Short-term Debt and Financial Crises: What we can learn from U.S. Treasury Supply*

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Abstract

We present a theory in which the key driver of short-term debt issued by the financial sector is the portfolio demand for safe and liquid assets by the non-financial sector. This demand drives a premium on safe and liquid assets that the financial sector exploits by owning risky and illiquid assets and writing safe and liquid claims against those. The central prediction of the theory is that government debt (in practice this is predominantly Treasuries) should *crowd out* the net supply of privately issued short-term debt (the private supply of short-term safe and liquid debt, net of the financial sector's holdings of Treasuries, reserves and currency). We verify this prediction in U.S. data from 1914 to 2011. We take a series of approaches to address potential endogeneity concerns and omitted variables issues: Testing additional predictions of the model (notably that checking deposits should be *crowded in* by government debt supply), including controls for the business cycle, exploiting a demand shock for safe/liquid assets, and exploring the impact of government supply on the composition of consumption expenditures. We also show that accounting for the impact of Treasury supply on bank money results in a stable estimate for money demand and can help resolve the "missing money" puzzle of the post-1980 period. Finally, we show that short-term debt issued by the financial sector predicts financial crises better than standard measures such as private credit/GDP.

JEL Codes: G12, G2, E44

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1 Introduction

There is a great deal of short-term debt in the economy. Much of this debt is issued by banks and other financial intermediaries. Banks take deposits. Finance companies issue commercial paper. Broker-dealers and hedge funds borrow by issuing repurchase agreements. The process of securitization throws off short-term debt tranches. Even non-financial firms borrow using short-term debt, for example, when such firms issue commercial paper. As is now widely appreciated, the funding structures of financial firms play a role in amplifying financial crises, and there has been much interest in understanding the factors driving the prevalence of short-term debt in the financial sectors' capital structure. For example, our data suggests that the short-term debt issued by the private sector (what we refer to as net private supply, below), as a ratio to GDP, reached a peak of 99 percent in 2007. This number compares to an average ratio of short-term debt to GDP over the period from 1914 to 2011 of about 66 percent.[1]

Why is there so much short-term debt in the economy? It is an important fact that banks, across many countries and throughout history, have borrowed predominantly via short-term debt. This fact holds across many different tax regimes. Thus, an explanation relying on the favorable tax treatment of debt cannot be the first-order reason for the predominance of debt. The fact also holds across many different regulatory regimes. For example, during the free banking period of the US in the 19th century, there was no insurance on bank deposits (or lender of last resort) and yet banks carried high leverage. An explanation that relies on government insurance on bank deposits also cannot be the first-order reason for banks' reliance on short-term debt. See Gorton (2012), and references therein, on the history of short-term debt and banking.

This paper provides evidence for a more primitive rationale for the prevalence of short-term debt, one that plausibly holds across many countries and histories. We show that investors have a large demand for safe and liquid investments, and that short-term debt satisfies this demand. Investors' demand translates into low yields on short-term debt that is safe and liquid. The financial sector supplies such debt by holding positions in other risky assets (loans, securities, etc.) that is funded by short-term debt. The corporate sector, particularly the high-grade segment, also satisfies this demand by issuing commercial paper. Our evidence supports standard theories of banking that emphasize the special role of banks in transforming risky, illiquid assets into safe and liquid assets (Gorton and Pennacchi (1990), Diamond and Dybvig (1983), and Dang, Gorton and Holmstrom (2010)). The evidence is also consistent with the idea that the shadow banking system played an important role in the production of safe and liquid assets over the last decade (Gorton, Lewellen, and Metrick, 2012).

To arrive at these results, we exploit variation in the supply of government securities. In Krishnamurthy and Vissing-Jorgensen (2012) we showed that Treasury bonds are "money-like" in many respects. We established this by showing that reductions in the supply of Treasury bonds lower the yield on Treasury

[1] We start our empirical analysis in 1914, the first year following the creation of the Federal Reserve System.

bonds relative to corporate securities that are less liquid and more risky than Treasury bonds, controlling for the default component of the corporate securities. Section 2 below reviews this evidence and extends it to show that results are similar if Treasury yields are replaced with the interest rate on bank accounts (time and savings deposits), suggesting that bank accounts (a large fraction of the financial sector's short-term debt) share the safety/liquidity features of Treasuries. Given that, section 3 offers a theoretical equilibrium model to explain how changes in Treasury supply can be expected to affect financial sector short-term debt quantities if both satisfy the safety/liquidity demand of the non-financial sector. The main implication is that Treasury supply should crowd out financial sector short-term debt because the reduction in the yield spreads between risky/illiquid asset and safe/liquid asset brought about by an increase in Treasury supply makes it less profitable for banks to take in deposits in order to invest in riskier, less liquid assets.

To test this main prediction, we construct the supply of government securities, defined as the net supply of Treasuries, reserves and currency by the U.S. Treasury and Federal Reserve (i.e. we subtract out the Federal Reserve's Treasury holdings from total supply of Treasuries) and study the relation between this government net supply variable and the net private supply of short-term debt. The latter variable is the total of all short-term debt issued by the financial sector net of the financial sector's holdings of Treasuries, reserves, and currency (and net of any short-term assets but these are tiny in practice). We show that the private net supply variable is strongly negatively correlated with the government net supply. This result, together with the result on the impact of Treasury supply on yield spreads between bank accounts relative to corporate securities, suggests that financial sector short-term debt is special and that the financial sector issues such debt in large part to satisfy the special demand for safe/liquid debt. Moreover, we show that reductions in government supply are correlated with increases in financial sector risky/illiquid loans. The picture that emerges from the data is that of a financial sector that is active in transforming risky/illiquid loans into liquid/low-risk liabilities.

These results are reminiscent of results from a large and older money demand literature. That is, our evidence suggests that financial sector debt is "money-like." However, the money-demand literature has given prominence to the liquidity features of a certain class of bank liabilities, namely liquid debt such as checking accounts at banks (included in M1). We instead focus on financial sector short-term debt in general. Nonetheless, it is useful to think about different components of financial sector short-term debt because it allows us to derive a second prediction of our framework. A special characteristic of checking accounts is that financial institutions typically back a lot of checking accounts by holdings of Treasuries, likely due to the liquidity properties of Treasuries. We show theoretically that this implies that checking accounts (and thus a standard liquidity aggregate such as M1) should be crowded *in* by government supply. We show that this holds up in the data, even if one controls for the standard arguments in a money demand function, i.e. the nominal interest rate and income. The effect of Treasury bond supply on M1 has not been recognized thus far in the literature. We show that accounting for such a relation can help reconcile some of the puzzling behavior in monetary aggregates since the 1980s (the “missing money” puzzle and the instability of money demand relations). The combined evidence that government supply crowd out the private sector’s net supply of short-term debt but crowds in liquid deposits emphasizes the need for careful analysis of the various components of banks’ balance sheets both theoretically and empirically.

An obvious concern with our results is that they may not be causal and instead driven by either omitted variables or reverse causality. US Treasury supply is driven mainly by wars and the business cycle, and these factors may independently affect the financial sector’s use of short-term debt and the financial sector’s lending to the non-financial sector. For example, if loan demand and the budget deficit had opposite cyclicalities, that could perhaps explain the negative relation between short-term debt (or bank lending) and US Treasury supply. Furthermore, financial sector debt and lending may drive Treasury supply via a banking crisis causing a recession and thus a budget deficit. To address these concerns we take a series of different approaches.

First, one of the main objectives of writing down a model is that we show that some types of short-term debt should be crowded out by government supply while others should be crowded in. It is hard to think of an omitted variables/reverse causality story which would explain this.

Second, we show that the negative relation between financial sector net short-term debt and government supply is unaffected by controlling for recent GDP growth. Essentially that is because government supply has little systematic cyclicality. It increases during recessions but also during wars which (in US history) are expansionary. Furthermore, our main relation is robust to dropping the most problematic years with respect to reverse causality, namely those following financial crisis.

Third, we show that consistent with the model, a positive demand shock for safe/liquid assets has the opposite impact on the financial sector’s net supply of short-term debt. The shock we exploit is the dramatic increase in foreign holdings of Treasuries since the early 1970s. It is hard to think of a story in which the US trade deficits that underlie this build-up of foreign Treasury holdings would also cause an increase in US short-term debt (if anything one would expect the opposite as corporate loan demand in the US would decline as more is produced abroad).

Fourth, we examine the composition of household expenditures. Our model implies that reductions in Treasury supply expand the supply of bank lending. In this scenario, the effective cost (where cost includes financing costs) of goods purchased on credit will fall, leading the expenditure share of such goods to rise. We define goods often purchased on credit to be NIPA categories ”Durable goods” plus ”Housing and Utilities”. We examine this prediction using a widely accepted model of household budget shares, Deaton and Muellbauer’s (1980) almost linear demand system, and confirm the negative relation between Treasury supply and the expenditure share on credit goods. The attractive feature of studying budget shares (as opposed to simply linking bank balance sheets to government supply) is that omitted variables become much less of an issue when estimating a relation for which there is a standard generally agreed upon framework for which variables should enter as explanatory variables – in this case relative prices and log total real expenditure. This approach resembles that of Rajan and Zingales (1998) who compared the impact of financial development on the relative growth rate of industries who have different dependence on external finance in order to identify the impact of financial development on growth.

Our last set of results concern predicting financial crises. There is a growing literature that argues that private credit growth, notably growth in bank loans, is a strong predictor of financial crises. Under our banking view, the risk of a financial crisis is primarily driven by the mismatch between the illiquidity/risk of the financial sectors' assets and liabilities. That is, for predicting crises, it is not loan growth per-se that is important but rather loan growth that is funded by short-term debt. We use our measure of the net private short-term debt supply to predict crises in the U.S. and show that it has more explanatory power than ones based only on loan growth.

The next section of the paper reviews and expands evidence on the impact of Treasury supply on interest rates. Then we lay out a model for understanding the relations between Treasury supply, private demand for short-term liquid and safe debt, and the private supplies of such debt. We then describe how we empirically measure government supply and the private supply variables suggested by the model. Finally, we present our empirical results linking net government supply, private supply, and financial crises. All figures and tables appear at the end of the paper.

2 Price evidence on the moneyness of Treasury bonds and bank accounts

Figure 1 is from Krishnamurthy and Vissing-Jorgensen (2012). The figure graphs the yield spread between Aaa rated corporate bonds and Treasury securities against the US government Debt-to-GDP ratio (i.e. the ratio of the market value of publicly held US government debt to US GDP). The figure reflects a Treasury demand function, akin to a money demand function, that stems from investors' demand for the high liquidity and safety of Treasuries. We argue in that paper that investors value these money-like features of Treasuries so that when the supply of Treasuries is low, the value that investors assign to the liquidity and safety attributes offered by Treasuries is high. As a result the yield on Treasuries is low relative to the yield on the Aaa corporate bonds which offer less liquidity and safety. Here are the results from that paper which support these conclusions:

1. Table I of the paper shows that the coefficient in a regression of the Aaa-Treasury spread on the log of the Debt-to-GDP ratio, controlling for default risk and default risk premia, is -0.80 ($t-stat = -5.12$).

Using the Baa-Treasury spread (since Aaa bonds may themselves have some safety properties), the coefficient is -1.31 ($t - stat = -7.55$).

2. Table I also shows that the coefficient in the regression of short-term commercial paper rates minus Treasury bill rates (high-grade CP minus Bills) on the log of the Debt-to-GDP ratio, after suitable controls, is -0.554 ($t - stat = -3.56$). Using the spread between lower-grade commercial paper and bills, the coefficient is -1.96 ($t - stat = -3.97$).

3. Moreover, we show that these effects are driven by investors' valuation of both the safety and liquidity of Treasury bonds. Table II, column (5), shows that a regression of the spread between 6-month FDIC insured bank CDs and Treasury bills, which is likely a pure measure of the liquidity premium on Treasury bonds, on the log of the Debt-to-GDP ratio, after suitable controls, gives a coefficient of -1.884 ($t - stat = -1.71$). Table II, column (4), shows that the regression of short-term low grade commercial paper rates minus high grade commercial paper rates (P2-P1 spread) on the log of the Debt-to-GDP ratio, after suitable controls, gives a coefficient of -0.888($t - stat = -4.34$). This spread measures the value of a safe short-term debt investment to investors because P2 rated commercial paper has much lower default risk than P1 rated paper, but has similar transactional liquidity.[2]

These effects are quantitatively significant. For example a one-standard deviation decrease in the debt-to-GDP ratio from its mean value of 0.44 to 0.24 increases the premium on Treasuries relative to Aaa bonds by 44 basis points. They are also hard to reconcile as an effect on a risk premium using standard CAPM or C-CAPM arguments, so that the liquidity/safety premium arguments we offer in Krishnamurthy and Vissing-Jorgensen (2012) are plausibly the most important factors driving these effects. For example, take the following CAPM logic for these effects. As a set of extreme assumptions to maximize the possible effects, suppose that the correlation between the excess return on Aaa bonds over Treasuries with the return on investors' overall wealth is one, and that households have no human capital. The risk premium component of the Aaa-Treasury spread is then $\sigma_{Aaa-Treas} \times \gamma \times \sigma_W$, where γ is the coefficient of relative risk aversion and σ_W is the volatility of the representative investors' wealth. Suppose that the volatility of wealth is given by $\sigma_W = (1-\alpha_T)\sigma_{risky} + \alpha_T\sigma_{Treasury}$, where α_T is the fraction of wealth that is Treasury bonds. Moreover, suppose that Treasury bonds are riskless so that $\sigma_{Treasury} = 0$, and hence $\sigma_W = (1 - \alpha_T)\sigma_{risky}$. Then, the

[2]The safety channel is not the same as the risk premium of a standard asset pricing model; it reflects a deviation due to clientele demand. One way to think about investor willingness to pay extra for assets with very low default risk, and to distinguish our explanation from a conventional asset pricing relation between default risk and risk premia, is to plot an asset's price against its expected default rate. We argue that this curve is very steep for low default rates, with a slope that flattens as the supply of Treasuries increases. This dependence of the price on the supply of long-term Treasuries is how Krishnamurthy and Vissing-Jorgensen (2010) distinguish a standard risk premium explanation of defaultable bond pricing with the clientele-driven safety demand.

risk premium on the Aaa-Treasury spread is $\sigma_{Aaa-Treas} \times \gamma \times (1-\alpha_T)\sigma_{risky}$. This model implies that increases in Treasury supply by increasing α_T will cause the risk premium to fall. However, quantitatively this effect is likely to be small. Here is a simple calibration. Suppose that $\gamma\sigma_{risky} = 0.4$ which is the Sharpe ratio on the market portfolio. Suppose that $\sigma_{Aaa-Treas}$ is equal to 2%, with the 2% chosen to give a risk premium on the Aaa-Treasury of 80 basis points, which is near the historical average level of this spread. Suppose that α_T is 18% which is approximately the ratio of Treasury supply to total net worth based on Flow of Funds numbers from 2011 (tables B.100 and L.209). Then if α_T falls from 17.6% to $17.6 \times (0.24/0.44) = 9.6\%$, the spread would rise by $\sigma_{Aaa-Treas} \times \gamma \times \sigma_{risky} \times \Delta\alpha_T = 200$ basis-points $\times 0.4 \times (0.176 - 0.096)$ which equals 8 basis points and is much smaller than our empirical finding of 44 basis points. Accounting for human capital and a correlation less than one would substantially reduce the effect to be even smaller than the 8 basis points.

The evidence thus suggests the investors have a special demand for liquid and safe assets and that Treasury bonds, because they possess these attributes, have lower yields. The next section of this paper offers an equilibrium model to reconcile this finding. The argument is that reductions in the supply of Treasury bonds reduce a broad aggregate of safe/liquid assets and, given a special demand for safe/liquid assets, reduce the yields on such assets. More interestingly, the model shows that reductions in Treasury supply should increase the supply of private sector assets that are safe/liquid substitutes because such assets also carry a lower yield. Under the hypothesis that financial sector debt is safe/liquid, the theory predicts that the financial sector should issue more safe/liquid debt when Treasury supply falls. This is the central testable implication of our theory that financial sector short-term debt is driven by a demand for safe/liquid assets not captured in standard asset pricing models. We will verify this quantity prediction in the data thus offering insights into to the determinants of the short-term debt funding of the financial sector and the risk of financial crises.

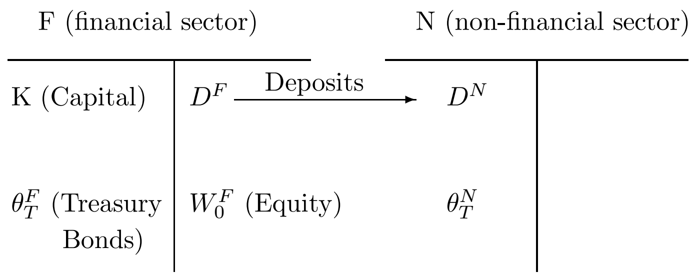
Before turning to the model and the evidence based on quantities it is helpful to first document based on price data that bank accounts share the safety/liquidity features of Treasuries. While it is uncontroversial that checking accounts must have special features (including transactions benefits) in order for them to attract customers despite paying interest rates equal to or close to zero, the same is not obvious for time and savings accounts. These constitute, as we will document in detail below, a larger share of the financial sector's short-term debt than do checking accounts. In Table 1 we therefore estimate regressions similar to those from Krishnamurthy and Vissing-Jorgensen (2012) but replacing Treasury yields by the interest rate on banks' time and savings accounts. We calculate the latter based on data from the FDIC's Historical Statistics on Banking web page. Specifically, we divide the total dollar interest paid on deposits in domestic offices by the dollar amount of time and savings deposits (we use the average of beginning of year and end of year amounts of deposits). We compare this interest rate on time and savings accounts to low-grade corporate bonds, either long Baa-rated corporate bonds or P1/P2 rated commercial paper. Both corporate yield series are the same as used in Krishnamurthy and Vissing-Jorgensen (2012). We use both a long and a short corporate benchmark since the typical duration of time and savings accounts is unclear. It is shorter than for the long bonds used in the Baa index (which have at least 20 year remaining maturity) and probably longer than for the typical commercial paper, but the exact duration is unclear. To further control for any duration mismatch the regressions include the slope of the yield curve as a control along with a measure of expected corporate default (Moody's EDF). For consistency with later tables in this paper we use the total government supply/GDP as the main explanatory variable (as detailed below this variable includes the impact of the Federal Reserve), but results are similar if we use Treasury supply/GDP. The regression coefficients of -1.53 and -1.25 are quite similar to those reported above based on yield spreads between corporate securities and Treasuries, suggesting that time and savings accounts are similar in their safety/liquidity features to Treasuries. This is essential for our test of what drives financial sector short-term debt supply to make sense.

