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Money and Velocity During Financial Crisis: From the Great Depression to the Great Recession

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Abstract

This study models the velocity (V2) of broad money (M2) since 1929, covering swings in money [liquidity] demand from changes in uncertainty and risk premia spanning the two major financial crises of the last century: the Great Depression and Great Recession. V2 is notably affected by risk premia, financial innovation, and major banking regulations. Findings suggest that M2 provides guidance during crises and their unwinding, and that the Fed faces the challenge of not only preventing excess reserves from fueling a surge in M2, but also countering a fall in the demand for money as risk premia return to normal amid velocity shifts stemming from financial reform.
JEL codes: E410, E500, G11

Key words: money demand, financial crises, monetary policy, liquidity, financial innovation
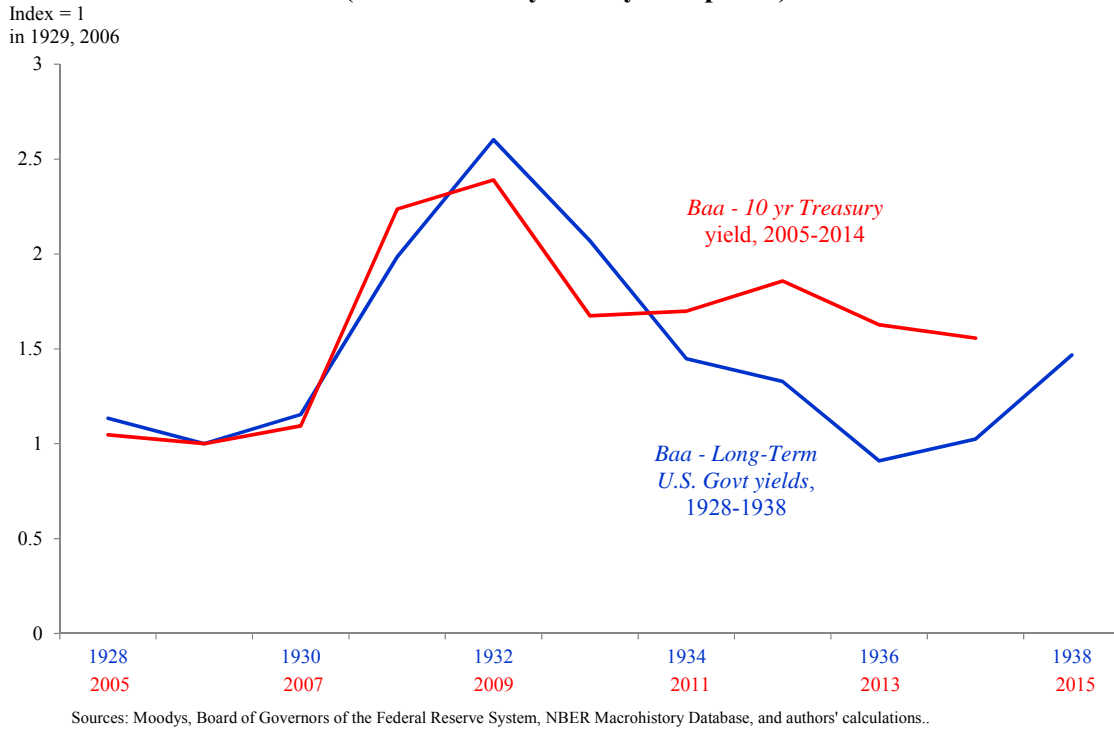
1. Introduction

The Great Depression and the Great Recession are acknowledged as the defining American financial crises of the past century.[1] It has been well-understood, at least since Bagehot, that extraordinary monetary policies are necessary as a crisis develops and later must be unwound as the crisis wanes. Best-practice monetary policy is to initially accommodate the large shifts in liquidity demand engendered by financial crises, due to flights-to-quality and elevated risk prema. Sharp increases in risk premia (tracked, for example, by the spread between yields on Baa corporate bonds and 10-year Treasury bonds, Figure 1) and decreases in M2's velocity (Figure 2) were signatures of the onset of the Great Depression and the Great Recession.
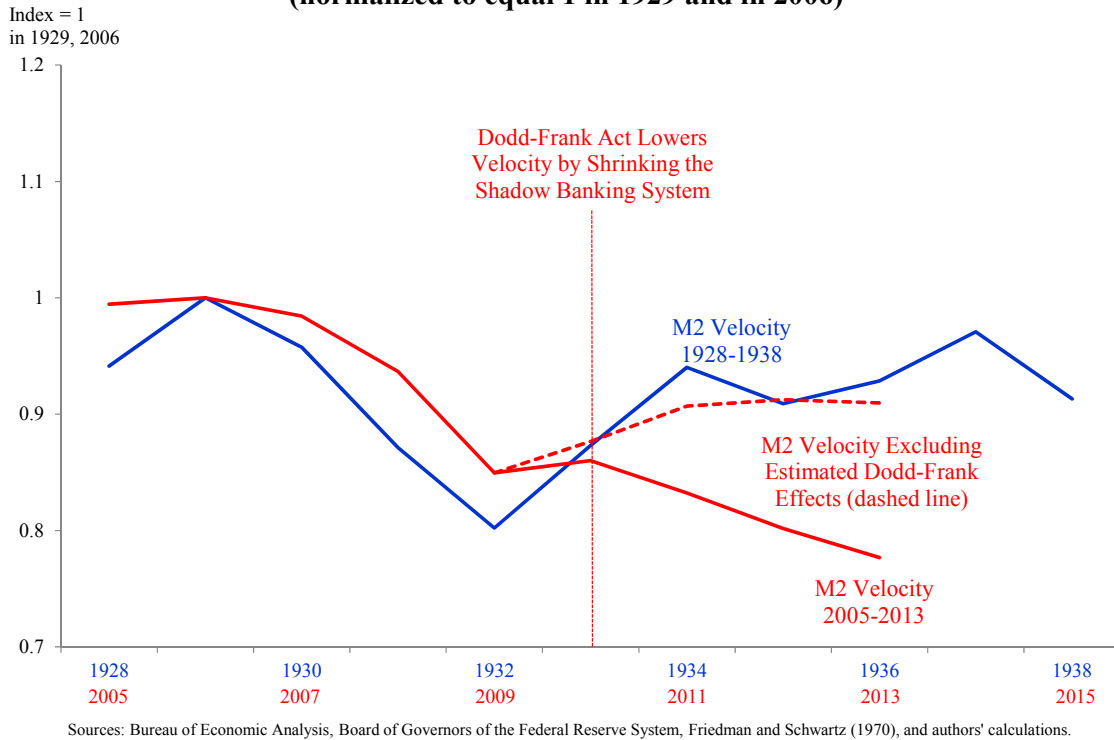
As the Great Depression abated, for example, risk premia decreased and velocity returned to more typical levels (Figure 1). Today, the Federal Reserve faces the challenge of returning monetary policy to a more normal stance following the Great Recession; a first step was taken this month (October 2014) by ending the Large Scale Asset Purchase program. Yet, uncertainty remains regarding the correct path for policy. As the macroeconomic effects of the most-recent crisis fade, for example, the Federal Reserve must unwind the aggregate demand stimulus of pushing the federal funds rate to zero and of asset purchases that have quadrupled its balance sheet. At the same time, policymakers must seek to prevent the money multiplier from increasing rapidly when risk premia and velocity revert to more traditional levels: the historical record shows that money demand will retreat in response to falling risk premia and increasing opportunity costs vis-à-vis bond yields. Resulting increases in velocity—not just broad money growth—along with understanding possible effects of financial reform will complicate interpreting movements in money, and hence challenge a successful exit. Our study suggests that the behavior of money demand before, during, and after the two largest financial crises of

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[1] In a related paper, Bordo and Haubrich (2012) discuss other American financial crises.

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Figure 1: Financial Market Risk Premium Circa Two Financial Crises
(Baa - Treasury bond yield spread)

Index = 1
in 1929, 2006

Baa - 10 yr Treasury
yield, 2005-2014

*Baa - Long-Term
U.S. Govt yields,*
1928-1938

Sources: Moodys, Board of Governors of the Federal Reserve System, NBER Macrohistory Database, and authors' calculations..

Figure 2: M2 Velocity Circa Two Financial Crises
(normalized to equal 1 in 1929 and in 2006)

Index = 1
in 1929, 2006

Dodd-Frank Act Lowers
Velocity by Shrinking the
Shadow Banking System

M2 Velocity
1928-1938

M2 Velocity Excluding
Estimated Dodd-Frank
Effects (dashed line)

M2 Velocity
2005-2013

Sources: Bureau of Economic Analysis, Board of Governors of the Federal Reserve System, Friedman and Schwartz (1970), and authors' calculations.

the past century—the Great Depression and the Great Recession—provides some guidance.

The importance of understanding velocity is very relevant to the recent crisis. While the historical paths of inflation/deflation and unemployment (Figures 3 and 4) suggest that Federal Reserve performed better in preventing deflation and quelling high unemployment during the Great Recession than in the Great Depression, the high levels of unemployment from 2008 to 2012 suggest a shortfall in meeting the full employment objective part of the Federal Reserve's dual mandate. Indeed, despite the Federal Reserve's efforts, the Great Recession has been characterized by a shortfall in nominal demand (Figure 5) even though, M2, a measure of broad liquidity that is available for during both crises, increased solidly during the Great Recession (except for 2010) while contracting dramatically during the Great Depression (Figure 6). At first pass, robust M2 growth during the recent crisis suggests that monetary policy provided adequate liquidity. Such an inference, however, requires comparing money *demand* with money *supply*: in crises, the demand for liquidity—such as for the safe assets in M2—surges.

This study provides a framework for gauging the impact of flights-to-quality and elevated risk premia. We construct a unified money demand framework for broad money (M2) that tracks velocity since 1929, including both crises. Our analysis emphasizes a mutually reinforcing, non-linear interaction between time-varying risk premia and decreasing transaction costs of money substitutes (in particular, lower transaction costs of bond and equity mutual funds)—lower transaction costs encourage more rapid portfolio rebalancing in response to shifting risk premia.

Our common framework illustrates both differences and similarities between the Great Depression and the Great Recession, as highlighted in Figures 1 and 2. Financial crises understandably increase risk premia. Measured by the spread between the yields on Baa-rated corporate bonds and 10-year Treasuries (Figure 1), risk premia peaked in 1932 and 2009 for the

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Figure 3: In Contrast to the Great Depression, the Fed Prevents Substantial Deflation in the Great Recession
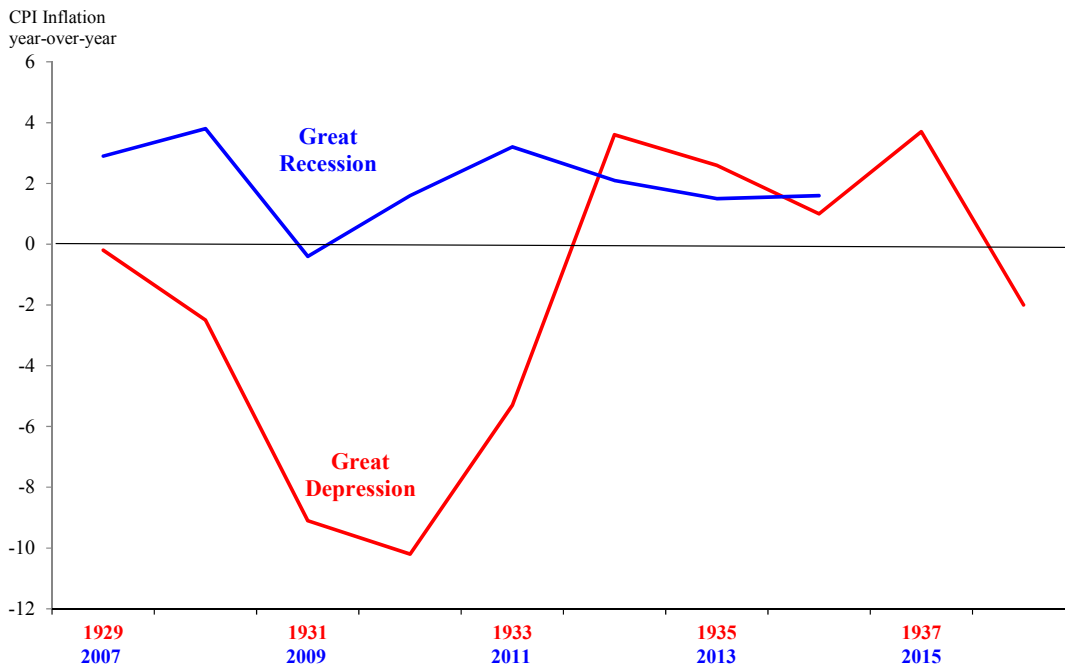
CPI Inflation
year-over-year

