Does Money Still Matter for U.S. Output?*

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Abstract

In this note, we use multivariate models estimated with Bayesian techniques and an out-of-sample approach to investigate whether money growth Granger-causes output growth in the United States. We find surprisingly strong evidence for a money-output link over the 1960-2005 period. However, further analysis indicates that this result is likely to be misleading; after the 'Great moderation', the Granger-causal role of money appears to have vanished completely.

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Keywords: Bayesian VAR, Out-of-Sample Forecasting, Granger Causality, Money, Output, Federal Reserve, Volcker

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1. Introduction

The question whether money plays a causal role for output has created a large literature over the years, and the discussion has been particularly heated for the U.S.. Ever since Sims (1972, p. 540) concluded that *the hypothesis that causality is unidirectional from money to income agrees with the postwar U.S. data*, researchers have vigorously prodded the robustness of the money-output link. The intensity of the debate is explained by its importance for macroeconomic theory and monetary policy, but it also reflects the fact researchers have come to vastly different conclusions.

To some extent, these differences seem to be driven by varying empirical approaches. Sims (1980) argues that the money-output link tends to be weaker in empirical models including a larger number of variables. King and Plossser (1984), Christiano and Ljungquist (1988), and Stock and Watson (1989) observe that using narrower monetary aggregates, growth rates instead of levels, or levels without properly modeling trends, respectively, tends to bias results against money.[1] Thoma (1994) points out that forcing a symmetrical output-effect of money has the same effect. Chao *et al.* (2001) argue that applying out-of-sample instead of within-sample tests also reduces the role of money.

Using Bayesian Vector Autoregressive (BVAR) modeling techniques, we find surprisingly strong evidence that money Granger-causes output over the 1960-2005 period. The full sample findings are particularly robust in the sense that they are based on an out-of-sample forecasting approach including symmetrical multivariate BVAR models using money growth—an approach that, based on the literature up to date, should introduce a bias against finding a money-output link.

But there are also clear indications of a systematic reduction in the role of money after the ‘Great moderation’ of the mid-1980s. In fact, we show that money ceases to Granger-cause output around Paul Volcker’s chairmanship at the Federal Reserve. This supports arguments made by Friedman and Kuttner (1993) and Psaradakis *et al*. (2005) stressing the

[1] Cheung and Fujii (2001) find failure to control for ARCH effects working in the same direction. See Hayo (1999) for a discussion of European evidence.

importance of sample length and seems to contradict Swanson's (1998) claim that the money-output link is stable across time.[2]

2. Methodology and Data

For money to be Granger-causal for output we require that the out-of-sample forecasting performance of a BVAR model including money exceeds that of an otherwise identical model excluding money. The criterion for forecasting performance is the root mean squared error (*RMSE*) of the forecast.[3] This approach is close to Granger's original idea of causality testing (Ashley *et al.*, 1980) and avoids problems of within-sample tests in multivariate frameworks. Using Bayesian VAR methods allow us to describe the data generating process but avoid over-parameterization, which hurts forecasting performance (Doan *et al.*, 1984; Litterman, 1986).

Our forecasting model is given by

$$\mathbf{G}(L)\mathbf{x}_t = \boldsymbol{\delta} + \boldsymbol{\eta}_t, \tag{1}$$

