The Portfolio Balance Channel of Monetary Policy: Evidence from the U.S. Financial Accounts

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Abstract: How does monetary policy affect the balance sheet of households? This is an important question in light of the recent large scale asset purchases that have been justified on the grounds of the portfolio balance channel. Many studies have attempted to quantify the effect of these LSAPs and find evidence for the portfolio channel. Most of these studies, however, focus only on one manifestation of the portfolio channel, the change in relative yields and typically do so in the narrow context of the zero lower bound. Little is empirically known about this channel in more conventional settings. This paper attempts to fill this gap in the literature by examining the overall validity of the channel away from the zero lower bound. We do this by examining how household portfolios responded to monetary policy shocks to the monetary base and to inflation forecasts for the period 1959:Q1 – 2007:Q4. We find strong evidence that the portfolio channel is an important part of the monetary transmission mechanism.

Keywords: portfolio balance channel, vector autoregressions, monetary policy shock, Financial Accounts

JEL Codes: E52, E51, G11

I. Introduction

How does monetary policy affect the balance sheets of households? The answer to the question is important, especially given the recent use of quantitative easing on the part of the Federal Reserve. The predominant mainstream theory of monetary transmission, as epitomized by the New Keynesian framework, emphasizes the role of the expected future path of the short-term interest rate.[1] The effects of monetary policy are independent of household portfolios.[2] Within this framework, a policy of quantitative easing can work only to the extent to which the policy affects the expected future path of the interest rate and/or inflation.

An alternative mechanism of monetary transmission is that of the portfolio balance channel.[3] Implicit in Friedman and Schwartz (1963b) and made explicit by Friedman (1974) and Friedman and Schwartz (1982) is the view that fluctuations in nominal income are the result of deviations between desired and actual money balances.[4] In the short run, such fluctuations result in changes in both output and prices. According

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[1] For an exposition of the New Keynesian framework, see Woodford (2003) and Galí (2008).

[2] New Keynesian models are often confined to two assets, money and bonds. Under a Ricardian regime, the supply of bonds is irrelevant to the monetary policy dynamics of the model. In addition, money is redundant in the sense that money demand simply varies endogenously with the behavior of the interest rate. There has been recent work in adding endogenous asset price dynamics to the New Keynesian model. See, for example, Carlstrom, Fuerst, and Paustian (2010) and Hendrickson (2011).

[3] A related idea is that of Tobin (1969), who emphasizes the imperfect substitutability of assets. There is a large, related literature that incorporates this concept in the context of consumer optimization, often with restrictions on the utility function. One recent example is Vayanos and Vila (2009) in which this type of imperfect substitution arises because investors have "preferred habits." Andrés, López-Salido, and Nelson (2004) examine the proposition of imperfect asset substitutability within the context of a dynamic stochastic general equilibrium model. There is overlap between the position described here and that following Tobin.

[4] See Nelson (2011) for a thorough discussion on Milton Friedman's view of the portfolio channel.

to this view, deviations between actual and desired money balances caused by changes in monetary policy are transmitted through the effects of household balance sheets. Specifically, Friedman and Schwartz (1963a: 230-1) argue that following an open market purchase by the central bank, the seller of securities to the central bank will have higher money balances than desired and seek to readjust their portfolio:

> It seems plausible that both nonbank and bank holders of redundant balances will turn first to securities comparable to those they have sold, say, fixed-interest coupon, low-risk obligations. But as they seek to purchase these they will tend to bid up the prices of those issues. Hence they, and also other holders not involved in the initial central bank open-market transactions, will look farther afield: the banks to their loans; the nonbank holder, to other categories of securities – higher-risk fixed coupon obligations, equities, real property, and so forth…
>
> As the prices of financial assets are bid up, they become expensive relative to nonfinancial assets, so there is an incentive for individuals and enterprises to seek to bring their actual portfolios into accord with desired portfolios by acquiring nonfinancial assets. This, in turn, tends to make existing nonfinancial assets expensive relative to newly constructed nonfinancial assets. At the same time, the general rise in the price level of nonfinancial assets tends to raise wealth relative to income, and to make the direct acquisition of current services cheaper relative to the purchase of sources of services. These effects raise demand curves for current productive services. The monetary stimulus is, in this way, spread from the financial markets to the markets for goods and services.

Economic agents thus re-allocate their portfolios causing changes in relative prices, output, and ultimately the price level, or inflation.[5]

Limited participation models, as developed by Lucas (1990) and Fuerst (1992), formalize this insight. These models capture the effects of monetary policy by utilizing the institutional fact that monetary policy works through financial intermediaries. Limited participation models formalize the notion that deviations between actual and desired money balances result in short run non-neutralities as it implies that some individuals (or sectors) will have limited information sets relative to others. In particular the ability of

[5] The emphasis on the relative price effects is also present in the work of Karl Brunner and Allan Meltzer. See, for example, the discussion in Brunner and Meltzer (1993).

some agents to adjust their portfolios is limited. As a result, there is a distributional effect of monetary policy.[6] For example, following a monetary injection, there will be some individuals (sectors) that hold a larger amount of real balances than would otherwise be the case. The real effects of monetary transmission are then the result of the subsequent reallocation of portfolios.

One major drawback of limited participation models is the inability to explain the persistence of the effects of monetary policy. Recent work by Williamson (2006), however, links the limited participation concept with the monetary search model of Lagos and Wright (2005). Williamson's model of limited participation and search demonstrates that monetary policy affects relative rates of return and that the effects of monetary policy are persistent.

The conclusions offered by these two classes of models reflect opposing views on the transmission of monetary policy. The differences are important for understanding monetary policy generally, but particularly policy conducted at the zero lower bound on nominal interest rates. For example, Krugman (1998) and Svensson (1999) each demonstrate that in a model with only two assets, money and bonds, the zero lower bound results in a steady state in which individuals are satiated with money balances. Any attempt to increase money growth or conduct open market operations will be ineffective because money and bonds become perfect substitutes and any increase in the money supply will simply be hoarded. With respect to conventional New Keynesian models more generally, the extent to which any monetary policy at the zero lower bound can be effective is dependent on its ability to influence the expected future path of the

[6] The formal modeling of the distributional effect of monetary policy is initially due to the work of Grossman and Weiss (1983) and Rotemberg (1984).

short-term interest rate and/or inflation. Policies of quantitative easing are unlikely to be effective.[7]

In contrast, monetary policy within limited participation models generates distributional effects, which are important in the context of the zero lower bound. For example, as Ireland (2005) notes, the addition of population growth to the models used by Krugman (1998) and Svensson (1999) creates a distributional effect to money growth resulting in a real balance effect thereby eliminating the liquidity trap. While the model in Ireland (2005) represents a distributional effect between households of different generations, the implications carry over to the limited participation models.

The different implications for monetary policy from these frameworks are particularly important in the context of the Federal Reserve's recent use of quantitative easing. In particular, Ben Bernanke (2010:9) cites the portfolio balance channel as supportive of the Federal Reserve's large scale asset purchases (LSAPs):

> I see the evidence as most favorable to the view that such purchases work primarily through the so-called portfolio balance channel, which hold that once short-term interest rates have reached zero, the Federal Reserve's purchases of longer-term securities affect financial conditions by changing the quantity and mix of assets held by the public.

Bernanke's argument is that the LSAPs of longer-term securities should reduce the duration risk of private sector portfolios—since long-term assets are being replaced with short-term ones—and thus cause risk premiums and yields on longer term securities to decline. This, in turn, should cause a rebalancing of portfolios as explained by Gagnon, et. al (2011: 43):

[7] See Curdía and Woodford (2011).