Figure 4: Unemployment in the Great Depression Rose Far More than in the Great Recession
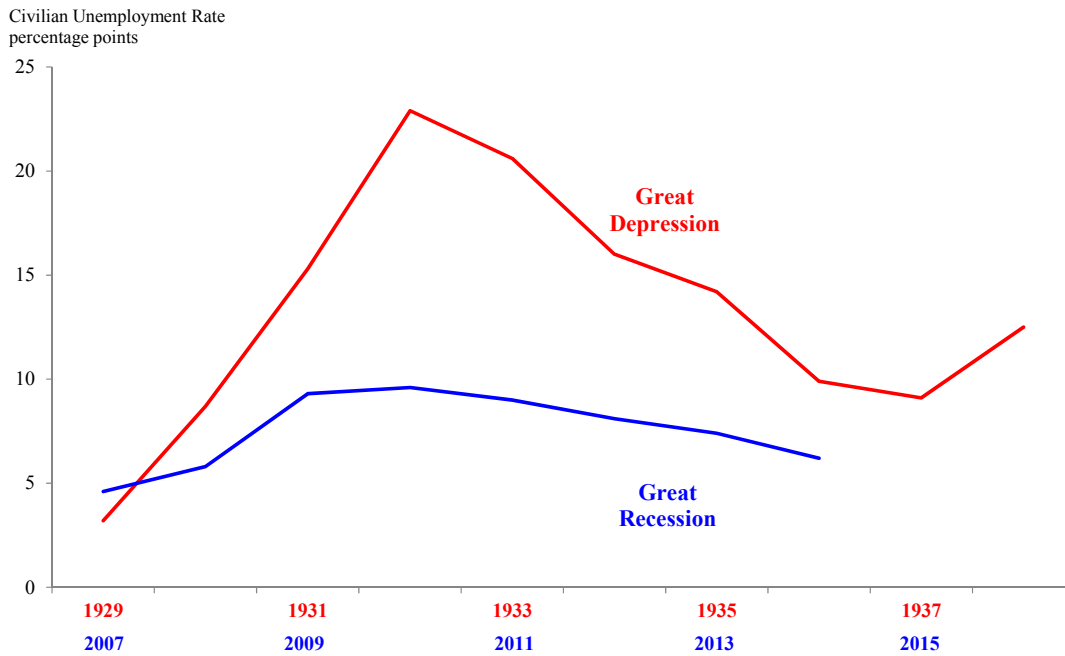
Civilian Unemployment Rate
percentage points

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Figure 5: Fed Better−But Imperfectly−Stabilized Nominal GDP Growth in the Great Recession than in the Great Depression

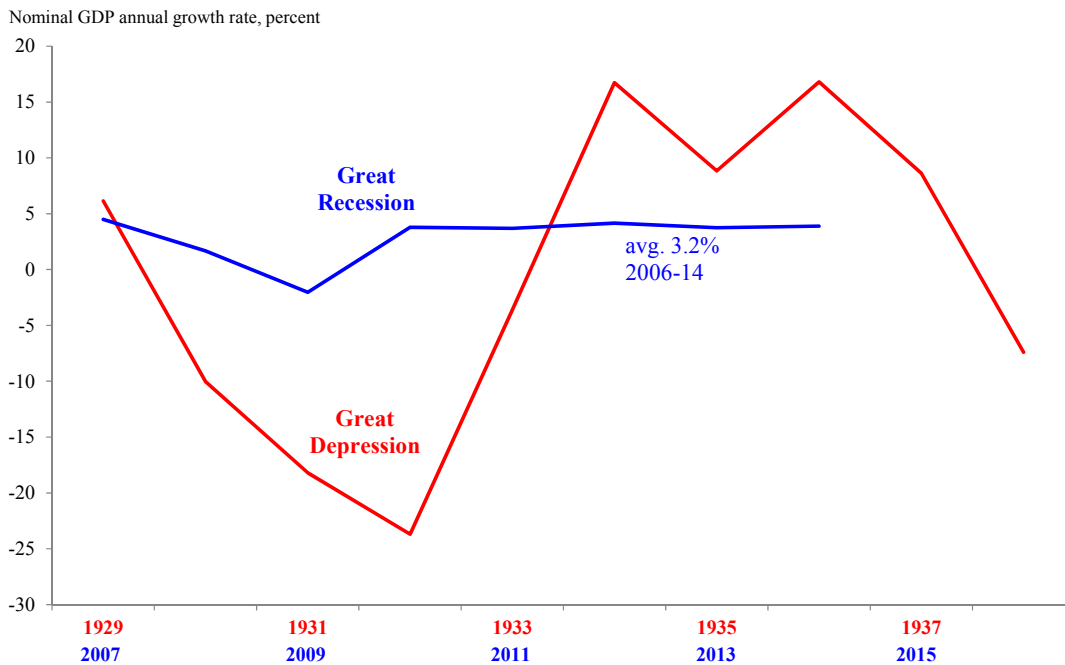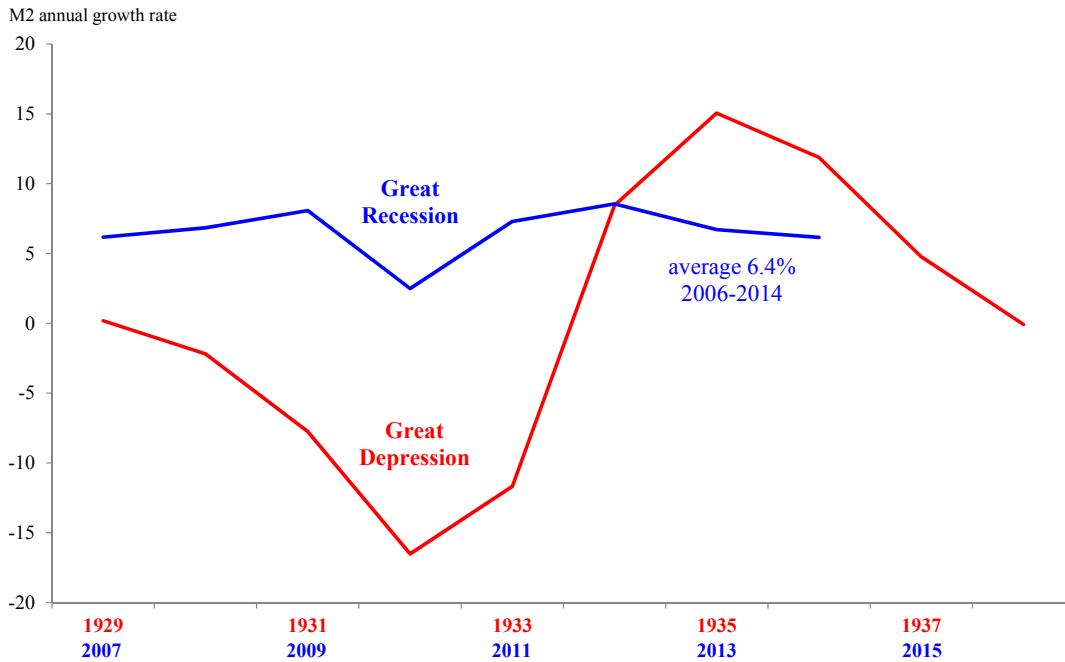Nominal GDP annual growth rate, percent

Figure 6: M2 Declined in the Great Depression, But, Except in 2010, Rose Solidly in the Great Recession

M2 annual growth rate

Great Depression and Great Recession, respectively. Perhaps surprisingly, measured risk premia retreated more rapidly during the Depression: 1929's premia was rejoined by 1935, while year-end 2013 risk premia remain above pre-crisis lows, albeit near 2002-2003 levels. Our empirical results suggest an important explanatory role of this premia for the behavior of velocity before and after the crises (Figure 2). In the Depression, velocity rapidly regained its earlier level following stabilization of the banking system; in the Great Recession, it has not. Both crises were followed by extensive bank regulatory reform—judging the relative impacts of the reforms on velocity is difficult. In Figure 2, for example, we show for the Great Recession both the actual path of M2 velocity and a counterfactual path based on an estimate of the Dodd-Frank Act's pressure to shift credit provision back into the formal banking sector from the shadow banking system (Duca, 2014). Because the latter derives much of its funding from M2 components, these provisions tended to lower M2 velocity, consistent with the view emphasized by Bordo and Jonung (1987, 1990, 2004) that major changes in financial institutions critically affect money demand. As a result, there are difficulties with disentangling financial reform from risk premia effects in the current environment. Estimation of these effects is discussed further below.

Our framework permits estimation of a demand equation for M2 that, by incorporating measures of risk and uncertainty, sensibly tracks M2's velocity through both the Great Depression and Great Recession. In both periods, an initial plunge in M2 velocity exceeded amounts suggested by historical changes in income and interest rates. Later, during the mid-1930s, velocity increased and stabilized as uncertainty ebbed, as noted by Friedman and Schwartz (1963). Velocity plunged again late in World War II likely due, in part, to fear of a post-war collapse similar to that following World War I and to forced saving by goods-rationed households (see Rockoff 1981). More recently, the surge in uncertainty that accompanied the

onset of the Great Recession induced a jump in the demand for money and a drop in velocity.

Our findings assist in understanding recent macroeconomic events. From yearend 2006 to 2014, broad money growth, nominal GDP growth, and inflation (GDP chain price index) increased, respectively, at 6.5, 2.9, and 1.6 percent annual rates. The pace of broad money growth, albeit 6 -1/2 percent, has been consistent with relatively low nominal GDP growth and inflation. Although many factors likely contributed to this outcome (including increased banking regulation), the difference includes flight-to-quality effects.[2] Broad money growth reflected the interaction of two forces: the expansion of bank reserves and a plunge in the money multiplier reflecting, as emphasized by Brunner and Meltzer (1966), both the lending activity of banks and the demand by households and firms to hold deposits at banks. Combining these factors, we attribute the decrease in broad money velocity to heightened risk premia and a decreasing opportunity cost of broad money relative to bonds.[3]

Our analysis also assists understanding the exit from extraordinary policy. A successful exit strategy must seek, via reductions in the monetary base, to temper the pace of broad money growth going forward *relative to* a money demand that is decreasing toward more normal levels as risk premia revert to typical levels. Monitoring broad monetary aggregates in the context of a well-developed demand model promises substantial assistance to implementing such a strategy.

Technically, our analysis extends to early historical periods the models of broad money demand developed by Anderson and Duca (2013) that permit the quantity of money demanded to respond to higher uncertainty during crisis periods and, later, revert to normal levels. These models of velocity covering the period since the mid-1960s, reconcile the low inflation, weak nominal income growth, and moderately robust broad money growth of the recent economic

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[2] Some (e.g., Svensson, 2009) argue that the recovery will remain slow so long as broad money growth is not strong.
[3] Friedman and Schwartz (1963) also emphasize the Fed's failure to protect the stability of the financial system, something which the Bernanke-led Fed largely avoided.

recovery.[4] To extend this framework to cover the Great Depression, the current study extends

estimates of mutual fund costs back to the 1920s and develops pre-WWII measures of own rates

of return for M2. By also controlling for shifts in risk premia and relevant financial innovations,

our framework provides a statistically sound and internally consistent way of modeling money

demand in both the short- and long-runs. The quality of our results is illustrated in Figure 7 by

our model's ability to track equilibrium M2 velocity since the early 1930s.[5]

To establish these and other results, this study is organized as follows. Section 2 reviews

previous money demand studies. Section 3 incorporates financial innovation to motivate and

derive our basic specification. Section 4 discusses the variables used to track standard factors

and financial innovations affecting money demand. Section 5 presents our velocity model results

that provide the basis for static simulations of velocity and nominal GDP in Section 6 under

different money growth and risk premia scenarios. The conclusion provides perspective on what

our findings imply about the demand not only for liquidity and its implications for monetary

policy in general, but also for how money demand and nominal GDP may behave during the

Fed's exit from the monetary accommodation it provided to counter the Great Recession.

2. Previous Literature

Studies of the demand for money over long periods of time must confront shifts in money

demand. Traditionally, studies regarding the demand for broad money in the United States

asserted or assumed that the effects of increasing financial sophistication and innovation are

well-captured either within either the definition of a broad money aggregate (as reconstructed for

earlier periods using contemporary definitions) or the path of nominal (or real) income. Although

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[4] By inducing outsized shifts in the neutral Wicksellian real rate, financial innovations and frictions also pose serious challenges for gauging monetary policy with Taylor-Rule rate frameworks. Indeed, Barsky, Justiniano, and Melosi (2014) estimate that the neutral real rate has shifted in a large 7 ½ percent range since 1990.

[5] Figure 3 and our models use various controls to address money demand shifts associated with World War II.

**Figure 7: M2 Velocity Tracked by Model Incorporationg
Financial Innovation and Risk Premia**

ln of velocity
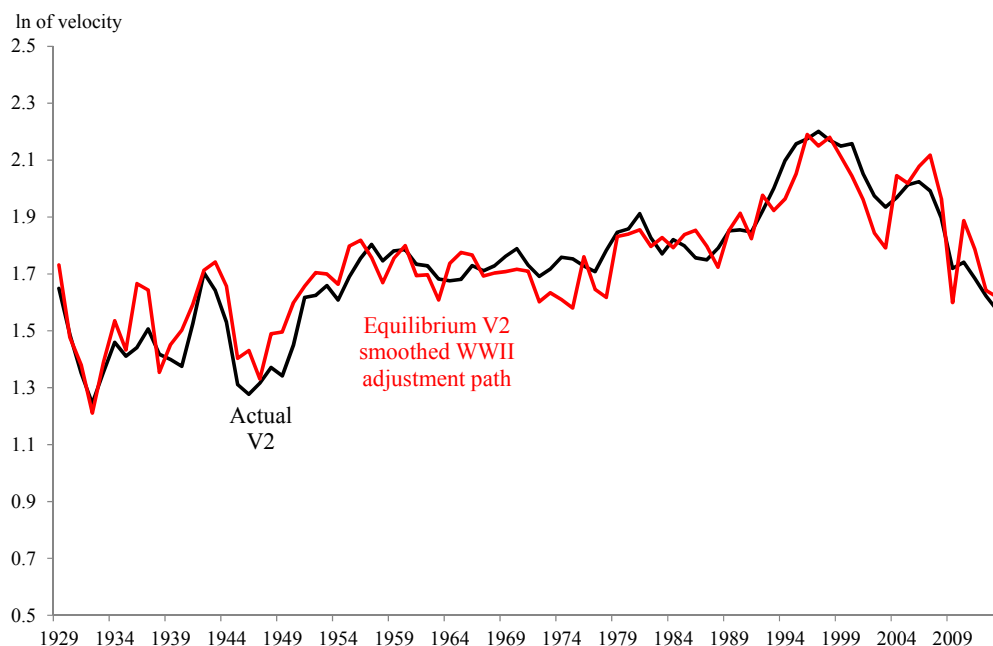
Sources: Board of Governors of the Federal Reserve System, Bureau of Economic Analysis, Friedman and Schwartz (1970), and authors' calculations.

the importance of financial innovation was acknowledged, its effects often were addressed only via exogenous dummy variables. "Breakdowns" in empirical money demand relationships, most often, were traced to the inadequacy of such variables.