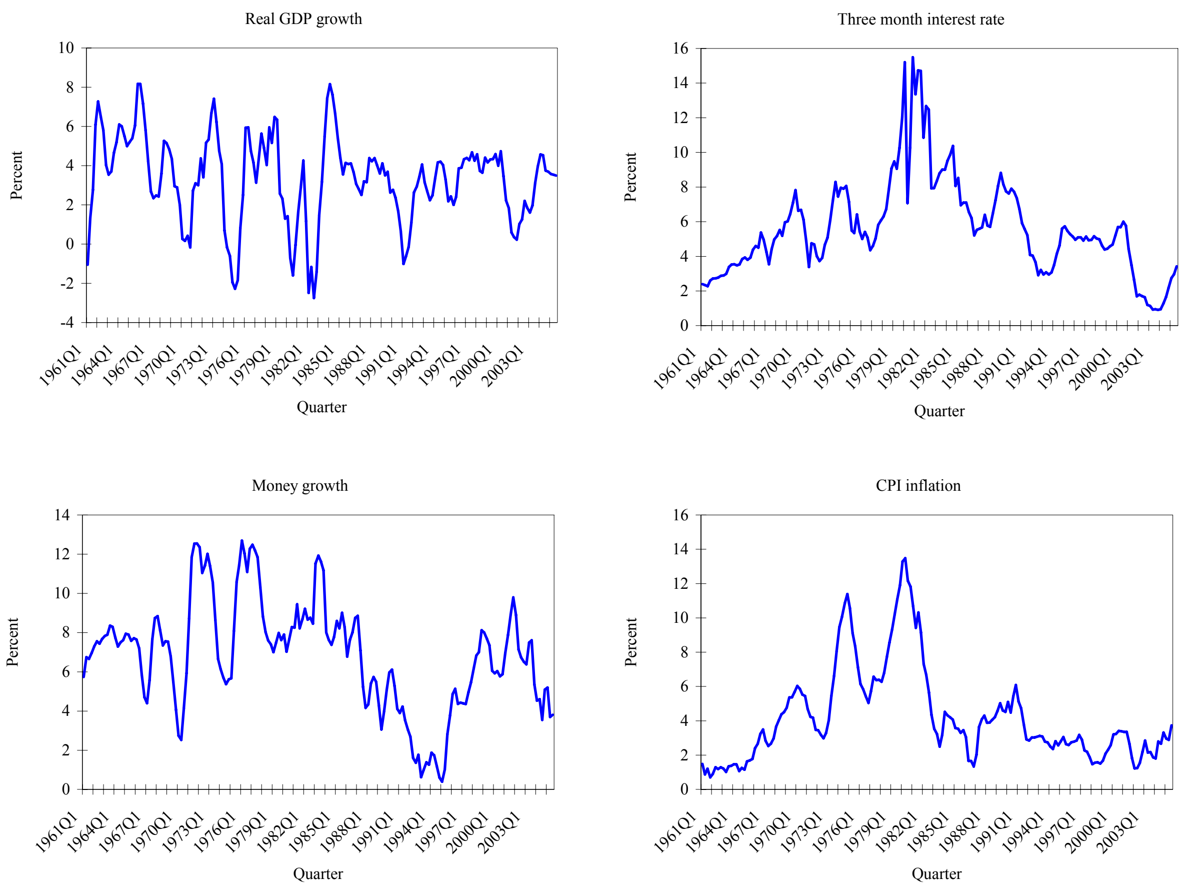
where $\mathbf{G}(L) = \mathbf{I} - \mathbf{G}_1 L - \ldots - \mathbf{G}_p L^p$ is a lag polynomial of order p, $\mathbf{x}_t$ is an nx1 vector of stationary macroeconomic variables and $\boldsymbol{\eta}_t$ is an nx1 vector of *iid* error terms fulfilling $E(\boldsymbol{\eta}_t) = \mathbf{0}$ and $E(\boldsymbol{\eta}_t \boldsymbol{\eta}_t') = \boldsymbol{\Sigma}$. In the fourvariate BVAR model, we have $\mathbf{x}_t = (\Delta y_t \quad \Delta m_t \quad \Delta p_t \quad i_t)'$, with Δy_t, Δp_t, Δm_t, and i_t representing real GDP growth, money growth, inflation, and interest rates, respectively. In the trivariate, bivariate, and univariate models, we have $\mathbf{x}_t = (\Delta y_t \quad \Delta p_t \quad i_t)'$, $\mathbf{x}_t = (\Delta y_t \quad \Delta m_t)'$, and $\mathbf{x}_t = (\Delta y_t)'$, respectively. In all models, the lag length is set to $p = 4$. We use a Minnesota-style prior on the dynamics: For variables in levels (first differences), the prior mean on the coefficient on the first own lag is one (zero); all other coefficients in $\mathbf{G}_i$ have a prior mean of zero. The prior for the covariance matrix is a mainstream diffuse prior.

[2] Both Friedman and Kuttner (1993) and Psaradakis *et al*. (2005) focus on within-sample evidence. The latter use Markov-switching to distinguish between periods with/without Granger-causality of money in a bivariate setting, restricting the underlying models to be the same across time.