> These portfolio-balance effects should not only reduce longer term yields on the assets being purchased, but also spill over into the yields on other assets. The reason is that investors view different assets as substitutes and, in response to changes in the relative rates of return, will attempt to buy more of the assets with higher relative returns. In this case, lower prospective returns on agency debt, agency MBS, and Treasury securities should cause investors to seek to shift some of their portfolios into other assets, such as corporate bonds and equities, and thus should bid up their prices. It is through the broad array of all asset prices that the LSAPs would be expected to provide stimulus to economic activity. Many private borrowers would find their longer term borrowing costs lower than they would otherwise be, and the value of long-term assets held by households and firms—and thus aggregate wealth—would be higher.

The LSAPs, therefore, should ultimately raise aggregate nominal spending through positive wealth and balance sheet effects as well increased long-term borrowing. A large number of recent studies have attempted to quantify the effects of the LSAPs and in so doing find evidence in support of the portfolio balance channel. For example, D'Amico and King (2010), Gagnon, et. al (2011), Greenwood and Vayanos (2010), and Hamilton and Wu (2011) find evidence that the LSAPs significantly lowered long-term yields—as much as 50 basis points—and that the effects of policy were widespread among asset classes.[8] These and other studies tend to focus on the portfolio channel in the context of LSAPs in a zero lower bound environment and usually view this channel through its effects on yields.[9] They generally do not shed any light on how portfolios get reallocated across different asset classes, how long the rebalancing takes, or whether the rebalancing actually affects real economic activity.

[8] Swanson (2011) examines the original Operation Twist using higher-frequency data that previous studies estimates that the policy has a significant effect on long-term Treasury yields. Point estimates show that the magnitude of the effect of Operation Twist was 15 basis points, or roughly the same size change as a 100 basis point surprise in the federal funds rate.

[9] Williams (2011) provides a nice summary of the LSAP literature.

This paper attempts to fill this gap by providing an empirical investigation into the overall validity of the portfolio balance channel from the perspective of the household balance sheet. We do this by using structural vector autoregressions (VAR) to estimate the effects of monetary policy shocks upon household portfolios. Specifically, we use the Federal Reserve's *Financial Accounts of the United States* data to construct asset shares of household portfolios over time so that we can examine how monetary policy shocks affect these shares as well as how long the rebalancing takes. We divide total household assets into twelve categories and are able to see how monetary policy shocks affect each category. These asset classes and their shares are shown in Figure 1.

[Show Figure 1 around here]

We estimate the structural VARs for the period 1959-2007 and thus are able to assess whether monetary policy in general—and not just in special cases of LSAPs at the zero lower bound—causes households to rebalance their portfolios in a manner that influences aggregate nominal spending and real economic activity.

As outlined above, the portfolio balance channel is premised on households having higher (lower) money balances than desired following an open market purchase (sale) by the central bank and then acting to rebalance their portfolios accordingly. Thus, in order to empirically assess this view one must observe how monetary policy shocks to the monetary base affect household portfolios while still accounting for the fact that Federal Reserve has been targeting the federal funds rate. In other words, this analysis requires that we isolate changes in the monetary base that were not demand-driven. We do that by first estimating a structural VAR that controls for broad and narrow money demand shocks so that we can properly identify monetary policy shocks to the monetary base. We then use these shocks to assess monetary policy's affect on household portfolios.

The New Keynesian framework suggests that monetary policy can be effective by altering intertemporal consumption decisions through its effect on inflation expectations. However, it is also possible that monetary policy can affect household portfolios through its influence on nominal expectations. That is, monetary policy shocks can change the future path of nominal variables and forward-looking households may respond to these changes by adjusting their portfolios. For example, if a series of positive monetary policy shocks raise expected inflation then households may try to diversify away from low-yielding, liquid assets into higher-yielding assets that serve as a hedge against inflation. From a rational expectations framework, whether one observes the effect of a monetary policy shock directly on household portfolios (e.g. they now have too high money balances and will rebalance their portfolios toward other assets) or indirectly by observing how household portfolios respond to change in the expected path of nominal variables as a result of that shock (e.g. they now expect higher inflation and will diversify away from the money assets), the result is the same. Thus, to the extent rational expectations serve as useful approximation of household behavior, we would expect a VAR that estimates a monetary policy shock to the monetary base and a VAR that estimates the effect of a monetary policy-created expected inflation shock should create the same dynamic effect on household portfolios. Though it is impossible to know what portion of changes in expected inflation can be attributed to monetary policy shocks, it is possible to estimate a structural VAR that shows the effect of inflation forecast shocks on household portfolios. We estimate this model to assess how monetary policy can affect household portfolios by altering nominal expectations and then compare it to the results of the previous structural VAR.

Finally, in order to assess whether the rebalancing of household portfolios actually influences aggregate nominal spending and real economic activity, we estimate a structural VAR that shows the effects of a shock to the household portfolio. In particular, we estimate a structural shock to the share of the household portfolio that is allocated to money assets. We interpret this shock as a shock to money demand and consider its economic implications. In addition, to the extent that shocks to money demand are symmetric to shocks to monetary policy, this approach can potentially ascertain a causal link between changes in household portfolios and economic activity.

Presaging our conclusions, we find that monetary policy shocks either to the monetary base or to the inflation forecast do cause a rebalancing of household portfolios that is consistent with the transmission mechanism outlined by the portfolio balance channel. We also find that shocks to the money asset share of household portfolios do create a significant response in aggregate nominal spending and real economic activity. We conclude the portfolio channel is a viable channel for monetary policy that is not limited to LSAPs or the zero lower bound.

II. Monetary Policy Shocks to the Monetary Base

II.A Empirical Model

The first objective in this paper is to estimate a structural VAR that allows us to examine the effect a monetary policy shock to the monetary base has on household portfolios. One issue, though, with using innovations to the monetary base as a measure of monetary policy shocks is that for most of the period in question the Federal Reserve used the federal funds rate as its operating instrument. Thus, for a given target federal funds rate, movement in the monetary base could be reflecting the Federal Reserve's response to changes in the demand for bank reserves rather than a monetary policy shock. What is needed, then, is to capture only those changes in the monetary base that are truly exogenous. In terms of an interest rate target this means identifying those movements in the monetary base that supported unexpected changes to the target federal funds rate. One way to isolate such policy shocks to the monetary base is to first identify and control for those shocks that cause changes in the demand for bank reserves. Such demand shocks include shocks to the demand for currency (which indirectly affect the demand for bank reserves) and shocks to the demand for bank reserves. Also, real money demand (i.e. velocity) shocks could affect the monetary base if such changes in broad money demand are accommodated by the Federal Reserve. After controlling for these demand shocks, the remaining unexplained variation in the monetary base should be the monetary policy shock.

We follow this approach in our study by identifying a money multiplier shock that captures unexpected changes to the demand for currency and the demand for reserves, a real money demand shock, and a monetary policy-induced shock to the monetary base. These three monetary shocks are identified by imposing long-run restrictions such that none of these monetary shocks can have a permanent effect on any real economic variable.[10] In short, we impose long-run monetary neutrality restrictions on the monetary shocks, an approach consistent with standard macroeconomic theory. Later in the paper we show that the impulse response functions created by these shocks are consistent with

[10] As we note later, there is one exception to this: the real money demand shock can permanently affect real money balances.

what standard macroeconomic theory predicts they should be. These results indicate that this approach properly identifies the three monetary shocks. It is also worth noting that identifying monetary policy shocks this way is robust to the monetary authorities' choice of operating instrument. As mentioned above, this approach can identify monetary policy shocks when the operating instrument is an interest rate by controlling for demand shocks. On the other hand, if the monetary authorities target the monetary base itself then this approach would obviously work too given it isolates monetary policy shocks to the monetary base. Either way, this identification approach works because it looks to the unexplained, non-demand driven variation in the instrument over which the Federal Reserve has direct control—the monetary base.