The literature is vast. Well before the recent financial crisis, Ford and Mullineux (1996) ably summarized the issues both for money demand and financial market stability:

"The recent decades, and more particularly the last two, have seen the most substantial evolution, maybe we should say revolution, in the financial and monetary sectors of the developed nations of the world. In the financial sector in the broad sense, many new types of financial claims (both assets and liabilities) have emerged. Some of these claims have appeared in what we might strictly call the banking sector. [Others] have arisen because of attempts to insure against the uncertainty in financial markets, which has become an increasingly important feature of the global economic scene. The volatility that has occurred in those markets probably owes a significant part of its existence to the integration, and liberalization, of markets that have been dominant phenomena in many western economics."

A decade later, Federal Reserve Chairman Ben Bernanke (2006) echoed the financial innovation

theme at the ECB's fourth central banking conference[6]:

Why have monetary aggregates not been more influential in U.S. monetary policymaking, despite the strong theoretical presumption that money growth should be linked to growth in nominal aggregates and to inflation? In practice, the difficulty has been that, in the United States, deregulation, financial innovation, and other factors have led to recurrent instability in the relationships between various monetary aggregates and other nominal variables.

…the rapid pace of financial innovation in the United States has been an important reason for the instability of the relationships between monetary aggregates and other macroeconomic variables. In response to regulatory changes and technological progress, U.S. banks have created new kinds of accounts and added features to existing accounts. More broadly, payments technologies and practices have changed substantially over the past few decades, and innovations (such as Internet banking) continue. As a result, patterns of usage of different types of transactions accounts have at times shifted rapidly and unpredictably.

…the empirical relationship between money growth and variables such as inflation and nominal output growth has continued to be unstable at times.

Financial innovation has figured prominently in other long-term money demand studies. Historically, it has been the economic function of financial innovation to increase the liquidity of otherwise less-liquid assets, that is, to reduce the transaction costs of converting assets that are not medium-of-exchange into medium-of-exchange (e.g., Hasbrouck, 2009). Some such innovation has occurred with the regulated, chartered banks, as noted above. But innovation also has occurred elsewhere, most notably in the mutual fund industry, where the costs of transferring assets into mutual fund accounts have fallen dramatically, prompting later increases in stock ownership rates among middle-income families.

Previous Studies of Long-Run US Money Demand

Although there are a number of previous studies of long-run U.S. money demand, most previous studies have used M1, not a broad monetary aggregate, e.g., Wang (2011), Lucas

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[6] Bernanke (2006) notes that the Federal Reserve Board's P* model (Hallman, Porter and Small, 1991) was developed to predict long-run inflation using long-run potential output and velocity. This model's performance can be improved by accounting for financial innovation, specifically, the decreasing transaction cost and increasing use of bond mutual funds; see Brecsi and Duca (1994). Judson, Schlusche, and Wong (2014) update the 1988 Federal Reserve Board M2 demand model (Moore, Porter and Small, 1990) and conclude that the model works well, with minor adjustments, from 1959-2011, when the period during which it performs poorly (1990-1993) is omitted.

(1988), Stock and Watson (1993), and Ball (2001). By using M1, however, these prior studies ignore the warning of Friedman and Schwartz (1970) that the data support only a broad money aggregate for long-run studies. Prior to mid-1930s, Friedman and Schwartz note that there was little economic difference between banks' different types of deposits. Regulatory changes during the 1930s that imposed new statutory reserve requirements and prohibited the payment of interest on demand deposits made important the distinction between M1 and broader aggregates. Given such advice, we focus on a broad aggregate, M2.

Friedman and Schwartz (1982)

The long-run money demand study most similar to ours is Friedman and Schwartz (1982).[7] They study a broad definition of money (currency plus all deposits held by the public at commercial banks) from the mid-1870s to the mid-1970s.[8] Prominent in their study are two themes: the public's increasing financial sophistication that tends to increase velocity and increasing per capita real income that tends to reduce velocity (as the quantity of real money demanded increases more rapidly than real income per capita). Interest rates also matter: they conclude that "a one percentage point change in the difference between the yield on financial assets and on money induces approximately a 9 percent change in the opposite direction in the quantity of money demanded," (p. 4). Because their money demand model has both transaction and portfolio motives, it includes the return on physical assets (including human capital).

Friedman and Schwartz's (1982) model impressively fits the data. In levels, the model has a residual variation of approximately 5 percent; in changes, approximately 1.5 percent. On

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[7] We use standard time-series methods, not the "reference phase" statistical framework of Friedman and Schwartz.
[8] Friedman and Schwartz (1982) note that the deposit figures for 1867 through 1946 are theirs, and for currency through 1942. Thereafter they use Federal Reserve figures. Subsequent changes in the definition of M2 make untenable using exactly the same figures. Our figures for 1946 to 1958 are from Rasche (1992); earlier data are from Friedman and Schwartz. See Anderson (2003). We avoid Friedman and Schwartz's difficulties regarding income and prices by using annual data and currently published Department of Commerce figures beginning 1929.

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balance, however, the interest rate and yield variables are found to have only modest explanatory value. Unfortunately, they have no measures of financial innovation and increasing financial sophistication—below, we use data on the mutual fund industry as a measure.

Bordo and Jonung (1987, 1990, 2004); Bordo, Jonung, and Siklos (1997)

A second well-known approach to modeling long-run U.S. money demand is that of Bordo and Jonung (1987, 1990, 2004) who examine the period 1880 to 2000, and Bordo, Jonung, and Siklos (1997), who examine the U.S. and three other countries from the late 1800s to the late 1900s. Their research echoes the flavor of our analysis in emphasizing the effect on money demand of increasing financial sophistication and decreasing financial transaction costs. Similar to Friedman and Schwartz, they do not have "direct" measures of either financial sophistication or transaction costs but, instead, examine a number of proxies.

Their basic model of the long-run demand for money per capita is

$$\log\left(M/PN\right) = a_0 + a_1 \log\left(Y/PN\right)^p + a_2 i + \varepsilon \tag{1}$$

where $\left(M/PN\right)$ is real money holdings per capita, $\left(Y/PN\right)^p$ is real permanent income per capita, and i is an interest rate. Defining $\log V = \log\left(Y/PN\right) - \log\left(M/PN\right)$ and assuming in long-run equilibrium $\left(Y/PN\right) = \left(Y/PN\right)^p$, their model equivalently is:

$$\log V = -a_0 + \left(1 - a_1\right)\log\left(Y/PN\right)^p - a_2 i + \varepsilon \ .$$

Their corresponding short-run model is

$$\log V = b_0 + b_1 \log\left(Y/PN\right)^p + b_2 i + b_3 \log\left(Y/Y^p\right) + b_4 p^e + \sum X_i + \varepsilon \tag{2}$$

where $\left(Y/Y^p\right)$ measures transitory deviations from permanent income, p^e measures the expected rate of inflation, and $\{X_i\}$ is a vector of one or more proxy variables. (They restrict $b_3 = 1$ a priori.) The proxy variables examined for the United States are:

- the share of the labor force in nonagricultural pursuits, as a proxy for monetization.

- the ratio of currency to money, as a proxy for the spread of commercial banking

- the ratio of total nonbank financial assets to total financial assets, as a proxy for financial development

- the six-year moving standard deviation of the annual percentage change in real income per head, as proxy for the influence of economic stability.

- total government expenditure less national debt interest payments and total government expenditures less interest payments and defense spending to proxy for economic stability.

World War II

Although this paper focuses on modelling velocity during and immediately following financial crises (that is, the effects of rapid increases in risk premia followed by a slower-paced return of risk premia to "normal" levels), our analysis necessarily is complicated by WWII. Wartime controls significantly disrupted the economy, including rationing and price controls that distorted consumption, saving, and asset holding. Velocity rose rapidly during the early years of the war, and decreased steadily but more slowly during 1944-46.[9] Movements in velocity, in part, reflected very low short-term rates and bond interest rate pegging by the Federal Reserve.

Velocity movements during WWII also were influenced by price controls (Friedman and

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[9] In contrast, velocity fell during most of WW I. See Friedman and Schwartz (1982), chapter 5.

Schwartz, 1982) and rationing that lowered consumption.[10][11] Modeling the effects of WWII is uncertain. For example, including defense spending or a dummy for the onset and lifting of price controls is unlikely to fully reflect the interaction of these effects and the expectations impacts arising from them.   In addition, including direct measures of defense spending raises simultaneity issues. Accordingly, we add separate yearly dummies for 1941-46 to control for the time-varying impact of WWII and to prevent such effects from biasing coefficient estimates.[12]

3. Incorporating Innovation into Estimable M2 Money Demand Models

In a world in which (i) the income elasticity of broad money is unity, (ii) risk premia are not highly variable, and (iii) financial innovations are internalized within a broad definition of money, velocity might be well-modelled as a function solely of the opportunity cost of money, that is, the difference between a short-term market yield (e.g., 3 or 6-month Treasury bill yield) and the money own rate-of-return. The omission of assets other than short-term Treasury securities asserts that the principal margin of portfolio substitution is between money and short-term government debt. Conditions (i)-(iii) imply that the opportunity cost of M2 (OC) is strongly mean-reverting and equilibrium long-run velocity is well-approximated by a constant, that is, a

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[10] Friedman and Schwartz (1982, pp. 101-2) argue that wartime real output is overstated because "price control meant that price increases took indirect and concealed forms not recorded in the indexes" and that "the large rise in price indexes when price control was repealed in 1946 consisted largely of an unveiling of the earlier concealed increase." They argue that "true" average prices during the war were unobservable because some transactions occurred above controlled prices and others were black market transactions. As noted above, Friedman and Schwartz (1982, chapter 4) develop a method of adjustment that replaces observed prices during 1943-46, and hence, changes measured real output. They note that, because of the "different economic circumstances" during World Wars I and II, they often present separate results calculated with and without the war years. They also make data adjustments for the price control period 1971 Q3 -1973 Q3.

[11] A reasonable person might disagree, arguing that the measured prices are accurate but, due to rationing, the measured prices were not market-clearing and the 1946 increase reflected only an adjustment to those prices. As an adjustment to published data, they argue that measured nominal income likely was less distorted by illegal activity than measured prices, and use the method of interpolation-by-related-series (interpolating the price index by net national product) to construct replacement values for the price index during 1943-46. Although elegant, we do not pursue the Friedman and Schwartz adjustment. Friedman and Schwartz (1982), pp. 104-105, make a similar adjustment for the 1971-74 price controls. For the reasons stated above, we do not make such an adjustment.

[12] The effect of the dummy variables, of course, is to set the residuals for these periods to zero, thereby removing their influence in estimating the equation's coefficients.

long-run "Cambridge"-style quantity theory of money demand, $M/P = kY$. Such a specification likely was defensible up to the late 1980s; see Friedman and Schwartz (1982), Lucas (1988), Meltzer (1998), Moore, Porter and Small (1990), Hallman, Porter, and Small (1991), Small and Porter (1989), Rasche (1989, 1992), and more recently Judson, et al. (2014). The accompanying short-run dynamic model, aside from dummy variables for special events, then necessarily asserts that changes in V2 reflected changes in money's opportunity cost.

Denoting long-run velocity as V_{t-1}^*, the long-run model might be written as

$$\ln V2^* = \beta_0 + \beta_1 OC^* + \sum D_i \tag{4}$$

where the $\{D_i\}$ are dummy variables of suitable shapes to act as short-run controls and V2* is estimated from

$$\ln V2_t = \alpha_0 + \alpha_1 \ln V2^* + \alpha_3 \left(OC_t - OC^* \right) + \sum D_i + \varepsilon_t \tag{5}$$

Then short-run deviations from the long-run equilibrium might be written as:

$$\Delta \ln V2_t = \beta_0 + \beta_1 \left(\ln V2_{t-1} - \ln V2_{t-1}^* \right) + \beta_2 OC_{t-1} + \beta_3 \Delta \ln V2_{t-1} + \sum D_i + \varepsilon_t \tag{6}$$

In long-run equilibrium, $V2^* = V2_t$ and $OC^* = OC_t$ for all t.

Empirical difficulties with this framework since the early 1990s are well-known, often described as an unanticipated increase in velocity or a period with "missing M2." What factors might have caused such problems? The most prominent suspects are two omitted variables: financial innovation and much sharper swings in risk premia since the early 1990s.

Financial innovation has reduced the cost of exchanging assets included in M2 for market-rate substitutes, including bonds, equities, and bond and equity mutual funds.[13] Empirically, this effect appears as a time-varying elasticity of substitution between M2 and alternative assets (Duca, 2000), and perhaps has been most pronounced for small-denomination time deposits (Carlson, et al., 2000).[14] An early approach to this problem was to redefine money (M2) either to exclude the most troublesome component, small-denomination time deposits (e.g., Carlson, et al., 2000) or include money substitutes, such as bond funds (Besci and Duca, 1994). Such attempts are generally seen as unsatisfactory because they have not largely captured the financial innovation and portfolio substitution effects that are altering money demand.

The most important—and perhaps most neglected—financial innovation of recent decades has been the increased holding by households of mutual funds. Mutual funds are of special importance because, arguably, they are the main vehicle for most households to feasibly own a diversified portfolio of stock and bonds. Further, mutual fund transaction costs are *proportional*, not fixed, costs, the type of cost most likely to alter velocity (Brunner and Meltzer, 1967). Duca (2000) was among the first to include mutual fund costs in a money demand model, postulating that long-run equilibrium velocity was a function of mutual fund transfer costs:

$$\ln V2^* = \alpha_0 + \alpha_1 \ln load \tag{7}$$

where *load* is the average load (that is, front-end fee) charged to customers when they transfer assets into bond or stock mutual funds.

