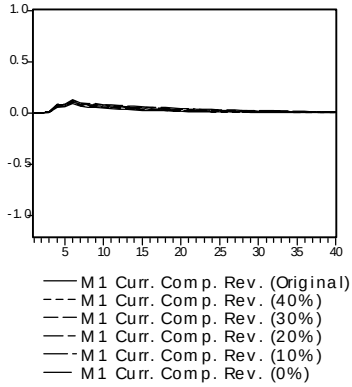












Appendix A.4

F-Statistics and χ-Square Statistics[44] for Federal Funds Rate and

Financial Variable in Nominal-Income Equation

Three-Variable System (Nominal Income, Federal Funds Rate, Financial Variable)

Period	1960:2-1978:1		1978:2-1995:4	
Variables	F-Statistic	χ-square	F-Statistic	χ-square
Nominal Income, Federal Funds Rate and M1				
$\Delta FUNDS$	2.554303 (0.048144)**	10.21721 (0.036923)**	2.971110 (0.026641)**	11.88444 (0.018232)**
$\Delta \ln(M1)$	4.032736 (0.005872)***	16.13095 (0.002848)***	0.318302 (0.864603)	1.273209 (0.865904)
Nominal Income, Federal Funds Rate and M2				
$\Delta FUNDS$	1.273626 (0.290596)	5.094502 (0.277738)	4.538614 (0.002942)***	18.15446 (0.001151)***
$\Delta \ln(M2)$	3.428600 (0.013788)**	13.71440 (0.008265)***	1.025244 (0.401983)	4.100978 (0.392512)
Nominal Income, Federal Funds Rate and Board of Gov. Adjusted Monetary Base				
$\Delta FUNDS$	3.258724 (0.017562)**	13.03489 (0.011107)**	4.752604 (0.002193)***	19.01042 (0.000782)***
$\Delta \ln(BGbase)$	2.641115 (0.042510)**	10.56446 (0.031921)**	1.313468 (0.275727)	5.253873 (0.262226)
Nominal Income, Federal Funds Rate and St. Louis Adjusted Monetary Base				
$\Delta FUNDS$	3.182356 (0.019585)**	12.72942 (0.012676)**	3.985602 (0.006339)***	15.94241 (0.003097)***
$\Delta \ln(SLbase)$	3.433384 (0.013694)**	13.73354 (0.008196)***	0.493952 (0.740170)	1.975807 (0.740209)
Nominal Income, Federal Funds Rate and currency component of M1				
$\Delta FUNDS$	3.798210 (0.008167)***	15.19284 (0.004318)***	5.035242 (0.001066)***	21.14091 (0.000297)***
$\Delta \ln(M1CUR)$	2.784122 (0.034630)**	11.13649 (0.025072)**	0.856743 (0.495392)	3.426973 (0.489069)

[44] The F- and χ-square statistics represents the tests, across different time periods, of the null hypothesis that all of the coefficients, respectively, on the Federal funds rate, and on the financial variable included next to the Federal funds rate into the autoregressive specifications are zero.

F-Statistics and χ-Square Statistics for Federal Funds Rate

and Financial Variable in Real-Income Equation

Four-Variable System (Real Income, Price Index, Federal Funds Rate, Financial Variable)

Period	1960:2-1978:1		1978:2-1995:4	
Variables	F-Statistic	χ-square	F-Statistic	χ-square
Real Income, Price Index, Federal Funds Rate and M1				
$\Delta FUNDS$	4.217444 (0.004758)***	16.86978 (0.002049)***	2.901364 (0.030123)**	11.60545 (0.020540)**
$\Delta \ln(M1)$	2.409334 (0.060154)*	9.637336 (0.047001)**	0.467061 (0.759606)	1.868246 (0.759976)
Real Income, Price Index, Federal Funds Rate and M2				
$\Delta FUNDS$	2.607682 (0.045402)**	10.43073 (0.033765)**	4.043600 (0.006117)***	16.17440 (0.002794)***
$\Delta \ln(M2)$	3.429718 (0.014211)**	13.71887 (0.008249)***	0.753201 (0.560286)	3.012804 (0.555685)
Real Income, Price Index, Federal Funds Rate and Board of Gov. Adjusted Monetary Base				
$\Delta FUNDS$	3.654589 (0.010374)**	14.61836 (0.005562)***	5.098581 (0.001470)***	20.39432 (0.000417)***
$\Delta \ln(BGbase)$	1.154317 (0.341007)	4.617270 (0.328868)	1.258217 (0.297756)	5.032866 (0.283942)
Real Income, Price Index, Federal Funds Rate and St. Louis Monetary Base				
$\Delta FUNDS$	3.322643 (0.016518)**	13.29057 (0.009940)***	4.277889 (0.004437)***	17.11156 (0.001839)***
$\Delta \ln(SLbase)$	1.210749 (0.316744)	4.842996 (0.303790)	0.895237 (0.473256)	3.580950 (0.465677)
Real Income, Price Index, Federal Funds Rate and Currency Component of M1				
$\Delta FUNDS$	3.537887 (0.012212)**	14.15155 (0.006827)***	5.328424 (0.001085)***	21.31370 (0.000274)***
$\Delta \ln(M1CUR)$	1.314687 (0.275987)	5.258750 (0.261763)	0.525287 (0.717555)	2.101148 (0.717162)