Another issue in estimating this model is a degree of freedom problem. In addition to the seven macroeconomic variables (discussed below) that will enter the VAR, there are twelve asset categories in the household portfolio. In order to address this issue, the estimation strategy adopted here is to first, estimate the macroeconomic portion of the model and identify the monetary policy shock to the monetary base and second, apply the monetary policy shock individually to each of the twelve asset categories. This way, the same monetary policy shock is being applied to each of the asset categories. We do this by estimating the VAR using the following vector of endogenous variables for each asset category:

$$x_t = \left(ps_t, y_t, i_t, s_t\ M_t^A / P_t, m_t, M_t^B, c_t\right)'$$

where ps_t is the portfolio share of a specific asset category for the household, y_t is real output, i_t is a short-term nominal interest rate, s_t is a corporate bond spread, M_t^A / P_t is real money balances, m_t is the money multiplier, M_t^B is the monetary base, and c_t is a commodity price index. Here $m_t = M_t^A / M_t^B$, where M_t^A is a broad monetary aggregate, while P_t in M_t^A / P_t is the price level. Since $M_t^B \times m_t = M_t^A$ and $(M_t^B \times m_t) / (M_t^A / P_t) = P_t$, the price level also is also implicitly in the VAR. We use this fact later to extract price level and nominal GDP responses to the structural shocks without having to explicitly estimate them. Corporate yield spreads are included in the VAR to control for financial risk while commodity prices are included since they may serve as a harbinger of future inflation.

In order to implement our degrees-of-freedom strategy, we impose on this VAR the restriction that the asset share can have no affect—either contemporaneously or with lags—on the other variables in system. The other variables, however, are allowed to influence the asset share. Given this block exogeneity restriction, we can separately estimate the VAR for every asset category and each time get the same monetary policy shock and thus its affect across the whole household portfolio.

As mentioned above, we also impose long-run identifying restrictions to identify the three monetary shocks. This identifying was first introduced by Blanchard and Quah (1989) and has been subsequently has been subsequently used in numerous other studies that examine the effect of money supply shocks on economic activity such as Gali (1992), Lastrapes (1998, 2006), Fackler and McMillin (1998), and Rapach (2001). In addition to its theoretical motivations of long-run monetary neutrality, this approach has the virtue of leaving the short-run dynamics of the VAR unconstrained. Formally, this approach starts with an autoregressive structural model of the form

(1) $$A_0 x_t = A_1 x_{t-1} + ... + A_p x_{t-p} + u_t ,$$

where x_t is the vector of endogenous variables, $A_0,..., A_p$ are n x n structural parameters matrices and u_t is a n x 1 vector of uncorrelated structural shocks that are assumed to be multivariate normal with mean zero and unit variance. As mentioned above, in order to identify policy-driven innovations to the monetary base one must control for changes in the monetary base originating from shocks to the money multiplier and real money demand. We do that by identifying all three monetary shocks using long-run restrictions. Consequently, structural shocks to the money multiplier, real money demand, and the monetary base can have no permanent effect on variables preceding them in the vector of endogenous variables. While it is apparent that the long-run monetary neutrality restrictions make sense for the real variables of y_t and sp_t, they are also reasonable to apply to the nominal interest rates, since these series mimic the behavior of the real interest rate in the long run. This is because a one-time monetary shock only affects the price level permanently but not inflation. We also apply the long-run monetary neutrality restrictions to the asset shares.

Given this framework, the structural autoregressive model in equation (1) must be transformed into a structural moving average form so that the relationship between the endogenous variables and the structural shocks can be defined. The structural moving average model can be shown to be

(2) $$y_t = (D_0 + D_1 L + D_2 L^2 + ...)u_t = D(L)u_t,$$

where $D_0 = A_0^{-1}, D_i = (A_0^{-1}A_i)^i A_0^{-1}$ and L denotes the lag operator. The coefficient matrices in $D(L)$ represent the dynamic multipliers of the structural shocks. As it stands, (2) is still a structural model and cannot be estimated directly. Rather, a reduced form version must be estimated and then identifying restrictions imposed to recover the structural model. The reduced form moving average can be expressed as follows:

(3) $$y_t = (I + C_1 L + C_2 L^2 + ...)\varepsilon_t = C(L)\varepsilon_t .$$

There is a mapping between the reduced-form parameters in (3) and the structural parameters in (2) since $\varepsilon_t = D_0 u_t$, $C(L) = D(L)D_0^{-1}$ and $E\varepsilon_t \varepsilon_t^{'} = \Sigma = D_0 D_0^{'}$. However, this mapping is not unique. Consequently, even though the reduced form parameters $C(L)$ and Σ are directly estimable, identifying restrictions need to be imposed to recover the structural shocks. As noted above, the identification scheme adopted here is to impose long-run monetary neutrality restrictions on shocks to the money multiplier, real money balances, and the monetary base. Given the ordering of variables in x_t, this requires taking the infinite horizon sum of $D(L)$, *D(1),* and imposing the following restrictions:

(4) $$D(1) = \begin{pmatrix} d_{11} & d_{12} & d_{13} & d_{14} & 0 & 0 & 0 & d_{18} \\ d_{21} & d_{22} & d_{23} & d_{24} & 0 & 0 & 0 & d_{28} \\ d_{31} & d_{32} & d_{33} & d_{34} & 0 & 0 & 0 & d_{38} \\ d_{41} & d_{42} & d_{43} & d_{44} & 0 & 0 & 0 & d_{48} \\ d_{51} & d_{52} & d_{53} & d_{54} & d_{55} & 0 & 0 & d_{58} \\ d_{61} & d_{62} & d_{63} & d_{64} & d_{65} & d_{66} & 0 & d_{68} \\ d_{71} & d_{72} & d_{73} & d_{74} & d_{75} & d_{76} & d_{77} & d_{78} \\ d_{81} & d_{82} & d_{83} & d_{84} & d_{85} & d_{86} & d_{87} & d_{88} \end{pmatrix}$$

Again, these restrictions mean that money supply shocks have a cumulative effect of zero on the real variables ordered above them in the VAR. Note that these restrictions are set up such that the monetary policy shocks to the monetary base have no permanent effect on the money multiplier. Finally, shocks to the monetary base and to the money multiplier can have no permanent effect on real money balances while real money demand shocks can, restrictions consistent with long-run monetary neutrality. Although this approach leaves the model under-identified, it does fully identify real money demand, money multiplier, and monetary policy shocks. It is implemented by taking a Choleski decomposition of the long run covariance matrix (Keating, 1996).[11]

Using these long run restrictions, the estimated VAR can be used to show the effect of exogenous shocks to real money demand, the money multiplier, and monetary policy on the endogenous variables through innovation accounting. Here, innovation accounting in the form of cumulative impulse response functions (IRFs) are used to show the typical cumulative dynamic response of an endogenous variable to the various monetary shocks. Then, the IRFs are used to show how the average treasury yield curve changed in response to the monetary policy shocks.