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[13]We are not the first to mention financial innovation as a culprit. As noted above, Friedman and Schwartz (1982) mention it throughout their analysis, often combined with the hope that omitting measures of innovation from their equations does little harm. Bordo and Jonung (1987, 2004) stress financial sophistication, which is closely related.

[14] The modelling challenge presented by such shifts is not be underestimated. Judson et al (2014), for example, simply omit 1990-1993 from their regressions because the regressions do not fit the data.

A second factor that has strongly affected U.S. money demand since the early 1990s, relative to earlier decades, is increasingly sharp swings in risk premia. These swings have notably altered the liquidity of nonmonetary assets, including stocks and bonds, by reducing the predictability of their future prices. Earlier monetary theorists argued that sharp shifts in risk premia could induce shifts in money demand, including Tobin (1958) who emphasized the speculative demand for money and Friedman and Schwartz (1963, chapters 11 and 12) who noted the link between higher corporate bond risk premia and the fall in money velocity during the Great Depression. Attempts to empirically track such effects by adding variables such as changes in stock returns have met with limited (Hamburger, 1966 and 1977) or mixed success (e.g., Carlson and Schwartz, 1999). The empirical relationship between money demand and risk premia appears to be neither stable nor empirically strong; attempts to account individually for asset transfer costs via mutual fund loads (Duca, 2000) or equity market risk premia (Hamburger, 1977) have been insufficient to resolve tracking errors in models of V2.

In this study, we demonstrate that economically and statistically meaningful omitted variable bias arises unless both loads and risk premia are included. Financial innovations that increase liquidity (i.e., reduce asset transfer costs) have lowered not only the cost of diversification but also the cost of hedging risk. The latter, in turn, has altered underlying portfolio behavior with respect to *how* risk premia affect money demand, consistent with Tobin's (1958) general equilibrium model. Lower asset transfer costs that alter investors' reactions to changes in relative returns and risk premia affect *both* the frequency/timing and magnitude of optimal portfolio reallocation.

We are not the first to note that transaction costs affect optimal portfolio. Transaction costs create a no-action zone in which it is optimal not to trade until portfolio misalignment is

sufficiently large to warrant incurring the transaction costs. The width of this zone is inversely proportional to the size of the transaction cost: as proportional transfer costs (such as mutual fund loads) decline, the zone of portfolio inaction narrows (e.g., Davis and Norman, 1990; Liu and Loewenstein, 2002; Zakamouline, 2002). The models imply that a decline in transaction costs (e.g, mutual fund loads) increases the likelihood that households will realign portfolios in response to a given change in the relative risk or rates of return on money versus other assets.

Lower transaction costs also increase the size of an optimal portfolio rebalancing in response to a given size change in relative returns or risk. Liu (2004) constructs a model in which fixed and proportional asset transfer costs affect the optimal consumption and portfolio behavior of households with constant relative risk aversion, and concludes that portfolio shares reflect differentials in pecuniary yields between safe and risky assets (e.g., the Treasury yield premium or a corporate-Treasury bond yield differential) scaled by proportional asset transfer costs in levels. More specifically, he finds that portfolio shares approximately reflect negative linear tradeoffs between expected return differentials and proportional asset transfer costs. In log specifications, this implies that the logs of a risk premium and an asset transfer cost series can enter as separate factors determining the long-run equilibrium velocity of ln M2 (ln $V2^*$). Letting the risk premium be measured by the difference between the Moody's Baa yield and the 10-year Treasury constant maturity yield, $Baa10TR$, we have for long-run velocity

$$\ln V2_t^* = \alpha_0 + \alpha_1 \ln(load_t) + \alpha_2 \ln(Baa10TR_t) + \alpha_3 OC_t + \varepsilon_t \tag{8}$$

where α_1 and $\alpha_2 < 0$, OC_t is an opportunity cost of holding M2, and ε_t is a stationary i.i.d. disturbance. In our empirical work, we do not reject that the variables $V2$, $load$, $Baa10TR$, and OC) are usefully modeled as I(1), that is, that the first-differences are covariance stationary, or

I(0). Omitting, therefore, either the risk premium measure (*Baa10TR*) or the financial innovation measure (*load*) will induce a composite non-stationary disturbance. Further, to the extent that $\ln(load_t)$ and $\ln(Baa10TR_t)$ are correlated, omitting either will cause least-squares estimators of α_0 and α_1 (or α_2) to be inconsistent. Further, models of M2 velocity that omit measures of risk premia and/or financial innovation (asset transfer costs) may display "money demand shifts" even if the models include yield term premia and default/liquidity risk premia.

Finally, larger fluctuations in market risk premia harm money demand (that is, velocity) models because familiar money demand models are unable to capture flight-to-quality dynamics. Empirically, the issue is manifest in correlation between the *size* of the Baa-Treasury yield spread and the *levels* of corporate equity and bond prices. During flights to quality, the spread widens as stock and bond prices decrease and Treasury prices rise. As a result, current-period yields on corporate assets fall and yields on Treasuries rise. In future periods, yields on corporate assets will increase relative to the current period and yields on Treasuries will fall. In such models, increases in opportunity costs are asserted to reduce the quantity demanded and increase velocity—but this need not happen after flights to quality because default and liquidity risk premia are changing. Although not perfect, including *Baa10TR* is a step towards preventing flight-to-quality effects from contaminating the effect of the opportunity cost.

We complete the model by augmenting eq. (8) with a dynamic short-run equation, in the form of an error-correction model:

$$\ln V2_t^* = \alpha_0 + \alpha_1 \ln(load_t) + \alpha_2 \ln(Baa10TR_t) + \alpha_3 OC_t + \varepsilon_t \qquad (9)$$

$$\Delta \ln V2_t = \beta_0 + \beta_1\left(V2_{t-1} - V2_{t-1}^*\right) + \beta_2\Delta\ln(load_{t-1}) + \beta_3\Delta\ln(Baa10TR_{t-1}) + \beta_4\Delta OC_{t-1} + \beta_5 D_t + v_t$$

where D_t denotes a vector of dummy variables used as short-run controls for events not otherwise captured.

4. The Empirical Model: Data

Our data consists of annual observations over 1927-2013. The scale variable is nominal GDP, beginning in 1929 from the U.S. Department of Commerce; we augmented the series for 1927-1928 by splicing Gordon and Balke's estimates to the later series. Money stock is broad money (M2) from Friedman and Schwartz (1970) for 1927-1945, then Rasche's (1992) series for 1946-1958, and the Federal Reserve Board's data thereafter.[15] Interest rates are annualized Treasury constant-maturity rates on a bond-equivalent basis. The Baa rate is the average yield to maturity on corporate bonds rated Baa by Moody's Investor Services. We follow Duca (2005) in measuring stock fund loads as the proportional fee (percent of assets) levied when a mutual fund is purchased or the fee levied for withdrawing funds within a year of purchase (Figure 9).[16]

Mutual Fund Loads

The assets included in the M2 monetary aggregate are primarily held by lower- to upper-middle income households. Among these households, those with higher incomes are relatively more likely to hold non-M2 financial assets; the most commonly held financial assets are stocks and bonds held via mutual funds. Hence, the transaction costs of moving into and out of mutual funds are the most relevant substitution margin for understanding M2 demand.

Lower mutual fund costs both ease portfolio substitution between M2 and stocks and tend to increase stock ownership rates, potentially thereby inducing further time-variation in the interest elasticity of money demand. Heaton and Lucas (2000) demonstrate that high asset transfer costs for households exhibiting habit formation in consumption can lead to a low stock ownership rate and a high equity premium. This implies lower asset transfer costs would induce

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[15] In this manner, we seek an M2 measure as consistent as possible, over our entire sample, with the definition of M2 as currently published by the Federal Reserve Board of Governors.

[16] We also tested loads using a longer 5 year horizon and/or adjusted for expense ratios (see Duca, 2005). These other variants were significant but did not perform as well as the series used here which corresponds more closely with tracking asset transfer costs.

greater stock ownership. Using data from the Federal Reserve's Survey of Consumer Finances, Duca (2005, 2006) finds that average equity fund transaction costs (loads) and stock ownership rates have a significant negative correlation of about −1 for both overall and indirect (e.g., mutual fund) stock ownership rates (Figure 8). Detailed SCF data reveal that higher equity participation stemmed from greater mutual fund ownership and had risen the most for middle-income families, whose M2 deposit balances grew more slowly relative to total financial assets compared to high-income families. Thus, the cross-section data on stock ownership ties it to lower cost barriers for accessing mutual funds.

To track transfer costs relevant for household demand for M2, we update and extend data on mutual fund costs from Anderson and Duca (2014) and Duca (2000). The substitution may entail a number of different types of funds and assets. Mutual fund families make it easy to shift assets within families of funds (money market, bond, and equity); hence, substitution between

Figure 8: Equity Fund Loads Fall and Stock Ownership Rates Rise
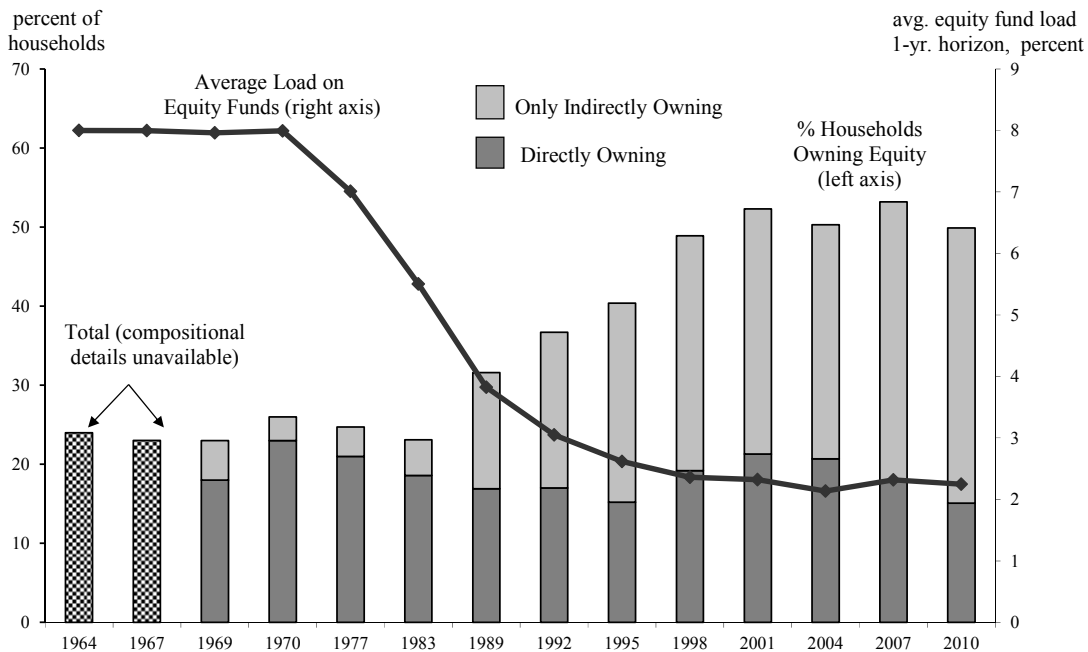
Sources: CDA/Wiesneberger, IBC/Donaghue, Morningstar, Duca (2005), Surveys of Consumer Finances, and authors' calculations.

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M2 and equity assets likely also affects money market mutual funds (MMMFs), shares in which are included in M2. Similarly, banks have eased customers' ability to shift between MMDAs (and bank asset management accounts) and equity funds. Indeed, during the stock market declines of 2000-01 and 2008-09, flows among money market mutual funds, MMDA, and M2 were larger than suggested by observed interest rate spreads and historical experience.

At the aggregate time series level, several empirical patterns imply that mutual fund loads are a driver of M2 velocity. Duca (2005) found that stock mutual fund loads mainly reflect evolving financial technology and in vector error-correction models, that loads were weakly exogenous to the use of mutual funds to own stock but not vice versa, while loads were not weakly exogenous to financial sector productivity, but the converse was true. Granger and Lin (1995) would view such results as evidence that mutual fund use is caused, in a long-run sense, by loads, which are caused by financial technology. Similarly, as we later show, stock mutual fund loads are weakly exogenous to M2 velocity, while V2 is not weakly exogenous to stock fund loads. These findings imply that trends in loads lead those in velocity, consistent with the view that asset transfer costs Granger cause money demand in a long-run sense.