3 Model

Time is indexed by $t = 0, 1$. The economy has two classes of agents. Type N agents have a demand for short-term debt while type F has no special debt demand. Furthermore, there is a financial sector that raises equity and debt, makes loans and holds government debt. Assume that type N agents are unsophisticated agents who do not hold bank equity but may hold bank debt, whereas type F agents are sophisticated investors who own all bank equity. In this model, the N agents then reflect the non-financial sector demanders of short-term debt. The F agents reflect the financial sector that supply such debt to the N agents. The modeling omits short-term debt demanders who may also be owners of bank equity.

The government issues Θ units of liquid assets, measured in face value and exogenous to the model.[3] We measure agent N and agent F's holdings (θ_T^N and θ_T^F) in units of face value. We solve for the endogenous determination of the financial sector's supply of short-term debt assets. The diagram below illustrates the relevant balance sheets which we explain in detail next.

[3]At this writing of the paper, we do not distinguish between short-term government debt and long-term government debt and treat Θ as the total value of all government debt. We intend to more fully explore the effects of government debt maturity in the next version. Greenwood, Hanson, and Stein (2012) have studied the effects of government maturity structure on financial sector risk within a theoretical model.



There is a unit measure of N-types who have a special demand for short-term debt. Each N agent maximizes utility function,

$$\max_{D^N,\theta_T^N} c_0^N + v\left(\frac{D^N}{1+r_D} + \frac{\theta_T^N}{1+r_T}\right) + D^N + \theta_T^N, \tag{1}$$

where r_D is the interest rate on deposits, r_T is the interest rate on government debt, and c_0^N is date 0 consumption. The agent purchases deposits and Treasury bonds which payoff $D^N + \theta_T^N$ at date 1 and offer an extra utility of $v(\cdot)$ (note that the discount rate is assumed to be zero). The function $v(\cdot)$ takes as argument the market value of debt assets. We assume that $v'(\cdot) > 0$ and that $v''(\cdot) < 0$. While we model the debt demand in reduced form, the literature has noted a number of possible rationales for a demand for short-term debt beyond its simple use for transfering resources to consume later. The money-demand literature motivates a role for checking deposits as a payment medium. The finance literature has motivated a desire for holding a liquid asset to meet unexpected consumption needs of households or unexpected production needs for firms. Krishnamurthy and Vissing-Jorgensen (2012) have shown that there is a demand from investors for "extremely safe" assets (above and beyond what can be rationalized by a CCAPM model) which may be satisfied by short-term financial sector debt as well as Treasury bonds. We first outline the model without taking a stand on the underlying driver of the demand. In the next section, we derive additional predictions of the model based on considerations of the demand for liquid assets.

Agent N's date 0 budget constraint is,

$$c_0^N + \left(\frac{D^N}{1+r_D} + \frac{\theta_T^N}{1+r_T}\right) = W_0^N.$$

The agent has an initial endowment of wealth W_0^N which we assume to be sufficiently large that in all equilibria we study the agent is able to set c_0^N strictly above zero.

F-types (financial sector) have no direct debt-demand. Their objective is to maximize,

$$U^F = E[W_1^F] - \frac{1}{2}Var[W_1^F], \tag{2}$$

given an initial endowment of wealth W_0^F. The F-types issue short-term debt to fund a capital investment that converts one unit of date 0 goods into $1+\tilde{r}$ units at date 1, where $\tilde{r}$ is a random variable and $E[\tilde{r}] = r_K > 0$. When taking the model to data, we interpret capital as lending by the financial sector to the private sector, which in practice is mainly banks' corporate loans and mortgage loans. We assume that only the F-types have access to this investment technology. Implicitly we have thus combined the bank with the corporate sector and assumed that banks own the housing stock and rent to households (one could add N-type utility from housing and rent payments to the bank without substantial changes in results).

F types issue debt of D^F, purchase Treasury bonds of θ_T^N, and invest in capital:

$$K + \frac{\theta_T^F}{1+r_T} = W_0^F + \frac{D^F}{1+r_D}.$$

This results in wealth at date 1 of,

$$W_1^F = (1+\tilde{r})K + \theta_T^F - D^F = (1+\tilde{r})W_0^F + \frac{D^F}{1+r_D}(\tilde{r} - r_D) - \frac{\theta_T^F}{1+r_T}(\tilde{r} - r_T) \tag{3}$$

We allow that W_1^F may be less than zero. That is we do not impose limited liability on the F-types who are the owners of the financial sector. We do this primarily for simplicity as it ensures that deposits are riskless. More realistically, a model could allow for limited liability and government insurance of deposits. This would introduce risk-shifting incentives as well as a need for government regulation of banks. While these issues are interesting, they do not directly touch on the subject of this paper and are moreover the subject of an extensive literature in banking.

We next solve for equilibrium. Note that D and θ enter the same way into both objective and constraints for both N and F. That is, deposits and Treasuries are perfect substitutes. This observation has two implications. First, r_D is equal to r_T. Second, the equilibrium only pins down net debt holdings of $D^N + \theta_T^N$ for N and $D^F - \theta_T^F$ for F. This is an important observation because it implies that when considering the short-term debt provided by the financial sector in the data it is important to net out financial sector holdings of Treasury bonds against issued short-term debt.

Consider N's problem in further detail. The first order condition for choosing $D^N + \theta_T^N$ is,

$$\frac{1}{1+r_D} = 1 + \frac{1}{1+r_D} v'\left(\frac{D^N + \theta_T^N}{1+r_D}\right)$$

or, rewriting:

$$-r_D = v'\left(\frac{D^N + \theta_T^N}{1+r_D}\right). \tag{4}$$

Deposits trade at a premium so that $r_D < 0$ (with a sufficiently positive discount rate, r_D would be positive but less than the discount rate). Equation (4) is a demand function for debt from N (i.e., $-r_D$ is the "convenience yield" cost of buying short-term debt and $\frac{D^N+\theta_T^N}{1+r_D}$ is the purchased amount of debt). Given our assumptions on $v(\cdot)$, the demand function is downward sloping.

F chooses the net debt supply, $D^F - \theta_T^F$, to solve,

$$\max_{D^F - \theta_T^F} E\left[(1+\tilde{r})W_0^F + \frac{D^F - \theta_T^F}{1+r_D}(\tilde{r} - r_D)\right] - \frac{1}{2}\left(W_0^F + \frac{D^F - \theta_T^F}{1+r_D}\right)^2 \sigma_r^2.$$

The first order condition is,

$$E[\tilde{r} - r_D] - \left(W_0^F + \frac{D^F - \theta_T^F}{1 + r_D} \right) \sigma_r^2 = 0$$

or,

$$r_K - r_D = \left(W_0^F + \frac{D^F - \theta_T^F}{1 + r_D} \right) \sigma_r^2 \tag{5}$$

There is a spread between r_K and r_D that is increasing in $D^F - \theta_T^F$. Equation (5) traces out a supply function for the net debt issued by the financial sector. Note that since r_K is fixed by technology, this first order condition really pins down r_D.[4]

There are two market clearing conditions. First, the deposit market must clear,

$$D^F = D^N;$$

second, the Treasury bond market must clear,

$$\theta_T^F + \theta_T^N = \Theta.$$

We are interested in understanding how changes in Θ affect equilibrium. Equations (4) and (5) trace out the demand and supply for bank deposits. However, note that the effect of a change in Θ on D is ambiguous. On the one hand, focusing on the demand equation, more Treasury supply could increase θ_T^N and reduce demand for deposits. On the other hand, focusing on the supply equation, more Treasury supply could increase θ_T^F and increase the supply of deposits. The identity of who absorbs the Treasury supply is essential for pinning down D. When we add money demand to the model (see Section 3.1), the model offers some structure on which agents may be expected to absorb the Treasury supply and thus provides additional predictions of the model.

We will approach the problem differently and derive a market clearing condition for the net supply of deposits by the financial sector. Consider thus the equilibrium condition for the overall market for safe/liquid assets. It says that the demand from the non-financial sector must equal the supply from the government plus the net supply of the financial sector

$$\frac{D^N + \theta_T^N}{1 + r_D} = \frac{\Theta}{1 + r_D} + \frac{D^F - \theta_T^F}{1 + r_D}. \tag{6}$$

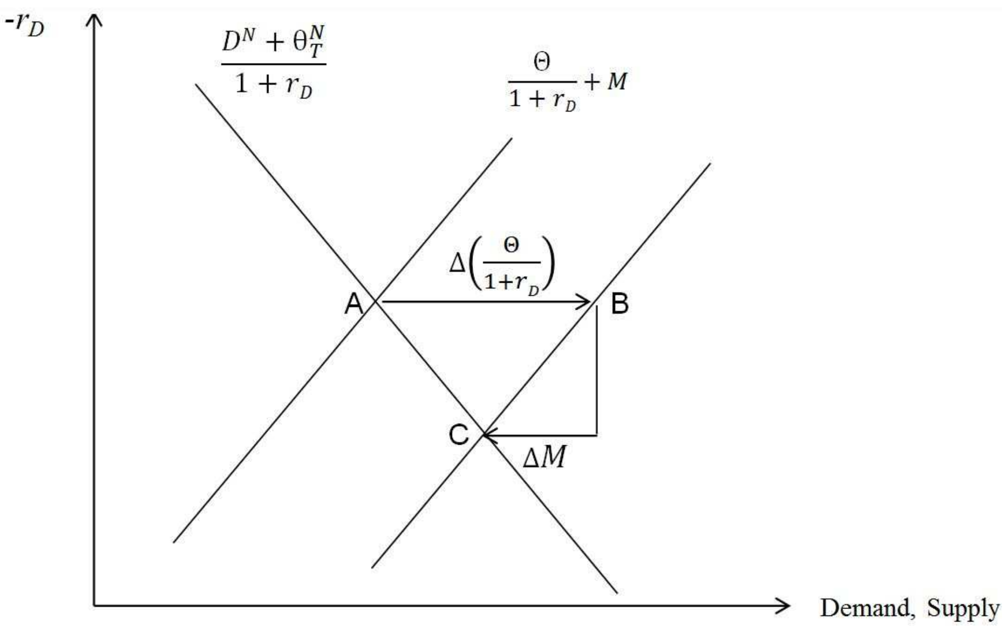
From equation (4) the non-financial sector's demand is a decreasing function of $-r_D$ since a higher convenience yield of buying short-term debt makes this less attractive. From equation (5) the net supply of the financial sector is higher the lower is r_D, since this increases the expected return discount on deposits and

[4]It is interesting to note that the premium $r_K - r_D$ is driven both by the special demand for debt by N (which leads F to leverage via deposits) and the risk aversion of F. That is, without a special demand for debt, the premium $r_K - r_D$ would be considerably smaller. Moreover, if F is risk neutral, the premium would be zero irrespective of N's debt demand.

Treasury bonds, so financial sector net supply is an increasing function of $-r_D$. Let us define the net market value of short-term debt supply issued by the financial sector as,

$$M = \frac{D^F - \theta_T^F}{1 + r_D}.$$

We will construct this measure from financial sector data. Unlike the case of D, the determination of M is unambiguous. The figure below illustrates the equilibrium.



There are two comparative statics that we highlight from this figure:[5]

- An increase in government supply Θ is a rightward shift in supply that causes the convenience yield, $-r_D$, to fall and M to fall. The direct impact of the increase in government supply is indicated by the shift from point A to point B in the figure. The indirect effect is to lower the convenience yield on short-term debt ($-r_D$) and thus crowd out private sector net supply, $M = \frac{D^F - \theta_T^F}{1+r_D}$, moving the equilibrium from point B to point C.

- An increase in the demand for debt (not illustrated in the figure for readability) is a right shift in the demand schedule and will cause the convenience yield on short-term debt and thus M to rise.

Total capital investment of the financial sector can also be related to M:

$$K = W_0^F + D^F/(1 + r_D) - \theta_T^F/(1 + r_T) = W_0^F + M$$

[5] We can also see that an increase in the volatility of $\tilde{r}$, σ_r, is a left-shift in supply, causing the convenience yield to rise and M to fall.

Thus, an increase in Θ decreases M and reduces K. This is a crowding out effect. If the government supplies more liquidity, the non-financial sector reduces its need for financial sector supplied debt, which reduces funding of the financial sector and reduces lending. Conversely, an increase in the demand for debt increases M and hence increases K.

The final measure which is relevant for the analysis is the probability of a financial crisis which we take to be the probability that W_1^F falls below zero. Rewriting (3),

$$Prob[W_1^F < 0] = Prob\left[(1+\tilde{r})W_0^F + M(\tilde{r} - r_D) < 0\right] \tag{7}$$

Note that total credit, K, does not enter this expression. Total credit is still informative in empirically forecasting crises because $M = K - W_0^F$, and in the data, W_0^F (i.e. equity) does not vary much. A simple example to see the difference between K and M is as follows: imagine a bank that has equity of W_0^F and makes risky loans of $K = W_0^F$. Such a bank will never go bankrupt. Thus, it is M rather than K that should better predict crises in our model. Additionally, more equity, W_0^F, decreases the probability of the crisis since $1 + \tilde{r} > 0$.

Holding W_0^F and r_D constant, the probability of a crisis is increasing in M. There is also a general equilibrium effect on r_D which can affect the probability through changing the mean value of W_1^F, although in realistic cases the direct effect of M is plausibly more significant than the indirect effect. An increase in Θ reduces M and increases r_D. The direct effect reduces the probability of a crisis, while the indirect effect may reduce financial sector profits on average and hence increase the probability of a crisis. An increase in debt demand increases M and reduces r_D. The direct effect increases the probability of a crisis, while the indirect effect reduces it. In the summary below, we assume the direct effects dominate.

We summarize the main observations from the model which we will take to the data as follows:

1. *In equilibrium, only the financial sector's net debt supply,* $M = \frac{D - \theta_T^F}{1 + r_D}$*, is pinned down.*

2. *An increase in* Θ *decreases* M*, the debt premium* $r_K - r_D$*, financial sector lending to the private sector, and the probability of a financial crisis. The effect on the amount of bank deposits (D) and on the size of the financial sector* ($D + W_0^F$) *is theoretically ambiguous.*

3. *An increase in debt demand increases* M*, the premium, financial sector lending to the private sector, and the probability of a financial crisis. The effect on the amount of bank deposits (D) and on the size of the financial sector* ($D + W_0^F$) *is theoretically ambiguous.*

3.1 Money Demand

We next modify the objective (1) to capture money or liquidity demand which is an especially important consideration for bank liabilities. Doing so allows us to clarify how changes in Treasury bond supply interact with money-demand effects and offers additional predictions of the model.

We divide the N agent into one-half measure of households (NH) and one-half measure of institutional investors (NI). The N household maximizes,

$$\max_{D^{NH},\theta_T^{NH},L^{NH}} c_0^{NH} + \mu\left(\frac{L^{NH}}{1+r_L}\right) + v\left(\frac{D^{NH}}{1+r_D} + \frac{\theta_T^{NH}}{1+r_T} + \frac{L^{NH}}{1+r_L}\right) + D^{NH} + \theta_T^{NH} + L^{NH}. \tag{8}$$

Here, L^{NH} are checking/demand deposits paying interest rate r_L. The function $\mu(\cdot)$ is a standard money-demand function taking as argument liquid assets that can be used for transactions, unexpected expenditures, etc. The function $v(\cdot)$, as in the earlier specification, is a demand for safe debt so that all of checking accounts, Treasury bonds, and time/saving deposits (D^{NH}) are arguments. We write agent NH's date 0 budget constraint as $c_0^{NH} + \left(\frac{D^{NH}}{1+r_D} + \frac{\theta_T^{NH}}{1+r_T} + \frac{L^{NH}}{1+r_L}\right) = W_0^{NH}$.

The N institutional investor maximizes,

$$\max_{D^{NI},\theta_T^{NI}} c_0^{NI} + \mu\left(\frac{\theta_T^{NI}}{1+r_T}\right) + v\left(\frac{D^{NI}}{1+r_D} + \frac{\theta_T^{NI}}{1+r_T}\right) + D^{NI} + \theta_T^{NI}. \tag{9}$$

subject to $c_0^{NI} + \left(\frac{D^{NI}}{1+r_D} + \frac{\theta_T^{NI}}{1+r_T} + \frac{L^{NI}}{1+r_L}\right) = W_0^{NI}$. The function $\mu(\cdot)$ is also demand for liquid financial assets, but taking as argument only Treasury bonds. The idea here is that institutional investors (e.g., Microsoft, China) who need to hold a large quantity of liquidity are likely to hold it in Treasury bonds rather than in checking deposits. It is straightforward to mix these objectives and allow each N-type to hold both Treasury bonds and bank deposits with different liquidity valuations of these securities, but the present setup is simpler to exposit.

Consider the NH agent. Following the same analysis as earlier we get the following first order conditions:

$$-r_D = v'\left(\frac{D^{NH}}{1+r_D} + \frac{\theta_T^{NH}}{1+r_T} + \frac{L^{NH}}{1+r_L}\right), \tag{10}$$

$$r_D - r_L = \mu'\left(\frac{L^{NH}}{1+r_L}\right). \tag{11}$$

The first relation is the same as earlier, taking as argument all debt assets. There is a premium on debt that is short-term but not necessarily liquid (i.e., D^{NH}), given N's special demand for such debt. The second relation indicates that liquid checking accounts offer an even lower yield because they are valued for their liquidity.

Likewise for the NI agent, we find:

$$-r_D = v'\left(\frac{D^{NI}}{1+r_D} + \frac{\theta_T^{NI}}{1+r_T}\right),$$

$$r_D - r_T = \mu'\left(\frac{\theta_T^{NI}}{1+r_L}\right).$$

We aggregate across the first of these relations involving r_D to come up with the demand for debt from the N sector:[6]

$$-r_D = v'\left(\frac{D^N}{1+r_D} + \frac{\theta_T^N}{1+r_T} + \frac{L^N}{1+r_L}\right) \tag{12}$$

where the quantities with superscript N now refer to the aggregates across the N sector. This demand function is the same as in the model without money demand but incorporating the fact that liquid deposits (L) are also short-term debt and should thus enter the aggregate.