F-Statistics and χ-Square Statistics for Federal Funds Rate

and Financial Variable in Price Equation

Four-Variable System (Price Index, Real Income, Federal Funds Rate, Financial Variable)

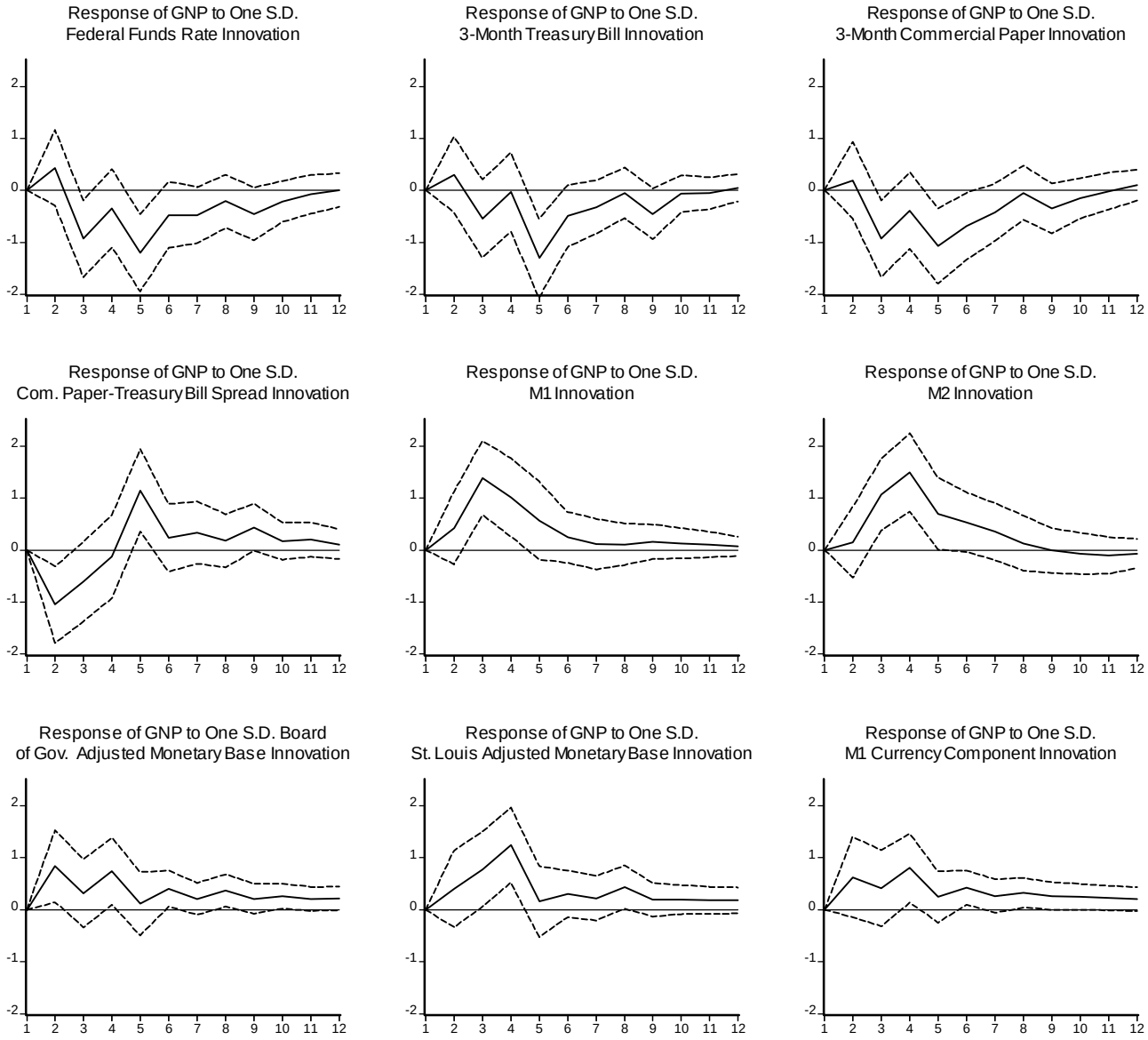
Period	1960:2-1978:1		1978:2-1995:4	
Variables	F-Statistic	χ-square	F-Statistic	χ-square
Price Index, Real Income, Federal Funds Rate and M1				
$\Delta FUNDS$	3.579745 (0.011517)**	14.31898 (0.006344)***	1.168823 (0.334842)	4.675291 (0.322265)
$\Delta \ln(M1)$	1.465736 (0.225139)	5.862945 (0.209620)	0.327459 (0.858330)	1.309837 (0.859704)
Price Index, Real Income, Federal Funds Rate and M2				
$\Delta FUNDS$	3.271479 (0.017751)**	13.08591 (0.010864)**	1.206085 (0.318921)	4.824341 (0.305801)
$\Delta \ln(M2)$	1.036971 (0.396544)	4.147885 (0.386362)	0.285970 (0.885828)	1.143880 (0.887249)
Price Index, Real Income, Federal Funds Rate and Board of Gov. Adjusted Monetary Base				
$\Delta FUNDS$	2.915955 (0.029328)**	11.66382 (0.020034)**	1.295739 (0.283300)	5.182955 (0.269035)
$\Delta \ln(BGbase)$	2.371166 (0.063499)*	9.484666 (0.050063)*	1.689151 (0.165940)	6.756603 (0.149323)
Price Index, Real Income, Federal Funds Rate and St. Louis Adjusted Monetary Base				
$\Delta FUNDS$	4.016099 (0.006279)***	16.06440 (0.002934)***	0.906445 (0.466823)	3.625780 (0.459013)
$\Delta \ln(SLbase)$	2.383253 (0.062420)*	9.533013 (0.049073)**	0.641700 (0.635083)	2.566798 (0.632716)
Price Index, Real Income, Federal Funds Rate and Currency Component of M1				
$\Delta FUNDS$	3.357388 (0.015731)**	13.42955 (0.009357)***	1.642970 (0.176865)	6.571881 (0.160317)
$\Delta \ln(M1CUR)$	1.018450 (0.405955)	4.073801 (0.396110)	1.463828 (0.226001)	5.855312 (0.210217)

