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THE IMPACT OF TREASURY SUPPLY ON FINANCIAL SECTOR LENDING AND STABILITY[†]

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 safe and liquid government debt should crowd out financial sector lending financed by short-term debt. We verify this prediction in U.S. data from 1875-2014. We take a series of approaches to rule out "standard" crowding out via real interest rates and to address potential endogeneity concerns.

JEL Classification: E4, G12 and G2
Keywords: banking, financial stability, monetary economics and treasury supply

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1 Introduction

The financial sector holds long term risky and illiquid assets that are predominantly funded by short-term debt. Based on data from 1875 to 2014, we report in Table 1 that on average the ratio of financial sector short-term debt to GDP is 0.58. Financing from long-term debt and equity funding is small, averaging 0.08 relative to GDP. These funds were used mainly to fund long-term investments which average 0.52 relative to GDP, with the remainder invested in Treasury bonds, reserves and currency. Theoretical models show that this funding structure is fragile and associated with financial crises (Diamond and Dybvig, 1983). Empirical work has shown that high bank credit growth, which is largely funded by short-term debt, increases the likelihood of a financial crisis (Schularick and Taylor, 2012).[1]

Why does short-term debt fund so much of bank lending? The theoretical literature offers several distinct (but not mutually exclusive) explanations. The agency view of short-term debt, modeled in Calomiris and Kahn (1990) and Diamond and Rajan (1998), is that short-term debt serves as a device to ensure that bank management takes efficient actions, i.e., actions that maximize bank value. A second view of short-term debt highlights the insurance offered by the government on deposit financing. In this view, articulated prominently by Admati and Hellwig (2013), banks issue short-term debt to take advantage of mispriced deposit insurance and implicit bailout guarantees. A third view of short-term debt emphasizes the special role of banks in creating liquidity. In this view, modeled in Diamond and Dybvig (1983), Gorton and Pennacchi (1990), and Dang, Gorton and Holmstrom (2010), the financial intermediary sector plays an important role in transforming illiquid long-term assets into liquid short-term liabilities that offer non-pecuniary services to the non-financial sector. This paper provides evidence in favor of this third view of banking and short-term debt. We show that investors have a large demand for safe and liquid investments, and that short-term bank 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 assets (loans, securities, etc.) that are funded by short-term debt.

To arrive at these results, we exploit variation in the supply of government securities. In Krishnamurthy and Vissing-Jorgensen (2012) we showed that Treasury securities are "money-like" in several respects. We established this by showing that reductions in the supply of Treasuries lower the yield on Treasuries relative to corporate securities that are less liquid and more risky than Treasuries. This is true even controlling for the default component of the corporate securities. That is, Treasury securities carry a moneyness premium, and this premium is declining in the total supply of Treasuries. If financial sector short-term debt is due to demand for safety/liquidity, then Treasury supply should crowd out financial sector short-term debt via effects on the equilibrium prices of safety and liquidity.

Section 2 presents a simple model of banking, where banks own loans and securities and fund these

[1] These ideas linking credit and debt to financial crises go back at least to Fisher (1933).

with equity and short-term bank debt. The key assumption of the model is that short-term bank debt and Treasury securities offer non-pecuniary services to households, so that the yields on these assets are lower than that of loans. The theory predicts that increases in Treasury supply will crowd out financial sector lending funded by short-term debt. This is because the reduction in the yield spreads between risky/illiquid loans and safe/liquid assets 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 loans. Prior theoretical work, in particular by Holmstrom and Tirole (1998, 2011), has also drawn the connection between the government supply of liquid securities and the private supply of such securities. Holmstrom and Tirole (2011) show that when there is a shortage of government supplied liquid assets, a liquidity premium arises which induces the private sector to invest in projects that generate liquid assets.

To test this prediction, we construct the aggregate balance sheet of the U.S. financial sector and the supply of U.S. government securities over the last 140 years. We define government supply as the supply of unbacked Treasury issues plus metal-backed Treasury supply, minus foreign official holdings of Treasury securities. By unbacked Treasury bonds we refer to Treasury securities (of all maturities) plus Treasury issued currency (which accounts for the pre-Federal Reserve period where the Treasury issued currency) and by metal-backed supply we mean Treasury issues of gold/silver coins and gold/silver certificates. We subtract out foreign official holdings of government securities from this sum since we are interested in the privately held supply of U.S. government issues. We study the relation between government supply and the U.S. financial sector's net 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 government securities and short-term assets. This net short-term debt measure by construction equals the amount of long-term lending to the private (i.e. non-government) sector financed by short-term debt. We show that the financial sector's net short-term debt supply (relative to GDP) is strongly negatively correlated with the government supply (relative to GDP). This result, together with the result in Krishnamurthy and Vissing-Jorgensen (2012) on the impact of Treasury supply on yield spreads between risky/illiquid assets and Treasuries (representing safe/liquid assets), suggests that financial sector short-term debt is special in the same way that government-supplied securites are and that the financial sector issues short-term debt in part to satisfy the special demand for safe/liquid debt. 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, profiting from the spread between these securities.

An obvious concern with our crowding out result (the negative relation between financial sector net short-term debt and government supply) is that it may not be driven by safety/liquidity effects but instead by the "standard" mechanism taught in macro textbooks in which government supply crowds out private capital formation by raising real interest rates. We show that this is unlikely by including measures of the real interest rate and the capital stock in our regressions and showing that the crowding out of net short-term debt by government supply is robust to including these control variables. Moreover, our model of safety/liquidity-induced crowdout has the unique prediction that the ratio of bank lending to capital should be crowded out by increases in Treasury supply. That is our model predicts changes in the lending against existing capital, and not only changes in the accumulation of new capital. We show that this prediction is borne out in the data.

An equally important issue is that our result may not be causal and instead driven by either omitted variables or reverse causality. Treasury supply is affected 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, the negative relation between short-term debt (or bank lending) and Treasury supply could be driven by opposing cyclicality of loan demand and the budget deficit. Furthermore, financial sector debt and lending may drive Treasury supply via a banking crisis causing a recession and thus a budget deficit (reverse causality). To address these concerns we take several different approaches.

First, we show that our crowding-out result is unaffected by controlling for recent real GDP growth (and thus the business cycle) and is robust to dropping years following financial crisis where the financial sector contracts and the associated recession causes an increase in government debt.

Second, we isolate two episodes where underlying shocks are unlikely to be correlated with US economic conditions. The first shock we exploit is the large gold inflows into the US during the 1933-1940 period of European political instability. These inflows lead to a large increase in the government supply of liquid and safe assets and we show, consistent with our model, that they crowd out net short-term bank debt. The second shock we exploit is the dramatic increase in foreign official (i.e. central bank) 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). We show that this demand shock, which represent a reduction in the remaining supply available to be held by private investors, crowds in net short-term bank debt, consistent with the theoretical prediction of the model.

Third, we examine the composition of household expenditures. Our model implies that an increase in government supply reduces the supply of bank lending. In this scenario, the effective cost (where cost includes financing costs) of goods purchased on credit will rise as government supply is increased, leading the expenditure share of such goods to fall. We define goods often purchased on credit to be NIPA categories "Durable goods" plus "Housing and Utilities" and test whether the expenditure share for such goods is crowded out by government supply. 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.

The next section of the paper lays out a model for understanding the relations between government 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 how to construct an overall balance sheet for the financial sector going back 140 years. Finally, we present our empirical results linking government supply and private supply. We finish by a discussion of institutional changes over our long sample period.

2 Model

We study an endowment economy with two dates, $t = 0$ and $t = 1$. All financial claims are bought at date 0 and are repaid at date 1. There is no uncertainty and no default. The model has a household sector, a financial sector, and a government. The household sector owns equity and deposits in the financial sector, as well as government bonds. The household sector is endowed with home/business capital. A fraction $\lambda_K < 1$ of this capital can be used as collateral to secure a loan from the financial sector. The financial sector owns Treasury bonds and loans against home/business capital and is funded by equity and deposits.

2.1 Government bonds

Both the household and the financial sector own government bonds. Bonds are issued at date 0 and retired at date 1. Proceeds from the issue are transferred lumpsum to the households at date 0 and retired at date 1 using lumpsum taxes on the household sector. Denote the interest rates on these bonds as r_T and the total supply of these bonds as Θ. The date 0 transfer to households from bond issuance is

$$T_0 = \frac{\Theta}{1 + r_T} \tag{1}$$

and the date 1 transfer (tax) from retiring the bonds is

$$T_1 = -\Theta \tag{2}$$

The model has only one maturity of bond when in practice there are different maturities of bonds. We return to a discussion of government bond maturity later in this section.

2.2 Households

Households are endowed with K units of a Lucas (1978) tree. The tree provides a date 0 dividend of y_0 and date 1 dividend of y_1. The tree also has date 1 terminal value of K (in terms of consumption), so that the endowment at date 1 is $y_1 + K$. In practice, one should think of the tree as corresponding to a home or business. Households are also endowed with one share in the financial sector that is worth E at date 0 (pre-dividend) and pays dividends of $Dividend_0$ at date 0 and $Dividend_1$ at date 1 (these dividends will be determined in equilibrium). Finally, households receive lump sum transfers/taxes of T_0 and T_1.

Households make an investment decision at date 0. Their investment options include:

- Take on a bank loan at interest rate r_K against collateral of $\lambda_K K$ to receive proceeds of $\frac{\lambda_K K}{1+r_K}$;
- Retain a fraction α of their equity in the financial sector.
- Buy deposits in the financial sector of D at cost $\frac{1}{1+r_D}$ per unit;
- Buy Treasury bonds, θ^H at cost $\frac{1}{1+r_T}$ per unit.

Households maximize utility

$$u(c_0) + u\left(c_1 + y_1 \times v\left(\frac{S}{y_1}\right)\right) \tag{3}$$

The function $v(\cdot)$ takes as argument the ratio of bank deposits plus Treasury bonds to the date 1 income from the tree, where,

$$S = D + \theta^H \tag{4}$$

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 bank debt and for government 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 government bonds. We explicitly say “short-term" financial sector debt here since we follow Stein (2012) in arguing that the financial sector can better target safety demand by issuing short-term debt. This is because the financial sector cannot issue much completely default-free long-term debt given that worst-case losses on loans in the long term are likely to be substantial and given that the financial sector, unlike the government, cannot back its borrowing with taxation. For this reason we do not introduce long-term financial sector borrowing below when we consider several maturities of government debt.

The household date 0 budget constraint gives,

$$c_0 = y_0 + (1-\alpha)E + \alpha Dividend_0 + \frac{\lambda_K K}{1+r_K} - \frac{D}{1+r_D} - \frac{\theta^H}{1+r_T} + T_0 \tag{5}$$

while date 1 consumption is

$$c_1 = y_1 + \alpha Dividend_1 + (1-\lambda_K)\,K + D + \theta^H + T_1 \tag{6}$$

We define

$$s = \frac{S}{y_1} \tag{7}$$

$$C_0 = c_0 \tag{8}$$

$$C_1 = c_1 + y_1 v(s) \tag{9}$$

The FOC for equity investment gives

$$E = Dividend_0 + \frac{u'(C_1)}{u'(C_0)} Dividend_1. \tag{10}$$

Define the return on equity as,

$$1 + r_E = \frac{Dividend_1}{E - D_0}$$

where $E - D_0$ is the ex-dividend price. Then the FOC for equity investment is

$$1 + r_E = \frac{u'(C_0)}{u'(C_1)} \tag{11}$$

The FOC for the loan against home/business assets is

$$1 + r_K = \frac{u'(C_0)}{u'(C_1)} \tag{12}$$

Clearly, $r_E = r_K$. The return on bank equity and the return on bank loans are the same because there is no risk in the model.

The FOC for households' investment in deposits is

$$(1+r_D)(1+v'(s)) = \frac{u'(C_0)}{u'(C_1)} \tag{13}$$

The term $v'(s)$ reflects the additional value that households place on deposits because they satisfy households' short-term debt demand. The FOC for government bonds is

$$(1+r_T)(1+v'(s)) = \frac{u'(C_0)}{u'(C_1)} \tag{14}$$

Clearly, $r_D = r_T$ because both deposits and government bonds equally satisfy households' debt demand.