On the financial sector side, we modify the model as follows. We assume that F has to hold some liquid assets in order to be able to meet the liquidity needs that may arise from N possibly withdrawing demand deposits. In particular we require that,

$$\frac{L^F}{1+r_L} \leq \frac{\theta_T^F}{1+r_T} + \kappa. \tag{13}$$

This relation is similar to Bansal and Coleman (1996), where demand deposits are required to be backed by liquid assets. The term κ is new and is the amount of capital investment that is liquid. We assume that F can pay a cost $\Phi(\kappa)$ to make some of its capital investment liquid. In practice this may mean investing resources in setting up a repo market against securities, creating a loan sales market, or an asset-backed securities market. With such an investment, F can treat a portion of its K as liquid and use it to back demand deposits. We assume that the function $\Phi(\kappa)$ is increasing and convex with $\Phi(0) = 0$.

With these changes, the budget constraint for F is,

$$W_0^F + \frac{L^F}{1+r_L} + \frac{D^F}{1+r_D} = \frac{\theta_T^F}{1+r_T} + K$$

and date 1 wealth is,

$$W_1^F = (1+\tilde{r})K + \theta_T^F - D^F - L^F - \Phi(\kappa).$$

We can substitute from the budget constraint to rewrite date 1 wealth as,

$$W_1^F = (1+\tilde{r})W_0^F + \frac{D^F}{1+r_D}(\tilde{r} - r_D) + \frac{L^F}{1+r_L}(\tilde{r} - r_L) - \frac{\theta_t^F}{1+r_T}(\tilde{r} - r_T) - \Phi(\kappa).$$

Let us define the net debt supply of the financial sector as:

$$M = \frac{L^F}{1+r_L} + \frac{D^F}{1+r_D} - \frac{\theta_T^F}{1+r_T}.$$

Then, the first order condition for D^F gives a supply function for net debt supply:

$$r_K - r_D = (W_0^F + M)\sigma_r^2 \tag{14}$$

[6] That is, first invert the demand curves:

$$\frac{D^{NH}}{1+r_D} + \frac{\theta_T^{NH}}{1+r_T} + \frac{L^{NH}}{1+r_L} = v'^{-1}(-r_D); \quad \frac{D^{NI}}{1+r_D} + \frac{\theta_T^{NI}}{1+r_T} = v'^{-1}(-r_D).$$

and then sum across to find the aggregate demand.

The market clearing condition for (overall) deposits now becomes:

$$\frac{D^N}{1+r_D}+\frac{\theta_T^N}{1+r_T}+\frac{L^N}{1+r_L}=\frac{\Theta}{1+r_T}+M$$

where the left hand side is decreasing in $-r_D$ by equation (12) and the right hand side is increasing in $-r_D$ by equation (14). Thus, the determination of M does not change with the addition of money and liquidity demand. The predictions of that analysis continue to hold. Increases in Θ reduce M, reduce the premium on deposits, reduce total lending of K, and reduce the probability of a crisis.

Let us consider two new predictions arising from the introduction of liquidity demand. First, note that for F, if $r_T > r_L$, F will purchase all of the Treasuries and issue more demand deposits. Thus in an interior equilibrium it must be that[7] $r_T = r_L$. This in turn means that we can write the liquidity demand from both N agents in terms of the spread $r_D - r_L$:

$$r_D - r_L = \mu'\left(\frac{L^{NH}}{1+r_L}\right) \quad \text{and,} \quad r_D - r_L = \mu'\left(\frac{\theta_T^{NI}}{1+r_T}\right).$$

Aggregating across the N sector, the demand for liquidity is,

$$r_D - r_L = \mu'\left(\frac{L^N}{1+r_L}+\frac{\theta_T^N}{1+r_T}\right). \tag{15}$$

Turning back to the F agent, the first order condition for κ gives,

$$r_K - r_L = \Phi'(\kappa) + (W_0^F + M)\sigma_r^2$$

Liquifying capital costs at the margin $\Phi'(\kappa)$ which in turn allows F to issue more checking deposits and earn the expected return premium $r_K - r_L$, but at risk cost of $(W_0^F + M)\sigma_r^2$. We can subtract this spread expression from (14) and set $r_T = r_L$ to write a supply of liquidity function,

$$r_D - r_L \quad = \quad \Phi'(\kappa) \tag{16}$$

Equations (15) and (16) can be used to understand bank's choices over Treasury holdings. The market clearing conditions are, for the checking deposit market:

$$\frac{L^N}{1+r_L}=\frac{L^F}{1+r_L}\left(=\frac{\theta_T^F}{1+r_T}+\kappa\right)$$

and for the Treasury bond market:

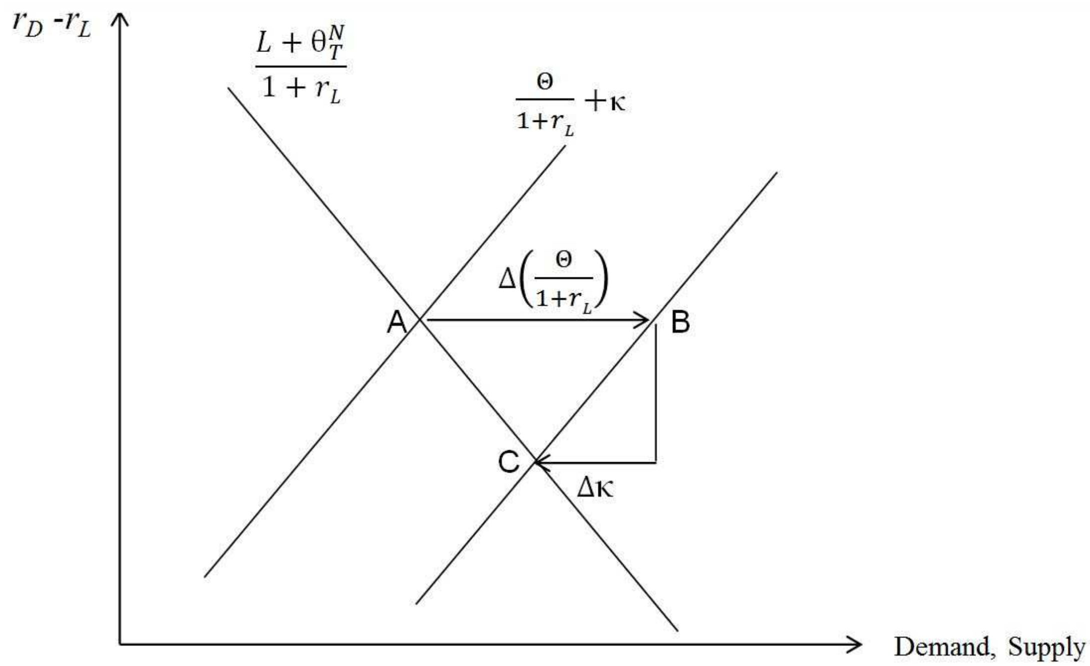
$$\theta_T^F + \theta_T^N = \Theta.$$

We combine these conditions to write a market clearing in terms of total liquidity demand from the N sector (left-side) equal to total physical liquidity supply of government bonds plus liquid private capital (right-side):

$$\frac{L^N+\theta_T^N}{1+r_L}=\frac{\Theta}{1+r_L}+\kappa \tag{17}$$

[7] It would be easy to modify the model so that $r_L < r_T$ as is likely in practice. For example, if we add some administrative costs for the financial sector of handling household checking accounts, then a spread would open between r_T and r_L.

The figure below graphs the market clearing condition (17). The downward sloping line is the demand relation $r_D - r_L = \mu'((L + \theta_T^N)/(1 + r_L))$. The upward sloping line is the supply relation $\Theta/(1+r_L)+\kappa$, where $\kappa = \Phi'^{-1}(r_D - r_L)$. The figure illustrates the effect of an increase in Θ on the equilibrium. In the figure, such an increase leads to a right-shift in total liquidity supply (the move from point A to point B). This causes the liquidity premium $r_D - r_L$ to fall, which by equation (16) crowds *out* the financial sectors supply of checking deposits backed by liquid capital, κ (the move from point B to point C). Despite this checking deposits are crowded *in* by the increases Treasury supply. This is clear from the fact that the NH agents satisfy their demand for liquidity with checking deposits only (not with Treasuries) and the equilibrium liquidity premium $r_D - r_L$ has fallen, thus increasing their liquidity demand (from equation (11)). Similarly, θ_T^N rises since it is also decreasing in $r_D - r_L$. The increase in checking deposits are made possible by the fact that since $r_T = r_L$ the financial sector is willing to provide extra deposits backed by Treasuries. Thus, the financial sector changes their backing of deposits such that $\frac{\theta_T^F}{\kappa + \theta_T^F} \left(= \frac{\theta_T^F/(1+r_T)}{L/(1+r_L)} \right)$, which we refer to as the financial sector's deposit coverage ratio, rises with Θ.



The analysis offers the novel insight that an important driver of a monetary liquidity aggregate such as M1 will be the total supply of government debt. This occurs because the supply of deposits is in part driven by the availability of liquid assets such as Treasury bonds, as backing. Moreover, the supply of deposits is driven by both Treasury backing as well as liquid capital. Thus the model further implies that as the supply of Treasuries rises, the financial sector substitutes away from using liquid capital and uses more Treasuries to back the deposit supply.

To summarize, the model with money/liquidity demand offers several more observations which we take to the data:

1. *There are two premia arising from investor preferences for debt: (1) a liquidity premium measured as* $r_D - r_T$ *where* r_D *is the interest rate on safe but less liquid debt such as time and savings deposit rate or commercial paper rates, and* r_T *is the interest rate on liquid Treasury debt; and, (2) a debt premium measured as* $r_K - r_D$, *where* r_K *is the expected return on an illiquid and risky loan.*

2. *Increases in* Θ *decrease both* $r_K - r_D$ *and* $r_D - r_T$.

3. *An increase in* Θ *leads to an increase in* L.

4. *An increase in* Θ *leads to an increase in the financial sector's deposit coverage ratio defined as* $\frac{\theta_T^F/(1+r_T)}{L/(1+r_L)}$.

Note that (1) and (2) are in line with the empirical evidence we have outlined in Section 2 from Krishnamurthy and Vissing-Jorgensen (2012). Thus, we will focus on testing (3) and (4).

4 Empirical framework

We focus on the period from 1914-2011. We begin our analysis in 1914 following the creation of the Federal Reserve System in 1913 in order to avoid any instability in supply or demand functions due to changes in financial sector risk as a result of the Federal Reserve.

The next section explains our data definition of the government's supply of safe and liquid assets. Section 4.2 explains our empirical framework for constructing the financial sector's balance sheet and mapping it to the concepts in the model.

4.1 Defining government net supply of safe and liquid assets

We are interested in the government's supply of safe and liquid assets, Θ. The main component of this is Treasury securities, but to capture the full impact of the government one should also consider the role of the Federal Reserve. We therefore add reserves and currency and security repurchase agreements that are liabilities of the Federal Reserve, but subtract the Federal Reserve's holdings of Treasuries as well as security repurchase agreements on the asset side of the Federal Reserve's balance sheet since these are used to back the reserves and currency and thus do not represent securities available for the private sector to hold.[8] Our definition is thus as follows:

[8]There are some other categories on both the asset and liability side of the Federal Reserve's balance sheet, but these are small in most years. The part of government supply coming from the Federal Reserve (reserves+currency+net security repurchase agreements issued by the Federal Reserve-Treasury securities held by the Federal Reserve) average only 5.5 percent

Government sector net supply of safe and liquid instruments (Θ)

=Treasuries at market value

+Reserves

+Currency, except for the part held by the Treasury

+Net security repurchase agreements issued by the Federal Reserve

−Treasury securities held by the Federal Reserve

We construct Treasuries at market value as in Krishnamurthy and Vissing-Jorgensen (2012) who construct it based on the book value of Treasuries/GDP from Henning Bohn, multiplied by a market/book adjustment calculated by the authors using data from the CRSP bond database. From 1945 on reserve data are from FoF L.109 line 28, currency from FoF L.109 line 29+35+36+37, net security repos from FoF L.109 line 38-line 9, and Treasuries held by the Federal Reserve from FoF L.109 line 12. We use the FoF release of December 8, 2011. Prior to 1945 we obtain reserves from Banking and Monetary Statistics (1914-1941 Section 3 Table 39, 1941-1970 Section 3 Table 3.1), currency from Friedman and Schwartz (Table 1), and Federal Reserve Treasury holdings from Banking and Monetary Statistics (1914-1941 Section 13 Table 149, 1941-1970 Section 13 Table 13.4). Repurchase agreements were not used by the Federal Reserve during this period. Note that Friedman and Schwartz's currency measure excludes holdings of the Treasury, consistent with our definition above. However, Friedman and Schwartz's currency measure also excludes currency holdings of banks. We therefore add bank holdings of currency with data obtained from All Bank Statistics (1959) Table A-1.

4.2 Constructing an overall balance sheet for the U.S. financial sector

We use data on the financial sector from the Flow of Funds Accounts (FoF) from 1952 to 2011. Prior to 1952 we use data from All Bank Statistics (1959) Table A-1.

To test the implications of our model we need to address a series of issues regarding the financial sector.

First, the financial sector is increasingly complex, extending far beyond just commercial banks. We need to construct a comprehensive framework to capture all parts of the financial sector including the shadow banking system. Conceptually, in our model F refers to any institution who is a supplier of liquid/safe assets backed by holdings of capital and government bonds. From a certain point of view, one could think that F

of GDP, while our total supply variable averages 47.0 percent of GDP. Conceptually it makes sense that the Federal Reserve's contribution to the net supply of safe and liquid assets is small. If, as a simple case, the Federal Reserve issued currency and reserves and backed these 100 percent with Treasury securities, then Federal Reserve's contribution to the net supply of safe and liquid assets would be zero. The part of government supply coming from the Federal Reserve is at its highest (reaching almost 20 percent of GDP) around 1940 due to substantial amounts of reserves and currency being backed by gold. It was less than 1 percent of GDP in 2007 but then increased to about 8 percent as a result of purchases of agency debt and agency MBS purchases financed by reserves under the Federal Reserve's quantitative easing programs.

is also a liquidity demander since F owns Treasuries. But this is a mistake. The key to identifying F is that F is a net supplier of liquidity/safety, after netting out Treasury holdings. Following this identification, we define the financial sector as the following sectors in the Flow of Funds Accounts, with FoF Table numbers indicated:

L.110 U.S.-Chartered Commercial Banks

L.111 Foreign Banking Offices in U.S.

L.112 Bank Holding Companies

L.113 Banks in U.S.-Affiliated Areas

L.114 Savings Institutions

L.115 Credit Unions

L.121 Money Market Mutual Funds

L.127 Finance Companies

L.129 Security Brokers and Dealers

L.130 Funding Corporations

L.124 Government-Sponsored Enterprises (GSEs)

L.125 Agency- and GSE-Backed Mortgage Pools

L.126 Issuers of Asset-Backed Securities (ABS)

L.128 Real Estate Investment Trusts (REITs)

Prior to 1952 we use data for "All Banks" (i.e. commercial banks and mutual savings banks) from Table A-1 in All Bank Statistics (1959).[9]

Second, in the model, the bank deposits (D and L) are contracts written between Ns and Fs. In the world, the existence of an interbank market means that Fs also write safe/liquid claims with each other. It is well understood that there are chains of liquid/safe assets and liabilities that Fs write with each other that arise in the interbank market, the repo market, etc. Our model has nothing to say about the amount of these interbank claims so that it would be inappropriate to include the amount of interbank claims in our measure of M. Interbank claims net to zero within the banking system. We address this by constructing, for each financial instrument, both the total asset and the total liabilitites of the financial sector and then working with the net holdings of that financial instrument. We then sort instruments into those that are net assets and those that are net liabilities for the financial sector, based on averages from 1914-2011 of the ratio (Assets-Liabilities)/GDP.

Third, in practice the financial sector's holdings of safe and liquid assets supplied by the government are not only Treasuries but also bank reserves and vault cash. We include these in our empirical measure of θ_T^F.

Fourth, while our model has only two asset categories (Treasuries, risky investments) and three liability

[9] In the next version of the paper we will use Flow of Funds data back to 1945, the first year these are available.

categories (checkable deposits L, other deposits D, and equity W_0^F), the financial sector holds many types of instruments within each category. A total of 33 different types of instruments show up as an asset and/or liability of one or more of the 14 parts of the financial sector from the FoF listed above (this is after grouping some similar subcatories together). Prior to 1952 (in All Bank Statistics) less detail is available so many of the 33 categories are set to zero. We list the 33 categories in Table 1. The first two are those supplied by the government/Federal Reserve. We group the remaining 31 categories into short-term assets (short-term debt securities not supplied by the government /Federal Reserve), long-term assets (long-term debt securities not supplied by the government/Federal Reserve), and equity-type investments on the asset side and short-term debt (broken into checkable deposits and other short-term debt), long-term debt and equity-type claims on the liability side.

Table 2 shows the resulting financial sector balance sheet. For each instrument we focus on (assets-liabilities)/GDP (or (liabilities-assets)/GDP for instruments that on average are net liabilities) thus taking out cross-holdings within the financial sector. Cross-holdings tend to be large for instruments that on average are net liabilities for the financial sector as shown in Panel B. Notice for example the substantial holdings by the financial sector of money market mutual fund shares, commercial paper, security credit, agency and GSE-backed securities, corporate bonds issued by ABS issuers, and equity (mainly investments by bank holding companies). This makes it clear that considering the financial sector as a whole is important.

As for the size of the various categories, on the asset side the financial sector is holding substantial amounts of Treasuries as well as cash and reserves, with ratios to GDP averaging 11.2 percent. The other main asset category is long-term assets, mainly mortgages, bank loans and consumer credit. Short-term assets and equity (on the asset side) are very small categories. The overall size of the financial sector relative to GDP averages 81.4 percent, but is much higher in recent years with the latest value at 152.6 percent. Figure 2 Panel A illustrates that the asset side of the financial sector's balance sheet has fluctuated widely over time. Holdings of assets supplies by the government increased dramatically from 1930 to the mid-1940s but have since declined aside from a spike up in recent years. Long-term assets have followed an opposite pattern. On the liability side of the financial sector's balance sheet, the vast majority of liabilities are in the form of short-term debt. On average checkable deposits and savings and time deposits are the largest categories, with money market mutual fund shares becoming increasingly important over time. Long-term debt is also becoming increasingly important over time, due mainly to ABS issuer issuing substantial amounts of long-term debt. Figure 2 Panel B illustrates the evolution of the three main categories on the liabilily side. Panel C shows the decomposition of short-term debt into checkable deposits versus other short-term debt. The two sub-components of short-term debt tend to move in opposite directions making the sum look more stable that either of the parts.