II.B Data

The following quarterly macroeconomic data are used in the VAR. Real GDP is used for real output, the 3-month treasury bill yield is used for the short-term interest rate, the corporate bond yield spread is constructed by subtracting Moody's seasoned AAA corporate bond yield from its seasoned BAA corporate bond yield, real money balances are constructed by dividing MZM by the GDP deflator, and the money multiplier is constructed by dividing MZM by the monetary base. We adopt MZM because it, unlike other monetary aggregates, has been shown to have a more stable money demand relationship (Teles and Zhou, 2005). All of these variables are in seasonally adjusted form and come from the St. Louis Federal Reserve's FRED data base. For commodity prices we use the CRB's spot commodity price index. The sample period runs from 1959:Q1 to 2007:Q4. The starting date of 1959:Q1 is used since that is when MZM is

[11] Keating (1996) shows that the ordering of the variables above the monetary ones is inconsequential to identifying the structural shocks.

first available. The ending date of 2007:Q4 is chosen since we want our sample to cover a period where the LSAPs and zero bound were not a factor.

Household asset data comes from table B.100 in the Financial Accounts of the United States data. This data also includes non-profit organization which cannot be completely separated out. There are a few asset categories that do break down the share going to households and nonprofit organization and these ones indicate that the latter only make up a small fraction of the whole.[12] Thus, we treat table B.100 as a good approximation for the household portfolio.

The twelve asset categories are as follows: (1) money assets which consist of cash, checking deposit, time and saving deposits, and money market fund shares; (2) treasury securities; (3) commercial paper; (4) agency securities; (5) municipal bonds; (6) corporate bonds; (7) mortgages and other loans; (8) corporate equity; (9) other financial assets which includes U.S. saving bonds, non-equity assets in life insurance and pension funds, and other miscellaneous assets; (10) noncorporate equity; (11) and real estate; (12) consumer durables. These categories sum up to total household assets and thus there is no overlap. Figure 1 shows each categories share of the total household portfolio.

Exogenous variables in each VAR equation includes a constant and seasonal dummies. Variables are transformed into log form and first differenced—except for the interest rates and asset shares which are first differenced while the corporate bond spread is left alone[13]—since standard unit root test indicate nonstationarity in the levels of the

[12] For example, table B.100 indicates that households consistently own about 90% of the real estate assets.

[13] Corporate bond spreads were found to be stationary and were the only variable not differenced.

variables and no convincing evidence of cointegration was found.[14] The VAR is estimated using 4 lags since the Ljung-Box Q test indicates that this many lags are sufficient to whiten the residuals of any serial correlation. AIC and SBC also indicate this number of lags is adequate.

II.C Empirical Results

Figure 2 reports the cumulative IRFs for all the variables—including the price level and nominal GDP[15]—to a one standard deviation shock to real money demand, the money multiplier, and monetary policy for the period of 1959:Q1 – 2007:Q4. The solid line shows the cumulative IRF point estimate while the dotted lines show standard error bands.[16] The IRF for the interest rates and corporate yield spread can be interpreted as showing the dynamic change to these variables in terms of basis points. For the other variables, the IRFs can be seen as the percent change to their level.

[Insert Figure 2 here]

Figure 2 shows that across all monetary shocks the economic variables respond in a manner consistent with macroeconomic theory. First note that the positive real money demand shock leads to a temporary decline in real GDP and a temporary increase in

[14] The two-step Engle-Granger cointegration test gives no indication of cointegration (regardless of which variable appears on the left-hand side of the first step of the test) and the Johansen test gives some evidence. Given this lack of convincing evidence and the fact that Lastrapes and McMillan (2004) found that the impulse response functions from monetary shocks with long-run restrictions are very similar in both first-differenced VARs and VECMs, we opt for the first-differenced VAR.

[15] The point estimates and standard error bands for the price level and nominal GDP are created by combining other variables using Monte Carlo techniques describe in footnote 15.

[16] The standard error bands are technically fractiles that come from using Monte Carlo techniques to estimate the posterior density of the response coefficients. Sims and Zha (1999) recommend with this approach, which characterizes the likelihood shape, the use of a 68% posterior probability.

default risk as indicated by the rise in corporate bond yield spreads. These two responses are consistent with each other and are matched by a significant fall in the price level and in aggregate nominal spending as measured by nominal GDP. The real money demand shock also leads to a brief spike in the treasury bill rate. What appears to be happening is that a typical positive real money demand shock leads to a temporary decline in spending that slows down the economy. That, in turn, raises the default risk and creates deflationary pressure. The increase in the money multiplier and the monetary base in response to this shock suggest the banking system and the Federal Reserve accommodate the real money demand shock. However, given the decline in economic activity and the price level, the accommodation by the Federal Reserve is not adequate to offset the typical real money demand shock. The VAR bears out the standard story told in macroeconomics that a sudden increase in real money demand that is not fully accommodated by the Federal Reserve will result in a slowdown in economic activity, higher interest rates, and a lower price level. It also suggests we have indeed measured a real money demand shock with our identification restrictions.

The second thing to note from Figure 2 is that the positive money multiplier shock—which we interpret as an unexpected decline the demand for the monetary base—also leads to responses that are largely consistent with standard macroeconomic theory, though in most cases not significant. First, the positive money-multiplier shock leads to a temporary, though not significant, increase in real GDP and a decline in the default risk. Second, commodity prices are significantly higher. Third, given this money multiplier-driven increase and the upward pressure it would be placing on the money supply, it appears the Federal Reserve attempts to offset the change by reducing the monetary base.

Though most of these responses are not significant, overall the direction seems consistent with a negative shock to the demand for the monetary base. We conclude, then, that the money multiplier shock is capturing demand shocks for the monetary base in our model.

The third thing to note from Figure 2 is that the positive monetary policy shock to the monetary base creates significant responses in the other variables that, again, are consistent with standard macroeconomic theory. First, the monetary policy shock leads to a hump-shaped increase in industrial production and a similar-shaped decrease in the default risk as seen in the corporate yield spreads. Second, there are significant liquidity effects in the short-term interest rate. Third, the positive monetary policy shock to the monetary base results not only in a permanent increase in the monetary base but also in the price level and aggregate nominal spending. Commodity prices increases as well but are never significant. The monetary base shock identified here, therefore, creates responses that are consistent with what macroeconomic theory predicts will happen in response to an exogenous change in monetary policy. Given that we have identified and thus controlled for broad money demand shocks and narrow money demand shocks, it is reasonable to infer that the shocks to the monetary base identified here are indeed monetary policy shocks. The main point of Figure 2, then, is that our estimated VAR along with the identifying restrictions have allowed us to reasonably identify monetary policy shocks.

[Insert Figure 3 around here]

Now that we have established our model properly identifies monetary policy shocks, we turn to Figure 3 which shows the cumulative IRFs of the asset shares to the monetary policy shock to the monetary base. Here, the IRFs show the percentage point changes in the shares of each asset category. The first thing to note from this figure is that monetary asset shares increase upon impact and treasury shares decline. This result is consistent with an open market purchase where the Fed buys treasuries and increases the monetary base. Interestingly, the rebalancing of the household portfolio away from money assets is gradual, taking several years. Treasury shares, however, take even longer and are still significantly different than zero five years out. This may reflect that that open market operations can permanently change the stock of publicly-available treasuries. The commercial paper share initially declines and that may be due to its lower yield that the monetary policy shock creates on short-term interest rates. The agency share, on the other hand quickly increases, though it is not clear why.[17] The municipal bond share does not significantly change upon impact, but corporate bond shares do. They jump up and only slowly decline. They are significantly different from zero almost four years after the shock. The corporate equity share experiences the biggest spike of all asset classes. It increases almost 30 basis points compared to the 1 to 4 basis point seen in the other asset shares so far. Unlike corporate bonds, though, corporate equity gains fall to zero quickly, within a year. The responses so far, then, are telling a story very similar to that told by portfolio balance channel. Households suddenly have more money assets and, given the lower short-term yields, attempt to rebalance their portfolios toward higher-yielding, moderately liquid assets like corporate bonds and stocks. The last row of Figure 3 completes the story. It shows that after household portfolios shift into higher yielding corporate securities, they then move into the illiquid but high yielding assets of

[17] Possibly, households are purchasing agencies to replace their treasuries.

noncorporate equity, real estate, and consumer durables. These latter asset categories see their initial share decline reversed within about a year.