[3] It should be noted that no valid test exists to test the null hypothesis of equal forecasting performance in our setting, that is, with recursively generated forecasts from nested models and a forecast horizon that is larger than one (Clark and McCracken, 2005).

Our quarterly data ranges from 1960Q1 to 2005Q3 and were provided by the Board of Governors of the Federal Reserve System (Figure 1). With the exception of the interest rate, all series are seasonally adjusted. Inflation is based on the consumer price index and the monetary aggregate is M2. The interest rate is the three-month treasury bill rate. All growth rates are calculated using logarithmic first-differences of the original series in levels, and all variables are measured in percent. For ease of interpretation, we will present *RMSEs* for four-quarter ended growth rates.

Figure 1. Data.



Note: Figure shows four-quarter ended growth rates for all variables but the interest rate.

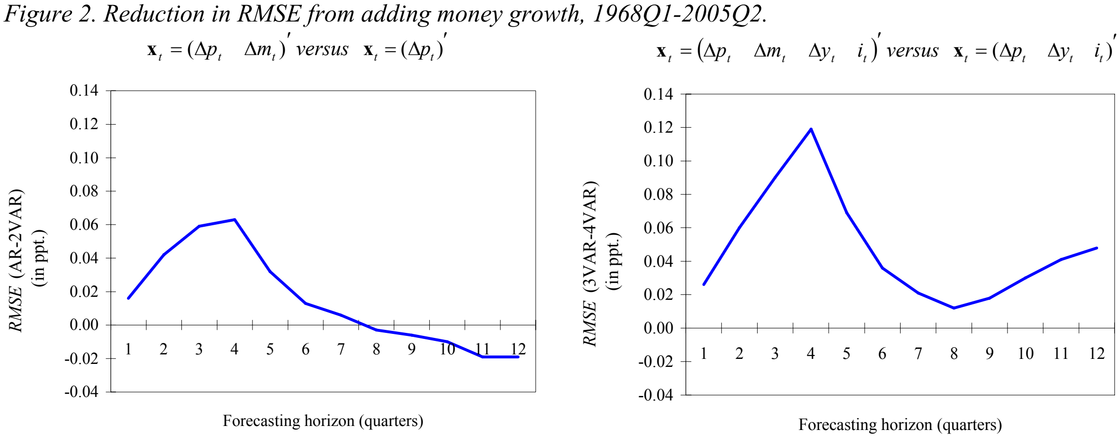
3. Money and Output Growth 1960-2005

We start by comparing the out-of-sample forecasting accuracy of model (1) for the full sample period. That is, we ask whether the bivariate model (*2VAR*) outperforms the univariate model (*AR*) and whether the fourvariate model (*4VAR*) outperforms the trivariate model (*3VAR*). The models are first estimated for a training period of eight years (1960Q1-1967Q4). Then dynamic forecasts for up to 12 quarters ahead are generated. Then the sample is extended one period, models are re-estimated, and new forecasts are produced until we reach the end of our sample 2005Q2. This produces between 151 and 140 GDP growth forecasts depending on the forecast horizon.

The forecasting method is standard: for each draw from posterior coefficient distribution of a given model, we draw a sequence of shocks to generate future data.[4] The evaluation is based on the median forecast from the predictive density.

Figure 2 shows the difference in *RMSE*s for the GDP growth (four-quarter ended) forecast between the *AR* and the *2VAR* (left panel) and the *3VAR* and *4VAR*. A positive value signals a positive contribution of money growth to the GDP growth forecast—that is, that money Granger-causes output.

Figure 2. Reduction in RMSE from adding money growth, 1968Q1-2005Q2.



Notes: RMSEs for four-quarter ended growth rates.

The results seem to suggest that money is indeed Granger-causal for output during the 1968-2005 period, in particular at horizons up to two years. That the improvement in forecasting accuracy is particularly strong compared to the trivariate model, where the *RMSEs* drop at all horizons and by as much as 0.12 percentage points when incorporating money growth, seems to stress the robustness of the finding.