Consider how the assets and liabilities in Table 2 map into the model. On the asset side, long-term assets correspond well to what we have called risky/illiquid capital (K) in the model. Short-term assets do not map well into K (since they are unlikely to be either very risky or illiquid). Thus we will subtract them from the short-term debt on the liability side and consider "net short-term debt", defined as short-term debt minus short-term assets. We also subtract the financial sector's holdings of assets supplied by the government in our net short-term debt measure consistent with the fact that only the net debt supply, $M = \frac{D-\theta_T^F}{1+r_D}$, is pinned down in the model. As for equity on the asset side, we could consider it part of K, or net it against the equity on the liability side. We do the latter. On the liability side short-term debt corresponds to $L + D$ (with checkable deposits mapping to L and the other short-term debt categories to D). Long-term debt does not fit well into the model (since it is unlikely that long-term financial sector debt satisfies the N agent's special demand for very safe assets). Therefore we will subtract them from the long-term debt on the asset side and consider "net long-term investments", defined as long-term assets minus long-term debt. We note that as shown in Table 2 short-term assets and equity on the asset side are very small and long-term debt is small except for the last couple of decades, suggesting that the main netting issue is not about these categories but about making sure to subtract the financial sector's holdings of assets supplied by the government in our net short-term debt measure.

Table 3 shows the financial sector balance sheet with short, long, and equity categories netted. Net long-term investments corresponds to K in the model, net short-term debt to $L + D - \theta_T^F$, and net equity to W_0^F. Figure 2 Panel D shows the evolution of the three net categories over time. It is clear from this graph that fluctuations in net long-term investments are driven almost entirely by fluctuations in net short-term debt with equity financing being fairly stable over time.

5 Results

5.1 The impact of government net supply on the financial sector's net short-term debt and lending

The predictions of the model regarding the impact of government supply on prices (i.e. spreads) are confirmed in Section 2. The main quantity predictions of the model were:

P1. *An increase in Treasury supply Θ decreases the financial sector's net short term debt* $M = \frac{L+D^F-\theta_T^F}{1+r_D}$ (defined as the financial sector's short-term debt minus short-term assets minus the financial sector's holdings of assets supplied by the government).

P2. *An increase in Treasury supply Θ decreases the financial sector's net long-term investments K (* defined as long-term assets minus long-term debt).

Table 4 Panel A and Figure 3 Panel A provide strong evidence in favor of prediction 1 and 2. In Table 4 we estimate regressions of various dependent variables (all scaled by GDP) on government supply/GDP and a trend. Regressions are estimated by OLS but with standard errors adjusted up to account for large positive autocorrelation in the error terms. Based on a standard Box-Jenkins analysis of the error term autocorrelation structure we model the error term as an AR(1) process. One could consider using a GLS estimator (which in many of the regressions would approximately amount to running the regressions in first differences), but as argued by Cochrane (2012) this removes a lot of the most interesting variation in the data. The regression estimates in Table 4 Panel A show that increases in government supply lead to dramatic reductions in the financial sector's net short-term debt and its net long-term investments, with regression coefficients in both cases around -0.5 and significant at the 1 percent level. The negative relations are apparent in Figure 3 Panel A and seem consistently present over the 98 year period. These results suggest that a one-dollar increase in Treasury supply reduce the net short-term debt issued by the financial sector by 50 cents, and reduce long-term lending of the financial sector by 50 cents.

5.2 Addressing potential omitted variables or reverse causality problems

As laid out in the introduction we take four different (and complementary) approaches to rule out that our main result that government supply crowds out the financial sector's net short-term debt supply is driven by omitted variables or reverse causality.

5.2.1 Testing additional predictions of the model

One of the objectives of the model was to show that some types of short-term debt should be crowded out by government supply while others should be crowded in. Furthermore, the model predicts that government supply should affect the way the financial sector backs checking deposits. In particular, because of the ability of the financial sector to use Treasuries to back checking deposits the model generated the following additional predictions:

P3. *An increase in Treasury supply Θ leads to an increase in checkable deposits L.*

P4. *An increase in Treasury supply Θ leads to an increase in the financial sector's deposit coverage ratio defined as* $\left(\frac{\theta_T^F}{1+r_T}\right)/\left(\frac{L}{1+r_L}\right)$ (the financial sector's holdings of assets supplied by the government/checkable deposits)

A secondary objective of studying checkable deposits is to relate to the literature on money demand and the instability of money demand functions. Many authors have commented on the instability of traditional money demand functions (see Goldfeld and Sichel, 1990). The finding in the literature is that while there is a stable relation between real money demand M1/P, the nominal interest rate (typically measured as the commercial paper rate), and real income, in the period before 1980, this relation breaks down post-1980. The most prominent puzzle in the literature is the "missing money" of the post-1980 period, when interest rates fell but money balances rose, but not as strongly earlier estimates would have predicted. We will show that accounting for the effects of Treasury supply, as in our model, as well as changes in foreign holdings of Treasuries, can help account for the missing money.

Table 4 Panel C tests prediction 3. Increases in government supply are associated with increases in liquid short-term debt (checkable deposits) with a regression coefficient of about 0.22. Figure 3, Panel B, plots the two underlying series where one can see the positive relation.

Table 4 Panel B shows that increases in government supply leads to an even larger increase in the financial sector's holdings of government supplied assets, with a regression coefficient of about 0.45. Figure 3 Panel D plots the two series, and one can see the strong positive relation between them. These two results indicate that the financial sector's deposit coverage ratio is increasing in government supply consistent with prediction 4. This is illustrated in Figure 3 Panel C, which illustrates the positive relation between the government supply and the financial sector's holdings of government assets divided by checkable deposits. Regressing the deposit coverage ratio on government supply/GDP and a trend results in a coefficient of 1.15 with a t-statistic above 2.

In Table 5 we present estimates of money demand, measured as log of M1/P divided by real GDP (M1 is checkable deposits plus currency), where we include Government supply/GDP as a regressor in addition to the standard regressors of log of nominal yield of the 3-month commercial paper rate and log of real GDP (see e.g. Teles and Zhou (2005)). In Panel A we use data on checkable deposits from our framework plus currency data from Friedman and Schwartz (1970). In Panel B we use data on M1 from Friedman and Schwartz. The two measures of M1 should conceptually be identical absent data issues and they are in fact very close, see Figure 4 Panel A (we will investigate the small difference further in the next draft).[10]

Before discussing the results, it is worth understanding why Treasury supply may affect money demand and help resolve the missing money puzzle. In our model, money balances for the NH agent is determined by $r_D - r_L$. Most papers in the literature set r_L equal to zero, but it is typically recognized that this may not be a good assumption. In the period after 1980, financial innovation leads to the creation of checking or near-checking accounts that pay interest. Even in the period pre-1980, non-interest-rate effects such as the density of bank branches which affect the ease of withdrawing cash from a bank account should enter the spread $r_D - r_L$ (see Kroszner and Strahan, 1999). Thus, it is clear that $r_D - r_L$ is mismeasured in money

[10] For further comparison with the the literature Figure 4 Panel B compares our measure of the financial sector's short-term debt other than checking deposits to the difference between M3 and M1. Our measure is highly correlated but a bit larger than M3-M1.

demand estimations and it is possible that such mismeasurement is the source of the instability in money demand. While we do not directly measure $r_D - r_L$, our theory suggests that it is driven by Treasury supply. In the missing money period, there is not enough Treasury supply to back more bank deposits, which works against the fall in the level of interest rates by introducing a factor that raises $r_D - r_L$. By accounting for this latter effect, our model helps explain the missing money puzzle.

The comparison of panel A, column (1) and column (4) reveals the standard instability result reported in many other papers: over the period from 1914 to 1979, a money-demand function with a unit income elasticity and interest rate elasticity of -0.3 is a good fit for money demand; over the period from 1914 to 2011, the same regression produces an extremely poor fit for money demand with the regression R^2 falling from 66% to 12% and interest rate elasticity going from -0.3 to -0.18. The R^2 difference is ameliorated if we allow for income elasticity different than one, as in column (2) and column (5). But now the estimated elasticities on the interest rate and on income differ considerably over the two samples, again underscoring the instability result.

In columns (3) and (6) we add our government supply variable (in logs to match the left-hand side variable) as suggested by the theoretical model. Government supply is important both in the pre-1980 period and the post-1980 period, as indicated by the significant coefficient estimates on government supply and the substantially higher R^2 in column (3) than in column (2) and in column (6) than in column (5). That is, the fact that the pre-1980 money demand estimates from the literature were stable was lucky, as even over this period the demand function had omitted an important covariate.

In column (7) we also add the log of Foreign Treasury holdings/GDP. We obtain data on Foreign Treasury holdings from FoF L.209 from 1945 on and set the ratio Foreign Treasury holdings/GDP to 0.01 before that when foreign treasury holdings as far as we can determine were negligible (the ratio is around 0.01 in the first years for which FoF data are available). We still using US GDP in the denominator. From our theoretical model, foreign investors' purchase of the Treasury supply can be thought of as a reduction in the supply of Treasuries to domestic banks and investors (i.e., a reduction Θ). Thus, we may expect a negative coefficient on foreign holdings. On the other hand, an increase in foreign purchases may be correlated more broadly with an increase in foreign demand for US safe/liquid assets. Theory thus does not provide a clear prediction on the magnitude or sign the relation between foreign treasury holdings and money since foreign purchases of US assets have multiple facets. The results in column (7) suggest that the second effect is small in the context of checking accounts. Most important, notice that the coefficient estimates on interest rate, income, and government supply are all very similar over the two samples when comparing column (3) and (7) (Foreign Treasury holdings were small for most of the pre-1980 period so we omit that variable for the pre-1980 sample). In short, adding government supply variables leads to a stable estimate of money demand over the entire sample.

Table 4, Panel B presents the same results using our measures of Federal Reserve and Friedman and Schwartz measures of money. As one would expect based on Figure 4 Panel A, the results are not driven by our construction of money aggregates.

Figure 5 presents the money-demand instability results graphically, focusing on the “missing money” period post-1980. In Panel A, we graph actual M1/GDP along with the predicted value of money based on the specifications of Table 5 Panel B column (2) (allowing income elasticity to differ from one) and column (3) (including government supply). The graph illustrates that the predicted values from column (3) provide a better fit of the data after around 2000, but there is still lots of money missing. Figure 5, Panel B, suggests what is missing. We plot the missing money based on our estimates from column (3) against foreign holdings of Treasury bonds. The two lines show strong trends after around 1980 in opposite directions and of similar orders of magnitude. Figure 5, Panel C shows that the predicted values from column (7), based on the full sample, are very close to the actual ones.

5.2.2 Including controls for loan demand. Dropping observations following financial crisis

Our second approach to address potential omitted variables or endogeneity problems concerning the negative relation between government supply and the financial sector’s net short-term debt is to include controls for loan demand and drop observations following financial crisis.

The obvious variable that could, in principle, drive both government supply and net short-term debt is recent economic growth. For example, booms are associated with high loan demand (and thus short-term debt) but low government debt supply. In Table 6 Panel A we include the growth rate of real GDP (based on data from NIPA Table 1.1.6) over the past five years as a control (using a longer or shorter period does not affect the results substantially). Column (1) shows our baseline finding from Table 4 Panel A. Column (2) adds the growth control and column (3) shows the results from the regression without the growth control but estimated over the same sample as column (3). Comparing column (2) and (3) it is clear that including the growth control has essentially no effect on our main result. The lower estimate on government supply/GDP in column (2) than column (1) is entirely driven by the different samples. The underlying reason that including the growth control does not matter is that government supply has little cyclicality on average. It increases during recessions but also during wars which (in US history) are expansionary.

Another potential omitted variables concern is that government spending or taxation may affect loan demand. For example, perhaps high government supply is associated with high current or future taxation, or low current or future government spending, which could depress loan demand. Column (4) includes the (summed) primary deficit over the past 5 years and over the subsequent 5 years as controls, using deficit data from Henning Bohn’s web page. Column (5) estimates the regression without the control but over the same sample period as used in column (4). The negative relation between government supply and the financial sector's net short-term debt is robust to inclusion of the deficit control variables.

Finally, column (6) drops years where reverse causality is likely, namely years following financial crisis where the financial sector contracts and the associated regression causes and increase in government supply. Again this has little impact on the coefficient of government supply/GDP.

5.2.3 Testing whether a demand shock for safe/liquid assets has the opposite effect on financial sector net short-term debt

Our third approach to address endogeneity concerns is to consider the impact of a demand shock for safe/liquid assets and show that it has the opposite effect of government supply, consistent with the model. The shock we exploit is the dramatic increase in foreign holdings of Treasuries since the early 1970s. It is hard to think of a story in which the US trade deficits that underlie this build-up of foreign Treasury holdings would also cause an increase in US short-term debt (if anything one would expect the opposite as corporate loan demand in the US would decline as more is produced abroad).

In terms of magnitude one would expect the impact of the demand shock on the financial sector's net supply of short-term debt to be larger in absolute value than that of government supply since foreign Treasury purchases likely have two effects. They reduce how much of the government supply is available for US holders and in that respect should affect the financial sector's net short-term debt supply in the same way as government supply decrease. Furthermore, if both government supply and the financial sectors' short-term debt satisfy foreigners demand for safety/liquidity, then foreigners will hold not just Treasuries but also some of the short-term financial debt. This channel further increases short-term debt supply. Notice that both effects work to increase short-term debt supply unlike in the case of checking deposits where they worked in opposite directions leading the impact of foreign demand on checking deposits to be theoretically ambiguous.

The potential importance of foreign demand is visually apparent from Figure 3 Panel A. There seems to be "too much" net short-term debt and net long-term investments in the last few decades based on the amount of government supply over this period. One possible explanation is demand shock for safe/liquid US assets due to purchases by foreigners. Netting out foreigners Treasury holdings seems to lead to a more stable relation between the remaining government supply and the US financial sector's net supply of short-term debt. The hypothesis that there has been a demand shock for US safe assets over the last few decades has been made prominently in the literature on global safe-asset imbalances (see Bernanke, 2005, Caballero and Krishnamurthy, 2009, Caballero, 2010).

In Table 6 Panel B we test formally whether foreign Treasury holdings are positively related to net short-term debt (column (1)) and net long-term investments (column (2)). This is strongly the case, both in economic and statistical terms. The coefficents on foreign Treasury holdings/GDP are as expected larger in absolute value than those of government supply. Notice also, by comparing Table 4 Panel A and Table 6 Panel B that while there is a strong unexplained trend in net short-term debt when foreign Treasury holdings are not accounted for this is much less the case once these are included as a regressor.

5.2.4 "Rajan-Zingales identification": Expenditure shares for "credit" goods

Our final approach is to examine the composition of household expenditures. We have argued that reductions in government supply lower the cost of borrowing of banks and increase their lending. Following this chain one-step further, we may expect that the expansion in bank lending will lower the cost of credit to borrowers. We focus on this effect by considering the expenditures of households on goods typically purchased on credit. If bank lending expands in a causal way with a reduction in government supply, we would expect that the expenditure share of households on goods often purchased with credit will rise. We examine this prediction in the context of the Deaton and Muellbauer (1980) demand system. In addition to providing evidence that helps address endogeneity concerns, documenting an impact of government supply on households' consumption mix is by itself interesting as it adds to the set of outcome variables affected by government supply.

In terms of how studying the composition of household expenditure helps document that government supply has a causal impact on lending here is the argument. US Treasury supply/GDP variations are driven to a large extent by war spending and the business cycle, factors that could potentially be driving net short-term debt and net long-term investments in the opposite direction. If so, then our main finding would not be evidence of a causal impact of government supply. Our results including business cycle controls already suggest that results are robust to this, but one may be concerned about further omitted variables. Estimating budget share equations where there is widespread agreement about which controls should be included should further support our argument that the impacts of government supply are causal. The standard controls in estimation of budget share equations are relative prices and the log of total real consumption, and for products purchased on credit measures of the availability or price of credit.

We define products often bought on credit as NIPA categories "Durable goods"+"Housing and utilities". We regress the budget share for these goods on ln(Total real consumption), ln(Relative price of these goods compared to the overall price level), and Government supply/GDP. Obviously these goods may be more/less luxurious than average so their budget share could move with the business cycle (or wars), as could Govt supply/GDP. However, this is controlled for by including ln(Total real consumption) as regressor. Business cycles and wars should not drive budget shares beyond any effect through relative prices and total expenditure.

One can think of this identification approach as a more structural version of the Rajan and Zingales (1998) approach to identifying a causal impact of financial development on growth. They ask whether industries predicted to be in more need of external finance for technological reasons (e.g. project scale, gestation period, cash-harvest period etc.) grow faster in countries with more developed financial markets, conditional on all (potentially unobservable) country- and industry-specific factors driving growth. This approach controls for the fact that overall country growth may drive financial development or that both may be driven by some unobservable. This identification works if the driver of financial development does not directly affect industries with high vs. low external dependence differently. We ask whether consumption expenditures for products where buyers for technical reasons often buy on credit (usefulness as collateral and size of purchase) larger in periods with less Treasury supply, conditional on all (potentially unobservable) period- and product-specific factors driving the level of expenditures. Our approach controls for the fact that private borrowing and Treasury supply may both be driven by some unobservable (wars/the business cycle). Following the comments on Rajan-Zingales, it may seem that this identification only works if the driver of Treasury supply (notably wars and the business cycle) does not affect expenditures on products usually purchased with borrowed money differently. However, this is not the case when estimating equations for budget shares, since one can allow the budget share for credit goods to be related to the business cycle or wars via the impact of these variables on total consumption and relative prices. What is needed is only that wars and business cycles do not drive budget shares beyond any effect through these controls.

Table 6 Panel C presents the results. The regression coefficient of -0.064 in column (1) implies that a one standard deviation reduction in government supply (a change of 0.22) leads to an increase in the budget share for credit goods of 0.014. The mean of the budget share is 0.297 and the standard deviation is 0.028, implying that the estimated effect of 0.014 corresponds to about a half of a standard deviation of the budget share. This estimate may be conservative since increased availability of credit may increase the relative price of goods that frequently are purchased on credit. Column (2) omits the relative price variable and results in a slightly higher effect of government supply.

Figure 6 illustrates the relation between the budget share for credit goods and government supply. There is a clear negative relation between the two series variables (the correlation is -0.78).