Appendix A.5

VAR Impulse Responses[45]

A.5a Nominal Income

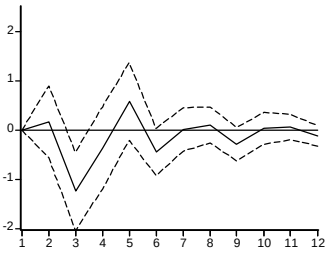
VAR 2-Variable (Nominal Income, Financial Variable)
Period: 1960:2-1978:1



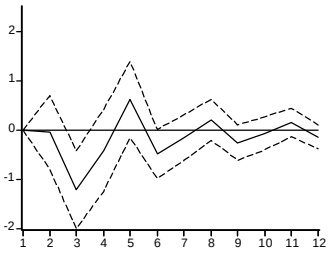
[45] Ordering for unrestricted VAR systems is given in parentheses. The four lags of each variable were used. The 95% confidence bounds displayed in the graphs were calculated by the asymptotic method.

VAR 2-Variable (Nominal Income, Financial Variable)
Period: 1978:2-1995:4

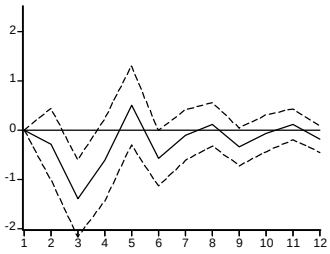
Response of GNP to One S.D.
Federal Funds Rate Innovation



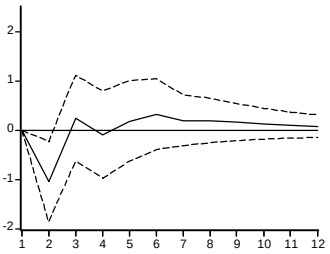
Response of GNP to One S.D.
3-Month Treasury Bill Innovation



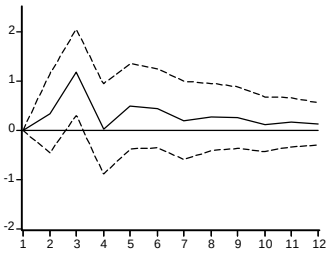
Response of GNP to One S.D.
3-Month Commercial Paper Innovation



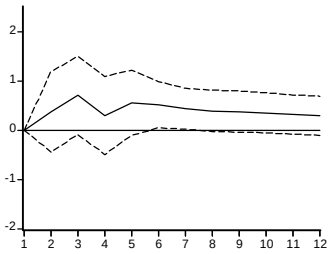
Response of GNP to One S.D.
Com. Paper-Treasury Bill Spread Innovation



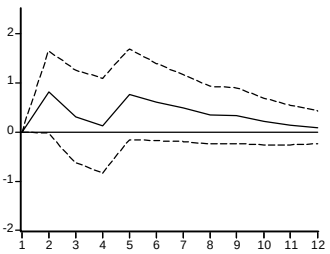
Response of GNP to One S.D.
M1 Innovation



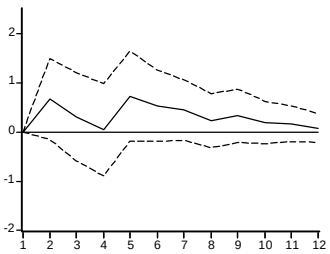
Response of GNP to One S.D.
M2 Innovation