We can combine the deposits and loan FOC to find

$$(1+r_D)(1+v'(s)) = 1 + r_K \tag{15}$$

which implies that

$$\frac{r_K - r_D}{1 + r_D} = v'(s) \tag{16}$$

Thus a higher equilibrium value of s lowers the spread between the interest rate on loans and the interest rate on deposits and government bonds.

2.3 Financial sector

The model includes a financial sector whose economic function is to make loans to households and to issue deposits, D, to satisfy households' demand for safe/liquid debt. The financial sector equity is owned by the households. One should think of the financial sector as a technology that converts claims against capital (mortgage or business loans) into deposits that are valuable to households. The Modigliani-Miller theorem fails in our model because of the extra value that households assign to deposits (and Treasuries).

The financial sector has a portfolio of loans and government bonds to back the deposits. We assume that the representative bank faces a constraint on deposit issuance:

$$D \leq \lambda_K K + \theta^F \tag{17}$$

That is, a bank can create deposits one-for-one with government bonds but at the haircut $1 - \lambda_K$ against trees. When taking the model to data we interpret $\lambda_K K$ as lending by the financial sector to the private sector, which in practice is mainly banks' corporate loans and mortgage loans. As noted, we assume that only the financial sector has access to this investment technology.

It will be helpful to go through an example to understand a simplifying assumption we have made. In practice, a bank may make an \$80 loan against a home worth \$100 (i.e., 80% loan-to-value ratio). The bank may use this loan to create a mortgage backed security that backs \$60 of a short-term debt asset such as a repo. In this case, the \$100 of the home corresponds to $K = 100$, and the deposit corresponds to $D = 60$. We see in this example that there are two haircuts starting from the \$100 home. There is a 20% ($= 1 - \frac{80}{100}$) haircut on the mortgage loan, and a 25% ($= 1 - \frac{60}{80}$) haircut on the repo loan. In our model, we explicitly model the first haircut but this is without loss of generality. Our model is isomorphic to one where we model both of these haircuts. Intuitively this is because the households own all of the equity in the economy, both the bank equity and the equity in their home. If we approached the model from the planner's perspective, increasing households' home equity and decreasing bank equity, or vice-versa, has no effect on the total amount of deposits created from K of homes. This total number of deposits is the only object of economic value created by the private sector in our endowment model, because households place extra value on these deposits.

We assume that λ_K is a choice variable of the bank. To choose $\lambda_K > 0$ costs $\phi(\lambda_K) \geq 0$ which is paid at date 0. The bank can spend resources to screen, monitor borrowers, etc., in order to create short-term debt up to $\lambda_K K$ of home/business loans, but at cost ϕ. We assume that $\phi(0) = 0, \phi'(0) = 0, \phi'' > 0$ and $\phi'(1) = \infty$, which ensures that $\lambda_K \in [0, 1]$.

At date 0, the representative bank chooses λ_K, θ^F, and D, to generate cash flow to equity holders of

$$Dividend_0 = \frac{D}{1+r_D} - \frac{\lambda_K K}{1+r_K} - \frac{\theta^F}{1+r_T} - \phi(\lambda_K)K. \tag{18}$$

These choices also result in a cash flow to equity holders at date 1 of

$$Dividend_1 = \lambda_K K + \theta^F - D. \tag{19}$$

The value of bank equity is then

$$Dividend_0 + \frac{Dividend_1}{1+r_E} = \frac{D}{1+r_D} - \frac{\lambda_K K}{1+r_K} - \frac{\theta^F}{1+r_T} - \phi(\lambda_K)K + \frac{1}{1+r_E}\left(\lambda_K K + \theta^F - D\right). \tag{20}$$

The bank maximizes this value, subject to the deposit issuance constraint.

We first note that the bank will always choose to saturate the deposit constraint of (17) as long as $v'(s) > 0$ (and $v'(s)$ is always strictly positive as we have assumed that household demand for safe debt does not have a satiation level). When $v'(s) > 0$ we have that $r_E > r_D$. Suppose that the deposit constraint were slack. In this case, $Dividend_1 > 0$. But the bank could do better by increasing D by $\delta > 0$, incurring no additional costs, and thereby increasing the date 0 dividend by $\frac{\delta}{1+r_D}$ while reducing the present value of date 1 dividends by $\frac{\delta}{1+r_E}$. Since $r_E > r_D$, the bank gains $\frac{\delta}{1+r_D} - \frac{\delta}{1+r_E} > 0$.

Substituting in for D with a binding deposit issuance constraint, and noting that $r_D = r_T$ by the households' FOCs, we rewrite the bank's objective as,

$$E = \max_{\lambda_K}\left(\frac{\lambda_K K}{1+r_D} - \frac{\lambda_K K}{1+r_K}\right) - \phi(\lambda_K)K \tag{21}$$

The value of bank equity is the maximized profit, which comes from investing in loans at interest rates higher than the rate the bank pays on deposits.

Note that since $r_D = r_T$ by the households' FOCs, banks are indifferent over their choice of government bonds, θ^F, financed with bank deposits. That is, banks make the same profits for any choice of θ^F financed by deposits. We have earlier also noted that households are indifferent over their own holdings of D versus θ^H. Together these results mean that our model does not pin down θ^F and θ^H. While this may appear problematic, below we show that the robust prediction of our model regards a net debt measure, $D - \theta^F$.

The FOC for λ_K is

$$\phi'(\lambda_K) = \frac{r_K - r_D}{(1+r_D)(1+r_K)} \tag{22}$$

This last expression is central to our analysis. In a model with no special debt demand, $r_K - r_D = 0$, and hence $\lambda_K = 0$ (since $\phi'(0) = 0$). As $r_K - r_D$ rises, λ_K rises. That is, banks respond to a higher spread between loan rates and deposits rates by increasing lending financed by deposits.

2.4 Effects of changes in government bond supply

We now ask how changes in the supply of government bonds affect equilibrium prices and quantities.

Proposition 1 *An increase in Θ increases s and reduces spreads, $r_K - r_D$ $(= r_K - r_T)$, while decreasing ϕ.*

- *The ratio of bank loans to existing capital, λ_K, decreases in government bond supply.*
- *Bank loans, $\lambda_K K$, decreases in government bond supply.*

Proof: The proof is by contradiction. We have that

$$S = D + \theta^H = \lambda_K K + \Theta$$

Suppose that S falls with an increase in Θ. Then the spread $r_K - r_D$ rises. Since λ_K is increasing in the spread, we must have that λ_K rises, which then means that S rises, which is a contradiction. Thus S is increasing in Θ. The statement regarding spreads follows from equation (16). ∎

The decrease in spreads caused by an increase in government bond supply leads to a decrease in bank lending, $\lambda_K K$, against the existing capital stock K. That is, our model predicts that the ratio of bank-loans to total capital falls with increases in government bond supply. This is a pure financial crowding-out effect that is unique to our model. It may also be that an increase in government bond supply reduces capital accumulation, and hence the capital stock (K), through a more standard crowding out effect. This standard crowding out effect would also be present in our model if banks or households had a capital accumulation margin. In such a model a further effect that is special to our setting is that banks/households would increase investment particularly in forms of capital that are good collateral against which to write short-term debt. For example, assets that are common in securitization such as real estate and consumer durables would be especially affected.

It follows from Proposition 1 that decreases in government supply leads to increases in bank lending. It is also important to note that such increases in bank lending is funded by debt. Debt-fueled credit expansions have been a prominent factor in many financial crises, linking our results to concerns regarding financial stability (see Schularick and Taylor, 2012). This observation is clear from the FOC (22). Bank lending is chosen based on the spread between bank loan rates, r_K, and deposit rates, r_D. In our model, the spread between loan rates and the return on equity, $r_K - r_E$, is equal to zero. That is, expanding bank lending is only profitable when funded by debt, because debt is "cheap" since it offers special services to households. If a bank made loans financed purely with money from shareholders, the bank would lose money since $r_K = r_E$ and lending suffers the screening cost of $\phi(\lambda_K) K > 0$.

If we considered our model but with no special services from debt, changes in government bond supply would have no effects on equilibrium prices or quantities. The lack of price effects is similar to the Ricardian benchmark as presented in Barro (2014). Our model is different from Barro's because there is a single representative household in our model. If we modeled heterogeneity along the lines of Barro, than there would be some change in bank debt quantity in response to changes in government bond supply, but no change in equilibrium prices. We focus on a model where government bond supply affects quantities via prices because we have elsewhere (Krishnamurthy and Vissing-Jorgensen (2012)) documented price effects of Treasury supply.

To test our model we document the relation between $\lambda_K K$ and government bond supply. We are particularly interested in lending financed by short-term debt, so we also define the "net short-term debt" of the financial sector as

$$\text{Net-ST} = D - \theta^F, \tag{23}$$

and analyze its relation with government bond supply. Intuitively, the net debt measures strips out the narrow bank component of banking – i.e., deposits backed by Treasury holdings – leaving the deposits used to fund loans, which is the object of interest for our model.

Corollary 1 *An increase in Θ decreases loans funded by short-term debt, Net-ST.*

Proof: Rewriting the deposit constraint (17), we have that Net-ST $= \lambda_K K$, which is increasing in Θ given the result in Proposition 1 ∎

2.5 Bank portfolio substitution and household debt substitution

The main prediction of the model we take to the data is Proposition 1's statement that an increase in Treasury supply reduces the amount of bank lending funded by short-term debt. We provide support for this prediction. We will also document the mechanisms through which the banking sector balance sheet adjusts to changes in Treasury supply.

Bank and household Treasury holdings are indeterminate in our model because households view Treasury bonds and deposits as perfect substitutes and banks can use Treasury bonds to back deposits one-for-one. Our model has unambiguous predictions for the net short-term debt variable, but does not have clear predictions for the equilibrium quantity of deposits. Nevertheless it is interesting to understand in the data how changes in Treasury supply affect bank balance sheets.

Conceptually, there are two ways that changes in Treasury supply could affect the banking sectors' lending funded by short-term debt. First, consider the bank deposit constraint, $D = \lambda_K K + \theta^F$. Consider an extreme case where D is fixed and banks absorb the fluctuations in Treasury supply by changing θ^F. Then an increase in bank Treasury holdings must lead to a fall in $\lambda_K K$ and hence a fall in Net-ST. We refer to this as a "bank portfolio substitution effect."[2]

Second, consider another extreme situation where the increase in Treasury supply is fully absorbed by the households. In this case, households will decrease their demand for bank deposits at every interest rate, which will lead to a decrease in the equilibrium value of D. Banks will then reduce lending, $\lambda_K K$, given that there are less bank deposits that need backing. We refer to this as a "household debt substitution effect."

Finally, note that the bank portfolio substitution effect leads to a positive relation between Treasury supply and D, while the household substitution effect leads to a negative relation between short-term Treasury supply and D. Regardless of these opposing effects, it is always the case that Net-ST falls with increases in Treasury supply.

2.6 Extension: Short and long-term Treasury bonds

In this section, we consider a variant of the model in order to shed light on the separate effects of changes in the supply of short and long-term Treasury bonds on equilibrium. As we do this within our one-period structure, our modeling needs more explanation.

We suppose that there are two classes of Treasury bonds that differ in the attributes they offer households and banks. "Short-term" government bonds are assumed to be perfect substitutes for deposits:

$$S = D + \theta_{ST}^{H}.$$

That is, short-term government debt (θ_{ST}^{H}) and bank deposits satisfy the safety/liquidity demand of households. Additionally, the bank's deposit constraint is

$$D \leq \lambda_K K + \theta_{ST}^{F} + \lambda_{LT}\theta_{LT}^{F} \tag{24}$$

so that banks can write deposits one-for-one against their holdings of short-term government bonds. Note that short-term government bonds are modeled exactly as we have modeled all government bonds in the basic model.

The deposit constraint has a new term, $\lambda_{LT}\theta_{LT}^{F}$, which corresponds to "long-term" government bonds. We assume that there is another class of government bonds that is worse collateral than short-term government bonds in backing bank deposits. That is, $\lambda_{LT} < 1$. We can think of λ_{LT} as the (complement) of a repo haircut. For example, Krishnamurthy (2010) notes that repo market haircuts on long-term Treasury bonds are 5% while they are closer to 2% on short-term bonds.