5.3 Predicting financial crises

The last prediction of the model that we test is that the probability of a financial crisis (by which we mean a banking crisis) should be increasing in net short-term debt and that an increase in Treasury debt should decrease the probability of a financial crisis.

P5. *The probability of a financial crisis is increasing in net short-term debt, M. An increase in Treasury supply Θ decreases the probability of a financial crisis by reducing net short-term debt M.*

The US has had three major banking crisis during the 98 year period we study, associated with the Great Depression, the S&L crisis, and the Great Recession. We obtain the specific timing of the first year of each of these crises from Schularick and Taylor (2012) who date them 1929, 1984, and 2007. We estimate logit models to predict crisis. We follow the methodology of Gourinchas and Obstfeld (2012) who use variables known in year t to predict crisis in year $t + k$ with k either 1 or 3 years. Error terms are robust to heteroscedasticity. Observations are dropped if year t itself is a crisis year or any of year $t - 1$, ..., $t - 4$ were crisis years in order to avoid biases due to the fact that we are predicting the first year of a crisis and if you are currently in a crisis then you mechanically cannot be at risk of entering a new crisis until you get out of the current one. Sprague (1915) and Silber (2007) argue that there was a crisis in 1914 so we drop the observations for 1914-1918 in the regressions.

Table 7 Panel A presents the main estimations. Column (2) (predicting a crisis in any of the next 3 years) and column (6) (predicting a crisis next year) uses net short-term debt as predictor and confirms the part of prediction 5 that says that the risk of a crisis increases in net short-term debt. The regressions include a trend, so for reference columns (1) and (5) show results with a trend as the only predictor. To get a sense of the ability of the various models to predict crisis, we follow Schularick and Taylor (2012) and estimate Receiver Operating Characteristic (ROC) curves. An ROC curve plots the true positive rate (i.e., of all the crises that did happen, what fraction did you predict?) against the false positive rate (i.e., when the regression predicts crisis, how often does it not actually happen?). To get a curve, various cutoffs for the predicted probability are used to classify whether the model predicted a crisis or not. A model with no explanatory power results in a 45 degree line whereas a model with a perfect fit would result in an line going vertically from (0,0) to (0,100) and then horizontally from (0,100) to (100,100). Goodness of fit can thus be measured based on the area under the ROC curve (AUROC), with 0.5 corresponding to no explanatory power and 1 to a perfect fit. In column (2), we report the AUROC and its standard error when using net short-term debt as a predictor, indicating statistically significant predictive power (AUROC=0.865 with a standard error of 0.065, implying that the AUROC minus 2 standard errors is above 0.5).

In columns (3) and (7) we compare our findings to what one would obtain using the most popular predictor in the banking crisis literature, namely private credit/GDP (see Schularick and Taylor (2012), Gourinchas and Obstfeld (2012), and International Monetary Fund (2011) for recent examples). Private credit is used to refer to lending by the financial sector to the non-financial private sector (i.e. not to the government). This corresponds to (Short-term assets + Long-term assets) in our framework. This asset-side based predictor of crisis is seen to also have predictive power, although not quite as much as our net short-term debt/GDP measure (comparing the AUROC values). In practice short-term assets are small, so conceptually private credit/GDP differs from net short-term debt by not subtracting long-term debt, and not subtracting net equity (in our framework Net short-term debt =Net long-term investment - Net equity, and private credit captures the asset component of net long-term investment). Since net equity does not fluctuate much, the main difference in the movements of private credit/GDP and net short-term debt will be driven by whether a lot of the private credit is financed by long-term debt or not. As shown in Table 2 Panel B, long-term debt has increased in prominence over time as a funding source for the financial sector (currently standing at 44.4 percent as ratio to GDP). This suggests that the distinction between the two predictors is likely to remain relevant going forward. Moreover, as discussed in the model, private credit is informative in forecasting crises because it is correlated with net short-term debt. However, an expansion of private credit that is funded purely through equity or long-term debt leads to little liquidity/maturity mismatch and should not lead to a crisis. Thus our results clarify that the crisis variable that should be of most interest is net short-term debt and not private credit.

Turning to the role of government supply, columns (4) and (8) of Table 7 Panel A use our measure of government supply/GDP as predictor of crisis, along with the asset demand shock measured as Foreign Treasury holdings/GDP.[11] The results confirm the second half of prediction 5 that an increase in Treasury debt should decrease the probability of a financial crisis, and conversely for the asset demand shock. Figure 7 Panel A graphs the predicted probability that a crisis will occur over the next 3 years from each of the models in Table 7 Panel A column 2-4. All of the models show a dramatic increase in the probability of crisis starting in the early 2000s. The private credit/GDP model appears to do a poor job predicting the crisis of 1929, with the other models both showing an increase in predicted probabilities leading up to that crisis. As for the S&L crisis, both the net short-term debt model and the private credit model has the predicted probability peaking in 1987. It is possible that the dating of the crisis to 1984 is a bit too early in the sense that data from the FDIC show that the peak of the S&L crisis is much later than 1984, with the largest numbers of S&L and bank failures during the period 1980-1994 occuring in 1988, 1989 and 1990, see FDIC (1998).[12]

In general, one may not expect government supply/GDP and Foreign Treasury holdings/GDP to work as well in terms of predictive power as net short-term debt/GDP, since the part of net short-term debt/GDP that is not explained by these variables may also have predictive power for crises (whether or not this is the case is not addressed by our model). Table 7 Panel B shows that for predicting crisis over the next three years, the predicted value from regressing net short-term debt/GDP (or private credit/GDP) on government supply/GDP and Foreign Treasury holdings/GDP has predictive power, whereas the same is not true for the residual from this regression.

[11] Jorda, Schularick, and Taylor (2011) have shown that current account imbalances are correlated with private credit growth, which is still the best predictor of financial crises, consistent with their work in Schularick and Taylor (2012).

[12] All of the models also predict a crisis at the start of the sample in 1914, consistent with Sprague (1915) and Silber (2007) dating this year as a crisis.

Since our analysis (at this point) focuses only on the US, we only have 3 banking crisis in our sample (despite using almost 100 years of data). Performing out of sample analysis is therefore difficult so we only attempt one simple exercise. We estimate the models in Table 7 Panel A using data for 1914-1999 and calculate predicted crisis probabilities for the subsequent years to see if the models would have predicted the recent crisis based on the prior historical data. This is the case for both the net short-term debt/GDP model and the private credit/GDP model with the model using both government supply/GDP and Foreign Treasury holdings/GDP doing poorly (this could suggest overfitting when including two predicted values in a sample which in the pre-2000 data has only 2 crisis).

6 Conclusion

We argue that the amount of short-term debt in the economy, issued by the financial sector, is in large part driven by the non-financial sector's willingness to pay a premium on liquid/safe debt. The financial sector earns a profit by holding illiquid and risky assets and issuing liquid and riskless claims against these assets. We present several pieces of evidence in support of our argument. First, we show that the supply of total financial sector short-term debt falls when there are more government securities outstanding (principally less Treasury securities). That is, Treasury securities crowd out financial sector net short-term debt. Second, if we further recognize that the financial sector can profitably use Treasury securities to back their most liquid form of short-term debt, namely checking deposits, then we would expect that Treasury securities crowd in checking deposits, and that when Treasuries are plentiful, the use of Treasuries to back checking deposits (summarized by the ratio of bank's holdings of Treasuries to outstanding checking deposits) rises. The data also supports these predictions. Furthermore, we show that when Treasuries are scarce, and banks issue more short-term debt, they uses these funds to expand bank loan supply.

While it is possible to find alternative hypotheses for some of these results – for example, the negative correlation between Treasury supply and outstanding bank debt could be due to both variables being driven by business cycle variation and wars – our theory of banking can simultaneously rationalize all of the results. To further address potential endogeneity of Treasury supply, we verify that including business cycle controls or dropping the observations corresponding to the first 10 years after a financial crisis, when the causality from banking crisis to Treasury supply may be most problematic, does not alter our results substantially. In addition, we examine the impact of a demand shock for US safe/liquid assets and study the impact of government supply on the composition of household expenditures, showing that household expenditures on "credit" goods rise when Treasuries are scarce. We interpret this as driven by the fall in the cost of credit. We also show that government supply has predictive power when included in a standard money demand function. The evidence on budget shares and money demand helps overcome endogeneity concerns because both settings are ones in which there is general agreement about which explanatory variables should be included, implying that any explanatory power of Treasury supply is unlikely to be driven by omitted variables problems.

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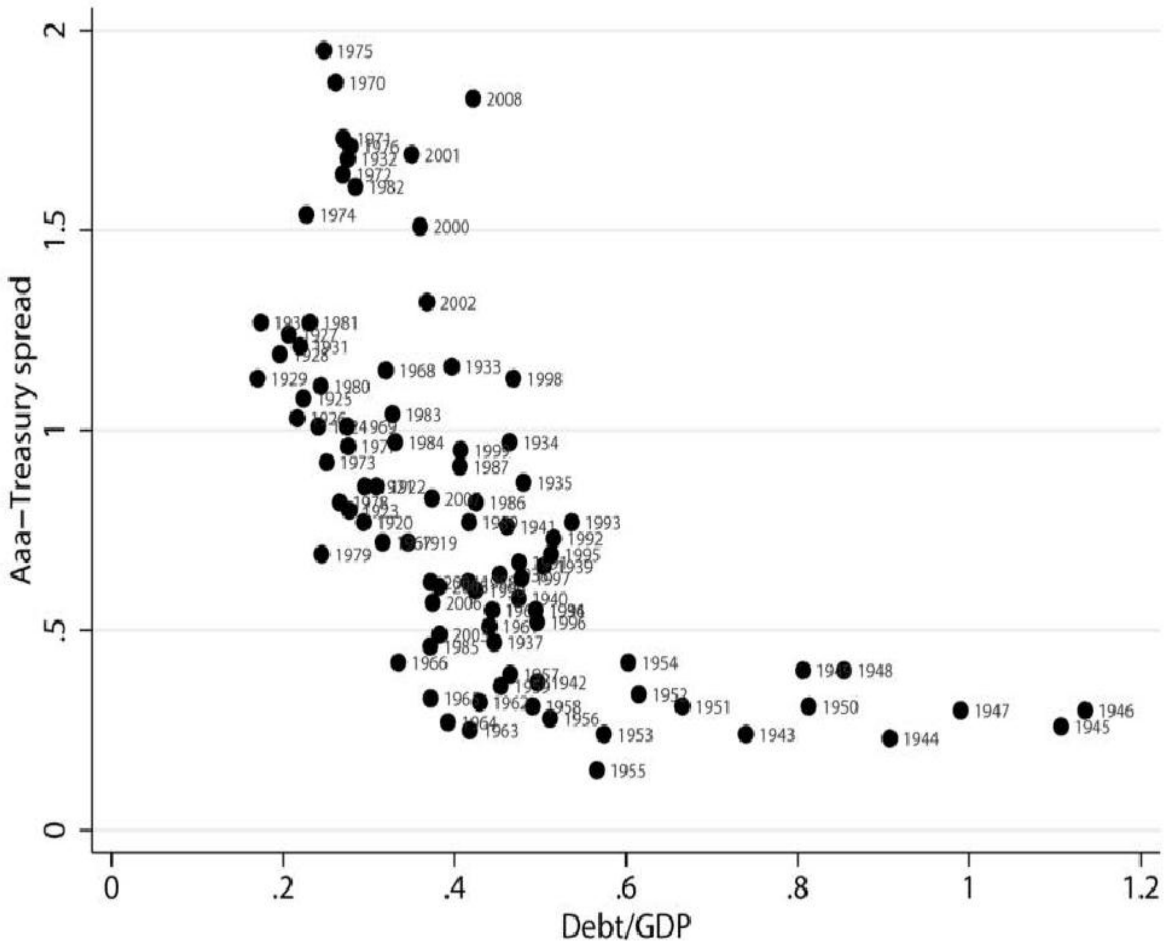
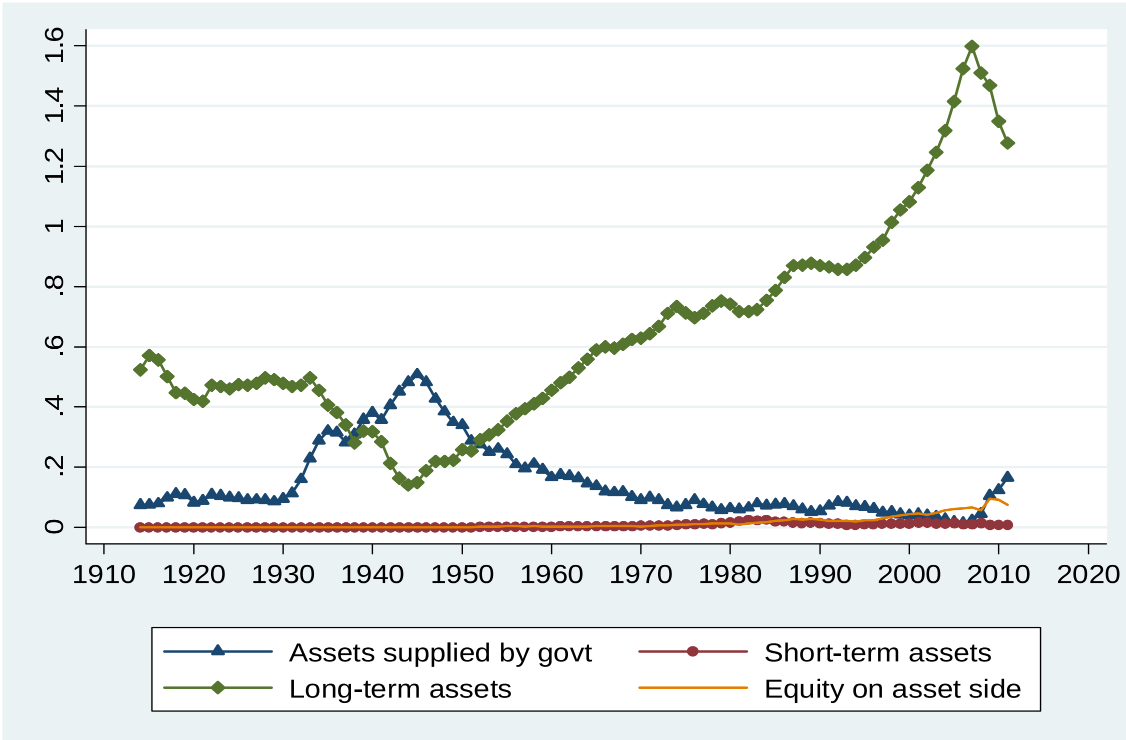
Figure 1. Relation between Aaa-Treasury yield spread and Treasury supply



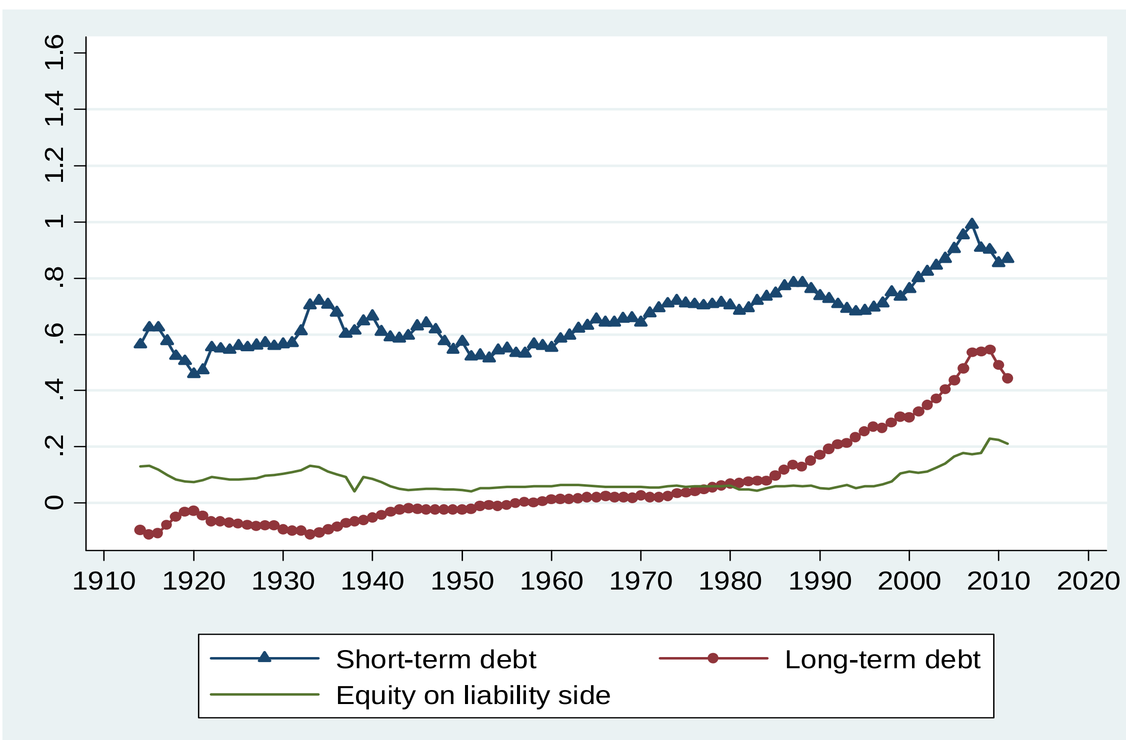
Note: This figure is taken from Krishnamurthy and Vissing-Jorgensen, JPE, 2012. It plots the Aaa-Treasury corporate bond spread (y axis) against the debt-to-GDP ratio (x axis) on the basis of annual observations from 1919 to 2008. The corporate bond spread is the difference between the percentage yield on Moody's Aaa long-maturity bond index and the percentage yield on long-maturity Treasury bonds.