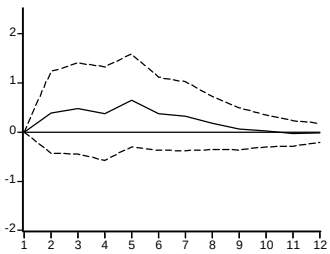
Response of GNP to One S.D. Board
of Gov. Adjusted Monetary Base Innovation



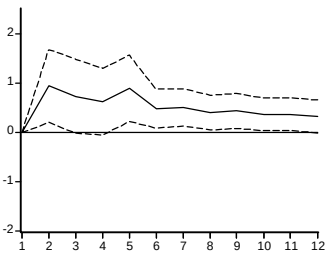
Response of GNP to One S.D.
St. Louis Adjusted Monetary Base Innovation



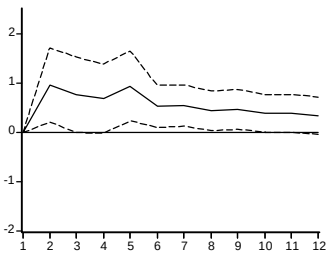
Response of GNP to One S.D.
M1 Currency Component Innovation



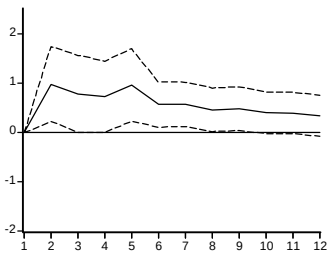
Response of GNP to One S.D.
M1 Curr. Comp. Revised Innovation
(Original Data, around 50% abroad in 1977)



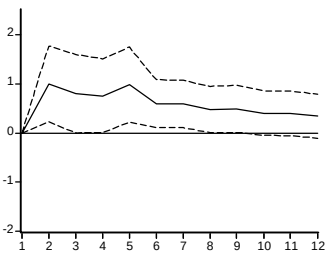
Response of GNP to One S.D. M1 Curr.
Comp. Revised Innovation (40% Abroad in 1977)



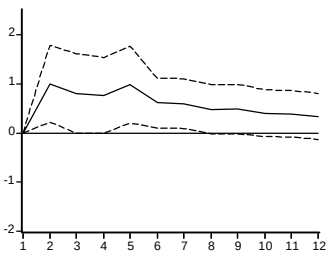
Response of GNP to One S.D. M1 Curr.
Comp. Revised Innovation (30% Abroad in 1977)



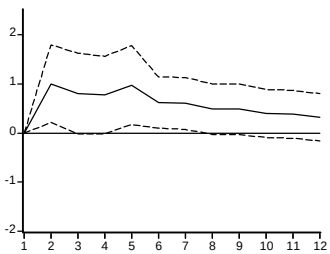
Response of GNP to One S.D. M1 Curr.
Comp. Revised Innovation (20% Abroad in 1977)



Response of GNP to One S.D. M1 Curr.
Comp. Revised Innovation (10% Abroad in 1977)



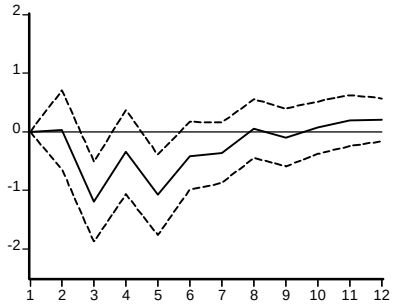
Response of GNP to One S.D. M1 Curr.
Comp. Revised Innovation (0% Abroad in 1977)



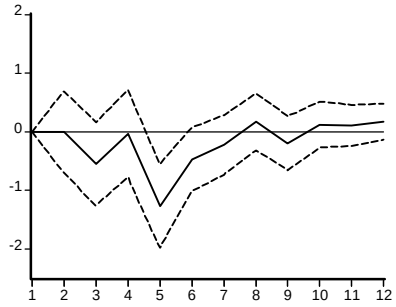
A.5b Real Income

VAR 3-Variable (Real Income, Price Index, Financial Variable)
Period: 1960:2-1978:1

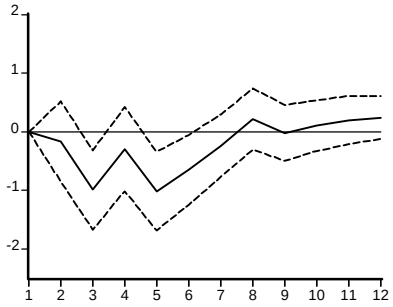
Response of Real GNP to One S.D.
Federal Funds Rate Innovation



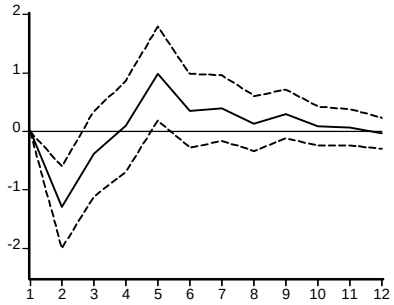
Response of Real GNP to One S.D.
3-Month Treasury Bill Innovation