Finally, we assume that household utility is

$$u(c_0) + u\left(c_1 + y_1 \times v\left(\frac{S}{y_1}\right) + y_1 \times \mu\left(\frac{\lambda_{LT}\theta_{LT}^{H}}{y_1}\right)\right) \tag{25}$$

[2] In the model, households receive a transfer from the government from the sale of government bonds and in this extreme case use (almost) all of it to reduce loans $\lambda_K K$ and keep their deposits about the same.

We include a new term, $\mu(\cdot)$, which assigns a special value to the safety/liquidity value of holdings of long-term government bonds, $\lambda_{LT}\theta_{LT}^{H}$. This function can be motivated as in Krishnamurthy and Vissing-Jorgensen (2012) as capturing households desire for a safe long-term store of value. Note that we assume that banks cannot issue long-term bonds to satisfy households demand for a long-term store of value, as in Stein (2012). Additionally, for simplicity, we have set the parameter λ_{LT}, which governs how much store-of-value services are provided by long-term government bonds to households, to be the same value as the parameter in the bank's deposit constraint that governs the collateral value of long-term government bonds (again λ_{LT}).

To summarize, our extension considers dividing government supply into two parts: One part that is better collateral, which we identify in practice as short-term government bonds, and a part that is worse collateral, which identify with long-term government bonds. Thus although our model only has one-period, the extension allows us to understand the separate effects of varying the supply of government bonds with different collateral attributes. Short and long-term government bonds in practice do have different collateral properties, likely stemming from risk/liquidity differences between these bonds.

Rather than resolving agents' decisions problems and deriving equilibrium, it is easier to focus on deriving the equilibrium as the solution to the planner's problem. That is, given that there are no externalities present, this solution will give the competitive equilibrium (this is easy to verify). The only resource cost is $\phi\left(\lambda_K\right)K$ to be paid at date 0. Thus,

$$c_0 = y_0 - \phi\left(\lambda_K\right)K \tag{26}$$

$$c_1 = y_1 + K \tag{27}$$

$$C_0 = c_0 \tag{28}$$

$$C_1 = c_1 + y_1 v\left(\frac{S}{y_1}\right) + y_1 \mu\left(\frac{\lambda_{LT}\theta_{LT}^{H}}{y_1}\right) \tag{29}$$

$$S = \lambda_K K + \Theta_{ST} + \lambda_{LT}\theta_{LT}^{F} \tag{30}$$

where $\Theta_{ST} = \theta_{ST}^{F} + \theta_{ST}^{H}$ is the total supply of short-term Treasuries, and define $s = S/y_1$. The planner solves

$$\max_{\lambda_K, \theta_{LT}^{F}} u(C_0) + u\left(C_1\right) \tag{31}$$

This gives a pair of first order conditions,

$$v'\left(\frac{\lambda_K K + \Theta_{ST} + \lambda_{LT}\theta_{LT}^{F}}{y_1}\right) = v'(s) = \frac{u'(C_0)}{u'(C_1)}\phi'(\lambda_K) \tag{32}$$

and,

$$v'\left(\frac{\lambda_K K + \Theta_{ST} + \lambda_{LT}\theta_{LT}^{F}}{y_1}\right) = v'(s) = \mu'\left(\frac{\lambda_{LT}\theta_{LT}^{H}}{y_1}\right). \tag{33}$$

The first of these conditions is the same as in our basic model. That is, since $v'(s) = \frac{r_K - r_D}{1+r_D}$ and $\frac{u'(C_0)}{u'(C_1)} = 1 + r_K$, we recover exactly the same FOC as earlier. The second determines household holdings of long-term government bonds, θ^H_{LT}, and thus bank holdings of long-term government bonds $\theta^F_{LT} = \Theta_{LT} - \theta^H_{LT}$, where Θ_{LT} is the total supply of long-term government bonds.

We rewrite the first order conditions as,

$$v'\left(\frac{\lambda_K K + \Theta_{ST} + \lambda_{LT}\Theta_{LT} - \lambda_{LT}\theta^H_{LT}}{y_1}\right) = \frac{u'(C_0)}{u'(C_1)}\phi'(\lambda_K) \tag{34}$$

and,

$$v'\left(\frac{\lambda_K K + \Theta_{ST} + \lambda_{LT}\Theta_{LT} - \lambda_{LT}\theta^H_{LT}}{y_1}\right) = \mu'\left(\frac{\lambda_{LT}\theta^H_{LT}}{y_1}\right). \tag{35}$$

These two conditions determine the values of λ_K and θ^H_{LT} as a function of Θ_{ST} and Θ_{LT}. Note that Θ_{ST} and $\lambda_{LT}\Theta_{LT}$ enter symmetrically everywhere in equations (34) and (35). Thus it follows that an equal increase in Θ_{ST} and $\lambda_{LT}\Theta_{LT}$ have the same effect on theequilibrium, crowding out Net-ST the same. Since $\lambda_{LT} < 1$, it further follows that an increase in Θ_{ST} has a larger crowding out effect on Net-ST than an equal increase in Θ_{LT}. Thus $\lambda_K K$ and Net-ST falls more with an increase in Θ_{ST} than an increase in Θ_{LT}. We will examine this differential crowding-out prediction in the data, although (as we will explain) it is empirically hard to sort out this maturity effect in the data as we lack exogenous variation in the government's choice of Treasury maturity structure.

2.7 Extension: Transaction demand for money

There is an extensive literature examining the transaction demand for money, where money includes non-interest bearing deposits (checking deposits) at banks (e.g., see Goldfeld and Sichel, 1990). Our analysis has been silent on any transactions demand for bank deposits. We now extend our basic model to include transaction demand services from checking accounts. We show that the predictions of the basic model carry over in the extended model. That is, our analysis has not been limited by omitting standard money demand considerations.

Suppose that household utility is

$$u\left(c_0 + y_0 \times \psi\left(\frac{M}{y_0}\right)\right) + u\left(c_1 + y_1 \times v\left(\frac{S}{y_1}\right)\right) \tag{36}$$

Here, M is checkable deposits, while $\psi(\cdot)$ are transaction services from checkable deposits. The S and $v(\cdot)$ are the aggregate and the debt utility function of the basic model. Denote NTD as non-transaction deposits (time and savings deposits in practice), so that

$$S = M + NTD + \theta^H. \tag{37}$$

Consider the household problem first. The FOC for NTD is the same as that of D from earlier:

$$(1 + r_D)(1 + v'(s)) = \frac{u'(C_0)}{u'(C_1)} \tag{38}$$

This is because at the margin a non-transaction deposit pays interest of r_D and provides special services of $v'(s)$.

We assume that checkable deposits are regulated to pay no interest. This can be motivated by Regulation Q which required banks to pay zero interest on checking deposits over most of the sample period we study (we study 1875-2014 of which Regulation Q set the interest rate on checking deposits to zero from 1934-2011). The FOC for checkable deposits gives

$$\frac{1+v'(s)}{1-\psi'(m)} = \frac{u'(C_0)}{u'(C_1)} \tag{39}$$

where $m = M/y_0$. Combining the above two expressions we find

$$\psi'(m) = \frac{r_D}{1+r_D} \tag{40}$$

The opportunity cost of holding a checking deposit is to forego interest at the time deposit rate of r_D. The benefit of holding transaction deposits is $\psi'(m)$. We rewrite this expression as

$$m = \psi'^{-1}\left(\frac{r_D}{1+r_D}\right) \tag{41}$$

which is a standard transaction money demand function.

We next turn to the bank problem. The bank faces the deposit backing constraint on overall deposits

$$M + NTD \leq \lambda_K K + \theta^F. \tag{42}$$

The bank maximizes the date 0 dividend,

$$\max_{\lambda_K}\left(M + \frac{NTD}{1+r_D} - \frac{\lambda_K K}{1+r_K} - \frac{\theta^F}{1+r_T}\right) - \phi(\lambda_K)K, \tag{43}$$

where the term involving M indicates that transaction deposits pay no interest.

Banks are willing to supply transaction deposits, as they are regulated to pay no interest. We also assume that banks have a local monopoly on transaction deposits. With this assumption, we rule out banks competing on non-interest-rate terms for profitable transaction deposits. The volume of transaction deposits is then demand determined, $m = \psi'^{-1}(r_D/(1+r_D))$. Since a bank is a price taker (r_D is taken as given), from the bank's perspective m is a constant. As a result, the FOC for the bank in choosing λ_K is exactly the same as before:

$$\phi'(\lambda_K) = \frac{r_K - r_D}{(1+r_D)(1+r_K)} \tag{44}$$

Thus, the predictions of the model under Proposition 1 and Corollary 2 are unaffected by transaction deposit considerations. Intuitively this is true because a transaction deposit is inframarginal. Increasing λ_K allows at the margin for more deposits which pay interest rate r_D, which then allows the bank to capture a profit $r_K - r_D$ on the intermediation service.[3]

[3] The logic we have offered will carry through in cases where checking deposits may effectively pay interest. Consider the

3 Empirical framework

We present evidence consistent with Proposition 1 and Corollary 1, showing a robust negative correlation between government supply and net short-term debt. We also show evidence consistent with both the bank asset substitution and household debt substitution effects. Proposition 1 also predicts that increases in government supply reduce the spreads on long-term government bonds, $r_K - r_{LT}$, and the spreads on short-term government bonds, $r_K - r_{ST}$, and short-term private safe/liquid debt, $r_K - r_D$. Evidence for the spread relations is presented in Krishnamurthy and Vissing-Jorgensen (2012) (see Table 1 and Table 2). Thus, we will focus on testing the quantity predictions regarding bank lending.

We acknowledge at the outset an important shortcoming of our empirical approach: We lack instruments for Treasury supply. While we present a number of approaches to rule out alternative explanations for our results, we cannot definitively rule out omitted variables or reverse causality concerns. Following an earlier version of this paper, Greenwood, Hanson, Stein (2014) have proposed an instrument for short-term Treasury supply. They exploit high-frequency variation in T-bill supply caused by the Federal tax calendar which leads to peaks in issuance of T-bills leading up to tax deadlines. They provide empirical evidence that T-bill supply affects the yield-discount on short-maturity Treasuries. Consistent with that, they show that quantities of financial commercial paper (which is all short-term, typically less than 8 weeks) are crowded out by T-bill supply but not by non-bills supply over the period since 1952. They focus on financial commercial paper because it is plausibly the easiest for the financial sector to adjust at a high frequency. While they have a convincing instrument for high-frequency fluctuations in T-bill supply, they do not have an instrument for the lower-frequency movements which we focus on here and do not have an instrument for non-bills supply.

We study the period from 1875-2014, which is the longest time span for which we can construct reliable time series for our main variables of interest. The next section explains our data definition of government debt. Section 3.2 explains our empirical framework for constructing the financial sector's balance sheet and mapping it to the concepts in the model.

3.1 Defining government debt supply

We are interested in the government's supply of safe and liquid assets, Θ. We divide this quantity by GDP in order to scale it by the size of the U.S. economy. Our definition of government supply is as follows, with

realistic case where banks compete for checking deposits by offering transaction services at a cost. In this case, banks would provide transaction services upto the point where the marginal profit on attracting checking deposits (i.e., the profits from paying zero interest on checkable deposits minus the cost of transaction services) relative to non-transaction deposits is zero. This would determine M. But the FOC for λ_K would be unaffected. To expand the marginal non-transaction deposit and earn profits proportional to the spread $r_K - r_D$ costs $\phi'(\lambda_K)$ at the margin, and hence the FOC for λ_K is the same.

explanations given below the definition.

$$\begin{aligned} & \text{Government supply/GDP} \\ = \; & \text{(Treasury supply-Foreign official Treasury holdings)/GDP} \\ = \; & \text{(Treasury unbacked supply-Foreign official Treasury holdings)/GDP} \\ & \text{+(Treasury metal-backed supply)/GDP} \end{aligned}$$

where

$$\begin{aligned} & \text{Treasury unbacked supply} \\ = \; & \text{Treasury securities (bills, bonds, notes, certificates, savings bonds)} \\ & \text{+Currency issued by the Treasury} \end{aligned}$$

$$\begin{aligned} & \text{Treasury metal-backed supply} \\ = \; & \text{Gold and silver coin+Gold and silver certificates+Treasury notes of 1890.} \end{aligned}$$

The majority of Treasury supply under the above definition comes from Treasury securities (which one could equivalently refer to as tax-backed Treasury supply). Currency issued by the Treasury refers to United States notes (often called greenbacks) and fractional currency. Both were fiat money issued in the 1860s and 1870s. Treasury metal-backed supply refers to gold and silver coins minted by the U.S. Mint for the Treasury along with gold and silver certificates and Treasury notes of 1890 which are all Treasury-issued and backed by equivalent holdings of gold and silver. In including metal-backed supply in our government supply measure we implicitly assume that the coin and certificates represent a net addition to the economy-wide supply of safe and liquid assets, i.e. that the gold and silver that backs the coin and certificates could not be used with equal safety or liquidity in place of coin or certificates had the Treasury not issued these.[4] We account for the metal-backed supply for completeness but including it does not substantially affect any of our results.