The results from Figures 2 and 3 show, then, that a positive monetary policy shock to the monetary base leads to a rebalancing of the household portfolio, an increase in aggregate nominal spending, and an rise in real output. These results lend support to the portfolio balance channel of monetary policy.

III. Monetary Policy Shocks to the Inflation Forecast

III.A Empirical Model

In this section we examine what happens to household portfolios when there is a shock to the inflation forecast. The objective here is to see how monetary policy shocks to expected inflation would cause households to rebalance their portfolios. Though we do not identify monetary policy shocks to the inflation forecast directly, we are able to identify expected inflation shocks in general and use them to gauge how monetary policy shocks would influence household portfolios by changing nominal expectations.

The structural VAR estimated here is simply a modified version of the one in section two. Specifically, we replace real money balances, the money multiplier, and the monetary base with an inflation forecast and the MZM money supply and explicitly add aggregate nominal spending. The vector of endogenous variables now is as follows:

$$x_t = \left(ps_t, y_t, s_t, \pi_t^e, i_t M_t^A, as_t, c_t\right)'$$

where the π_t^e is the forecasted inflation rate for the next year, M_t^A is the MZM money supply, as_t is aggregate nominal spending, and all the other variables are the same as before. As before, we identify only the expected inflation shock and do so by imposing long-run monetary neutrality restrictions. That is, we assume the expected inflation shock can have no permanent influence on the real variables ordered above it in the vector, but allow it to permanently affect the nominal variables ordered below it. Like before, these long-run restrictions leave the model under-identified, but this is not a problem since we only are interested in identifying the inflation forecast shock.

III.B Data

The same macroeconomic and asset share data is used as in section two. The forecasted inflation data comes from two surveys of economic forecasters provided by the Philadelphia Federal Reserve Bank. The first one is the Quarterly Survey of Professional (QSP) Forecasters. It is a quarterly survey that began in 1968 and, among other things, asks professional forecasters to provide inflation forecast at varying horizons. The only inflation forecast that goes back to 1968 is the GDP deflator forecast. Forecasters provided GDP deflator forecasts for the next six quarters. While they do not provide explicit annual inflation forecasts, one can be created by taking the average of the next four quarters annualized growth rates for the GDP deflator.

The QSP data, however, only provides data back to 1968:Q4. In order to compare the effects of an inflation forecast shock with that of a monetary base shock, data is needed over the same sample period. To fill in the gap for the 1959:Q1 to 1968:Q3 period, we calculated expected inflation over the next year using the annual CPI forecast data from the Livingston Survey. Though this survey does have an implicit GDP deflator forecast—it provides forecasts for real and nominal GDP—it does not start until 1959. The survey is also bi-annual which means two quarters every year have to be interpolated to get quarterly data. We therefore linearly interpolated the expected annual inflation growth rates to get the missing data in the Livingston Survey. As a robustness check, we regressed the entire Livingston expected CPI inflation data—including the interpolated values—against the corresponding expected GDP deflator inflation data from the QSP for their sample periods that overlap (1968Q4-2011:Q1). The R^2 was 95.53 percent, indicating our constructed forecasted inflation is reasonable. We also ran the VAR with the full sample and with just the QSP data beginning in 1968:Q4. The results were similar, though with the longer sample they were more efficiently estimated.

Once again, exogenous variables in the VAR include a constant and seasonal dummies. Variables are also transformed as before since standard unit root test indicate nonstationarity in the levels of the variables and again no convincing evidence of cointegration was found. The VAR is estimated using 4 lags since the Ljung-Box Q test indicates that this many lags will whiten the residuals and because the AIC and SBC also indicate this number of lags is adequate.

III.C Empirical Results

Figure 4 reports the cumulative IRFs for all the variables—including the price level[18]—to a one standard deviation shock to the inflation forecast for the period of 1959:Q1 – 2007:Q4. The IRFs for the interest rates, corporate yield spread, and expected inflation series can be interpreted as showing the dynamic change to these variables in terms of basis points while for the other variables, the IRFs can be seen as the percent change to their level.

[Insert Figure 4 and Figure 5 around here]

This figure reveals that a positive shock to the forecasted inflation rate significantly raises real GDP and lowers the corporate bond spread upon impact. Aggregate nominal

[18] Once again, these are constructed from combinations of the other variables using Monte Carlo methods.

spending also increases sharply upon impact and continues to slowly grow over time. The positive shock to expected inflation permanently raises the expected inflation rate and this, unsurprisingly, is matched by a rise in the short-term interest rate. The price level is slow to respond, but once it does it continues to rise over time. Commodity prices are quick to respond to the shock, but within a year and half start declining. One way to interpret these responses is that the unexpected rise in expected inflation causes aggregate nominal spending to increase, which given sticky prices cause real GDP to increase as well. The default risk falls as a result and eventually prices do respond.

The one seemingly odd IRF is that of the MZM money supply. It actually declines following the shock to expected inflation. The response of assets shares, as seen in Figure 5, indicate that the MZM response may not be so odd after all. This figure reveals that the money asset share significantly declines upon impact. These two responses suggest that the expected higher inflation causes an immediate rebalancing of the household portfolio away from money assets. Though this response of the money asset share is different than what happened in the VAR that shocked the monetary base, the responses appear consistent in that they are both rebalancing away from money assets. In both cases, then, it seems households find themselves in a situation where they are holding more money balances than they desire and act accordingly.

This interpretation seems reasonable because the rest of the asset shares respond in very similar fashion here as they did in response to the monetary base shock. The treasury share once again has a prolonged decline and commercial paper initially declines too. The corporate bond share rises immediately and still remains significantly different than zero five years out. And here too, the corporate equity share experiences the greatest gain with an increase of 45 basis points. Finally, after moving into corporate bonds and equities, household appear to rebalance their portfolios toward the illiquid but higher yielding assets of noncorporate equity, real estate, and consumer durables. These asset share responses and their similarity to the previous ones suggest that a monetary policy shock to the inflation forecast can also cause a meaningful rebalancing of household portfolios. In addition to providing further evidence for the portfolio balance channel, these results also imply that monetary policy can influence household portfolio rebalancing and its affect on the economy by properly managing nominal expectations.

IV. Household Portfolio Shocks

The results so far provide strong evidence for the portfolio balance channel of monetary policy. All that has been shown, however, is that monetary policy shocks do cause of rebalancing of household portfolios along the lines of that portfolio balance channel and that it coincides with an increase in aggregate nominal spending and real economic activity. To get a better sense of whether the portfolio rebalancing is merely coincidental or causal, we estimate a third structural VAR in this section that shows the effect of a shock to the household portfolio. In particular, we estimate the effect on broader economic activity of a shock to the share of the household portfolio that is allocated to money assets. We interpret this as a shock to money demand since an increase (decrease) in the money asset share would indicates a greater (lesser) desire to hold money asset and consider its economic implications. In addition, to the extent that a negative money demand shock can be seen as analogous to an expansionary monetary policy shock, this can potentially provide causal evidence in favor of the portfolio balances channel.