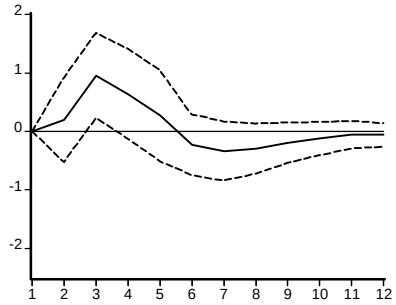
Response of Real GNP to One S.D.
3-Month Commercial Paper Innovation



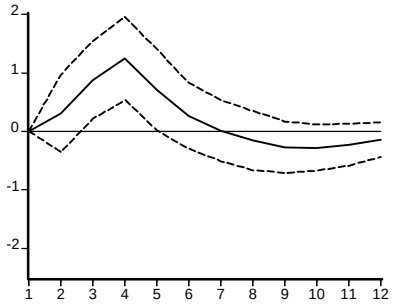
Response of Real GNP to One S.D.
Com. Paper-Treasury Bill Spread Innovation



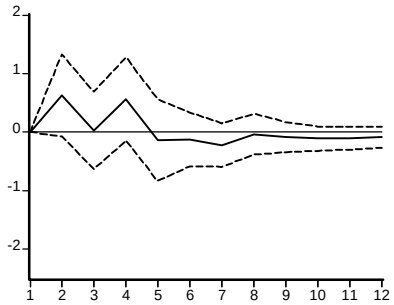
Response of Real GNP to One S.D.
M1 Innovation



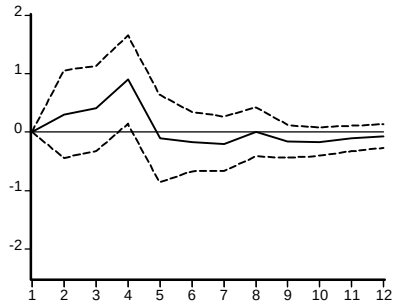
Response of Real GNP to One S.D.
M2 Innovation



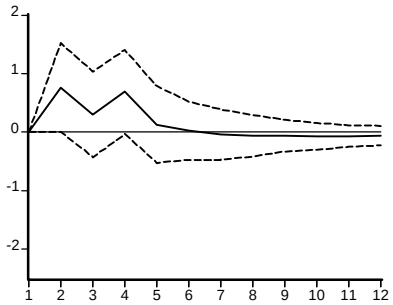
Response of Real GNP to One S.D. Board
of Gov. Adjusted Monetary Base Innovation



Response of Real GNP to One S.D.
St. Louis Adjusted Monetary Base Innovation

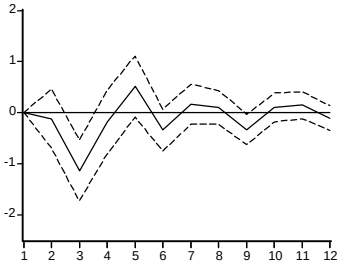


Response of Real GNP to One S.D.
M1 Currency Component Innovation

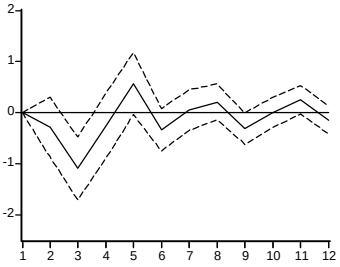


VAR 3-Variable (Real Income, Price Index, Financial Variable)
Period: 1978:2-1995:4

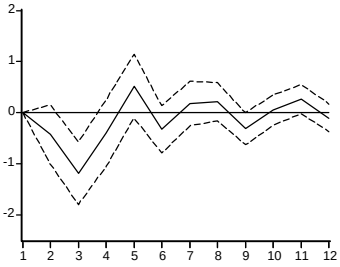
Response of Real GNP to One S.D.
Federal Funds Rate Innovation



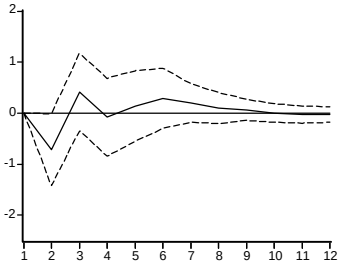
Response of Real GNP to One S.D.
3-Month Treasury Bill Innovation



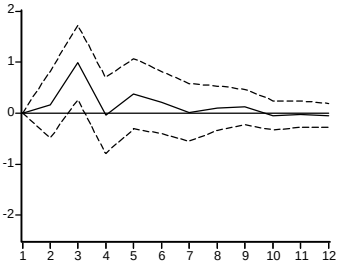
Response of Real GNP to One S.D.
3-Month Commercial Paper Innovation