Importantly, in both Treasury unbacked supply and Treasury metal-backed supply, we include amounts held by the Federal Reserve. When the Federal Reserve issues Federal Reserve currency and reserves, it backs these with its holdings of Treasury unbacked supply (Fed holdings of Treasury securities) and Treasury metal-backed supply (Fed holdings of gold coin and gold certificates). By including Fed holdings of Treasury unbacked and metal backed supply in our government supply measure, and not adding in Fed-issued currency or reserves, we are thus effectively considering the Fed as having a net zero impact on the supply of safe

[4] This would be the case if, for example, privately produced gold or silver coins or certificates would be less trustworthy due to concerns about their actual metal content or due to concerns about counterfeiting of any private certificates.

and liquid assets in the sense that the Fed supplies an equal amount of safe and liquid assets as it uses to back these assets. During the period of quantitative easing following the financial crisis, the Fed has issued large amounts of reserves to fund purchases of not only Treasuries but also mortgage-backed securities and agency debt. This is likely not net zero in terms of its impact on the overall amount of safe and liquid assets available for private investors. Our results are not materially affect by excluding the period from 2008-2014.

Our data sources for implementing the above government supply variable are as follows. We obtain data on Treasury unbacked supply and on GDP for 1875-2012 from Henning Bohn's web page. Bohn's debt series which for the early years comes from Historical Statistics of the United States, includes United States notes and fractional currency. The series is at book (principal) value and refers to publicly held debt (i.e. it excludes intra-governmental holdings, but includes Fed holdings). We update the series to 2014 using data on debt from the Monthly Statement of the Public Debt and on GDP from NIPA Table 1.1.5. For 1926-2014 it is possible to adjust the Debt/GDP series by a market/book adjustment using data from the CRSP bond database as done in Krishnamurthy and Vissing-Jorgensen (2012). This make very little difference to our results. Therefore, since we cannot make this adjustment prior to 1926, we use the book-value series for Treasury unbacked supply throughout.

A dramatic shock to the amount of Treasury supply available for investment by the private sector occurs with the increase in foreign official holdings of Treasuries starting in the early 1970s. While foreign official holders held around 2 percent of Treasuries in 1952 they have held about 1/3 of Treasuries in recent years. We are interested in the amount of Treasuries available to be held by private U.S. and private foreign investors (households or banks) and therefore subtract foreign official Treasury holdings. Treasury purchases by foreign official holders represent a reduction in the overall government supply of safe and liquid dollar-denominated assets available for the private sector to hold.

We obtain data on foreign official Treasury holdings from 1952 onward from the Financial Accounts, Table L.106 line 11. From 1945-1951 we obtain data from the annual data available in the Financial Accounts, Table L.106 for those years.[5] We set foreign Treasury holdings to zero prior to this, since the number listed for all foreign Treasury holdings in Historical Statistics of the United States, Colonial Times to 1970, Series U-39 is close to zero in 1940 and zero before that.

For 1875 to 1951 we measure metal-backed supply as the holdings outside the Treasury and the Fed of gold and silver coin and certificates and of Treasury notes of 1890 (using data from Banking and Monetary Statistics 1914-1941 Table 109, and Banking and Monetary Statistics 1941-1971 Table 11.1), plus Fed holdings of gold coin and certificates (using data from Banking and Monetary Statistics 1914-1941 Table 85, and Banking and Monetary Statistics 1941-1971 Table 9.1). From 1952 onward we assume that holdings of gold

[5]After the June 2014 release the Financial Accounts no longer split foreign Treasury holdings into private and official. We assume the split is the same in Q3 of 2014 as it was in Q1 of 2014.

and silver coin and certificates and Treasury notes of 1890 outside the Treasury and the Fed are negligible relative to GDP (as they are in 1951) and measure metal-backed supply as Fed holdings of gold coin and certificates from Financial Accounts Table L.108 line 2 (U.S. official reserve assets).

Figure 1 shows the three ingredients of our government supply series, Treasury unbacked supply, Treasury metal-backed supply and foreign official Treasury holdings, all scaled by U.S. GDP. The Treasury unbacked supply/GDP is what is commonly called Debt/GDP. Our goverment supply series tracks this series fairly closely, but the adjustments for metal-backed supply are substantial in the early and middle part of our sample and the adjustment for foreign official Treasury holdings is large in the last few decades of the sample.

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

Defining the financial sector:

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 the financial sector refers to any institution who is a supplier of short-term debt backed by loans and government bonds. We therefore include all parts of the financial sector that have substantial fractions of their funding from short-term debt.

For 1952-2014, we start from the list of sectors included in the category "Financial Business" in the Financial Accounts. We include all parts of the private financial sector that have substantial fractions of their funding from short-term debt financing. For financial stability, the sectors financed mainly with equity or with long-term debt are likely less of a concern than sectors financed mainly with short-term debt. This inclusion rule leads to the following sectors: U.S.-Chartered Depository Institutions, Foreign Banking Offices in U.S., Banks in U.S.-Affiliated Areas, Credit Unions, Money Market Mutual Funds, Issuers of Asset-Backed Securities, Finance Companies, Mortgage Real Estate Investment Trusts, Security Brokers and Dealers, Holding Companies, and Funding Corporations. In terms of which sectors we do not include, the list is as follows. We drop the Federal Reserve since we consider it part of the government and it is accounted for in our construction of government supply. We drop the following sectors because they do not have substantial amounts of short-term debt finance: Insurance companies (Property-Casualty Insurance Companies and Life Insurance Companies), Private and Public Pension Funds, Mutual Funds (these are separate from money market mutual funds which we include), Closed-End and Exchange-Traded Funds, GSEs, Agency-and GSE-Backed Mortgage Pools, and Equity Real Estate Investment Trusts[6]. The data appendix provides table and release information for the Financial Accounts and explains how to implement

[6] We have considered studying crowd-out of long-term debt financed lending. However, empirically a challenge in studying this issue is that the data has a very strong (and not well understood) trend in the post-WW2 period.

this financial sector construct in the pre-1952 period.

Accounting for cross-holdings within the financial sector:

In the model, the bank deposits (D) are contracts written between households and the financial sector. In practice, the existence of an various types of interbank markets means that financial sector participants also write safe/liquid claims with each other. It is well understood that there are chains of liquid/safe assets and liabilities that financial sector participants 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 it would be inappropriate to include the amount of interbank claims in our measure of net short-term debt. Interbank claims net to zero within the banking system (aside from data issues). We address interbank claims by constructing, for each financial instrument, both the total asset and the total liabilities 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 1875-2014 of the ratio (Assets-Liabilities)/GDP. By subtracting out cross-holdings within the financial sector, our reported measure of the size of the financial sector will be smaller than what the raw dollar value of the sum of the assets (or liabilities) of the financial sector would suggest. It is possible that systemic risk is generated by cross-holdings, but we leave that for future work, focusing here on the mismatch between the safety and liquidity characteristics of the financial sector's assets and of its liabilities.

Finally, note that we are unable to use an aggregated balance sheet for the non-financial sector such as L.100 plus L. 101 in the Financial Accounts because we need to deal with these netting issues. For example, in the L.100 and L.101 balance sheets, the non-financial sector is credited with a substantial number of money market fund shares. However, money market funds are a perfect example of the netting issues. These funds typically hold short-term debt claims against other parts of the financial sector (including bank certificates of deposits and repurchase agreements) as well as large amounts of Treasury securities, so that their net supply of safe/liquid debt to the non-financial sector is much smaller than the value of the amount of money market mutual fund shares outstanding.

Defining categories of financial instruments:

We classify the instruments that appear as an asset and/or a liability of one or more parts of the financial sector into 29 categories (this is after grouping some similar subcategories together). We list the 29 categories in Table 1. The data appendix provides additional detail on the categories that are not self-explanatory.

For each instrument we report (Assets-Liabilities)/GDP (or (Liabilities-Assets)/GDP for instruments that on average are net liabilities) thus taking out the 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 fund shares, federal funds and security repos, security credit, commercial paper, corporate bonds, and equity (mainly investments by bank holding companies). This makes it clear that considering the financial sector as a whole is important.

Table 1 indicates which categories of assets and liabilities we classify as short-term, long-term, or equity-like. By short-term we mean that the claim has contractual maturity of a year or less. While we do not have data on the exact duration of each category of claims, our classification of which categories are short-term claims should be fairly uncontroversial. Many of our short-term categories have zero or overnight duration and can be classified unambiguously (reserves, currency and coin, checking deposits, money market fund shares, federal funds, and most repos) whereas others are known to have duration of a year or less (commercial paper). Of the remaining short-term categories, the one most difficult to assess in terms of duration is savings and time deposits. To assess this we estimated regressions relating the average interest rate on savings and time deposits deposits to a constant maturity Treasury yield. We used data from 1986-2013 since deposit rates on savings and time deposits were fully deregulated in 1986 (more on this issue in section 4.6 below). We considered Treasury yields for 3 months and 1, 2, 5 and 10 years and found that rates on savings and time deposits moved the closest (based on R^2 values of the regressions) with yields on 3-month bills, suggesting that these deposits are of duration less than one year.[7] In the sources we use prior to 1952 less detail is available so some of the 29 categories are set to zero in those years. In the period prior to 1914, we group together checkable deposits and savings and time deposits. Friedman and Schwartz (1970, p. 4) note that reliable data on the split between checking deposits (demand deposits) and non-checking deposits become available only from 1914 when the Federal Reserve Act introduced different reserve requirements on checking and non-checking deposits.

As for the size of the various categories, on the asset side the financial sector holds substantial amounts of Treasuries with the ratio to GDP averaging 8.6 percent for Treasuries over the 1875-2014 period. The other main asset category is long-term assets, mainly bank loans, mortgages, and consumer credit. Short-term assets and equity categories on the asset side are very small. The overall size of the financial sector relative to GDP averages 65.8 percent over our entire sample, but has trended up over time, peaking at 133.8 percent in 2007. 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, savings and time deposits and checking deposits are the largest categories, with money market mutual fund shares becoming increasingly important over time. Equity is comparatively small. Long-term debt is becoming increasingly important over time, due mainly to ABS issuers issuing substantial amounts of long-term debt.

Mapping the categories to the model concepts:

[7] These regressions are available upon request. We obtained data on interest rate paid on savings and time deposits and amount of such deposits from the FDIC web page and obtained Treasury yields from CRSP's Fixed Term Indices. Results were not sensitive to whether regressions were run in annual differences or in levels with a time trend included.

Consider how the assets and liabilities in Table 1 map into the model. Our main objective is to measure the quantity of risky and/or illiquid assets financed with short-term debt, as opposed to equity. This is the net short-term debt of the model.

We define risky and/or illiquid assets in the data as long-term assets minus long-term debt. In terms of our model, long-term assets correspond well to what we have called bank loans ($\lambda(\phi)K$). Our model has no long-term debt (since it is unlikely that most long-term financial sector debt satisfies the household's special demand for liquid/safe assets), so we net long-term debt against long-term assets. We refer to the resulting difference as net long-term investments.

We define short-term debt in the data as short-term liabilities (which corresponds to D in the model, with checkable deposits mapping to M and the other short-term debt categories to NTD) minus the small amount of short-term assets (our model has no safe/liquid assets so we net the short-term assets against short-term liabilities). We also subtract the financial sector's holdings of Treasuries in our net short-term debt measure because we want to focus on short-term debt used to finance risky/illiquid assets. The resulting variable is net short-term debt.