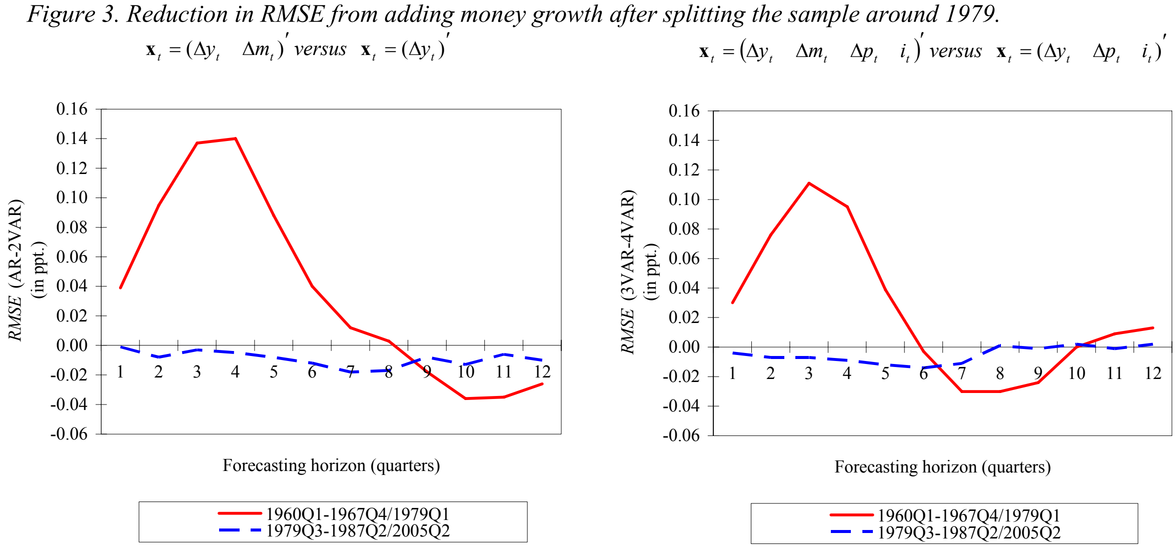
[4] We thus get as many paths for each variable as we have iterations in the Gibbs sampling algorithm (10,000). Note that we restrict the sampling to draws which ensure the stationarity of the estimated models. This restriction has no qualitative effect on our results..

4. The Vanishing Role of Money

There is, however, reason to suspect that the relationship between money and output changed over time. Paul Volcker's eight-year chairmanship of the Federal Reserve System's Board of Governors starting in August 1979 is an often cited watershed separating the high-inflation period of the 1970s from the calmer times that followed (that is, the 'Great moderation')—an event that presumably also changed the dynamic relation of money and output.

Figure 3 shows that the contribution of money to forecasting output differs starkly before and after 1979. Keeping the length of the training periods constant, the solid and dotted lines depict the change in forecasting performance from adding money growth during the two forecasting periods 1968Q1-1979Q1 and 1987Q3-2005Q2.[5] While the findings for the first period identify money growth as Granger-causal for real GDP growth for horizons of up to 8 quarters, the second period clearly does not.[6]

Figure 3. Reduction in RMSE from adding money growth after splitting the sample around 1979.



Notes: RMSEs for four-quarter ended growth rates.

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[5] The starting point for the second period was set at Volcker's introduction as chairman. Both subsamples use an eight-year training sample. The forecast evaluations are based on 46-35 and 73-62 observations, respectively, depending on the forecast horizon.

[6] Further results show that the change in the money-output link identified here was indeed not a gradual one. Computing *RMSE* differences for alternative out-of-sample forecasting periods of similar length we find that money ceases to Granger-cause output rather suddenly around 1979 or 1980 as suggested by Figure 3. Specifically, we compared results for forecasting windows for 1967Q3-1985Q2, 1972Q3-1990Q2, 1977Q3-1990Q2, 1982Q3-2000Q2, and 1987Q3-2005Q2 for both models, with a unified six-year training period. Additional results available on request.

5. Conclusion

The question whether money plays a causal role for output has created a large literature over the years, and the discussion has been particularly heated for the U.S.. To some extent, these differences seem to be driven by varying empirical approaches. Choosing a setup commonly considered as biased against finding a money-output link, we still find surprisingly strong evidence that money Granger-causes output out-of-sample over the 1960-2005 period. Further investigation puts these results into doubt though, as we show that the Granger-causal role of money has vanished completely after the 'Great moderation'. Our findings hence support earlier results stressing the importance of sample length for the money-output link and also indicate potential importance of the policy regime.

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