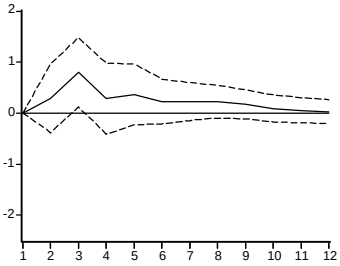
Response of Real GNP to One S.D.
Com. Paper-Treasury Bill Spread Innovation



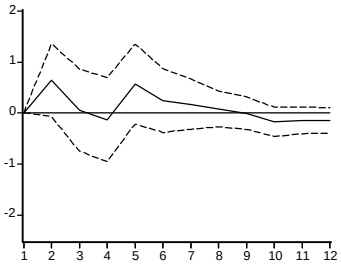
Response of Real GNP to One S.D.
M1 Innovation



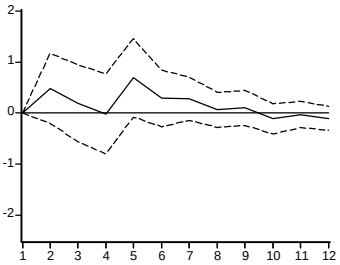
Response of Real GNP to One S.D.
M2 Innovation



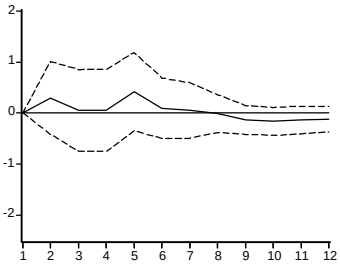
Response of Real GNP to One S.D. Board
of Gov. Adjusted Monetary Base Innovation



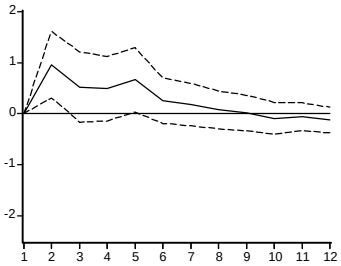
Response of Real GNP to One S.D.
St. Louis Adjusted Monetary Base Innovation



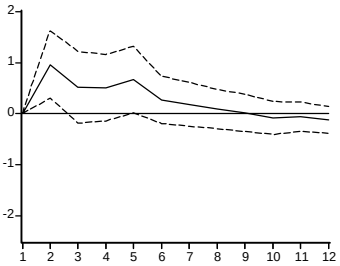
Response of Real GNP to One S.D.
M1 Currency Component Innovation



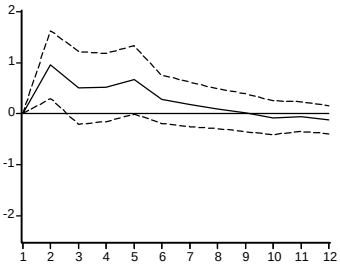
Response of Real GNP to One S.D.
M1 Curr. Comp. Revised Innovation
(Original Data, around 50% abroad in 1977)



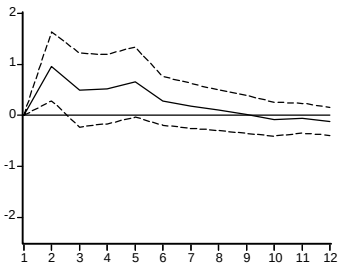
Response of Real GNP to One S.D. M1 Curr.
Comp. Revised Innovation (40% Abroad in 1977)



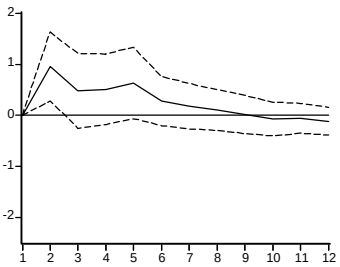
Response of Real GNP to One S.D. M1 Curr.
Comp. Revised Innovation (30% Abroad in 1977)



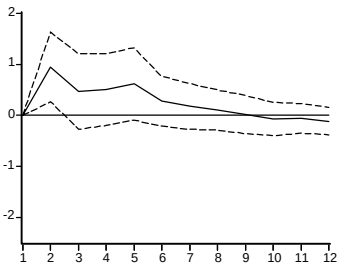
Response of Real GNP to One S.D. M1 Curr.
Comp. Revised Innovation (20% Abroad in 1977)



Response of Real GNP to One S.D. M1 Curr.
Comp. Revised Innovation (10% Abroad in 1977)



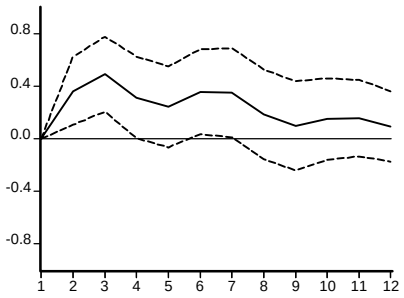
Response of Real GNP to One S.D. M1 Curr.
Comp. Revised Innovation (0% Abroad in 1977)