In their studies of quarterly M2 velocity since the mid-1960s, Duca (2000) and Anderson and Duca (2014) use bond fund loads, which they found outperformed stock fund loads over their samples. However, for two reasons, we use stock fund rather than bond fund loads to proxy asset transfer costs. First, in contrast to stock funds, data on bond funds do not cover the 1920s and 1930s and provide limited evidence on the 1940s.[17] Second, as discussed below, we use a proxy for risk premia—the spread between yields on Baa-rate corporate and 10-year Treasury bonds—which reflects the riskiness of both stocks and private bonds. We follow Duca (2005) in

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[17] Only one bond fund existed before 1950 and it started in 1940, whereas a few stock mutual funds existed in the 1930s, with two prominent ones starting in the 1920s.

measuring stock fund loads as the proportional fee (percent of assets) levied when a mutual fund

is purchased or the fee levied for withdrawing funds within a year of purchase (Figure 9).[18]

While this stock fund load series does not span all aspects of asset transfer costs and

technology, for two reasons it likely proxies the general time series movements in asset transfer

costs and technology that affect household porfolios. First, empirical evidence points to changes

in financial technology driving mutual fund costs. Specifically, limited sample data (1968-1998)

Figure 9: Stock Mutual Fund Loads Shift in the Last Several Decades

% assets, front and
backend (1 yr.) loads

Stock Mutual
Fund Loads
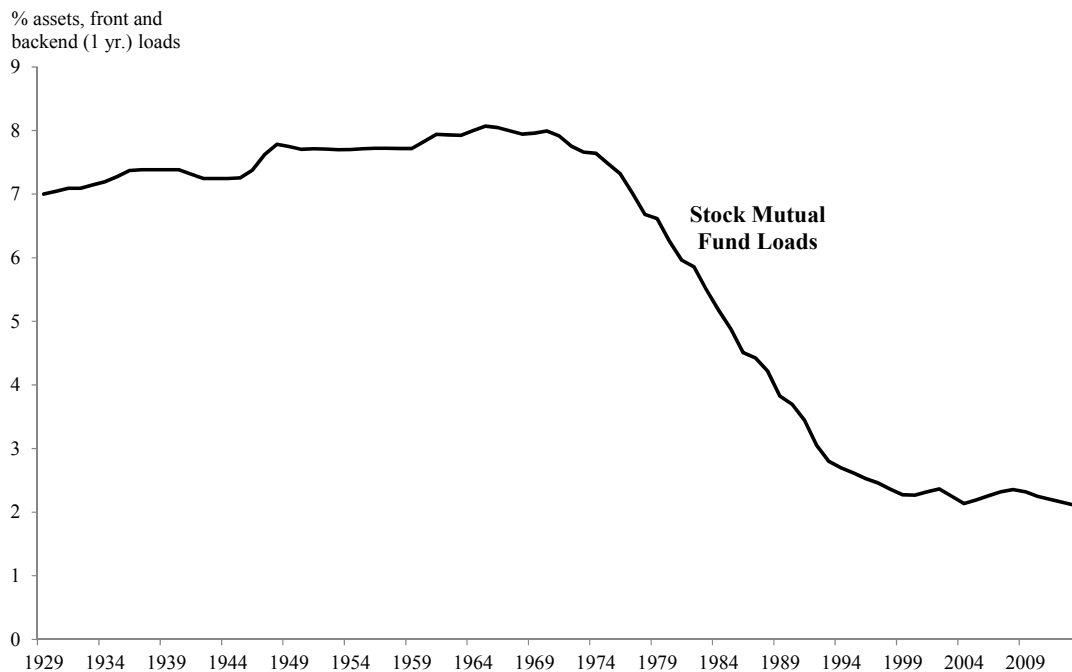
Sources: CDA/Wiesneberger, IBC/Donaghue, Morningstar, Duca (2005), and authors' calculations.

on banking sector productivity is the closest time series proxy for financial sector productivity in

the U.S. This data series is cointegrated with mutual funds costs and weak exogeneity tests

indicate that bank productivity granger causes stock mutual fund loads in a long-run sense

(Duca, 2005). Second, evidence implies that mutual fund costs notably influence the

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[18] We also tested loads using a longer 5 year horizon and/or adjusted for expense ratios (see Duca, 2005). These other variants were significant but did not perform as well as the series used here which corresponds more closely with tracking asset transfer costs.

composition of household portfolios. In particular, stock mutual fund costs are cointegrated with—and are highly and negatively correlated with—stock ownership rates, with weak exogeneity tests indicating causality running from long-run trends in mutual fund loads to equity participation rates (Duca, 2013). Together, these findings imply that financial technology changes (rather than simple economies of scale) drove down mutual fund costs, which, in turn, induced large increases in the use of mutual funds as a means of owning stock.

Risk Premia and Stock Returns

The portfolio share of stocks for the household sector shows much more variation than that of bonds (Federal Reserve Financial Accounts), implying that including a risk premia that both have in common can parsimoniously control for private risk premia in a cointegrating framework. The spread between yields on Baa corporate and 10-year Treasury spreads is arguably such a premium. Not only does it compensate investors for the higher default and liquidity risk on a benchmark, investment grade corporate bond, but this premium is built into stock prices. An equity risk premium defined as the gap between the earnings-price ratio for nonfinancial corporate stocks and a real ex post bond yield is more stable using the Baa corporate than the 10-year Treasury yield (chart available upon request from the authors).

To measure this spread we use the Baa yield tracked by Moodys from the 1920s to 2013, but use a spliced series on long-term Treasury yields. From April 1954-2013, we use the constant maturity 10-year Treasury yield, onto which splice Federal Reserve data over 1941-54 on the average yield on long-term U.S. Government securities and a separate U.S. government bond yield series from 1926-41. Small additive adjustments are used to splice the data and are based on available overlapping data within one year of overlap. The three component series are available upon request, with Figure 1 plotting the implied splice-based Baa-Treasury spread,

which has a unit root according to ADF tests. The trends in risk premia are even more pronounced when scaled by stock fund loads (Figure 10), which according to Liu's (2004) model, should be correlated with portfolio behavior.

In addition to including a conventional measure of M2's opportunity cost vis-à-vis Treasury bills, the baseline model also includes a variable tracking the opportunity cost of M2 relative to stocks. This stock opportunity cost term (*OCST*) equals the ex post returns on all U.S. stocks (dividends and capital gains, source: Shiller, 2014) minus the own rate of return. *OCST* is stationary and enters the error-correction model as a short-run determinant with a t-1 lag and in levels, reflecting several negative annual values (Figure 11). The inclusion of stock loads in the cointegrating vector and its lagged first differences implicitly controls for the time-varying sensitivity of V2 to stock returns and risk premia owing to changes in asset transfer costs.

Conventional Opportunity Cost of Money

Our baseline specification includes a conventional measure of the opportunity cost of M2, namely the gap between a short-term Treasury bill rate and the average pecuniary rate of return on M2 balances. For the former, we use the bond-equivalent 3-month Treasury bill rate since 1934, onto which we used an additive break adjustment to splice 1926-33 data on the average 3-month and 6-month Treasury bill rate. For the average pecuniary yield on M2 balances we use annual averages of Federal Reserve Board estimates from 1958-2013. Pre-1958 data are derived as follows. We calculate the average rate on demand and time deposits from OCC reports on active banks, and weight these rates by demand and time deposit shares of M2, taking into account currency outstanding. Using overlapping data, we use a minor additive adjustment to splice the pre-1958 data onto post-1957 data (for see Appendix B). Because the resulting annual opportunity cost series (*OC*, Figure 11) has a unit root and has some negative

Figure 10: The Spread Between Baa Corporate and 10 Yr. Treasury Yields Trends, Especially When Scaled by Mutual Fund Transfer Costs
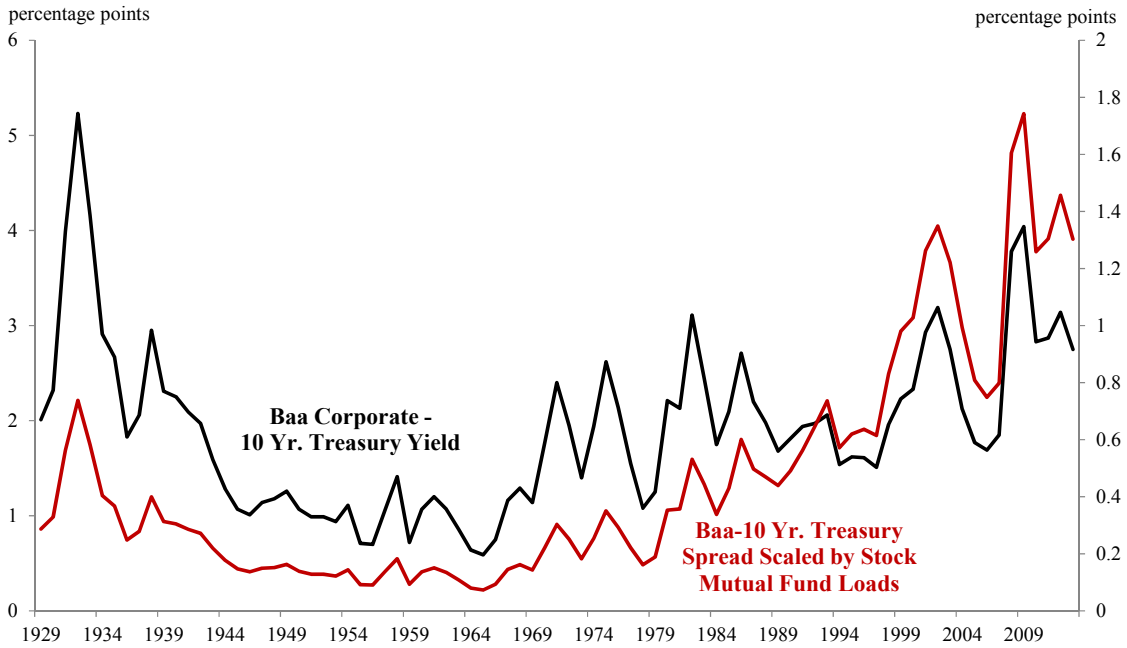
Spread equals Moodys' Baa corporate bond yield minus a Treasury yield series from splicing three time series on U.S. government bond yields. Spread scaled by loads uses the average front-end and back-end load on stock mutual funds at a one year horizon.

Figure 11: M2 Opportunity Costs Relative to T-Bill Rates Have Trends, But Relative to Stock Returns Are Volatile
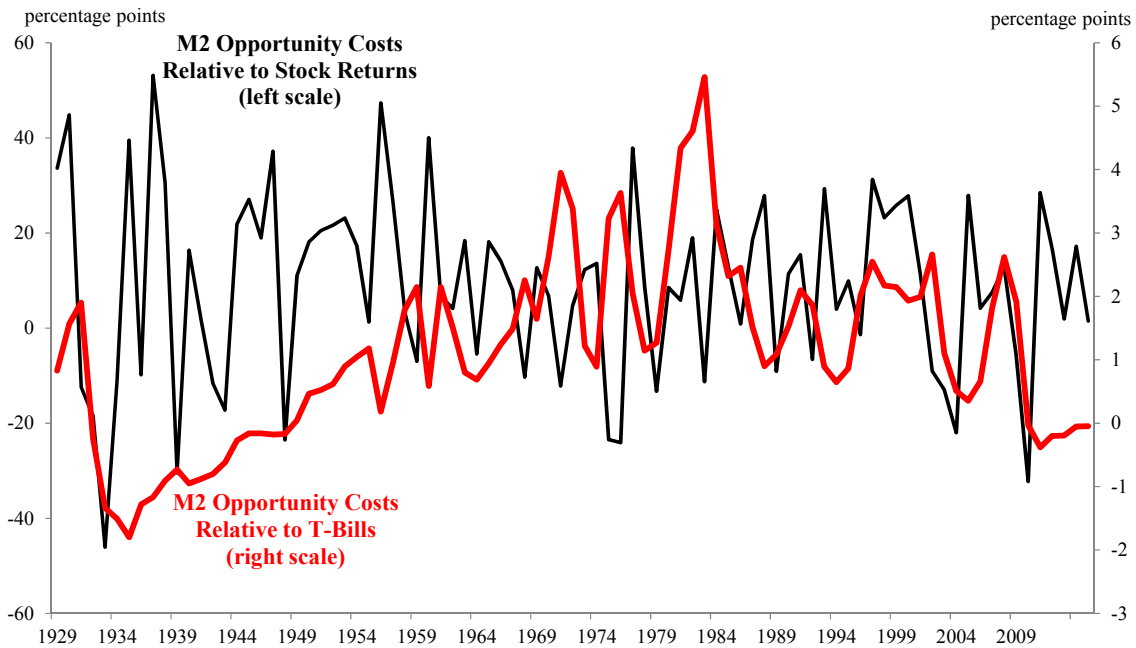
Opportunity cost terms use authors' calculations of M2 own rates of return, a spliced 3 month Treasury Bill rate series, and Shiller's (2014) data on annual ex post stock returns.

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values, its level enters the model by being a determinant of long-run velocity, thus affecting the change in velocity via the error-correction term and lagged first-difference terms.

B. Additional Short-Run Money Demand Variables

Several special regulatory and monetary policy actions had notable short-run effects on money demand, including the Bank Holiday of 1933, the Treasury-Fed Accord of 1951, deregulation allowing money market deposit accounts (MMDAs), and the Dodd-Frank Act. Beginning with the first bank crisis of October 1930, it seems reasonable that increased risk premia induced velocity declines early in the Great Depression; velocity during 1932 was three-quarters of its 1929 level.[19] Velocity increased in 1933, the year of the March Bank Holiday, even as the level of M2 averaged lower during the year. Why did M2 demand decrease during 1933? Perhaps there are two plausible explanations. One is that commercial bank depositors experienced losses of 2.15 percent (Friedman and Schwartz, 1963, p. 438) in this pre- deposit insurance era that directly lowered M2 and likely in households temporarily shifting to currency, which reduced the money multiplier and M2 balances.[20] Another related explanation is that before the Bank Holiday, there was a belief that the Fed's lender of last resort role would prevent the suspension of deposits, a rationale for creating the Fed. That belief was undermined by the suspension of deposits at failed banks and could have conceivably lowered the demand for money until the start of FDIC insurance in 1934. To control for this, the baseline V2 models include a *BankHoliday* dummy equal to 1 in 1933, and 0 otherwise.

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[19] Although nominal M2 in 1932 was 75 percent of its 1929 level, "real" M2 (adjusted by the GDP price deflator) was 98.5 percent of its 1929 level. Friedman and Schwartz (1963), ch. 7, note that the 1930 banking crisis was as severe as most during the nineteenth century and, absent the presence of the Federal Reserve, likely would have resulted in a restriction of the convertibility of deposits into currency. It is unreasonable to argue that the crisis did not increase risk premia for bank deposits.