IV.A Empirical Model and Data

The structural VAR estimated in this section is premised on the notion that a shock to the money asset share is effectively a shock to money demand. If so, then one would expect to see variables like velocity and aggregate nominal spending respond positively to a negative shock to the money asset share (i.e. a decrease in money demand). Given sticky prices, such developments should in turn lead to changes in real economic activity. To test this theory, we estimate the following vector of endogenous variables:

$$x_t = \left(y_t, s_t, ps_t, v_t, i_t, as_t\right)'$$

Where ps_t is the money asset portfolio share, v_t is the velocity, as_t is aggregate nominal spending, and the other variables are as before. Since a shock to the money asset share is assumed to be a money demand shock, we again impose long-run monetary neutrality restrictions such that it cannot permanently influence the real variables ordered above it, but can permanently influence velocity and the nominal variables ordered below it. This leaves the model underidentified, but does adequately identify the money asset share shock.

The same macroeconomic data is used as before with the only new variables being velocity and nominal GDP. Velocity was created by dividing nominal GDP by the MZM money supply. The variables are transformed as before since standard unit root test indicate nonstationarity in the levels of the variables and again no convincing evidence of cointegration was found. Exogenous variables include a constant and seasonal dummies. The VAR is estimated using 4 lags since the Ljung-Box Q test indicates that this many lags will whiten the residuals and because the AIC and SBC also indicate this number of lags is adequate.

IV.B Empirical Results

Figure 6 reports the cumulative IRFs for all the variables—including the price level—to a negative one standard deviation shock to the money asset share. Once again, the IRF for the interest rates, corporate yield spread, and money asset share can be interpreted as showing the change to these variables in terms of basis points while for the other variables, the IRFs can be seen as the percent change to their level.

[Insert Figure 6 around here]

This figure reveals that a negative shock to the money asset share does significantly increase velocity and aggregate nominal spending upon impact. The price level, however, remains sticky and thus real GDP also responds positively to this reduction in the share of money assets held by households. Corporate default risk falls and there is even briefly a significant liquidity effect. These results indicate that the rebalancing of household portfolios by itself has an effect on macroeconomic variables. Based on this evidence, then, portfolio rebalancing is more than just a byproduct of households having too many money balances and wanting to rebalance their portfolios. It is important part of monetary transmission mechanism that in conjunction with other channels brings efficacy to monetary policy.

V. Conclusion

The portfolio balance channel of monetary transmission suggests that monetary policy works by altering the household balance sheet. Specifically, changes in monetary policy generate deviations between actual and desired money balances on household balance sheets thereby producing the incentive for reallocation. This process of reallocation causes changes in relative prices, real economic activity, and ultimately the price level.

Recently, this channel of monetary transmission has received renewed attention due to the unprecedented asset purchases carried out by the Federal Reserve.

The purpose of this paper is to empirically examine the role of the portfolio balance channel not only for large-scale asset purchases, but monetary policy more generally as seen through the household perspective. The empirical analysis presented above produces three main results. First, monetary policy shocks generate a significant change in the composition of the household balance sheet that is consistent with the portfolio balance channel. Second, shocks to inflation expectations produce effects analogous to the monetary policy shock. To the extent to which monetary policy can effect inflation expectations, the transmission is not merely through an intertemporal substitution in consumption, but rather operates through portfolio rebalancing. Finally, shocks to the money share of household assets generate results that are consistent with monetary policy shocks. To the extent to which a negative money demand shock is analogous to a positive money supply shock, this suggests that there is a causal link between portfolio reallocation and real economic activity. Taken as a whole, these results provide evidence in favor of the portfolio balance channel of monetary transmission. In addition, while this suggests that large scale asset purchases on the part of the Federal Reserve can have real effects, the results also demonstrate that the effectiveness of the portfolio balance channel is not limited to times in which the short term nominal interest rate is at the zero lower bound.

Figure 1
Asset Share in Household Portfolio
1951:Q4 – 2011:Q1

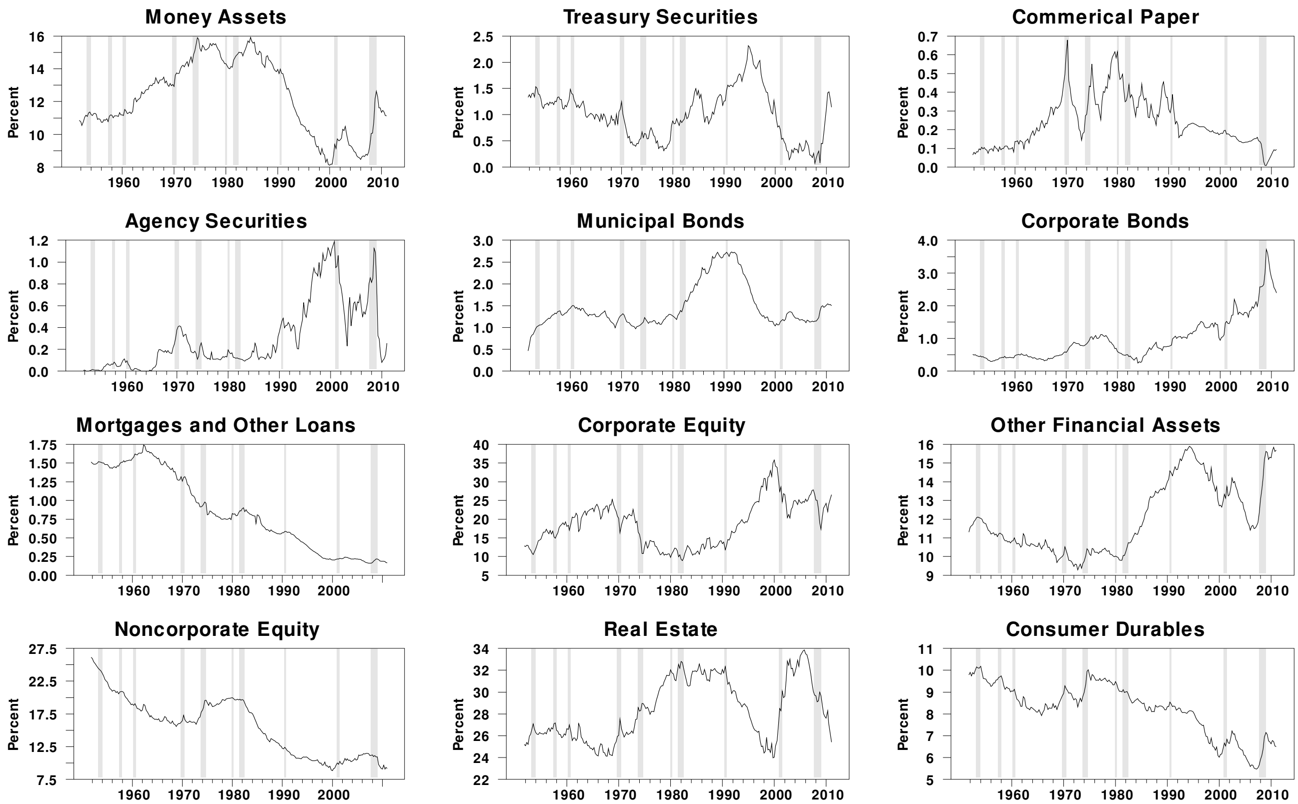


Figure 2
Cumulative Impulse Response to a Standard Deviation Shock
1959:Q1 – 2007:Q4