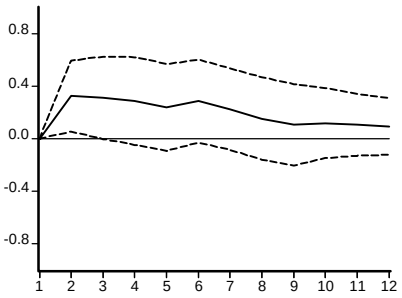
A.5c Inflation

VAR 3-Variable (Price Index, Real Income, Financial Variable)
Period: 1960:2-1978:1

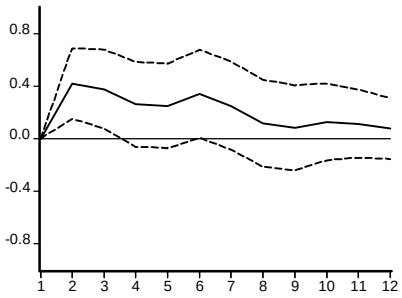
Response of GNP Deflator to One S.D.
Federal Funds Rate Innovation



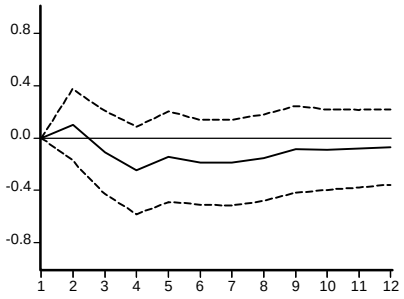
Response of GNP Deflator to One S.D.
3-Month Treasury Bill Innovation



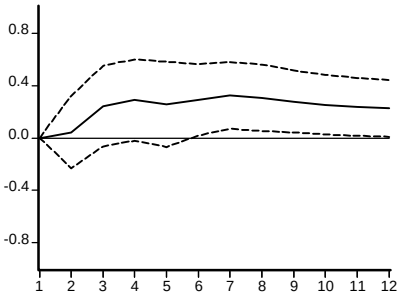
Response of GNP Deflator to One S.D.
3-Month Commercial Paper Innovation



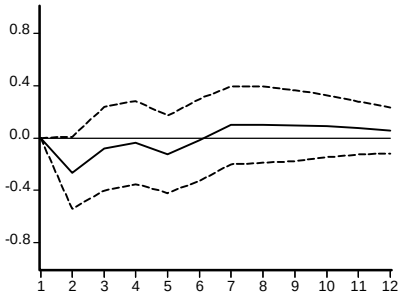
Response of GNP Deflator to One S.D.
Com. Paper-Treasury Bill Spread Innovation



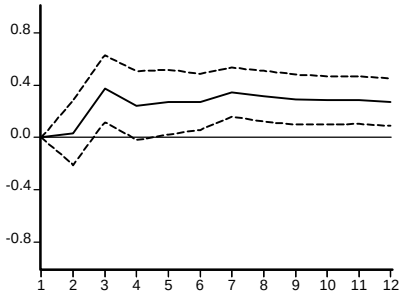
Response of GNP Deflator to One S.D.
M1 Innovation



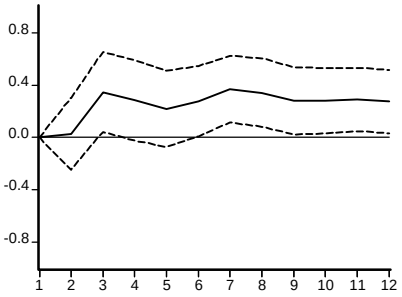
Response of GNP Deflator to One S.D.
M2 Innovation



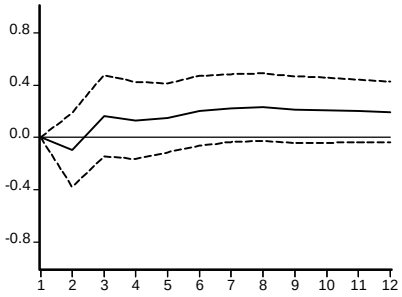
Response of GNP Deflator to One S.D. Board
of Gov. Adjusted Monetary Base Innovation



Response of GNP Deflator to One S.D.
St. Louis Adjusted Monetary Base Innovation

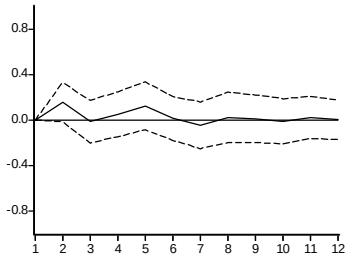


Response of GNP Deflator to One S.D.
M1 Currency Component Innovation

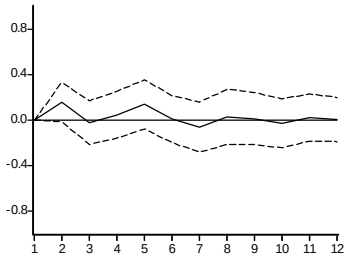


VAR 3-Variable (Price Index, Real Income, Financial Variable)
Period: 1978:2-1995:4