[20] Friedman and Schwartz (1963), ch. 8, note that most licensed banks resumed business after the bank holiday without significant restriction, but unlicensed banks (more than 5,000 at the time of the holiday) were slow to reopen and almost half never reopened.

Deflation also is a special event. Conventional measures of M2's opportunity cost embody the impact of inflation on money demand because positive nominal interest rates reflect expected inflation. The zero lower bound on nominal interest rates prevents these measures from doing the same during periods of deflation. To address this omitted effect, we test a dummy (*DeflationPCE*) equal to 1 in years when year-over-year inflation as measured by the personal consumption expenditure price index was negative (1930-33, 1937, 1938, 1949, and 2009).

The 1951 Treasury-Fed Accord was another shock to V2. Prior to that agreement, the Federal Reserve had acted from 1942-1952 to sustain ("peg") short- and long-term Treasury rates at low levels. An inflation spike following the end of WWII price controls and a second spike in the first year (1950) of the Korean War; when coupled with the Fed's interest rate peg, these events risked undermining the Fed's inflation credibility. Even though V2 rose in 1951, it rose by less than what other money demand determinants indicated. Plausibly, by reestablishing monetary independence in wartime, the Accord helped enhance the demand for M2 as a store of value, thereby unusually lowering V2, ceteris paribus. To control for this effect, many models include a dummy (*Accord*) equal to 1 in 1951

In the short-run, money demand is affected by changes in banking regulations that alter the attractiveness of money relative to other assets. We include a dummy variable (*DMMDA* = 1 in 1983) for the introduction of MMDA deposits in 1983. Because interest rates on MMDAs could track market rates, MMDA accounts attracted funds from non-M2 assets (see Small and Porter, 1989, and Duca, 2000; see Lucas and Nicolini for regulatory effects on M1).

The Dodd-Frank Act (DFA) of 2010 appears to be another regulatory change that raises money demand and lowers velocity. Aspects of DFA, including requiring banks to retain some loss exposure in securitized loans and requiring "systemically important" banks and nonbanks to

pass "stress tests," tend to reduce the attractiveness of the shadow banking system as financial intermediaries relative to chartered commercial banks (Duca, forthcoming). If so, DFA may reduce both the assets held, and liabilities issued, by the shadow banking system while increasing these at commercial banks. Because M2-type instruments are a major source of funding for banks but not for shadow banks, this effect of DFA perhaps will lower V2. We include an annual dummy (*DFA*) equal to 0 before 2010, .25 in 2010 (DFA was passed in summer 2010) and 1 thereafter. Since this level shift occurs at the end of the sample, we anticipate that it will be difficult to identify, partly as M2 was affected by the 2001 change in the assessment of FDIC insurance premiums that induced banks to shift deposits booked overseas to onshore (Judson, et al., 2014).

We examine the covariance stationarity of our variables in Table 1, which shows ADF test stastics. The tests suggest that the log of nominal M2 (m), the log of the GDP price deflator (p), the log of nominal GDP (y), the log of M2 velocity (v), M2's opportunity cost measured relative to yields on short-term Treasury securities, stock mutual fund loads, the log of the spread between the Baa yield and the yield on long-term Treasury securities, and real M2 (m-p) are I(1), that is, the levels display unit root behavior but the differences do not. Based on the tests, we accept that the variables in eq. (9a) are I(1); below, we conclude that a single cointegrating vector exists for eq. (9a). We also accept that two intervention variables that enter into the dynamic model, eq. (9b), are covariance stationary: *OCST*, the opportunity cost of M2 measured relative to stock returns, and YC, the slope of the Treasury yield curve.

5. The Empirical Model: In-Sample Estimates

Our baseline empirical framework is equations (9a, b), repeated here for convenience:

$$\ln V2_t^* = \alpha_0 + \alpha_1 \ln(load_t) + \alpha_2 \ln(Baa10TR_t) + \alpha_3 OC_t + \varepsilon_t \tag{9a}$$

$$\Delta \ln V2_t = \beta_0 + \beta_1\left(V2_{t-1} - V2_{t-1}^*\right) + \beta_2\Delta \ln(load_{t-1}) + \beta_3\Delta \ln(Baa10TR_{t-1}) + \beta_4\Delta OC_{t-1} + \beta_5 D_t + v_t$$

$$\tag{9b}$$

Eight variants of equations (9a, b) are presented in Table 1. The models differ with respect to sample periods, explanatory variables, and short-run controls (dummy variables). All models include six individual-year dummies to control for WW II effects during 1941-46.[21]

The models shown in columns 1, 2, 3, 6 and 7 assert a long-run equilibrium that includes M2's opportunity cost, the corporate-Treasury yield spread, and stock fund loads. The model in column 4 specifies a long-run equilibrium that omits stock fund loads; the models in columns 5 and 8 omit stock fund loads and the corporate-Treasury yield spread. The short-run dynamic models in columns 1, 2, 4, 5, and 8 include a full set of short-run variables, the model in column 3 omits the bank regulatory dummy variables, and the models in columns 6 and 7 omit the Dodd-Frank dummy variable. Models also differ by sample period: the models in columns 1, 3, 4, 5, 7, and 8 are estimated using the full sample, the models in columns 2 and 6 use a shorter sample.

All models are estimated with a lag length of 4, leaving a "full-sample" period of 1932-2013. The lag length was chosen judgmentally according to three criteria: a unique cointegrating vector, a rapid speed of adjustment, and clean residuals. No time trend was included in the models' cointegrating vectors, but time trends are permitted in the dynamic model.

The purpose of Model 2 is to assess the robustness of Model 1's coefficients to events beginning 2006 that foreshadowed the recent financial crisis. Model 3 seeks to assess the robustness of the long-run coefficients to the exclusion of most of the non-WW II short-run variables in model 1 except for the opportunity cost terms with respect to Treasury bonds (YC)

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[21] The six variables are simple binary dummy variables. For example, $D_i = 1$, if year is 1941; $= 0$ otherwise. Variables for 1942-1946 are specified similarly.

and stocks (*OCST*) and the DFA variable that controls for a regime change at the end of sample. Model 4 seeks to assess the robustness of Model 1 to omission of the stock fund load series; model 5 omits both stock fund loads and the corporate bond spread. Model 6, estimated through 1998, seeks to assess to what extent Model 2's estimates might be affected by the large rise and sudden fall of U.S. stock prices around the year 2000-date change and by the recent financial crisis. Models 7 and 8 are variants of models 1 and 3 that replace nominal GDP with nominal gross domestic income (GDI). Because GDI has recently grown faster than GDP, later benchmark revisions to GDP could alter coefficient estimates. Benchmark revisions usually narrow discrepancies between the income (GDI) and product sides of the NIPA accounts.

A unique and statistically significant cointegrating vector was identified in Models 1, 2, 3, 6, and 7, each of which contains M2's opportunity cost, stock mutual fund loads, and corporate-Treasury yield spreads. The estimated long-run coefficient on each of these terms was highly significant with the expected sign. Higher stock fund loads and higher corporate risk spreads reduce velocity because higher asset transfer costs lower the liquidity of non-M2 assets and raise the demand for M2. In contrast, higher opportunity costs of M2 with respect to Treasury bill rates (*OC*) reduce the incentive to hold M2 balances, increasing velocity. We note that *OC* is not statistically significant in the models that omit stock fund loads (4, 5, 8) or bond risk premia (models 5 and 8), plausibly reflecting omitted variable bias from excluding the statistically significant impacts of asset transfer costs and risk premia on velocity..

Within the set of models that include all three long-run determinants of velocity (1, 2, 3, 6, and 7), the coefficients on conventional opportunity costs, stock fund loads and corporate-Treasury yields spreads are very similar. We conclude that our baseline specification is robust to

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both whether it is estimated over a pre-crisis or post-crisis sample and to whether it includes short-run variables that control for unusual financial/regulatory/regime shocks (*BankHoliday*, *DumAccord*, *DMMDA*, and *DFA*) or a deflation (*DeflationPCE*).

Among the models that include a full set of short-run controls and are estimated over the full sample (1, 4, 5), model 1 outperforms models 4 and 5—which omit stock fund loads—in several dimensions. First, in model 1, the coefficient on *OC* is highly significant at the 99 percent confidence level and its estimated value is similar in size to the estimated values in models 2 and 3. The estimated coefficients in models 4 and 5 are not statistically significant. Second, the error-correction coefficient for model 1 is about three times as large as that for models 4 and 5. The coefficient estimate for model 1 implies that the current year change in velocity tends to remove 32 percent of the gap between actual and equilibrium velocity from the prior year. Hence, the discrepancy between actual velocity, V2, and its estimated equilibrium level, V2*, is largely eliminated in a plausible three-year time span rather than the implausibly long ten year spans suggested by models 4 and 5. Third, the fit of model 1 is higher than that of models 4 and 5, judged by the corrected R^2. This reflects information from stock fund loads (and compared to model 5, also from corporate bond spreads) coming through the error-correction term and lagged first differences. As illustrated earlier in Figure 3, the implied equilibrium level of velocity from model 1 tracks actual velocity well, particularly if the path is adjusted for the medium-run effects of WWII and the post-DFA financial regulatory regime. Similar qualitative results were obtained when velocity is defined using GDI instead of GDP in models 7 and 8, which correspond to Models 1 and 5, respectively.

The short-run variables, other than the WWII controls and lagged first difference terms of long-run vector variables, serve several roles. Two control for the short-run influences of money

opportunity costs vis-à-vis stocks (*OCST*) and long-run Treasury bonds (*YC*), as suggested by Friedman and Schwartz. Because their inclusion helps complete the specification's coverage of major substitution effects, they are included in all models. The variable tracking opportunity costs with respect to stocks (*OCST*) is highly significant in every regression, with higher values raising velocity via lowering money demand. The opportunity cost term tracking the Treasury yield curve slope, YC, has the expected positive sign, but is insignificant in seven of eight models, and is only marginally significant in the remaining model. In contrast, *DeflationPCE* which tracks deflationary episodes is highly significant with a negative estimated effect of minus 4 to 5 percent. Together with the significant impact of the conventional opportunity cost term, this finding is consistent with view that price changes influence money demand in ways that are normally tracked by traditional opportunity cost measures but not during periods of deflation.

To control for a likely regime shift at the end of the sample, each full sample model includes the *DFA* to track how the Dodd-Frank Act has helped to shrink the relative size of the shadow banking sector (Duca, forthcoming) and indirectly boost the size of the banking sector that relies on M2 deposits for much of its funding. In other models that omit *DFA*, other estimated coefficients are similar, but serial correlation arises in the residuals. This likely reflects that the Dodd-Frank Act effectively has imparted a persistent upward shift in money demand (and a downward shift in velocity) by altering the architecture of financial intermediation.

The inclusion of the other short-run variables also helps address serial correlation in residuals without affecting long-run coefficients, but that arising from shorter-lived shocks. For example, while the long-run coefficients in models 1 and 3 are similar, the residuals are not clean for model 3, which omits several short-run variables included in model 1. Among these

variables are the dummy for the Bank Holiday of 1933 (*BankHoliday*), which has the expected positive sign and is statistically significant with a large sized estimated effect (6-12 percent) in most regressions. Another variable, *DMMDA*, which tracks the short-run effect of introducing MMDAs in late 1982 and early 1983 has the expected negative sign, and is marginally significant in most models that include it with a notably sized effect of about 5 percent (0.05 in a log specification). The variable for the short-run effect of the Treasury-Fed Accord (*DumAccord*) also has the expected negative effect on velocity, plausibly reflecting how it may have bolstered money demand by increasing Fed independence. Nevertheless, its effect is only significant and notably sized in models that include the corporate bond spread and stock mutual fund load series. Comparing models 1 and 3 indicates that inclusion of these four short-run variables jointly increases the corrected R-square by a sizable 6 percent, while eliminating short-run serial correlation at a lag length of two.

6. Simulating Nominal GDP After the Great Recession with Enhanced Velocity Models

An important aspect of our analysis is to address this question: When economic activity returns to more "normal" levels and risk premia revert to more normal levels, what growth of the broad money supply will be consistent with low, stable inflation? We emphasized above that the historical record with regard to answering this question is slight—the 2008 financial crisis has as its precedent the Great Depression of the 1930s—and the historical record muddied by the interaction between broad money's changing opportunity cost and the wide fluctuations of risk premia during periods of financial stress.

The macroeconomic significance of our in-sample results with regard to providing answers for this question might be assessed via simulations of velocity, thereby drawing out its implications for nominal GDP under different scenarios for M2 growth and under a common set

of assumed future values for key variables that affect velocity. Herein, for *BaaTR*, we used average Blue Chip Financial forecasts (from August 2014) of the Baa Corporate rate and Congressional Budget Office forecasts of 10-year Treasury yields for 2014 and 2015. We construct a *BaaTR* path through 2019 by assuming that BaaTR will fall 0.1 percentage points during that period, converging to its 1970-2006 average spread of 2.0 percent. For the yield curve spread, we used CBO forecasts of the 10 year Treasury yield and assumed that the 1-year Treasury rate would equal the average of a given year's 3-mo. Treasury bill rate and the average forecasted for the next year. We assumed that *OC* would rise 0.1 percentage points per year to level out at 0.4 points.

We use coefficient estimates from model 1 to construct a forecast of velocity from 2014-19 before adjusting for DFA effects. To adjust for the future impact of DFA implementation on the log level of velocity, we treated the year estimated coefficient on the DFA dummy (equal to .25 in 2010, 1 in 2011-2013, and 0 thereafter) as a current year impact factor, to which we added the prior year's estimated level effect multiplied by one minus the estimated error correction speed. By construction, we effectively assume a roughly 30 percent annual adjustment speed, which translates into a 3-1/4 year transition to a DFA regulated world. Essentially, DFA permanently lowers velocity by a sizable 0.17. The resulting path in Figure 12 shows a mild upturn in V2* during 2015 and 2016, before leveling off. Since V2 adjusts with a lag, this suggests an uptick in V2 in 2016 and 2017.