We similarly construct net equity by subtracting the small amount of equity assets from the equity liabilities (our model has no equity assets).

Table 2 provides summary statistics for net long-term investments, net short-term debt and net equity. Importantly, because the balance sheet has to balance, net long-term investments equal the sum of net short-term debt and net equity. Therefore, net short-term debt is the part of net long-term investments financed with short-term debt, whereas net equity is the part of net long-term investments financed with equity. Our main object of interest is net short-term debt, i.e. the amount of risky and/or illiquid assets that is financed with short-term debt. Figure 2 Panel A graphs the series for net long-term investments, net short-term debt and net equity. It is clear that fluctuations in net long-term investments are driven almost entirely by fluctuations in net short-term debt with equity financing being comparatively stable over time.

4 Results

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

Figure 2 Panel A provides visual evidence consistent with our model of financial crowding out. There is a strong negative relation between the net short-term debt/GDP and government supply/GDP and it seems to be consistently present over the full 140 period. Figure 2 Panel B shows a scatter plot of net short-term debt/GDP against government supply/GDP (both variables are linearly detrended in this panel) clearly indicating the negative relation.

In Table 3 Panel A we estimate regressions of various dependent variables (all scaled by GDP) on government supply/GDP over the 1875-2014 period. 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. Our data-generating process is thus

$$\begin{aligned} y_t &= \alpha + \beta x_t + \gamma t + \varepsilon_t \\ \varepsilon_t &= \rho \varepsilon_{t-1} + v_t, v_t \ i.i.d. \end{aligned}$$

It is well documented as far back as Kendall (1954) that AR(1) coefficients estimated based on OLS regressions are downward biased (away from 1). Appendix B explains how this implies that AR(1) standard errors will be too small in finite samples. Appendix B also discusses how the Kendall bias-correction $\widehat{\rho}^{\text{Kendall}} = \widehat{\rho} + \frac{1+3\widehat{\rho}}{T}$ will be insufficient to address this problem. We have therefore developed a bootstrap approach to estimate the significance of β. The idea of our bootstrap approach is simple. We first estimate $y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t$ using OLS and then use the residuals to estimate $\varepsilon_t = \rho \varepsilon_{t-1} + v_t$ using OLS. Then we use a bootstrap to come up with a bias-adjustment to the OLS estimate $\widehat{\rho}$. We then use the bootstrap bias-adjusted value of ρ in a second bootstrap in order to assess the statistical significance of the OLS estimates $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$. We refer to our approach as a bootstrap-after-bootstrap approach. Appendix B provides details along with Monte-Carlo evidence that our bootstrap approach leads to more correct (i.e. larger) standard errors in the sense that t-tests for significance of β have rejection rates closer to the nominal significance level. There is still some over-rejection in our bootstrap approach but this approach is substantially better than other commonly used approaches. For example, for $\rho = 0.95$ (close to what we find in the actual data in Table 3 Panel A) and a nominal significance level of 1%, our approach rejects the null of $\beta = 0$ with probability 3.8%, the AR(1) approach rejects with probability 10.4%, and the Newey-West approach with 10 annual lags rejects with probability 23.3%.

The regression estimates in Table 3 Panel A show that increases in government supply lead to dramatic reductions in the financial sector's net long-term investments and in its net short-term debt (the part of net long-term investments financed with short-term debt), with regression coefficients around -0.50, significant at the 1 percent level.

An alternative approach to estimating the regression in levels would be to estimate it in differences (of various lengths).[8] Our assumed model implies

$$y_t - y_{t-d} = \gamma d + \beta \left(x_t - x_{t-d} \right) + \underbrace{\varepsilon_t - \varepsilon_{t-d}}_{u_t}.$$

If ρ is close to one, then the error term u_t in the difference specification is approximately MA(d-1), or MA(d)

[8] We thank an anonymous referee for suggesting this.

if one allows for measurement error, and Newey-West standard errors with d lags are approximately correct. Table 4 Panel A shows the result from estimating our main regressions (Net long-term investments/GDP on Government supply/GDP and Net short-term debt/GDP on Government supply/GDP) using differenced data. This corresponds to a differenced version of the results in Table 3 Panel A. We consider 1-year, 2-year, 3-year, 5-year and 10-year differences with standard errors based on the Newey-West approach with the same number of lags as the differencing, e.g. 5 lags for 5-year differenced data. Consistent with our results being driven by fairly slow-moving fluctuations in the series, the estimate of β from the regressions on differenced data are about the same as in the levels estimation once we use 5-year or 10-year differences. The relations are again statistically significant at the 1 percent level in the differencing approach.

A potentially important issue with respect to inference is that both the government supply/GDP and the net short-term debt/GDP series may be non-stationary. Bohn (1998) argues that while one cannot reject that Debt/GDP is non-stationary (I(1)), there is evidence of mean-reversion once one controls for war-spending and cyclical fluctuations in output, in the sense that the primary surplus/GDP responds positively to the level of Debt/GDP. If Debt/GDP (the main component of government supply/GDP) and net short-term debt/GDP are stationary then our above inference is appropriate. For robustness, given that the stationarity issue is somewhat unsettled in the literature, we also consider what would be an appropriate methodology if our main series were I(1). In that case, an appropriate approach would be to estimate an error correction model and determine whether our main variables are cointegrated. We take this approach in Table 4 Panel B.

We test whether each series is I(1) using the augmented Dickey-Fuller test (including a trend). While the coefficient on the lagged variable is negative in all cases, we cannot reject the null of non-stationarity for any of the series even at the 10% level. This conclusion is not sensitive to the lag length used in the test. We therefore proceed to test whether government supply/GDP is cointegrated with each of the financial sector net variables (in each case considering cointegration between government supply/GDP an one of the financial sector net variables). We use Stata's varsoc function to test for the appropriate lag order of the VECM. This function implements various lag selection methods and in all cases the various methods suggest 2 or 3 lags. We therefore test for cointegration using VECMs with 3 lags and Johansen's trace test (allowing for a restricted trend in Johansen's terminology). For government supply/GDP and net short-term debt/GDP the test indicates that there is a cointegrating relation and the estimated cointegrating relation is shown in Table 4 Panel B. The same is the case for government supply/GDP and net long-term investments/GDP. Importantly, the t-statistics on government supply/GDP within the cointegrating relations are larger than in Table 3 Panel A. Intuitively this says that if the series are non-stationary, then it is very unlikely to observe a negative relation between government supply and net short-term debt/GDP (and between government supply/GDP and net long-term investments/GDP) that is as tight as the one we see in the data. The crowding out coefficients in the cointegrating relations are similar to those in the OLS regressions.

Overall, our various specifications all suggest that our documented relations are highly significant. The three approaches complement each other: If ρ is not close to one, then the inference from our levels model in Table 3 using our bootstrap-on-bootstrap approach to calculating standard errors is approximately correct (as shown in the above Monte-Carlo in Appendix B where the rejection rates are closer to the nominal significance levels for lower values of ρ). If ρ is close to one (but still below one) then more substantial size distortions remain even for our bootstrap-on-bootstrap approach but then the difference estimation with Newey-West standard errors is approximately valid. This is Table 4 Panel A. Finally, if one is worried that ρ is one, then one should test whether each series is I(1) and, if yes, whether the two series are cointegrated. This is Table 4 Panel B. Since we find large t-statistics from all three approaches, it seems highly unlikely that our findings are spurious. The results in Table 3 and 4 for our full sample period (and focusing on the longest difference in the difference approach) suggest that a one-dollar increase in Treasury supply reduce the net short-term debt issued by the financial sector by between 51 and 57 cents, depending on approach used and reduce net long-term lending of the financial sector by between 57 and 59 cents (we return to subsample evidence below).

4.2 Alternative hypotheses

There are a number of plausible alternative explanations for our results. We present a series of approaches to address some of these alternatives, although since we lack an instrument for government supply, we cannot definitively rule out alternatives.

Standard crowding out: Textbook undergraduate macroeconomics teaches that government supply crowds out private capital formation by raising real interest rates. This standard crowding out hypothesis is the subject of an extensive empirical literature in macroeconomics, but which reaches no definitive conclusion (see Elmendorf and Mankiw, 1999).

We ask whether our results are a demonstration of this crowding out hypothesis. There are three reasons to not think so.

First, over the period since 1946 where we can measure inflation expectations, government supply and (expected) real interest rates are negatively correlated, which is the opposite sign of what would be predicted under standard crowding out. We construct a measure of the real interest rate as follows. We use mean expected inflation over the next 6 months from the Livingston Survey, available back to 1946. For the nominal interest rate, we use a short-maturity rate of an illiquid asset (to match the illiquidity of households and business loans). Specifically, we use the rate on 3-month Bankers Acceptances (a pre-decessor to commercial paper) from 1946-1990 (from the FRED database) and the rate on 3-month repo contracts backed by Treasury collateral from 1991-2014 (from Bloomberg).[9] This definition of a riskless illiquid short nominal rate follows Nagel (2014). We use expected inflation and the nominal rate to construct a short-term real interest rate for 1946-2014. Over the 1946-2014 period, the correlation between government supply/GDP and the real short rate is -0.23. Expected inflation is very volatile from 1946-1949. Over the period 1950-2014, the correlation between government supply/GDP and the real short rate is -0.28.

Second, we can explicitly introduce the level of real (or nominal) interest rates in our regressions, and we find that doing so has little effect on the estimated relation between net short-term debt and government supply. We do this in Table 5 Panel A column (2), with our baseline full sample regression repeated in column (1) for reference. The lower crowding-out coefficient is due to the different sample period rather than the inclusion of the real short rate. In column (3) of the same table we control for the level of the nominal short rate, which has little effect on the size of the crowding-out coefficient relative to column (1).

Third, a unique prediction of our financial crowding out theory is that Treasury supply reduces lending against the existing capital stock, beyond any effect it may have on the accumulation of new capital. In Table 5 Panel B column (1) we show that our crowding out effect is robust to controlling for the size of the private capital stock relative to GDP. We define the private capital stock as the sum of private fixed assets (non-residential and residential) and consumer durable goods, at current prices, with data available back to 1925 from the Bureau of Economic Analysis' Fixed Assets Accounts Table 1.1. In column (2) and (3) of the same table we decompose net short-term debt/GDP into net short-term debt/private capital stock and private capital stock/GDP. The regressions show that government supply/GDP is negatively related to both of these variables, with the statistically strongest effect on net short-term debt/private capital stock. Figure 3 illustrates the two separate relations. Based on our theoretical framework the impact of government supply/GDP on net short-term debt/private capital stock is likely to be causal. One can write extensions of our model in which there would also be a causal impact of government supply/GDP on the private capital stock/GDP, but our main take-away from Table 5 Panel B is that our main crowding-out result is robust to controlling for the size of the capital stock, which makes it less likely to be driven by standard crowding out effects.

Additional controls for loan demand: An obvious variable that could, in principle, drive both government supply and net short-term debt is recent economic growth. In Table 5 Panel A column (4) we include the growth rate of real GDP over the past five years as a control (based on data on GDP and the GDP deflator from Henning Bohn's data set updated to include 2013 and 2014 based on data from NIPA Table 1.1.5 and 1.1.4). Using a longer or shorter period for the real GDP growth rate does not affect the results substantially). This has almost no effect on the size and significance of the crowding-out coefficient. The

[9] Below we will use this nominal rate series back to 1918, with data from FRED going back to 1941 and data from the NBER Macrohistory Database used for 1918-1940.

reason that including the growth control does not matter is likely that government supply moves at a slower frequency than the business cycle. From Figure 2 Panel A, it is clear that the government supply/GDP series (and the series for net short-term debt/GDP) changes slope only about 10 times over the 140 year sample. For comparison, based on the NBER Business Cycle dates, there are 28 business cycle peaks and 29 business cycle troughs over this period. This implies that our main finding is unlikely to be driven by any omitted variable that moves at a business cycle frequency (we have experimented with variables related to the NBER dates finding none that affect the crowding-out results substantially).