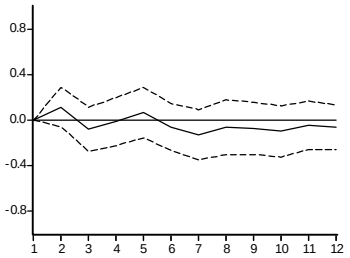
Response of GNP Deflator to One S.D.
Federal Funds Rate Innovation



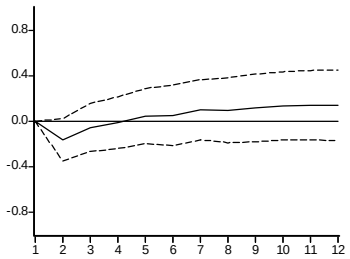
Response of GNP Deflator to One S.D.
3-Month Treasury Bill Innovation



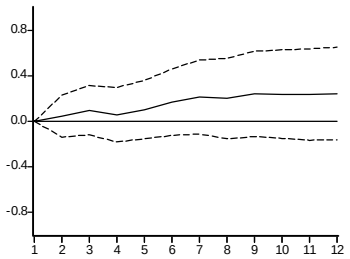
Response of GNP Deflator to One S.D.
3-Month Commercial Paper Innovation



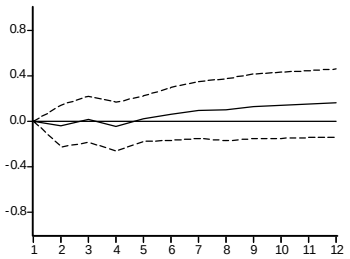
Response of GNP Deflator to One S.D.
Com. Paper-Treasury Bill Spread Innovation



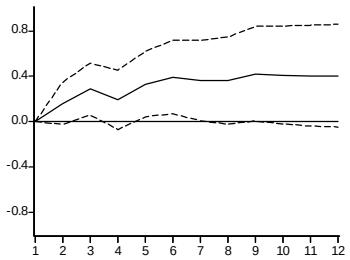
Response of GNP Deflator to One S.D.
M1 Innovation



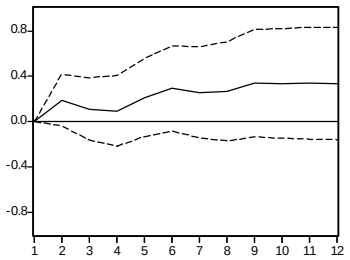
Response of GNP Deflator to One S.D.
M2 Innovation



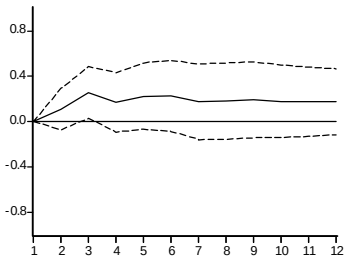
Response of GNP Deflator to One S.D. Board
of Gov. Adjusted Monetary Base Innovation



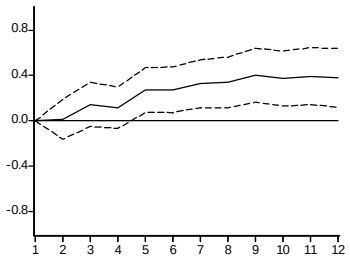
Response of GNP Deflator to One S.D.
St. Louis Adjusted Monetary Base Innovation



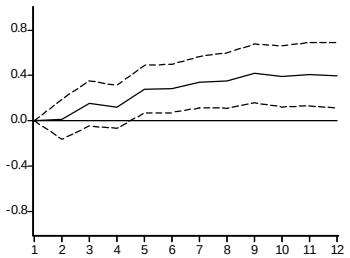
Response of GNP Deflator to One S.D.
M1 Currency Component Innovation



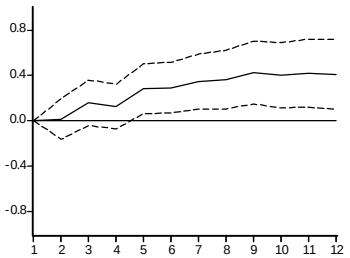
Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation
(Original Data, around 50% abroad in 1977)



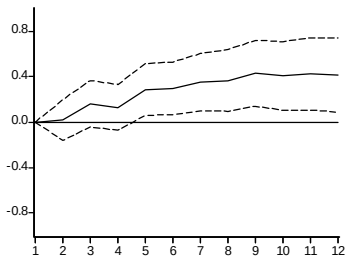
Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation (40% Abroad in 1977)



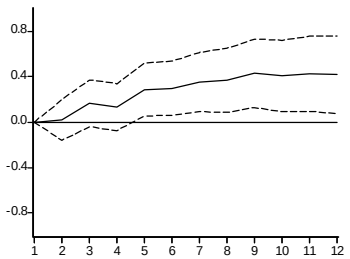
Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation (30% Abroad in 1977)



Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation (20% Abroad in 1977)



Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation (10% Abroad in 1977)



Response of GNP Deflator to One S.D. M1 Curr.
Comp. Revised Innovation (0% Abroad in 1977)