Figure 2. Financial sector balance sheet, 1914-2011

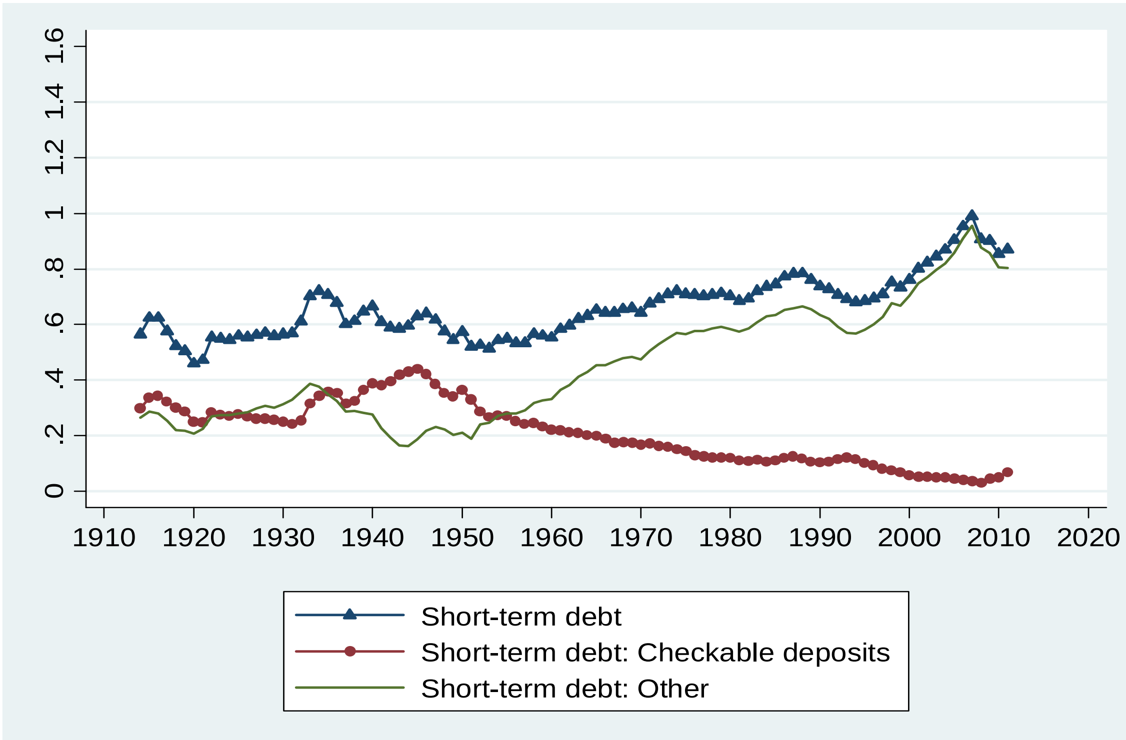
Panel A. Instruments that are net assets on average across years



Panel B. Instruments that are net liabilities on average across years



Panel C. Sub-components of short-term debt



Panel D. Financial sector balance sheet with short, long, and equity categories netted

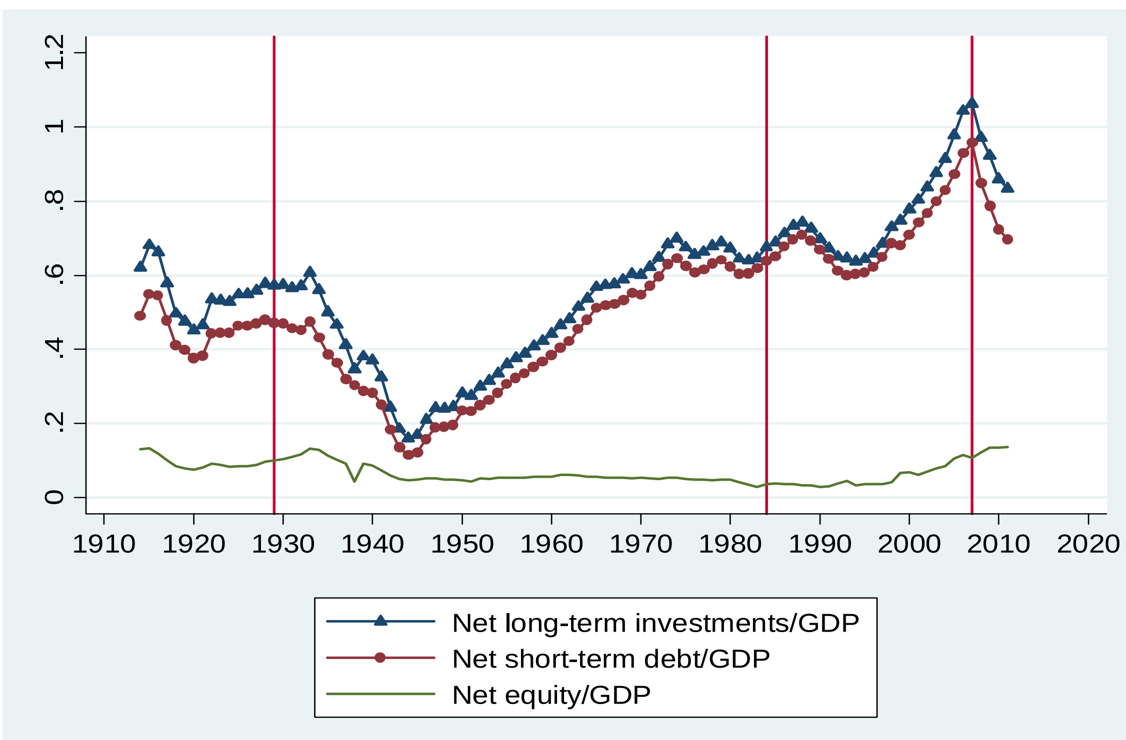
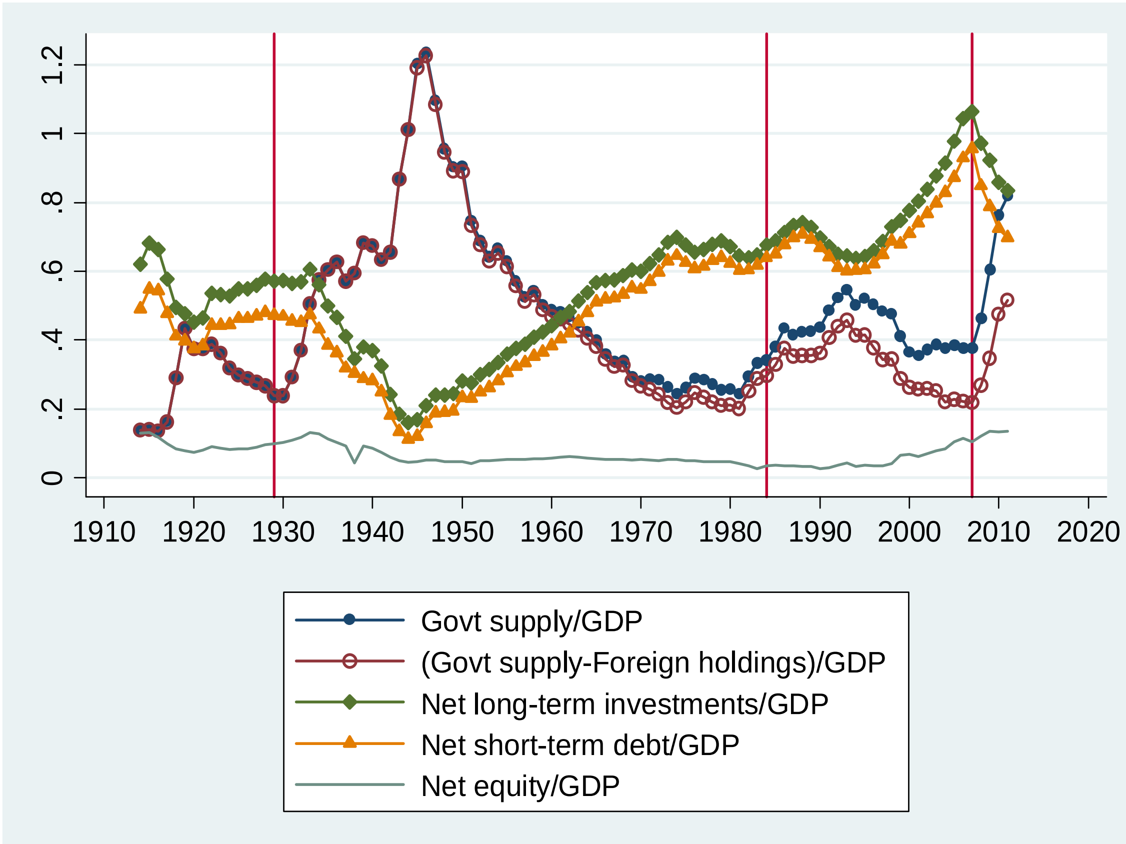
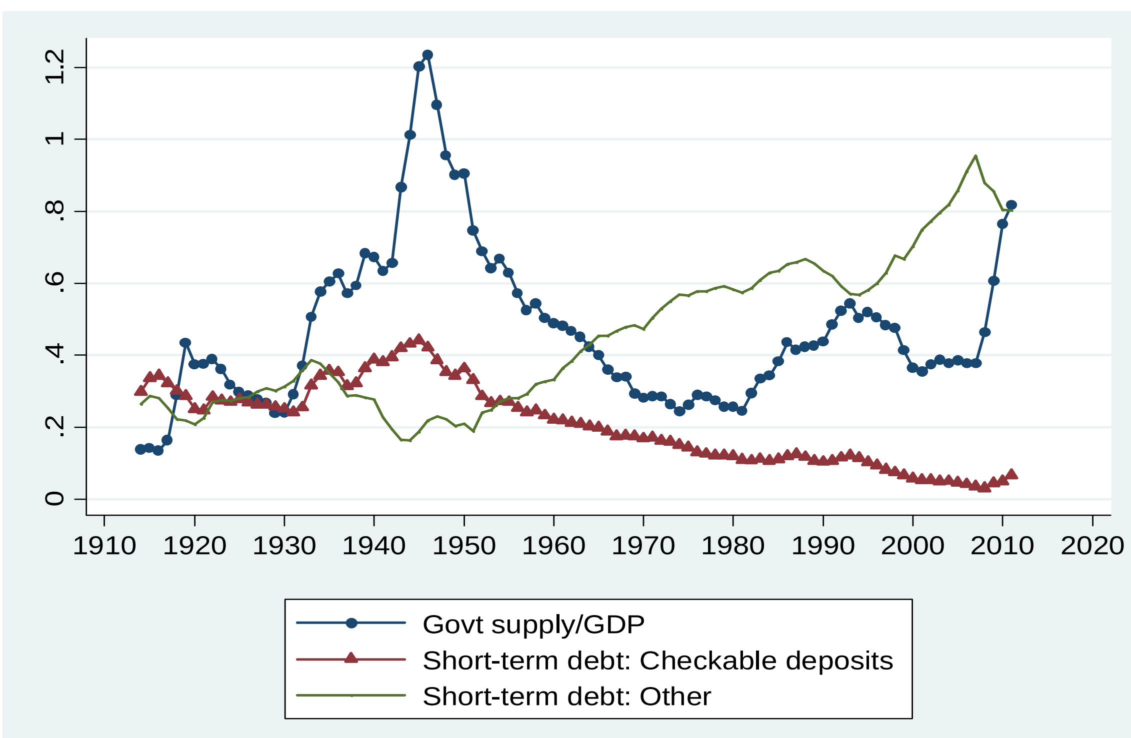


Figure 3. Impact of government supply on financial sector balance sheet, 1914-2011

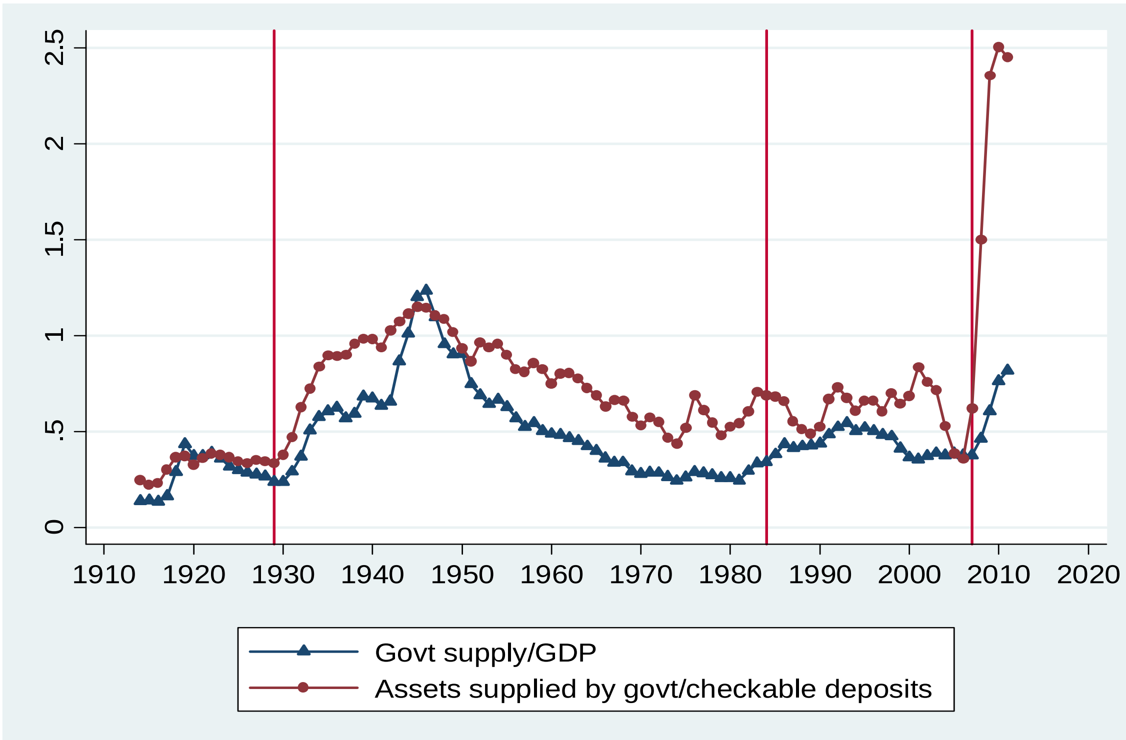
Panel A. Impact on short, long, and equity net categories



Panel B. Impact on sub-components of short-term debt



Panel C. Impact on ``deposit coverage ratio'' (financial sector holdings of government supplied assets/checkable deposits)



Panel D. Impact on financial sector holdings holdings of govt supplied assets

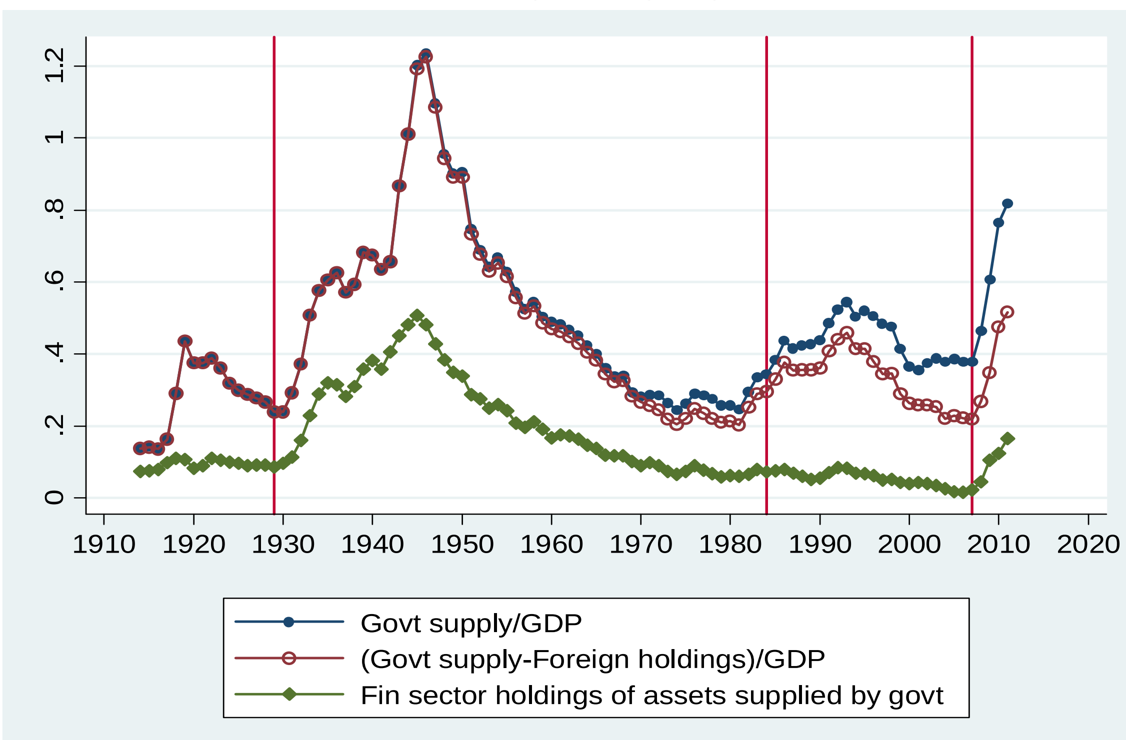
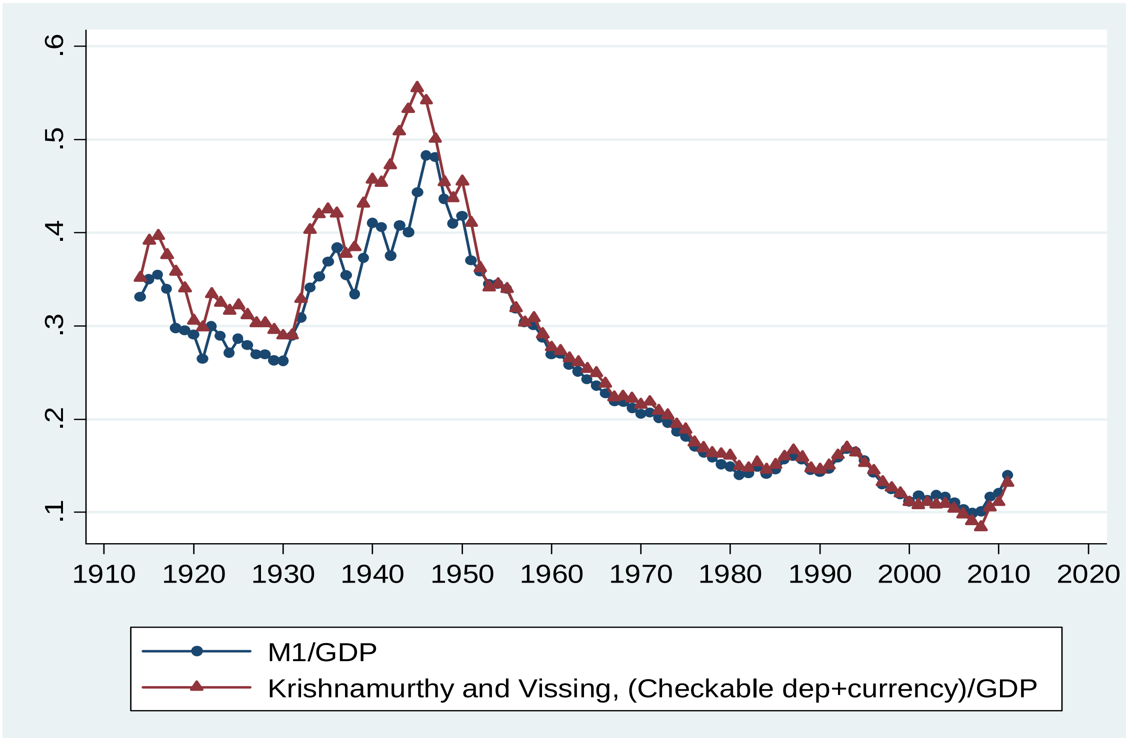
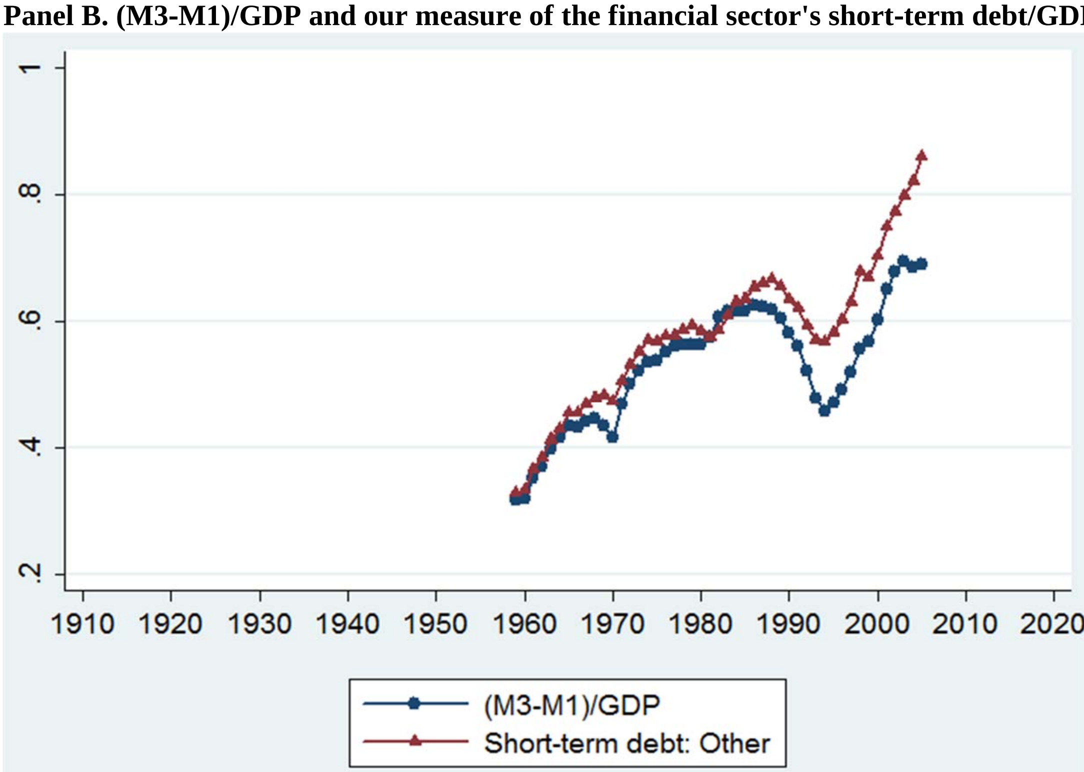