In Table 5 Panel A column (5) we include a control for recent federal deficits (the sum of Federal deficit/GDP over the five years from t-4 to t, using data from Henning Bohn's data set). High spending and/or low taxes associated with large deficits may positively affect loan demand. Not controlling for this could lead to an understatement of our crowding-out result since deficits/GDP and government supply/GDP are positively correlated. Consistent with this we find slightly stronger crowding-out in this specification.

Dropping financial crises: Table 5 Panel A column (6) drops years where reverse causality is likely, namely years following financial crisis where the financial sector contracts and the associated recession causes an increase in government supply. Again this has little impact on the coefficient of government supply/GDP.

4.3 Further evidence to support causality

Gold inflows as an exogenous supply shock: From 1933 to 1940, the Federal Reserve's balance sheet grew by about \$16B. The asset side of the Fed balance sheet was driven by an increase in Fed holdings of gold certificates by \$16B, with little change in Fed holdings of Treasury securities. On the liability side of the Fed's balance sheet, bank reserves at the Fed increased by around \$11B and Federal Reserve notes in circulation increase by \$3B (the discrepancy to \$16B is due to an increase in other deposits at the Fed, e.g. the Treasury's account at the Fed and foreign deposits at the Fed). The increase in reserves increased bank reserves/GDP from 0.047 to 0.145, i.e. by about 10 percentage points of GDP.

In a well known paper, Romer (1992) discusses the causes of the gold inflows. She argues (in agreement with the prior literature) that the gold inflows, and the resulting increase in money supply, were primarily due to political instability in Europe and thus exogenous to US economic conditions.[10]

The increase in Treasury metal-backed supply due to political instability in Europe provides an exogenous shock to test our model. Theory predicts that the gold inflows will have two effects on bank debt. First, the increase in government supply will crowd out bank debt in the same manner as other changes in Treasury supply. Second, to the extent that foreigners who bring in gold hold their assets as bank deposits the crowd out will be reduced. In the extreme case where foreign investors bring in gold and increase bank deposits

[10] The devaluation of the dollar in 1933 also played a role. Romer argues that the devaluation (and the decision to not sterilize gold inflows) could also not have been driven by the subsequent economic recovery in the US.

one-for-one, there will be no crowd out. However, for anything short of this extreme case, theory predicts that the gold inflows will crowd out bank debt. In the 1933-1940 period, the size of the financial sector relative to GDP (i.e. total liabilities, short-term+long-term debt+equity) declines somewhat from 0.685 in 1933 to 0.646 in 1940, suggesting that foreigners did not use the majority of their inflows for bank deposits. The increase in reserves is substantial enough to potentially explain about half of the decline in net short-term debt which was around 20 percentage points of GDP (from 0.459 to 0.251).

Figure 4 Panel A traces the dramatic increase in gold certificates (which are part of "Treasury metal-backed supply") during the 1933-1940 period. During this period, net short-term debt falls significantly despite this being the period of recovery from the Great Depression. Importantly, note that Treasury unbacked supply, as a ratio to GDP, is virtually unchanged during this period. That is, if one only considered the movements in Treasury unbacked supply, the decline in net short-term debt would be a puzzle. The increase in Treasury metal-backed supply helps resolve this puzzle.

Exogenous demand shock by foreign official investors: In our model, a demand shock for safe/liquid assets will have the opposite effect of government supply. We provide evidence consistent with this prediction. The shock we exploit is the dramatic increase in foreign official 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 official 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).

The potential importance of foreign demand is visually apparent from Figure 4 Panel B. There seems to be "too much" net short-term debt in the last few decades based on the amount of (Treasury unbacked supply+Treasury metal-backed supply)/GDP over this period. One possible explanation is the demand shock for safe/liquid US assets due to foreign official purchases. Netting out foreign official Treasury holdings seems to lead to a more stable relation between the resulting government supply/GDP and the US financial sector's net supply of short-term debt/GDP. 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).

It is clear from Figure 4 Panel A and Panel B that there is not much time series variation in either Treasury metal-backed supply/GDP (which mainly just moves up in response to the gold inflows discussed above and then moves back down as GDP increases) or Foreign official Treasury holdings/GDP. For completeness, in Table 5 Panel C, we regress net short-term debt/GDP in each of the three components of government supply/GDP to determine if they each have the expected sign and to determine whether either of the two components driven by shocks (Treasury metal-backed supply/GDP and Foreign official Treasury holdings/GDP) have statistically significant effects. We find the expected signs for Treasury metal-backed supply/GDP and Foreign official Treasury holdings/GDP but neither is statistically significant as would be expected given the limited variation in these series even over our long sample period.

Rajan-Zingales identification: Expenditure share for "credit" goods: 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 (or access to credit) for 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. 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. 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.

We define products often bought on credit as NIPA categories "Durable goods"+"Housing and utilities". Expenditure data are from NIPA Table 2.3.5 and price data from NIPA Table 2.3.4 (we use the price data along with quantity data from NIPA Table 2.3.3 to calculate a price index for durables and housing and utilities combined). 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 for personal consumption expenditures), and government supply/GDP. 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 (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 an unobservable. This identification works if the driver of financial development does not directly affect industries with high versus 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) are larger in periods with less government supply/GDP, 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 government supply may both be driven by some unobservable (wars/financial crisis/tax policy etc.). Following the comments on Rajan-Zingales, it may seem that this identification only works if the driver of government supply 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 underlying drivers of government supply via the impact of these variables on total consumption and relative prices. What is needed is only that the drivers of government supply do not drive budget shares beyond any effect through these controls.

Table 5 Panel D presents the results. The regression coefficient of -0.072 implies that a one standard deviation reduction in government supply/GDP (a change of 0.22) leads to an increase in the budget share for credit goods of 0.016. The mean of the budget share is 0.297 and the standard deviation is 0.027, implying that the estimated effect of 0.016 corresponds to about a half of a standard deviation of the budget share. Figure 5 illustrates the relation between the budget share for credit goods and government supply. There is a clear negative relation between the two series (the correlation is -0.78). The World War 2 period is a strong driver of this negative correlation. For robustness we show in column (2) of Table 5 Panel D that the negative effect of government supply/GDP on the budget share for credit goods is still present and significant at the 5 percent level even if we drop 1942-1951 (see additional discussion of the role of World War 2 in the section on history and institutional changes below).

4.4 Bank portfolio substitution and household debt substitution

Table 6 presents a decomposition of the relation between government supply and different components of the financial sector balance sheet. We discuss next how these patterns line up with the two channels for Treasury supply to affect net short-term bank debt described in the theory section, a bank portfolio substitution and household debt substitution channel.

Table 6 column (1) shows strong evidence of the bank portfolio substitution channel. Government supply crowds in financial sector holdings of Treasuries with a coefficient of 0.389, implying that asset reallocation away from loans and towards Treasuries can account for a substantial part of the overall crowding out of -0.536 of net short-term debt (repeated at the top of the table for reference).[11] The positive relation between government supply and financial sector Treasury holdings is apparent in Figure 6 Panel A.

Consider next the household debt substitution channel. If households view Treasury securities and financial sector short-term debt as substitutes, then we may expect to see that an increase in Treasury supply (and thus government supply) will reduce households holdings of short-term financial sector debt.

[11] The bank portfolio substitution channel is likely also present for non-banks since others will also have an incentive to reallocate towards Treasuries in response to changing spreads. For example, portfolio reallocation by pension funds and insurance companies may affect the supply of funding for high-grade corporate securities (which we have shown in Krishnamurthy and Vissing-Jorgensen (2012) partially share the safety attribute of Treasuries). We do not pursue evidence for this type of crowding out in this paper given that our focus is on the impact of Treasury supply on financial sector lending that is funded by short-term debt.

From Table 6, column (1), the liability side, it is clear that such household debt substitution channel appears to be present for non-checkable short-term debt, but with an almost off-setting crowding-in effect for checkable deposits. This crowding-in effect is robust to controlling for the level of (log) interest rates and GDP as would be appropriate for checking deposits based on standard money demand theory. It is possible that Treasuries are particularly important for backing checking deposits, more so than non-checkable deposits, so that the crowding-in of checking is a reflection of the bank portfolio substitution effect. Short-term debt/GDP overall, combining checkable deposits and non-checkable short-term debt, is only weakly crowded out by government supply, with an insignificant coefficient of -0.061 for the full 1875-2014 sample. From Figure 6 Panel A and Panel B it is however clear that the relative importance of the bank portfolio substitution channel and the household debt substitution channel changes over time. Since the end of World War 2, the importance of Treasury holdings on the asset side of the financial sector's balance sheet gradually declines in terms of amount and relation to government supply, as do checkable deposits on the liability side. In contrast, over time non-checkable short-term debt increases and is negatively correlated with government supply. Thus, over time the bank portfolio substitution channel declines in importance and the household debt substitution increases in importance. We confirm that these graphical impressions hold up in a regression framework in column (2) and (3) of Table 6. For the period since 1970 (picked based on the graphical impressions), government supply only crowds in financial sector holdings of Treasuries with a coefficient of 0.131, compared to 0.379 in the pre-1970 period. On the liability side, government supply crowds out short-term debt with a coefficient of -0.350 post-1970, compared to only -0.086 pre-1970, driven by increased crowd-out of non-checkable short-term debt. Thus, while the overall crowding of net short-term debt is fairly stable across these two sub-periods (as indicated in the first row of the table), the relative importance of each of the two underlying channels changes over time.

While the strength of bank portfolio substitution and household debt substitution effects are unstable over time, there is a robust empirical relation between Treasury supply and net short-term debt. Indeed from our theoretical model it is not obvious which of these substitution effects should be most present in the data since it is indeterminate whether banks or households absorb an increase in Treasury supply. The robust prediction of the model is between net short-term debt — that is, bank lending funded by short-term debt — and Treasury supply. Our analysis of this section underscores why it is important to study this net variable.

4.5 Debt composition

An important question from the perspective of optimal Treasury composition is whether some types of Treasury issues crowd out the financial sector's net short-term debt more than others. Empirically this is a difficult question to answer. Short-term (less than 1 year remaining maturity) and long-term Treasury supply is strongly positively correlated (around 0.5 based on the data we describe in this section). Thus, there is little independent variation in short and long supply and it is (to our knowledge) not fully understood what drives the changes in the Treasury's choice of maturity structure over time. Empirically, since around 1943, the fraction of short-term debt in total Treasury debt is strongly negatively related to Debt/GDP (Treasury unbacked supply/GDP).

A related issue is the choice between marketable and non-marketable debt. Bohn's measure of Treasury debt (which we use as our Treasury unbacked supply) is publicly held debt which means that it does not include intra-governmental holdings, i.e. Treasury debt held by various other parts of the government such as the social security trust fund and various governmental retirement funds (it does include Fed holdings as discussed above). Most publicly held debt is marketable (i.e. can be resold by the initial buyer) whereas most intragovernmental holdings are non-marketable. There is, however, one important category of non-marketable debt which is included in publicly held debt, namely savings bonds. According to the U.S. Treasury, savings bonds were introduced in 1935 with the objective of "encouraging broad public participation in government financing by making federal bonds available in small denominations specifically tailored to the small investor".[12] This was done by offering bonds with a schedule of fixed interest payments and redemption values, redeemable at any time after an initial holding period for the purchase price plus accrued interest. In other words, buyers selling savings bond prior to maturity face no duration risk. Savings bonds thus seem like an ideal security for households who have a special utility from extremely safe securities and they were purchased by tens of millions of households.

With the important qualifier that we do not have instruments for the maturity structure of marketable Treasury debt or for the Treasury's decision to offer savings bonds with more/less attractive features, we document in Table 7 the separate effects of three sub-components of Treasury unbacked supply/GDP (these three components sum to Treasury unbacked supply, i.e. to what is commonly called Debt/GDP): Marketable Treasury securities with remaining maturity of one year or less, marketable Treasury securities with remaining maturity of more than a year, and savings bonds, all relative to GDP. We have data on Treasury maturity structure from 1916-2014. We calculate the amount of marketable Treasury securities with remaining maturity of one year or less as follows. From 1916-1948 we obtain data on the outstanding amounts of securities with remaining maturity of a year or less from Banking and Monetary Statistics (1914-1941 Table 147, 1942-1948 Table 13.5 C plus Table 13.5 D).[13] From 1949-2014 we calculate the amount of marketable Treasury securities with remaining maturity of one year or less using the CRSP Monthly Treasury Masterfile from 1949-2014 (prior to 1949 the amounts outstanding are missing for a lot of the Treasuries in this source). For savings bonds, we get data for 1935-1970 from Banking and Monetary Statistics (1914-1941 Table 146,

[12] See https://www.treasurydirect.gov/indiv/research/history/history_sb1.htm for a description of savings bonds.