Real Money Demand Shock | **Money Multiplier Shock** | **Monetary Policy Shock**

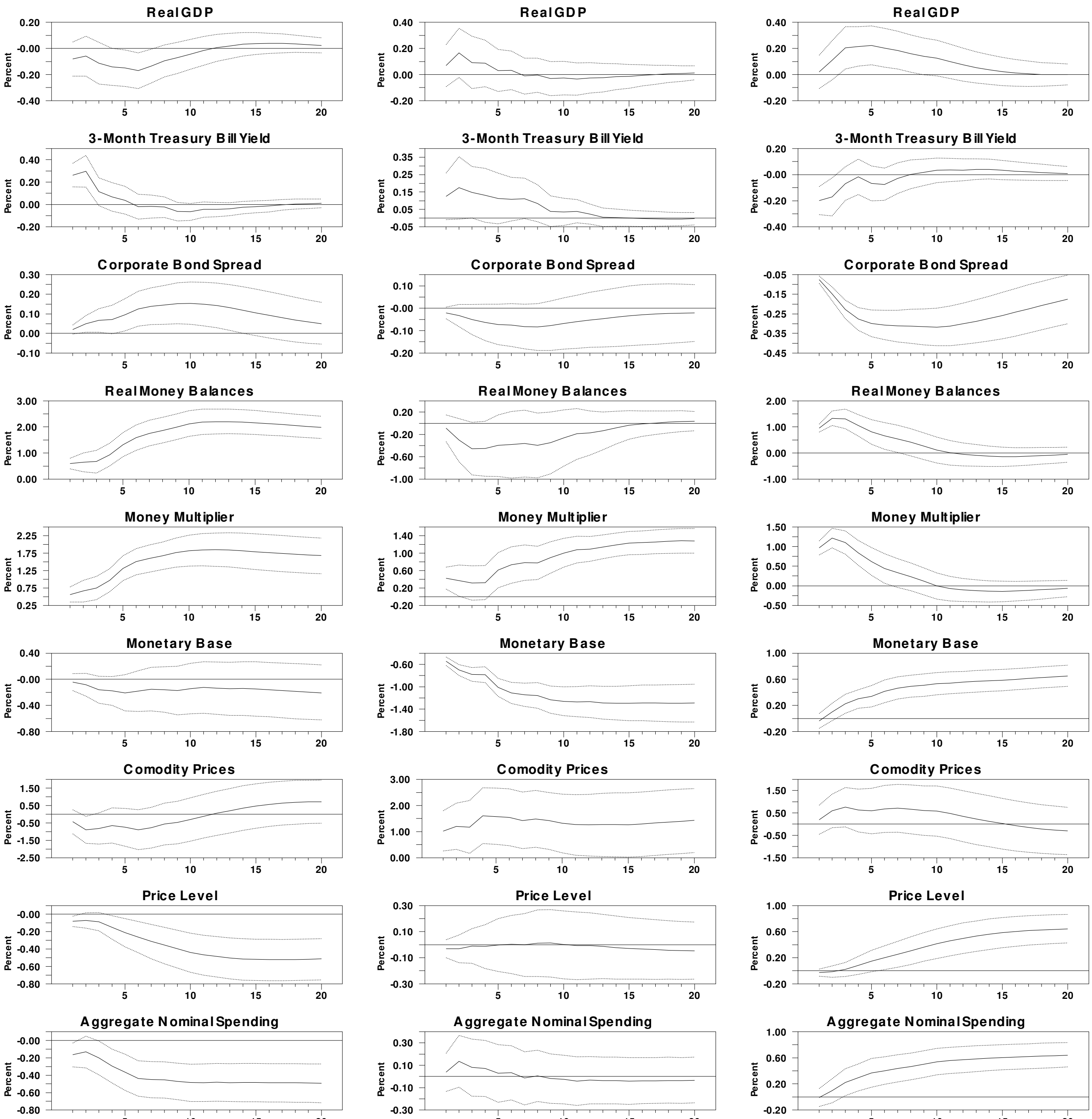


Figure 3
Asset Share Response to a Standard Deviation Monetary Policy Shock
1959:Q1 – 2007:Q4

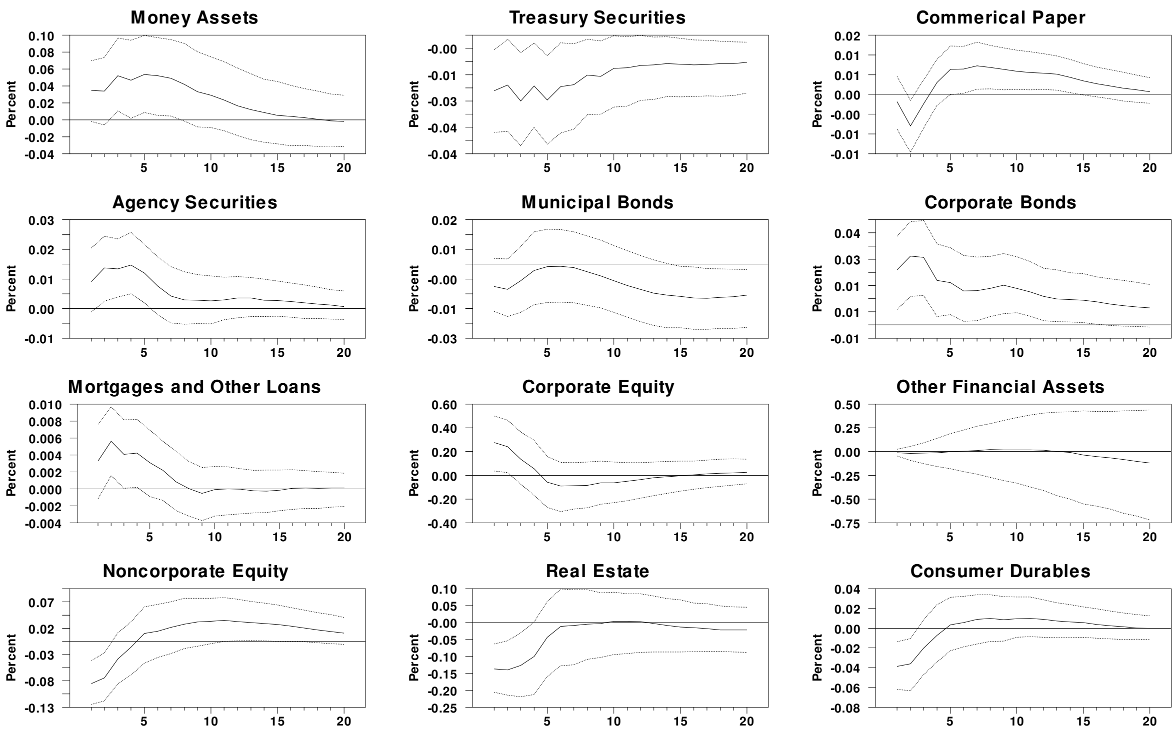


Figure 4
Cumulative Impulse Response to a Standard Deviation Expected Inflation Shock
1959:Q1 – 2007:Q4