As a partial equilibrium simulation, we multiply this path for velocity by different paths for M2 under the assumptions of continued near 6.5 percent M2 growth through 2019, as well as for 5 and 4 percent growth paths. This produces levels of simulated nominal GDP, from which we compute simulated growth rate paths for nominal GDP. As shown in Figure 13, a 6.5 percent

**Figure 12: M2 Velocity Likely to Stabilize
According to Static Simulations**
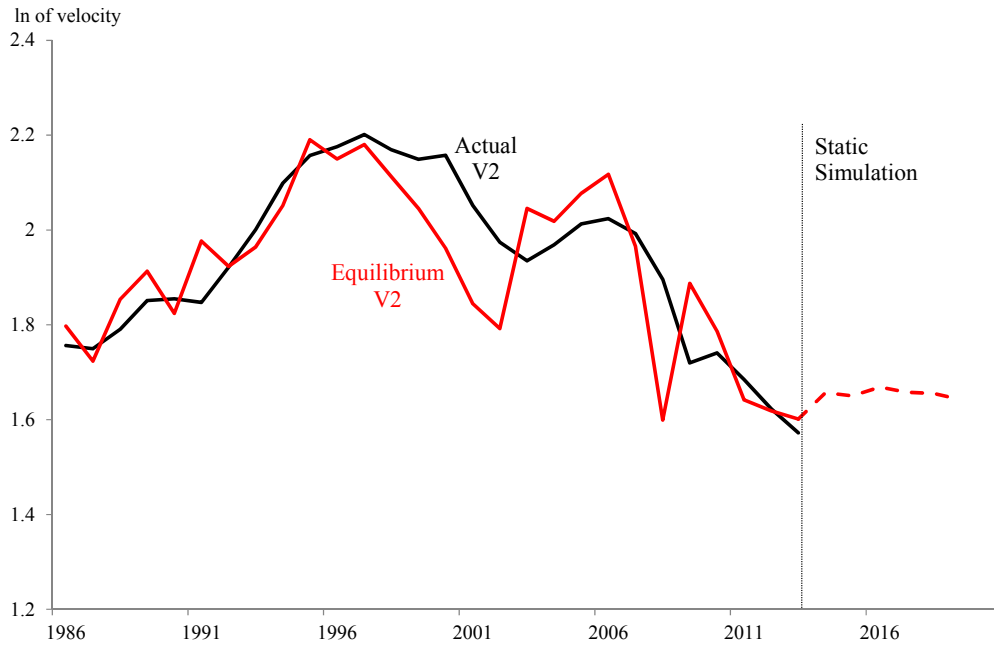
ln of velocity

**Figure 13: Nominal GDP Growth Paths
Under Different M2 Growth Scenarios**
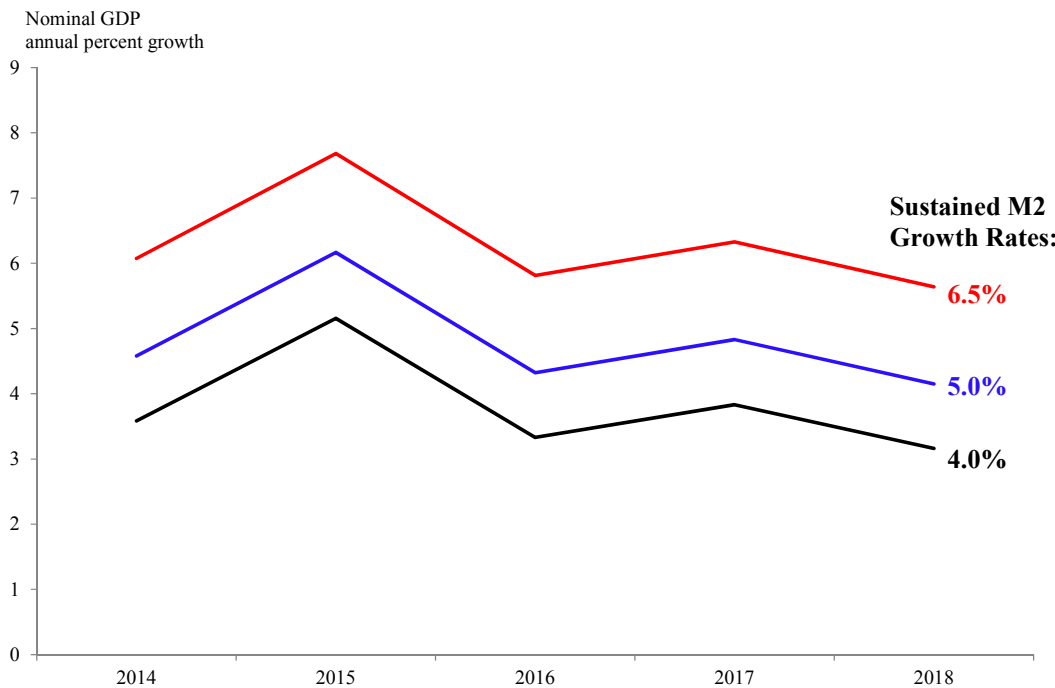
Nominal GDP
annual percent growth

Sustained M2
Growth Rates:

6.5%

5.0%

4.0%

M2 growth scenario induces about a 6 percent average path for nominal GDP over 2014-19, implying a mild acceleration of inflation. 5 percent M2 growth allows for enough near-term nominal GDP growth to enable a recovery to full employment, with about 2-½ percent inflation thereafter. Four percent M2 growth implies low-to-moderate nominal GDP growth, which is consistent with keeping long-run inflation at or just below 2 percent.

7. Conclusion

Our study constructs a straightforward model of U.S. broad money demand since the onset of the Great Depression to track velocity both during financial crises and in more orderly times. Our results stress the importance of incorporating implicit *interactions* among the levels of three variables: (i) the traditional opportunity cost of M2, (ii) long-run declines in the transaction costs of using M2 substitutes, and (iii) a measure of financial market participants' perceived risk. All three variables are economically and statistically significant in our long-run model. Because all three are covariance non-stationary and mutually correlated, omitting any from the model causes an implicit nonstationary disturbance and inconsistent parameter estimates. We conjecture that past "velocity shifts" and cases of "missing M2" are statistical consequences of such miss-specification that arises from not fully accounting for the major determinants of money demand.

Our estimated dynamic model tracks velocity well over the long time period spanning the two major U.S. financial crises of the past century. By so doing, it suggests that the path of a broad monetary aggregate contains information important to the task of conducting monetary policy. Models that accurately track M2 velocity are particularly valuable to policymaking not only during financial crises, but also during the periods of recovery that follow crises. During such periods, economic activity is returning to normal but velocity also is increasing as risk premia fall from their crisis peaks. This is particularly relevant in comparing the Great

Depression and the Great Recession. The starts of these crisis periods were marked by sharp increases in risk premia and falls in velocity, with recoveries in velocity when flights to money *started* to unwind. One difference is that recovery in velocity after the Great Recession ended was offset by the impact of the Dodd-Frank Act, which induced shifts into money from other assets by altering the structure of the U.S. banking and financial system, consistent with Bordo and Jonung (1987, 1990, 2004) and Duca (2014). As illustrated in Figure 2, our model estimates indicate that in a counterfactual scenario, velocity would have recovered much as it did in the Depression absent the impact of Dodd-Frank in shifting the provision of credit and money creation back into the formal banking system.

The average 6.5 percent growth in M2 since the financial crisis started in 2007-08 did not translate into moderately strong nominal GDP growth because financial reform and risk premia effects worked to increase money demand and lower velocity. The estimated speeds of adjustment in our preferred model strongly suggest that further velocity declines from the Dodd-Frank act are *not* likely to continue. Indeed, simulations based on our model estimates indicate that velocity is likely to rise toward a somewhat higher equilibrium level in coming years.

Preliminary simulations of our model suggest that the combination of an increasing equilibrium level of velocity and M2 growth of 6-7 percent per year may lead to inflation rising above 2% per year. As a result, policymakers may face the challenge of moderating M2 growth to a pace consistent with the FOMC's inflation objective—even while velocity increases toward a new equilibrium.

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Appendix A: Mutual Fund Data

Because data before the mid-1980s are sketchy and incomplete, mutual fund cots were based on a sample of large mutual funds. Funds were selected if their assets were at least $1 billion at year-end 1991 if the fund existed before the mid-1980s; were at least $2 billion at year-end 1994 if the fund's inception date occurred after 1983; were at least $5 billion at year-end 2003; or were at least $250 million at year-end 1975. The first criterion reflects whether a fund was sizable during early missing M2 period of the early 1990s. The second criterion reflects whether a growing but new fund was large near the end of the missing M2 period. The third criterion reflects whether a fund remained large following the stock market bust of the early 2000s. Given the stock and bond appreciation of the early 1990s, the hurdles for newer funds were higher for the 1994 and 2003 cutoff dates to keep data gathering costs from exploding. The fourth criterion avoids excluding funds that were relatively large in 1975 from distorting averages when fewer funds existed. Also excluded were funds that were closed-end, only open to employees of a specific firm, or institutional. Also omitted are funds with high minimum balances (100,000 or more) because such high hurdles make such funds poor substitutes for M2, which is predominantly held by middle income households. 46 non-municipal bond and 133 equity mutual funds are in the sample (a list is available from the author) using data from the funds and various issues of Morningstar, IBC/Donoghue, and CDA/Wiesenberger (a, b). The aggregate load series are based on using the size of net assets under management of a fund relative to the sum of all assets managed by funds in the sample. Year-end asset data are available since 1946.

For each year over 1926-45 we proxied asset weights on each fund by its 1946 asset weight divided by the sum of all 1946 asset weights for funds that in operation after the year of

their inception. For the years before and during a fund's inception its 1946 weight is replaced by zero. These proxied asset weights are combined with front-end loads levied by the funds (there were no funds charging deferred or back-end loads until the 1980s). Since most funds operating before 1946 charged loads between 6.5 and 8.5 percent, with the largest fund (Massachussetts Investors Trust) levying 7.5 percent, the annual weighted average load series SLD1 fluctuated in a narrow range between 7.5 and 7.8 percent over 1926-45, much as it did over 1946-1959. This suggests that the use of proxied annual asset weights before 1946 had a minimal effect on the resulting annual aggregate series. Annual expense ratios before 1946 were not available and pre-1945 expense ratios were assumed to equal their 1946 levels. As with the load series, the annual average expense ratios for 1926-45 were similar to those seen over 1946-59.   Moreover, the analysis focuses on using the load series without expense ratio adjustments—as it performed better than an expense-adjusted series, consistent with the non-adjusted series entering the money demand (velocity) specifications mainly as a proxy for asset transfer costs.

Appendix B: Historical Own Rates of Return on M2 and M2 Opportunity Costs

Conventional measures of the opportunity cost of M2 equal an average "own rate" of return on M2 minus a risk-free short-term interest rate. For the latter we spliced 1927-33 data on the average short-term (three to six months) Treasury interest rate (NBER MacroHistory DataBase) with the three month Treasury interest rate converted from a discount basis (360 days per year) to a 365 day basis. Consistent measures of the own rate of return on M2 are available from 1958 to present (source: Federal Reserve Bank of St. Louis), necessitating the construction of earlier readings. Pre-1958 readings equal the non-currency share of M2 multiplied by the average interest rate paid on deposits at financial intermediaries (banks, S&Ls, credit unions and mutual savings banks), which in turn equals the deposit-weighted average interest rate paid on demand and time deposits.

Average Interest Rates on M2 Balances

Prior to the Federal Reserve's September 1933 implementation of the Banking Act of 1933 banks were allowed to pay interest on the demand deposits and between 1933 and 1939, there were a small and declining number of grandfathered account balances which could offer the interest. Note that the distinction between demand and time deposits was more ambiguous in the 1930s than in more recent decades because it was not until the mid-1930s that the Federal Reserve started imposing different reserve requirement ratios on the two deposit types. Hence the distinction between M1 and nonM1 M2 deposits was less clear-cut and this measurement issue was among the reasons Friedman and Schwartz preferred M2 over M1. Using data from active (i.e., not suspended) national bank mid-year reports to the OCC, the average annual interest rate on demand deposits equaled the total interest paid over the prior 12 months on

demand deposits divided by average of mid-year demand deposit balances for years t and t-1. This average rate fell from a peak of 1.21 percent in 1929 to 0.01 in 1938 and 0 thereafter.

The average annual interest rate on time deposits equaled the total interest paid over the prior 12 months on time deposits divided by the mid-year total of time deposits using national bank mid-year reports to the OCC until 1939, and from 1940-58 the average time deposit rate equaled the December reported annual total of interest paid divided by the average deposit level for that year—approximated by the average of the year t and t-1 December deposit balances. Thrift institutions (mutual savings banks, savings and loans, and credit unions) typically offered either a common share or several time deposit accounts, which typically offered somewhat higher interest rates on what are typically classified as time or savings deposits. The interest rate on share deposits at mutual savings banks (MSBs), for example, typically exceeded the average time deposit rate paid at commercial banks using interest rate data at MSBs available before 1930 and after 1945. For this reason, our measure of time deposit rates and the average own rate on M2 (available using published data from the OCC up to 1964), while consistently measured over time for national (commercial) banks, likely understates what a more ideal and comprehensive series spanning commercial banks and thrift institutions, such as that from the Federal Reserve System.