[13] From 1916-1941 less detail is available and we assume that all bills and certificates plus 1/5 of other Treasury securities that mature within 5 years are of ≤ 1 year maturity.

1942-1970 Table 13.2) and for 1971-2014 from the Financial Accounts (Table L.209 line 2). We calculate the amount of marketable Treasury securities with remaining maturity of more than a year as the total public debt amount from Bohn, minus the amount of marketable Treasury securities with remaining maturity of one year or less, minus the amount of savings bonds. All debt variables are at book value. We graph the series in Figure 7. The positive correlation of short and long supply is visible in the graph. Savings bonds increase with overall debt as a way to fund World War 2 and then decline gradually in importance over time (relative to GDP).

In Table 7 we provide regressions both for the full 1916-2014 period and for a sample that excludes the World War 2 years. As discussed in the next section these years were special in that the Fed had large holdings of Treasury bills which may distort results. Regardless of the sample, we find about equal crowding-out of net short-term debt by short and long marketable Treasury securities, but consistent with these series being highly correlated the statistical significance of each is often low (column 1 and 3) even when the sum is significant (column 2 and 4). While short and long marketable Treasury supply have about equal crowding-out coefficients, it is important to note that the standard deviation of long supply is about twice than of short supply, implying that variation in long-term Treasury supply had a more significant impact on the financial sector's net short-term debt. Interestingly, savings bonds crowd out net short-term debt much more strongly than do marketable Treasury securities, consistent with savings bonds being specifically designed to fulfill household safety demand.

Greenwood, Hanson and Stein (2014) show theoretically that if short-term bank liabilities are more similar to short-term Treasuries than long-term Treasuries, then by shortening its debt maturity the government will crowd-out short-term bank debt more strongly. In their model this is desirable because of externalities from short-term bank debt. As noted above, they provide empirical evidence that quantities of financial commercial paper are crowded out by T-bill supply, but not by non-bills supply, over the period since 1952. Our evidence based on all financial sector debt and based on a long history does not indicate that short-term Treasuries lead to more crowding out of the financial sector's short-term debt than long-term Treasuries, but as discussed, we do not have an instrument for maturity structure and we view the issue of whether shortening government maturity structure increases financial stability as unresolved. Relatedly, the strong results for savings bonds in Table 7 calls for more work on their role in optimal Treasury debt management.

4.6 History and institutional changes over our sample period

We study a long period over which there have been many economic and institutional changes. Our regressions implicitly assume stability both in the banking sector, in terms of λ and ϕ which govern the technology that banks use to create deposits, as well as in the household sector, in terms of $v(s)$ which characterizes households' valuation of safe bank deposits. It is unlikely that these supply and demand conditions have been unchanged over our long sample. In this section we discuss particular periods and institutional changes of concern.

World War 2: During World War 2, banks were large buyers of government debt, with the Federal Reserve providing incentives to purchase such debt. The Fed promised to sell/buy Treasury bills at 3/8% (substantially below typical peacetime rates of 2 to 4%), thus effectively pegging short-term Treasury bill rates and enhancing the liquidity of Treasury bills, since they could be converted to reserves via a sale to the Fed. The Fed also offered discount loans to banks against Treasury collateral at 50 basis points below their general discount rate. Both of these steps greatly enhanced the attractiveness of government debt as an investment for banks, as discussed in Whittesley (1943). The spike during World War 2 in financial sector Treasury holdings/GDP is apparent in Figure 6 Panel A. The Treasury-Federal Reserve Accord of 1951 formally ended these programs.

Despite the large Treasury purchases by banks during the war, there are several reasons to expect that Treasury supply would lead to less crowding out of bank lending during this period. First, household savings rates were very high, averaging 26 percent from 1942-1945 (NIPA Table 2.1). This enabled households to both directly buy a large fraction of the Treasury debt issued to fund the war as well as to increase their bank deposits and thereby facilitate bank purchases of Treasuries without ensuing crowd-out of bank lending. Second, the government intervened in lending markets by offering loan guarantees to companies engaged in war production under Regulation V. These loan guarantees enhanced the credit-worthiness of a corporate loan to a bank. Thus, banks were active in lending to war enterprise. See Coleman (1952). Third, it is likely that that the actions of the government and the Federal Reserve flooded the market with safe and liquid assets, driving down $v'(s)$ to near zero. Indeed, Krishnamurthy and Vissing-Jorgensen find that safety and liquidity spread measures are at their historical lows during the World War 2 period. If $v'(s)$ is zero, then the safety/liquidity effects of our model are absent, and our model has nothing to say about the relation between government supply and net short-term debt.

In Table 3 Panel B we present regressions where we drop 1942 (the first year of large war-induced increases in Treasury supply) to 1951 (the year of the Treasury-Fed Accord). As expected, the estimated crowding out coefficients are now a bit more negative, consistent with less crowd-out during World War 2.

World War 1: Some of the actions taken by the government in World War 2 were also taken in World War 1 but at a much smaller scale. Whittesley (1943) reports that banks acted principally as agents to place government debt in the hands of private investors, and were active only in purchasing short-term Treasury debt. Whittesley suggests that banks may have purchased short-term debt because they were ordered to do so by Treasury, but there is little formal evidence on this point. Finally, banks also financed enterprises engaged in war production.

Regulation Q: Regulation Q (which was part of the Banking Acts of 1933 and 1935) prohibited payment of interest on demand deposits and authorized the Fed to set limits on the interest that banks could pay on time and savings deposits. Interest limits were phased out gradually from the late 1970s to the mid 1980s (see Gilbert (1986)) while the ban on interest payments on demand deposits remained in place until 2011. We have shown theoretically that our crowding-out prediction is robust to the presence of checking accounts with zero interest, so the main issue is whether the interest ceilings were sufficiently binding to constrain the equilibrium quantity of financial sector debt. Gilbert (1986) shows that ceiling rates on savings deposits were binding from the late 1960s until they were abandoned in 1986 since the ceiling was substantially below the rate on 3-month Treasury bills. However, ceiling rates on time deposits were higher and for large time deposits were abandoned in 1970 for time deposits over \$100,000. Over the 1970s and 1980s the average rate on savings and time deposits paid by banks was fairly similar to the rate on 3-month Treasury bills (see Gilbert's Chart 3). As a result of binding interest limits on savings accounts, the fraction of savings and time deposits that were held as time deposits increased from around 18 percent at the start of 1966 to almost 78 percent at its peak in 1982 (our calculations based on data from the Fed's H6 release). Similarly, money market funds (which were not subject to interest limits) grew rapidly from 1979 to 1982 as they competed savers with limited amounts to invest away from banks. It thus appears that investors actively shifted funds around within the financial sector to avoid Regulation Q limits. Our focus on the overall financial sector therefore overcomes a lot of the issues raised by Regulation Q. We have analyzed whether Regulation Q appears to have been binding at the level of the overall financial sector by including a dummy variable for the 1966-1986 period in our regressions in Table 3 Panel A for the 1875-2014 period. For each of the two regressions, the coefficient on the Regulation Q dummy was negative but small (-0.06 or closer to zero) and never statistically significant and its inclusion had little effect on the coefficient on our government supply/GDP variable (we omit the regressions with this dummy from the table for brevity).

FDIC Insurance: Government insurance on bank deposits (below a deposit ceiling) was initiated in 1934 as part of the Banking Act of 1933. As a result, from 1934 onward, bank deposits are somewhat safer than pre-1934, making bank deposits a better substitute for short-term Treasury bonds from 1934 on. In Table 3 Panel C and D we split our sample into pre- and post-1934 (with the World War 2 years dropped for the post-1934 period). We do not find evidence of increased crowd-out post-1934 implying that FDIC insurance is not the central driver of the safety/liquidity feature of bank deposits.

National Banking Era: The National Banking Act of 1863 had the objective of creating a single national currency. It gave national banks the right to issue national bank notes that circulated as money as long as banks deposited (with the U.S. Treasury) Treasury securities equal to 111 percent of bank note issuance (Friedman and Schwartz (1970)). This requirement was relaxed in 1900 to 100 percent of bank note issuance. Thus, during this period, banks owned Treasury securities with the explicit purpose of backing bank money, which is in keeping with the deposit creation constraint of our model.

In constructing our net short-term debt variable, we net financial sector holdings of Treasury securities against short term liabilities. Therefore, national bank notes have no effect on net short-term debt after 1900 and has only a small effect (a reduction of 11% of the value of national bank notes outstanding) prior to 1900. Over the period from 1875 to 1933 we find that net short-term debt is crowded out by 0.491 per one increase in Treasury supply (see Table 3, Panel C). This crowding out effect is present despite the mechanical link between Treasury holdings and bank deposits, and exceeds the pre-1900 mechanical 0.11 crowding out.

Creation of the Federal Reserve System: The creation of the Fed in 1913 affects our data series as follows. Over time Federal Reserve notes crowd out gold currency (gold coin and gold certificates) and national bank notes. The Fed's liabilities (notes and reserves) are (aside from mortgage-backed securities and agency debt purchases under quantitative easing) backed one for one by gold certificates and Treasuries. Prior to the creation of the Fed national banks backed national bank notes with Treasuries. Furthermore, bank reserves held at the Fed replace bank reserves held in the form of gold, silver, and Greenbacks. See Feinman (1993) for a description of reserve requirements prior to the Fed.

From the perspective of our construction of net short-term debt, the Fed crowding out national bank notes does not have much of an effect because, as described above, national bank notes have little effect on our net short-term debt measure. Similarly, since the Fed's liabilities (notes, reserves) are backed one for one with gold certificates and Treasuries, the Fed has no net effect on our measure of the amount of short-term assets (and Treasuries) available for the non-financial sector to hold. Of course, if one were to assign different weights to different instruments (e.g. using Barnett weights) this would change. We have experimented with including the size of the Fed's balance sheet as an additional regressor (for the 1914-2014 sub-sample), with little effect on our main crowding out result.

5 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 safe/liquid debt. The financial sector earns a profit by holding illiquid and risky assets and issuing liquid and riskless claims against these assets. Our main piece of evidence in favor of this explanation for the large amounts of short-term financing of the financial sector is that the quantity of financial sector net short-term debt (which is equal to the amount of financial sector lending to the private sector financed by short-term debt) falls when there are more government securities outstanding. In other words, government supply (which is mainly Treasury securities) crowds out financial sector net short-term debt because financial sector short-term debt appeals to the same safety/liquidity demand as does government supplied assets. Our evidence is consistent with the viewpoint 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 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 two shocks to the government supply available for the private sector to hold, one shock related to the large gold inflows into the US during the 1933-1940 period of European political instability, the other to the large increase in foreign official holdings of Treasuries since the early 1970s. We also argue, by including measures of the real interest rate and the capital stock in our regressions, that our crowding out result is not driven by the "standard" crowding out mechanism taught in macro textbooks in which government supply crowds out private capital formation by raising real interest rates.

6 Appendix A. Data descriptions

Data sources and timing:

Our sources for data on the US financial sector are as follows. For years 1952-2014 we use the Financial Accounts of the United States (formerly known as the Flow of Funds Accounts). For years 1896-1951 we use data from All-Bank Statistics (accessible via the Federal Reserve Archive FRASER). For 1875-1895 our data are from the Annual Report of the Comptroller of the Currency (also accessible via FRASER).

For 1896-1975 we use financial sector data as of the end of June and for years 1976-2014 we use data as of the end of September. This is done to match the timing of the U.S. government fiscal year end which was June before 1976 and September from 1976 on. For 1875-1895 our financial sector data are as of around October 1 of each year (data as of end of June are not available causing a slight mismatch for these years between the timing of the financial sector data and the U.S. government debt data).

Defining the financial sector:

For 1952-2014: We use data from the December 11, 2014 release of the Financial Accounts. The table numbers for the sectors included are:

L.110 U.S.-Chartered Depository Institutions

L.111 Foreign Banking Offices in U.S.