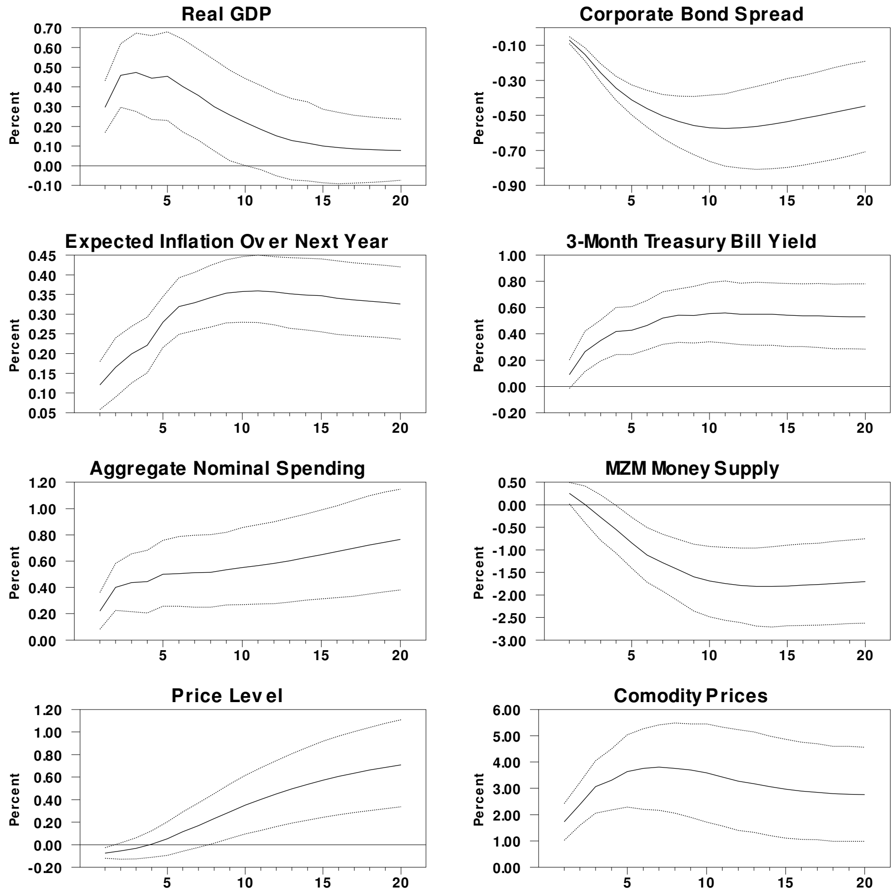


Figure 5
Asset Share Response to a Standard Deviation Expected Inflation Shock
1959:Q1 – 2007:Q4

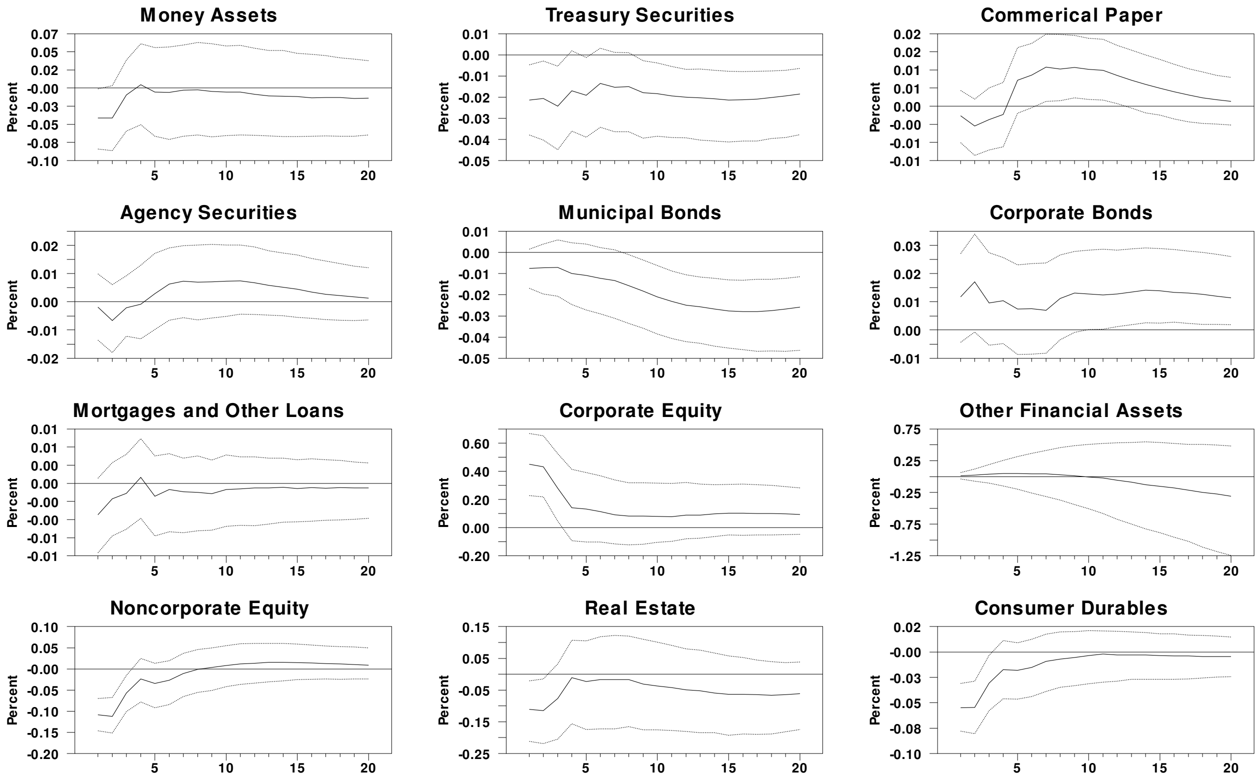
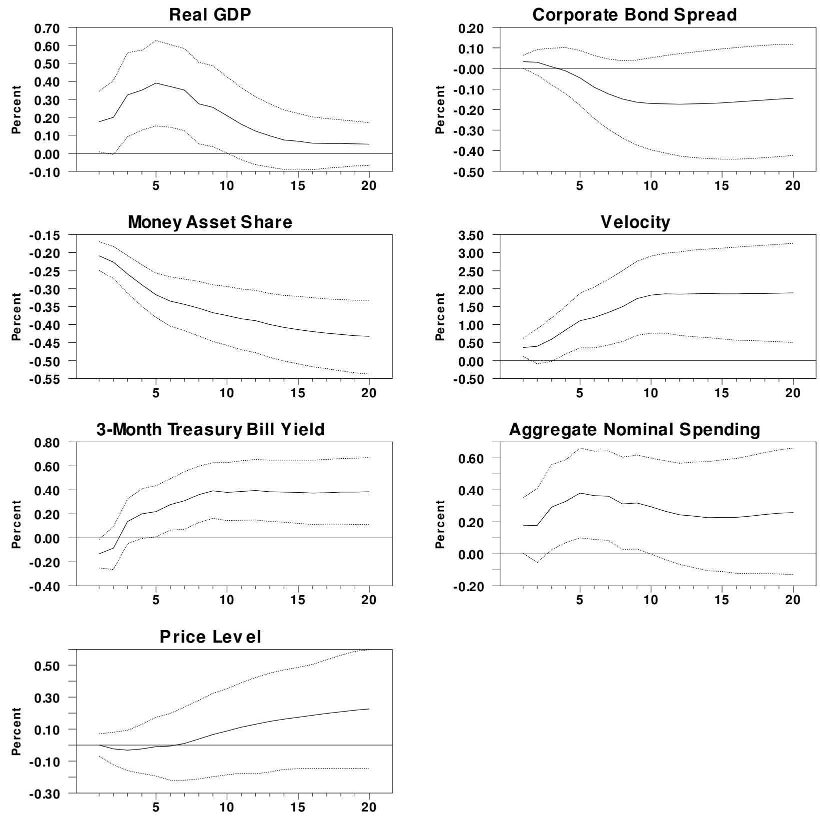


Figure 6
Cumulative Impulse Response to a Negative Shock to Money Share of Household Assets
1959:Q1 – 2007:Q4



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