Figure 4. Money supply measures and their relation to our financial sector debt measures
Panel A. M1/GDP and our corresponding measure



Note: Should conceptually be identical absent data issues

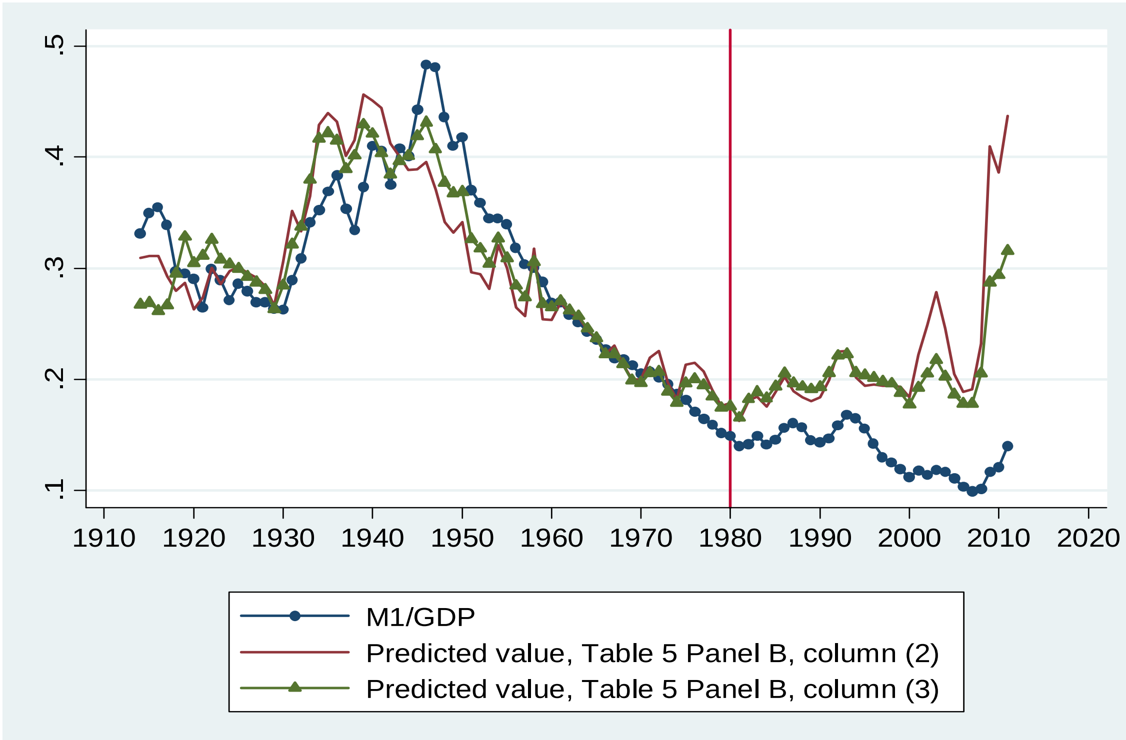
Panel B. (M3-M1)/GDP and our measure of the financial sector's short-term debt/GDP



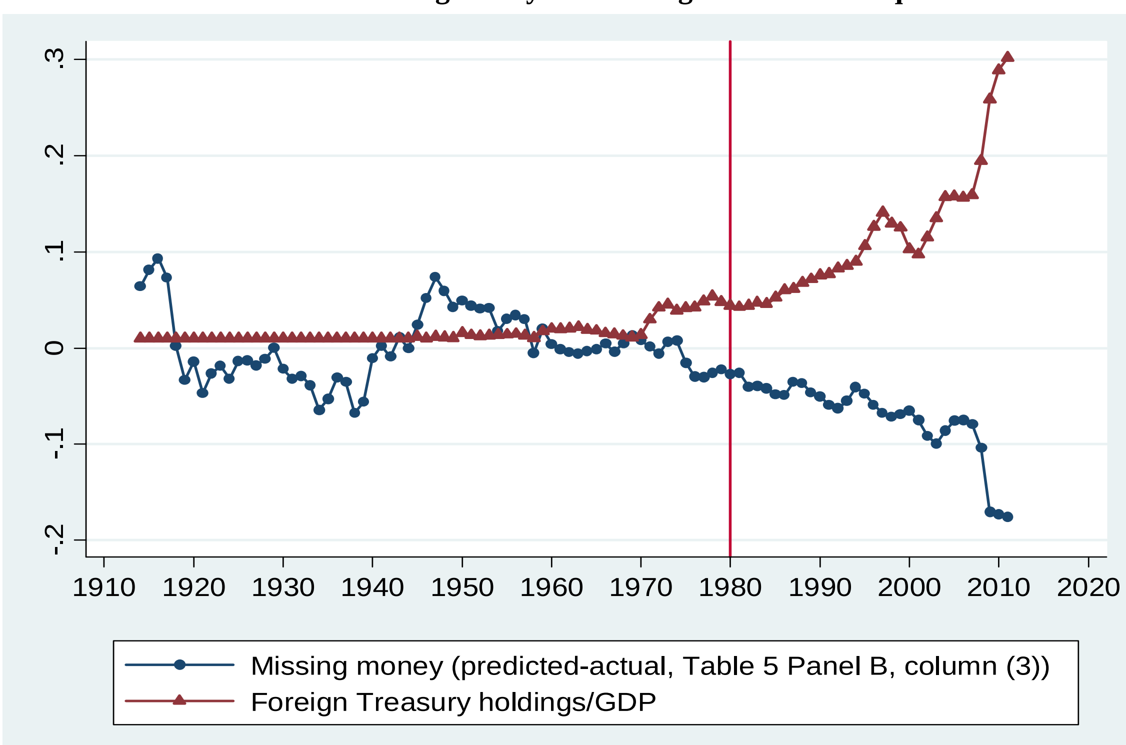
Note: Should not conceptually be identical if M3 misses some types of short-term debt.

Figure 5. Explaining M1/GDP

Panel A. Predicted values, estimations use data from 1914-1979



Panel B. Relation between ``missing money'' and foreign demand for liquid/safe US assets



Panel C. Predicted values including foreign Treasury holdings, full sample, 1914-2011

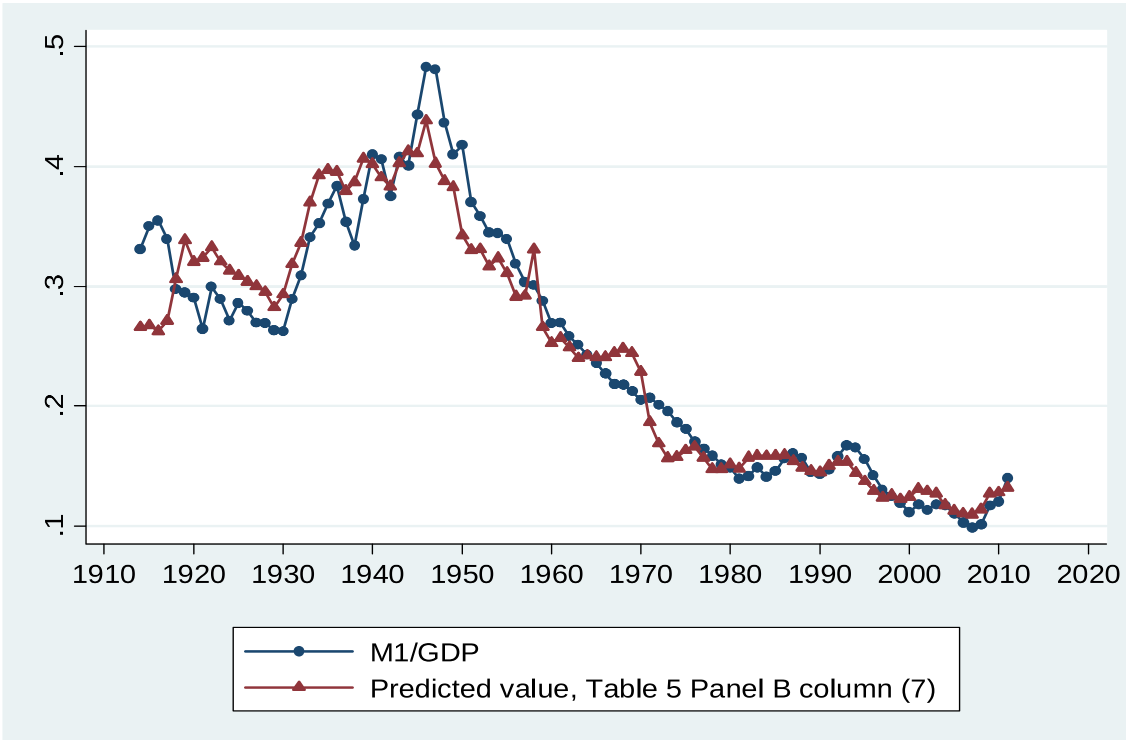


Figure 6. Expenditure share for ``credit goods'', 1929-2011

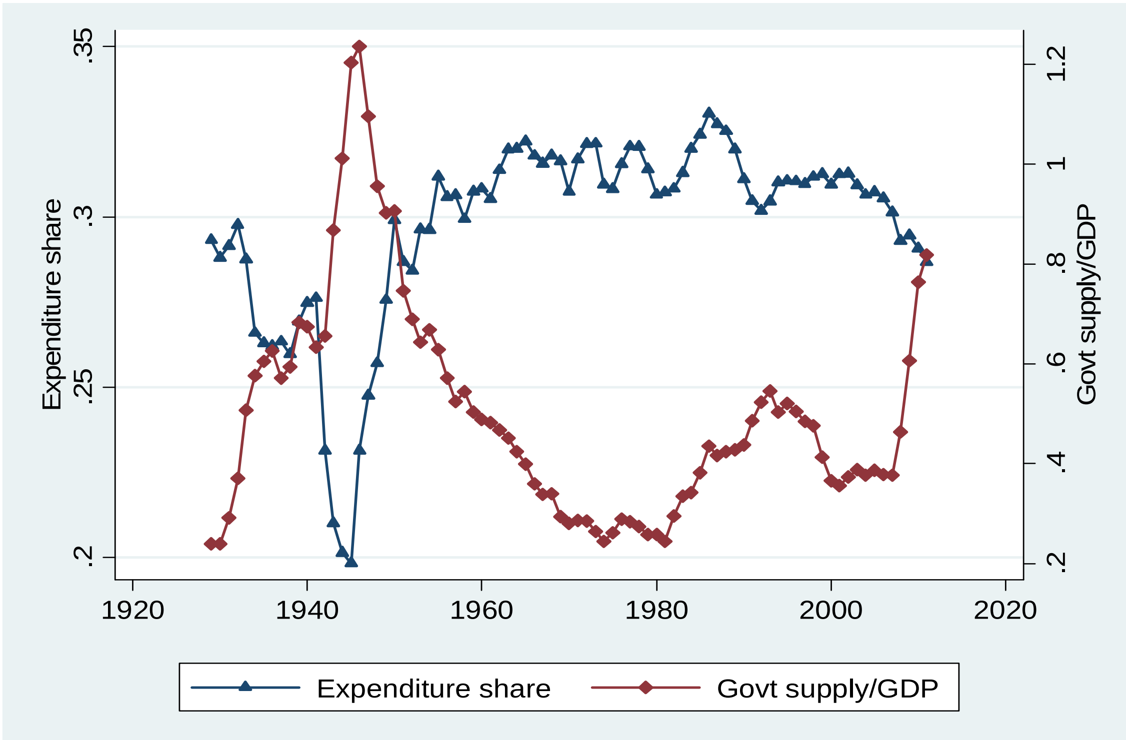
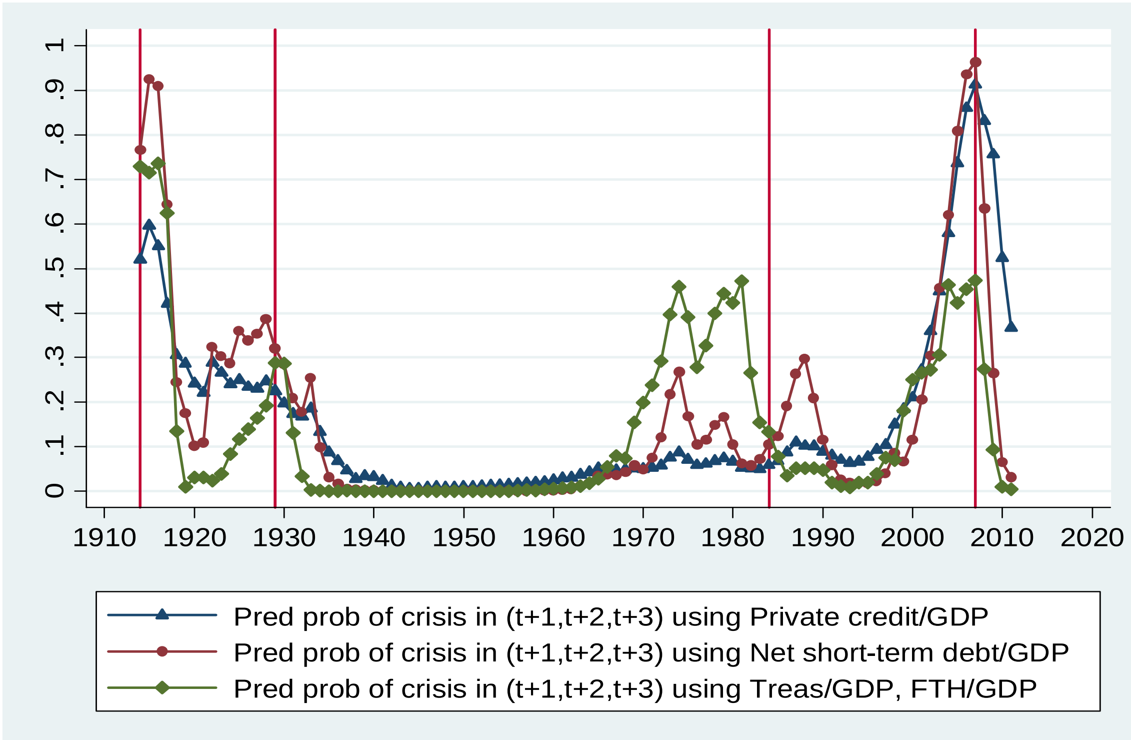


Figure 7. Predicting banking crisis in the US, 1914-2011

Panel A. Predicted crisis probability, full sample



Panel B. Predicted crisis probability, regressions estimated using data up to 2000