Consistent with this view, overlapping data for the period 1959-61 indicate that our pre-1958 measure understated M2 own rates by between 0.27 and 0.29 percentage points. To splice the two series, we add the 28 basis point average gap between them for 1959-61 to the pre-1958 raw average M2 yields. The resulting series is plotted in Figure 3. As a check on the splicing, we recalculated the average own rate on M2 using the balance-weighted average yield on currency, commercial (national bank) and thrifts using annually data on weights and 1929-32

and 1945-61 published data on MSB average share interest rates. The two series are plotted in Appendix Table A1. The resulting difference between this series and official Federal Reserve estimates for the 1959-61 overlap years were between 0.01 and 0.03 percentage points, implying that the splice is reasonable. In addition, the difference between the spliced and MSB-based series was about 0 between 1927 and 1930 and 1956-61, with the MSB series understating the spliced series by between 0.01 and 0.15 percentage points. Because MSB interest rate data are unavailable for 1933-45 and do not fully reflect interest rates offered at other types of thrift institutions, we use the spliced series in Figure 1 as the own rate on M2.

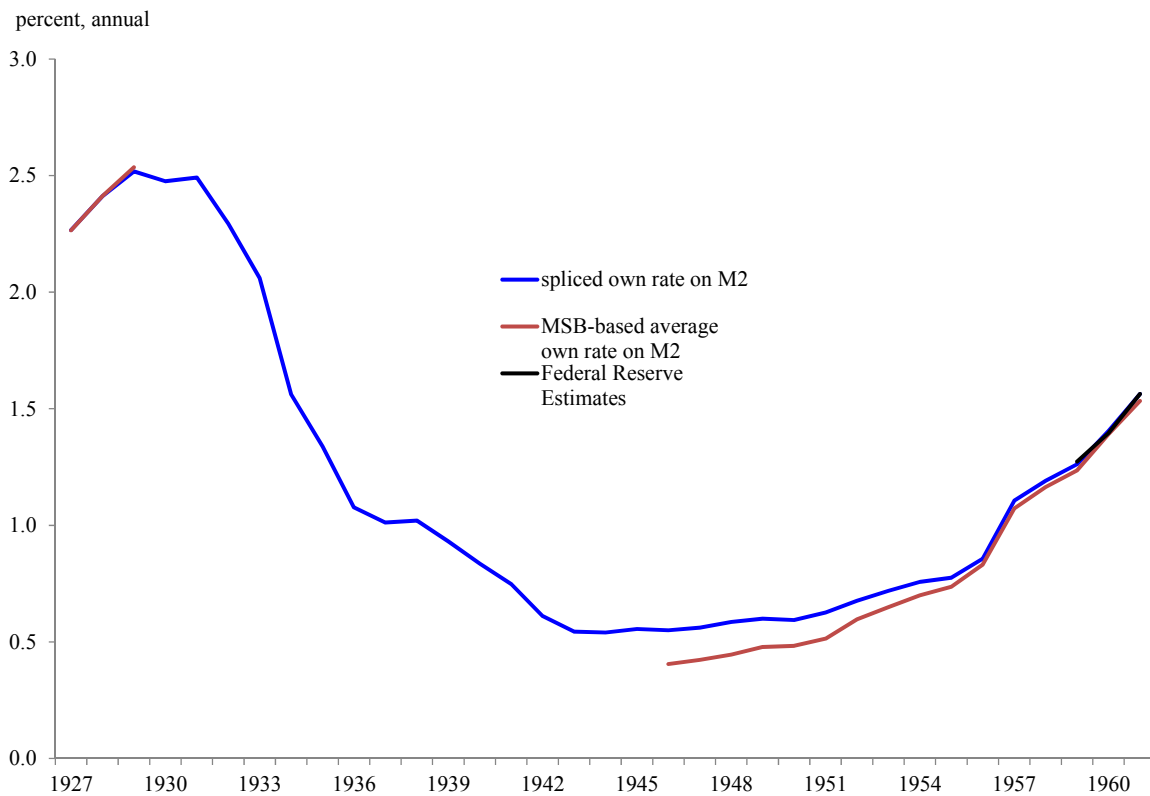**Figure B1: Weighted Average (Own) Interest Rate Paid on M2 Balances**

Table 1: Augmented Dickey-Fuller statistics

Variable	m	Δm	p	Δp	y	Δy
Specification	Constant Trend		Constant Trend		Constant Trend	
Longest Lag	0	1	0	1	0	1
ADF t-value	-2.52	-2.72	-3.31	-6.07	-2.48	-3.36
c.v. 5%	-3.46	-1.94	-3.46	-2.89	-3.46	-1.94
c.v. 1%	-4.06	-2.59	-4.06	-3.51	-4.06	-2.59

Variable	v	Δv	M2OC	ΔM2OC	ln(SLoad)	Δln(Sload)
Specification	Constant Trend		Constant Trend		Constant Trend	
Longest Lag	0	1	0	1	0	1
ADF t-value	-1.60	-6.62	-2.84	-8.74	-1.89	-2.71
c.v. 5%	-3.46	-1.94	-3.46	-1.94	-3.46	-1.94
c.v. 1%	-4.06	-2.59	-4.06	-2.59	-4.06	-2.59

Variable	Baa	ΔBaa	Treasury Yield Long (TR)	ΔTreasury yield Long	ln(Baa-TR Long)	Δln(Baa-TR long)
Specification	Constant Trend		Constant Trend		Constant Trend	
Longest Lag	0	1	0	1	0	1
ADF t-value	-1.10	-6.56	-1.23	-7.44	-2.65	-8.84
c.v. 5%	-3.46	-1.94	-3.46	-1.94	-3.46	-1.94
c.v. 1%	-4.06	-2.59	-4.06	-2.59	-4.06	-2.59

Variable	M2 Own Rate	ΔM2 Own Rate	Treasury Yield Short	ΔTreasury Yield Short	m-p	Δ(m-p)
Specification	Constant Trend		Constant Trend		Constant Trend	
Longest Lag	0	1	0	1	0	1
ADF t-value	-0.87	-6.57	-1.60	-7.88	-1.79	-4.23
c.v. 5%	-3.46	-1.94	-3.46	-1.94	-3.46	-1.94
c.v. 1%	-4.06	-2.59	-4.06	-2.59	-4.06	-2.59

Variable	OCST	YC	ΔYC
Specification	Constant Trend	Constant Trend	
Longest Lag	0	0	1
ADF t-value	-9.06	-4.07	-7.76
c.v. 5%	-3.46	-3.46	-1.94
c.v. 1%	-4.06	-4.06	-2.59

Notes:

Levels variables are in logs. Interest rate variables are in levels except SLoad. m=M2, p=GDP price deflator, y=GDP, v=velocity of M2, TR=average yield on long-term (10-year) Treasury securities, M2OC=M2own rate minus short-term Treasury rate, Sload=equity mutual fund front-end load, Baa=Moody's Baa bond yield, OCST=opportunity cost of M2 relative to stock returns, YC=yield curve slope equal to yield on long Treasury minus yield on short Treasury

Table 2: Vector Error Correction Models of Log M2's Velocity

Long-Run Equilibrium: $\ln V2_t = \alpha_0 + \alpha_1 OC_t + \alpha_2 \ln SLoad_t + \alpha_3 \ln BaaTR_t + \mu_t$ <u>GDI replaces GDP</u>

Model No.	1	2	3	4	5	6	7	8
<u>Variables</u>	1932-2013	1932-2006	1932-2013	1932-2013	1932-2013	1932-1998	1932-2013	1932-2013
Constant	0.854	0.854	0.850	0.542	0.491	0.870	0.846	0.436
OC_t	0.033**	0.033**	0.032*	0.022	0.042	0.025+	0.027**	0.031
	(3.54)	(3.20)	(2.59)	(0.66)	(1.44)	(1.78)	(2.93)	(0.98)
$\ln SLoad_t$	-0.183**	-0.186**	-0.175**			-0.187**	-0.181**	
	(11.37)	(9.35)	(8.11)			(2.86)	(10.99)	
$\ln BaaTR_t$	-0.091**	-0.094**	-0.105**	-0.053		-0.091**	-0.077*	
	(3.88)	(3.68)	(3.36)	(0.53)		(2.75)	(3.15)	
unique coint.	Yes*	Yes**	Yes**	No	Yes*	Yes	Yes*	Yes*
trace no vec.	84.03**	73.71**	65.40*	23.41	17.44	70.74**	87.70**	15.57
trace only 1	23.28	20.23	25.18	4.80	1.29	26.99	23.21	3.84

Short-Run: $\Delta V2_t = \beta_0 + \beta_1 EC_{t-1} + \Sigma\beta_{2i}\Delta OC_{t-i} + \Sigma\beta_{3i}\Delta SLoad_{t-i} + \Sigma\beta_{4i}\Delta BaaTR_{t-i} + Other\ S\text{-}Run\ Factors_t + \varepsilon_t$

	1	2	3	4	5	6	7	8
$EC_{t-1,}$	-0.315**	-0.316**	-0.281**	-0.096**	-0.102**	-0.288**	-0.312**	-0.076**
'adjust.speed'	(5.31)	(4.98)	(4.68)	(3.61)	(3.37)	(4.65)	(5.68)	(4.19)
$OCST_{t-1}$ x 100	-0.073**	-0.073**	-0.084**	-0.077**	-0.084**	-0.082**	-0.063**	-0.076**
	(3.85)	(3.62)	(4.19)	(3.92)	(4.71)	(3.68)	(3.34)	(4.19)
YC_{t-1} x 100	0.512	0.600	0.280	0.762+	0.519	0.167	0.230	0.350
	(1.21)	(1.30)	(0.66)	(1.70)	(1.22)	(0.33)	(0.55)	(0.81)
$BankHoliday_t$	0.077*	0.065+		0.073*	0.096**	0.046	0.065*	0.119**
	(2.42)	(1.85)		(2.14)	(3.05)	(1.29)	(2.18)	(3.85)
$DeflationPCE_t$	-0.047**	-0.047**		-0.049**	-0.043**	-0.042**	-0.052**	-0.042**
	(3.29)	(3.01)		(3.32)	(3.19)	(2.63)	(3.73)	(3.00)
$DumAccord_t$	-0.053*	-0.049+		-0.040	-0.032	-0.055+	-0.061*	-0.041
	(2.01)	(1.79)		(1.71)	(1.15)	(1.95)	(2.33)	(1.42)
$DMMDA_t$	-0.034	-0.031		-0.046+	-0.046+	-0.050+	-0.051+	-0.046+
	(1.21)	(1.05)		(1.67)	(1.72)	(1.79)	(1.94)	(1.66)
DFA_t	-0.077**		-0.073**	-0.044**	-0.047**		-0.040*	
	(4.90)		(4.39)	(2.70)	(2.87)		(2.40)	
$Dum1941_t$	0.086**	0.085**	0.095**	0.094**	0.087*	0.090**	0.082**	0.084**
	(3.46)	(3.19)	(3.51)	(3.43)	(3.23)	(3.37)	(3.33)	(2.87)
$Dum1942_t$	0.105**	0.108**	0.124**	0.082**	0.108**	0.103**	0.107**	0.116**
	(3.72)	(3.61)	(4.08)	(2.74)	(3.90)	(3.50)	(3.89)	(3.95)
$Dum1943_t$	-0.038	-0.036	-0.017	-0.067*	-0.060*	-0.041	-0.043+	-0.057+
	(1.44)	(1.31)	(0.62)	(2.42)	(2.19)	(1.54)	(1.63)	(1.93)
$Dum1944_t$	-0.061*	-0.062*	-0.058*	-0.070*	-0.078**	-0.058*	-0.075**	-0.095**
	(2.43)	(2.36)	(2.09)	(2.55)	(2.90)	(2.23)	(3.01)	(3.33)
$Dum1945_t$	-0.170**	-0.173**	-0.176**	-0.167**	-0.181**	-0.165**	-0.167**	-0.188**
	(6.49)	(6.26)	(6.11)	(5.81)	(6.48)	(6.07)	(6.25)	(6.15)
$Dum1946_t$	-0.092**	-0.098**	-0.116**	-0.070+	-0.082*	-0.099**	-0.082*	-0.082*
	(2.75)	(2.68)	(3.25)	(1.98)	(2.31)	(2.74)	(2.52)	(2.12)

Adj. R^2	0.754	0.724	0.698	0.705	0.697	0.752	0.753	0.680
S.E. x 100	2.157	2.275	2.392	2.365	2.395	2.203	2.297	2.517
VEC Auto (1)	12.86	14.54	16.52	6.74	4.39	9.87	13.76	3.46
VEC Auto (2)	26.03	23.74	32.40[**]	12.02	4.96	20.52	21.29	3.75
VEC Auto (4)	17.99	17.60	16.30	5.62	4.18	15.62	13.89	4.41

Notes: (i) Absolute t-statistics are in parentheses. [**]([*]) denotes significant at the 99% (95%) confidence level. VECLM significance levels vary
 with the size of the cointegrating vector.

(ii) Long-run: Maximum likelihood estimates of the long-run equilibrium relationship:

 $\ln V2_t = \alpha_0 + \alpha_1 OC_t + \alpha_2 \ln SLoad_t + \alpha_3 \ln BaaTR_t$
$+ \mu_t$ using a four equation system with (at most) one cointegrating vector.

(iii) Short-run: OLS estimates of the speed of adjustment and short-run dynamics using the estimated equilibrium correction terms in (ii),

$EC_{t-1} = CapRate_{t-1} - \alpha_0 - \alpha_1 OC_{t-1} - \alpha_2 \ln SLoad_{t-1} - \alpha_3 \ln BaaTR_{t-1}$

(iv) Lagged first difference terms of elements in the long-run cointegrating vector and the constant in the short-run model are omitted to conserve space.

(v) Lag lengths chosen to obtain unique significant vectors with sensible coefficients and clean residuals. Equal to 4 in all models.

(vi) Augmented Dickey Fuller (ADF) unit root tests statistics are below. The data used cover 1996q1 to 2013q4. The lag lengths in the ADF regressions, which included a constant, were selected based on the SIC.