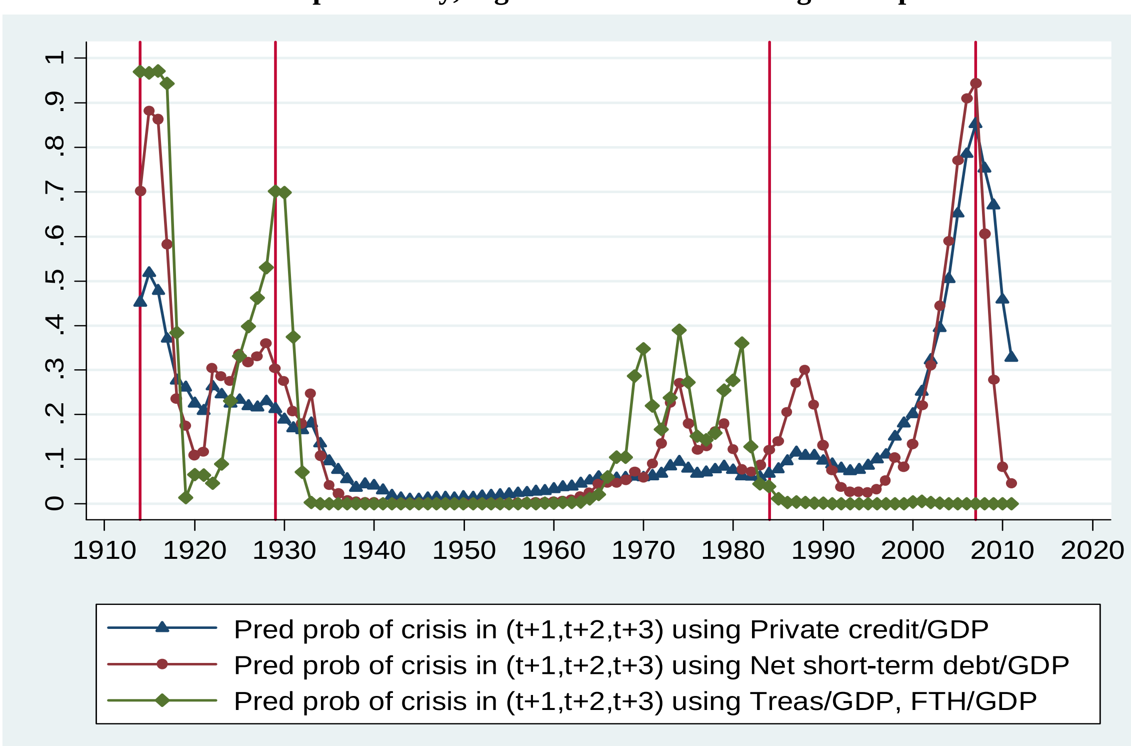


Table 1. The impact of government supply on the yield spread between corporate bonds and bank accounts

	(Baa-rated corporate bonds)-(Time and savings accounts)	(P2-rated commercial paper)-(Time and savings accounts)
Govt. supply/GDP	-1.53	-1.25
	(-2.50)	(-1.99)
EDF	1.39	-0.32
	(1.99)	(-0.46)
Slope of yield curve	0.83	-0.85
(10-year minus 6-month)	(5.36)	(-6.23)
Constant	0.78	1.78
	(1.22)	(2.47)
R^2	0.628	0.759
N	77	38
Time period	1935-2011	1974-2011

Note: t-statistics in parenthesis. OLS estimations with standard errors calculated assuming AR(1) error terms. EDF is Moody's expected default frequency for corporate bonds. We have EDF data from 1969-2010. Prior to 1969 and for year 2011, we use fitted values from a regression of EDF on stockmarket volatility (defined as in Krishnamurthy and Vissing-Jorgensen (2012)) estimated using data from 1969-2010.

Table 2. Financial sector balance sheet, 1914-2011

Panel A. Instruments that are net assets on average across years

Instrument		(Assets-Liabs.) /GDP			Assets ($B)	Liabs. ($B)	Assets-Liabs. ($B)
		Avg for 1914-2011	End of 2007	End of Q3 2011	End of 2007		
Assets supplied by government (Treasury/ Federal Reserve)							
1.	Treasury securities	11.2	1.8	5.6	245	0	245
2.	Vault cash and reserves at Federal Reserve (assets), Federal Reserve float+Borrowing from Fed Res banks (liabilities)	4.0	0.5	10.9	64	-1	65
Sum		15.1	2.2	16.5	310	-1	310
Short-term assets							
3.	Customers' liability on acceptances	0.3	0.0	0.0	0	0	0
4.	Foreign deposits	0.2	0.7	0.6	102	0	102
5.	Trade credit	0.1	0.3	0.2	105	62	42
Sum		0.6	1.0	0.8	207	62	145
Long-term assets							
6.	Mortgages	31.5	96.2	83.0	13,520	154	13,365
7.	Bank loans	15.2	11.9	11.7	1,915	261	1,654
8.	Consumer credit	7.9	18.2	14.1	2,531	0	2,531
9.	Municipal securities	3.9	3.9	1.4	713	167	546
10.	Miscellaneous	3.3	21.7	11.6	3,432	413	3,019
11.	Other loans and advances (loans made by GSEs or finance companies, syndicated loans, other)	2.6	7.9	5.9	1,898	796	1,101
Sum		64.3	159.9	127.8	24,009	1,792	22,217
Equity							
12.	Investment by bank holding companies (in nonbanks)	0.7	2.8	5.5	390	0	390
13.	Corporate equities	0.4	2.1	1.0	289	0	289
14.	Investment in foreign banking offices	0.3	1.6	0.9	225	0	225
15.	Mutual fund shares	0.0	0.2	0.3	31	0	31
Sum		1.4	6.7	7.6	935	0	935
Overall sum		81.4	169.9	152.6	25,461	1,854	23,607

Panel B. Instruments that are net liabilities on average across years

Instrument		(Liabs.-Assets) /GDP			Assets ($B)	Liabs. ($B)	Liabs.-Assets ($B)
		Avg for 1914-2011	End of 2007	End of Q3 2011	End of 2007		
Short-term debt							
16.	Checkable deposits and currency	20.9	3.6	6.7	209	708	499
17.	Savings and time deposits	36.8	50.9	54.0	388	7,463	7,074
18.	Money market mutual fund shares	3.2	15.0	12.8	702	2,780	2,078
19.	Federal funds and security RPs	1.9	11.7	2.3	702	2,324	1,623
20.	Securities loaned (for funding corporations)	1.1	10.2	4.8	0	1,415	1,415
21.	Commercial paper	1.1	2.4	0.1	961	1,300	338
22.	Interbank liabs to foreign banks	0.3	0.2	1.2	0	28	28
23.	Interbank liabilities to domestic banks	0.2	0.1	0.7	0	18	18
24.	Security credit	0.3	4.7	4.6	432	1,078	646
25.	Acceptance liabilities	0.1	0.0	0.0	0	0	0
26.	Taxes payable	0.1	0.3	-0.2	0	38	38
Sum		66.2	99.0	87.0	3,393	17,150	13,757
Long-term debt							
27.	Agency- and GSE- backed securities	6.1	30.4	30.0	2,846	7,077	4,231
28.	Corporate and foreign bonds	0.9	23.1	14.3	2,828	6,037	3,209
	Issued by ABS issuers	3.0	27.6	13.3	0	3,841	3,841
	Issued by other fin. inst's	-2.1	-4.5	1.0	2,828	2,196	-633
29.	U.S. govt. loans to GSEs	0.0	0.0	0.0	0	0	0
Sum		7.0	53.5	44.4	5,674	13,114	7,440
Equity							
30.	Financial sector equity	6.9	10.6	12.6	0	1,475	1,475
31.	Inv. by bank holding cos (in bank subsidiaries), by parent (in savings inst. and finance comp.'s), by affiliates (for security brokers and dealers) or by funding corp.'s in security brokers and dealers	1.1	4.7	6.5	1,623	2,280	656
32.	Foreign direct inv. U.S.	0.2	2.0	2.1	0	280	280
33.	Equity interest under PPIP (for funding corporations)	0.0	0.0	0.1	0	0	0
Sum		8.2	17.3	21.3	1,623	4,034	2,411
Overall sum		81.4	169.9	152.6	10,691	34,298	23,607

Table 3. Financial sector balance sheet with short, long, and equity categories netted, 1914-2011

Instrument	(Assets-Liabs.) /GDP			Assets ($B)	Liabs. ($B)	Assets-Liabs. ($B)
	Avg for 1914-2011	End of 2007	End of Q3 2011	End of 2007		
Net long-term investments						
=(Long-term assets)-(Long-term debt)	57.3	106.3	83.5	29,683	14,906	14,777
Overall sum	57.3	106.3	83.5	29,683	14,906	14,777
	(Liabs.-Assets) /GDP			Assets ($B)	Liabs. ($B)	Liabs.-Assets ($B)
	Avg for 1914-2011	End of 2007	End of Q3 2011	End of 2007		
Net short-term debt						
=(Short-term debt)-(Short-term assets)-(Assets supplied by government)	50.5	95.7	69.8	3,910	17,212	13,302
Net equity						
=(Equity on liability side-(Equity on asset side)	6.8	10.6	13.7	2,558	4,034	1,476
Overall sum	57.3	106.3	83.5	6,469	21,246	14,777

Table 4. Impact of Treasury supply on financial sector balance sheet, 1914-2011

Panel A. Short, long, and equity categories netted

	Govt. supply/GDP	Year	R2	Partial R2 of Govt. supply/GDP
Net long-term investments	-0.506	0.005	0.765	0.332
=(Long-term assets)-(Long-term debt)	(-3.84)	(2.62)		
Net short-term debt	-0.486	0.005	0.853	0.325
=(Short-term debt)-(Short-term assets)	(-5.02)	(4.49)		
-(Assets supplied by US govt./Federal reserve)				
Net equity	-0.020	-0.0003	0.118	0.022
=(Equity on liability side-(Equity on asset side)	(-0.47)	(-0.45)		

Panel B. Instruments that are net assets on average across years

	Govt. supply/GDP	Year	R2	Partial R2 of Govt. supply/GDP
Assets supplied by US govt. or Federal Reserve	0.453	-0.002	0.878	0.686
	(8.16)	(-2.82)		
Short-term assets	-0.009	0.0002	0.722	0.086
	(-1.92)	(3.84)		
Long-term assets	-0.490	0.010	0.769	0.103
	(-2.98)	(2.93)		
Equity	0.0002	0.0006	0.635	0.000
	(0.01)	(2.35)		
Sum (size of financial sector)	-0.045	0.009	0.710	0.001
	(-0.29)	-2.85		

Panel C. Instruments that are net liabilities on average across years

	Govt. supply/GDP	Year	R2	Partial R2 of Govt. supply/GDP
Short-term debt	-0.042	0.003	0.671	0.007
	(-0.52)	(3.77)		
Liquid ST debt:				
Checkable deposits	0.223	-0.003	0.942	0.196
	(6.19)	(-9.32)		
Other ST debt	-0.269	0.007	0.898	0.081
	(-2.98)	(5.95)		
Long-term debt	0.017	0.005	0.777	0.000
	(0.27)	(4.20)		
Equity	-0.020	0.0003	0.048	0.012
	(-0.39)	(0.22)		
Sum (size of financial sector)	-0.045	0.009	0.710	0.001
	(-0.29)	-2.85		

Note: t-statistics in parenthesis. In all panels of this table, the dependent variables are scaled by GDP. Estimations are by OLS with standard errors estimated assuming AR(1) error terms. Regressions include a constant (not reported for brevity).

Table 5. Including Treasury supply in money demand functions

Panel A. Using money measures constructed by us from Flow of Funds Accounts and All Banking Statistics

	ln((Checkable deposits+currency)/GDP)						
	1914-1979			1914-2011			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(Nom. yield on	-0.298	-0.256	-0.135	-0.182	-0.114	0.037	-0.041
3-mo com. paper)	(-4.08)	(-5.16)	(-2.62)	(-1.40)	(-2.11)	(0.75)	(-1.22)
ln(Real GDP)		-0.183	-0.236		-0.417	-0.457	-0.137
		(-2.93)	(-4.25)		(-4.07)	(-7.07)	(-1.77)
ln(Government supply/GDP)			0.232			0.457	0.270
			(3.01)			(3.98)	(3.60)
ln(Foreign Treasury holdings/GDP)							-0.311
							(-4.41)
Constant	-2.214	-1.593	-0.826	-2.069	-0.532	0.507	-2.050
	(-8.40)	(-5.95)	(-2.60)	(-5.11)	(-1.45)	(1.49)	(-3.59)
N	66	66	66	98	98	98	98
R^2	0.656	0.825	0.874	0.123	0.804	0.89	0.947

Panel B. Using conventional money measures from Friedman and Schwartz and the Federal Reserve's H6 release

	ln(M1/GDP)						
	1914-1979			1914-2011			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(Nom. yield on	-0.267	-0.233	-0.110	-0.174	-0.115	0.021	-0.053
3-mo com. paper)	(-3.98)	(-4.37)	(-2.22)	(-1.56)	(-2.34)	(0.47)	(-1.77)
ln(Real GDP)		-0.145	-0.200		-0.362	-0.397	-0.098
		(-2.10)	(-3.66)		(-3.63)	(-6.84)	(-1.47)
ln(Government supply/GDP)			0.235			0.413	0.237
			(3.16)			(3.96)	(3.60)
ln(Foreign Treasury holdings/GDP)							-0.292
							(-4.82)
Constant	-2.183	-1.689	-0.911	-2.093	-0.761	0.177	-2.221
	(-9.03)	(-5.81)	(-2.97)	(-1.56)	(-2.13)	(0.57)	(-4.50)
N	66	66	66	98	98	98	98
R^2	0.650	0.783	0.845	0.143	0.792	0.881	0.944

Note: t-statistics in parenthesis. In both panels regressions are estimated by OLS. Standard errors assume AR(1) error terms, except in column (4) in each panel in which AR(1)-based standard errors are infeasible because the AR(1) coefficient in the error term process is above 1. In these cases we use Newey-West standard errors based on 5 lags.

Table 6. Three additional approaches to address endogeneity concerns

Panel A. Controls for loan demand. Dropping most problematic years.

	Dependent variable: Net short-term debt(t)/GDP(t)					
	(1)	(2)	(3)	(4)	(5)	(6)
Govt. supply(t)/GDP(t)	-0.486	-0.309	-0.320	-0.556	-0.487	-0.516
	(-5.02)	(-4.81)	(-5.48)	(-5.03)	(-5.67)	(-4.84)
Real GDP(t)/Real GDP(t-5)		-0.094				
		(-2.20)				
Primary deficit/GDP, year t-4 to t				0.119		
				(1.36)		
Primary deficit/GDP, year t+1 to t+5				-0.053		
				(-0.83)		
Year	0.005	0.007	0.007	0.004	0.004	0.004
	(4.49)	(9.24)	(10.82)	(4.85)	(4.59)	(2.90)
R^2	0.853	0.928	0.923	0.900	0.886	0.878
Sample	1914-2011	1934-2011	As (2)	1918-2004	As (4)	Drop year t to t+9 after financial crisis

Panel B. Impact of a demand shock for safe/liquid assets

	Dependent variable:	
	Net short-term debt/GDP	Net long-term investments/GDP
	(1)	(2)
Govt. supply/GDP	-0.504	-0.531
	(-8.56)	(-7.95)
Foreign Treasury holdings/GDP	1.339	1.937
	(4.14)	(5.28)
Year	0.003	0.001
	(3.21)	(1.32)
R^2	0.925	0.906
Sample	1914-2011	1914-2011

Panel C. ``Rajan-Zingales identification'': Household expenditure shares for ``credit goods''. Are expenditure shares for products often bought with borrowed money higher when government debt supply is smaller?

	Dependent variable: Expenditure share of products often bought with borrowed money	
	(1)	(2)
	Coef.	Coef.
Govt. supply/GDP	-0.064	-0.081
	(-4.16)	(-4.41)
Log(real expenditure)	0.051	0.011
	(5.38)	(1.93)
Log(price of products often bought with borrowed money/price of all expenditure)	0.216	
	(5.52)	
R^2	0.814	0.696
Sample	1929-2011	1929-2011

Note: t-statistics in parenthesis. Estimations in all three panels are by OLS with standard errors estimated assuming AR(1) error terms. Regressions include a constant (not reported for brevity). In Panel C, expenditure on products often bought with borrowed money is defined as the sum of expenditure on durable goods and on housing and utilities. Expenditure data are from NIPA Table 2.3.5 and price data from NIPA Table 2.4.4.

Table 7. Predicting banking crisis in the US, 1914-2011
Panel A. Using predictors directly

	Dummy=1 if first year of a US banking crisis is in year t+1, t+2, or t+3				Dummy=1 if first year of a US banking crisis is in year t+1			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net short-term debt/GDP		24.277				21.355		
		(2.99)				(1.78)		
Private credit/GDP			8.100				7.195	
			(3.25)				(1.75)	
Government supply/GDP				-18.746				-12.674
				(-4.09)				(-3.50)
Foreign Treasury				21.287				15.627
holdings/GDP				(2.10)				(1.01)
Year	0.015	-0.099	-0.07		0.016	-0.094	-0.066	
	(0.79)	(-2.47)	(-2.34)		(0.48)	(-1.43)	(-1.30)	
Area under ROC curve (AUROC)	**0.628**	**0.865**	**0.783**	**0.873**	**0.631**	**0.862**	**0.747**	**0.818**
Std. error for AUROC	0.137	0.065	0.085	0.047	0.265	0.127	0.198	0.092
T	78	78	78	78	78	78	78	78

Panel B. Using predicted values and residuals from regressions of predictors on government supply/GDP and foreign Treasury holdings/GDP

	Dummy=1 if first year of a US banking crisis is in year t+1, t+2, or t+3		Dummy=1 if first year of a US banking crisis is in year t+1	
	(1)	(2)	(3)	(4)
Net short-term debt/GDP, predicted value	29.123		18.843	
	(2.75)		(1.59)	
Net short-term debt/GDP, residual	9.936		31.062	
	(1.16)		(2.39)	
Private credit/GDP, predicted value		10.027		6.049
		(3.10)		(1.57)
Private credit/GDP, residual		3.296		10.002
		(1.00)		(1.47)
Year	-0.1	-0.077	-0.097	-0.063
	(-2.46)	(-2.38)	(-1.50)	(-1.24)
(AUROC)	**0.874**	**0.836**	**0.833**	**0.747**
Standard error for AUROC	0.063	0.076	0.073	0.098
T	78	78	78	78

Note: t-statistics in parenthesis. Logit model estimation with standard errors robust to heteroscedasticity (White). Regressions include a constant (not reported for brevity). t-statistics in parenthesis. Observations are dropped if year t, t-1, t-2, t-3 or t-4 was a the first year of a crisis. Net short-term debt/GDP=((ST debt-ST assets)-(Assets supplied by the government))/GDP. Private credit/GDP=(Short-term assets+Long-term assets)/GDP.