L.112 Banks in U.S.-Affiliated Areas

L.113 Credit Unions

L.120 Money Market Mutual Funds

L.125 Issuers of Asset-Backed Securities

L.126 Finance Companies

L.127.m Mortgage Real Estate Investment Trusts

L.128 Security Brokers and Dealers

L.129 Holding Companies

L.130 Funding Corporations

For 1896-1951, we use the tables for "All Banks" in All-Bank Statistics. By "bank" this sources refers to financial institutions in the continental U.S. that accepts deposits from the general public or that mainly is engaged in fiduciary business. Specifically, this sources covers national banks, state banks, loan and trust companies, mutual and stock savings banks, and unincorporated "private" banks. The coverage in All-Bank Statistics thus maps to table L.110 in the Financial Accounts (numbers for total assets in 1952 are almost identical across All-Bank Statistics and table L.110 in the Financial Accounts). Furthermore, in 1952, the first year for which we use the Financial Accounts, table L.110 accounts for about 92 percent of the overall financial sector in terms of assets. Assuming the other categories were equally small before 1952, the omission of these categories in the pre-1952 period does not cause a substantial bias from the perspective of constructing comparable series for the overall financial sector over time.

For 1875-1895, we use data from various tables in the Annual Report of the Comptroller of the Currency to obtain data for the same types of banks as covered for 1896-1951 (national banks, state banks, loan and trust companies, mutual and stock savings banks and unincorporated “private” banks). We start our series in 1875 because this is the first year for which data for loan and trust companies are available (data for national, state and savings banks go back a bit further). Unincorporated “private” banks are only covered from 1887 (at which point their assets represent about 3 percent of total assets across the various types of banks). The coverage of banks in the Annual Report of the Comptroller of the Currency is in general a bit worse than that in All-Bank Statistics, with total assets of the financial sector in 1896 in the former source amounting to about 93 percent of total assets in the latter source. We have experimented with various ways of scaling up data for the early part of our sample (pre-1952 and pre-1896) with little impact on our results.

Categories of instruments:

Some categories of instruments require additional explanations.

Currency and coin:

We use this to refer to (a) Federal Reserve-issued currency, (b) Currency issued by the Treasury and Treasury metal-backed supply (as defined in section 3.1), and (c) bank-issued currency.

On the financial sector’s asset side, the following labels are used for components of our currency and coin category in our three data sources: “Vault cash” in the Financial Accounts (which refers to Fed-issued currency), “Currency and coin” in All-Bank statistics (which refers to a mix of all three categories, a)-c), see Appendix E of All-Bank Statistics), and (various wordings of) “Specie”, “Legal tender notes” and “National Bank Notes” in the Annual Report of the Comptroller of the Currency.[14]

On the financial sector’s liability side, the following labels are used for components of our currency and coin category in the three data sources: None in the Financial Accounts (there are no national bank notes on bank balance sheets after 1935), “National bank notes” in All-Bank Statistics, and (various wordings of) “Circulation outstanding” and “State bank notes” in the Annual Report of the Comptroller of the Currency.

The financial sector is a net issuer of currency and coin from 1875-1883 (i.e. has more liabilities than assets in this category) due to substantial amounts of national bank notes outstanding.

Net interbank liabilities to domestic banks:

We use this to refer to what is denoted “Net interbank liabilities to domestic banks” in the Financial Accounts, “Cash items in process of collection”, “Banker’s balances” and “Interbank deposits” in All-Bank

[14] For savings banks and for private banks the Annual Report of the Comptroller of the Currency does not break down the category “Cash on hand” into sub-components. We assume the majority of cash on hand is currency and coin.

Statistics, and (various wordings of) "Due to banks", "Due from banks", "Cash items" (for state banks and fpr loan and trust companies) in the Annual Report of the Comptroller of the Currency.

Foreign deposits, Trade credit, Other loans and advances, U.S. direct investment abroad, Mutual fund shares:

These are small categories that only appear in the Financial Accounts.

Miscellaneous:

In the Financial Accounts, this refers to various line items that the Financial Accounts do not clarify the content of. They are called "Miscellaneous" or "Other" (when detail is given identifying what they are we code them accordingly so this category only captures unidentified items). The specific line items are as follows.

Assets: L.110 line 30, L.111 line 16, L.112 line 10, L.113 line 14, L.120 line 12, L.126 line 10, L.127m line 10, L.128 line 14, L. 129 line 17.

Liabilities: L.110 line 51, L.111 line 29, L.112 line 16, L.113 line 23, L.126 line 21, L.127m line 17, L.128 line 29, L.129 line 24, L.130 line 22.

In All-Bank Statistics we include various types of "other" assets or liabilities. Appendix E of All-Bank Statistics has detail of what is included. We use this information to include the same types of assets and liabilities in the Annual Report of the Comptroller of the Currency in our miscellaneous category (along with a few categories that cannot be identified in the Annual Report of the Comptroller of the Currency).

We somewhat arbitrarily classify the miscellaneous category as long term but recoding it as short-term has no material effect on our main results.

Checkable deposits and currency: We borrow this label from the Financial Accounts, but need to clarify its relation to our category Currency and coin. Bank-issued currency are included in the Currency and coin category. To the extent that there is currency in the Checkable deposits and currency category it is only on the asset side (when a sector has Checkable deposits and currency as a liability in the Financial Accounts this cannot include currency liabilities since no bank-issued currency was outstanding during the 1952-2014 period).

In the Financial Accounts the division between checking and non-checking deposits is clear. In All-Bank Statistics it is clear except for U.S. government deposits and we assume they are checking deposits. We do not attempt to divide deposits in the Annual Report of the Comptroller of the Currency into checkable and non-checkable deposits.

Commercial paper:

This is referred to as "open market paper" or "commercial paper" in the Financial Accounts. There is no corresponding category in All-Bank Statistics the Annual Report of the Comptroller of the Currency. In

All-Bank Statistics we code the category "banker's balances (including reserves)" as an interbank claim and subtract reserves using data on reserves from Banking and Monetary Statistics.

Financial sector equity: The Financial Accounts do not have line items for equity. We define our category "Financial sector equity '' as the difference between assets and liabilities. In All-Bank Statistics, equity is "Capital" plus "Surplus and other capital accounts". In the Annual Report of the Comptroller of the Currency equity is "Capital" plus "Surplus fund" plus "Undivided profits" plus "Dividends unpaid" plus "Debenture bonds" (which according to All-Bank Statistics are part of equity).

Investment by holding companies, parent companies and funding corporations (in other parts of the financial sector): This category is defined in the Financial Accounts only. It should net to zero aside from data inconsistencies and this is approximately the case in all years. Gross amounts (i.e. assets and liabilities separately) are very large especially towards the end of the sample (over 20 percent of GDP) making this the most important category to account for in terms of cross-holdings within the financial sector. The specific line items are as follows. Assets: L.129 lines 11+14+15+16, L.130 lines 10+11. Liabilities: L.110 line 50, L.111 line 28, L.126 line 20, L.128 line 28.

7 Appendix B. Bootstrap-after-bootstrap standard errors

Stata code for implementing our approach is available on Annette Vissing-Jorgensen's web page. We lay out the approach for the case of just one explanatory variable, but additional variables are easily added on the right hand side.

Data generating process: Assume the data generating process is

$$y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t \tag{45}$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + v_t,\ v_t\ i.i.d. \tag{46}$$

Why not just use AR(1) standard errors?

The simplest approach to estimate this model would be to estimate (45) by OLS and then use the residuals to estimate (46). Based on this, the standard error of the OLS estimates in (45) could be estimated based on the usual formula for the variance of OLS estimates $\widehat{\delta}' = \begin{bmatrix} \widehat{\alpha} & \widehat{\beta} & \widehat{\gamma} \end{bmatrix}'$ in the presense of AR(1) errors: $V\left(\widehat{\delta}|X\right) = (X'X)^{-1} X'\Omega X (X'X)^{-1}$ with $\Omega_{i,j} = \frac{\sigma_v^2}{1-\rho^2}\rho^{|i-j|}$ with ρ and σ_v^2 estimated based on OLS estimation of (46). We are interested in testing whether $\widehat{\beta}$ is different from zero. Consider using the t-statistics based on the OLS estimate of (45) and the AR(1) standard error (the square root of element 2,2 of the estimate of the variance matrix just stated) along with critical values from the standard normal distribution.

While this t-test will have a rejection rate equal to the nominal significance levels asymptotically, it will over-reject in finite samples implying that one too often thinks that β is not zero when the null of $\beta = 0$ is in fact true. There are two reasons for this: First, the t-statistics are not normally distributed in small samples. Second, the OLS estimate of ρ in (46) is downward biased.

The objective of our bootstrap-after-bootstrap approach is to improve on this approach and construct more precise standard errors for the OLS estimates in (45) and in turn more accurate t-statistics and t-tests for the null of $\beta = 0$ with rejection rates closer to the nominal significance level assumed. We first state our approach and then provide Monte-Carlo evidence in its quality. For reference we also show how poorly the commonly used approach of using Newey-West standard errors does, even with as many as 10 lags in annual data. We note upfront that we also considered using the Kendall bias-adjustment to $\widehat{\rho}$ instead of a bootstrap approach. It turns out that the Kendall bias-adjustment is too small (i.e. that the bias-adjusted value of $\widehat{\rho}$ has a mean below the true value of ρ). While this is known (see Figure 2 of MacKinnon and Smith (1998)) we have conducted a separate Monte-Carlo study (available upon request) that shows the this problem with the Kendall bias-adjustment is worse when the AR(1) processes estimated is for residuals, as opposed to for "raw data". This is quite intuitive since the residuals are the true error terms plus estimation noise and the presence of noise in the right-hand side variable in the AR(1) estimation leads to attenuation bias.[15]

Our bootstrap-after-bootstrap approach:

The basic idea of our approach is simple. We first estimate (45) and (46) using OLS. Then we use a bootstrap to come up with a bias-adjustment to the OLS estimate $\widehat{\rho}$. We then use the bias-adjusted value $\widehat{\rho}^{\text{Bias-corrected}}$ in a second bootstrap in order to assess the statistical significance of the OLS estimates $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$. We therefore refer to our approach as a bootstrap-after-bootstrap approach. Our method is quite similar to that of Kilian (1998). He focuses on VAR estimation whereas our case is a linear regression with an AR(1) error term, but the basic idea is the same: To get appropriate inference about the object of interest (in our case α, β and γ) using a bootstrap approach, one needs to do the bootstrap starting from a set of parameters that are close to unbiased (in our case one needs to overcome the downward bias in the OLS estimate of ρ in (46)).[16]

The detailed steps of our approach are as follows:

Step 1. Initial estimation:

Estimate (45) by OLS to get $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$ and $\widehat{\varepsilon}_1, ..., \widehat{\varepsilon}_T$. Use $\widehat{\varepsilon}_1, ..., \widehat{\varepsilon}_T$ to estimate (46) by OLS to get $\widehat{\rho}$ and $\widehat{v}_1, ..., \widehat{v}_T$.

[15] There is an analogy to critical values for Dickey-Fuller tests: The critical values for testing whether a given variable is I(1) differs from the critical values for testing whether the residuals from a cointegrating regression is I(1) (Engle and Yoo (1987)).

[16] Our approach is a parametric bootstrap appraoch which exploits the AR(1) structure of the error term. We do not consider non-parametric bootstrap methods (e.g. a block bootstrap) because Berkowitz and Kilian (2000) show that parametric bootstrap methods are more accurate than non-parametric bootstrap methods (subject to the usual qualifier of using a valid parametric model). See their Figure 2 for Monte Carlo evidence.

Step 2. Bootstrap to construct a bias-adjusted estimate of ρ.

Each iteration i of this bootstrap is a parametric bootstrap based on the assumed model in (45) and (46) and works as follows (where * refers to a bootstrap sample and there are I bootstrap iterations in total):

- Draw one of the residuals $\widehat{\varepsilon}_t$ at random. Use it as ε_0^*.
- Draw values of $\widehat{v}$ with replacement and use them as $v_1^*, ..., v_T^*$.
- Use ε_0^*, $v_1^*, ..., v_T^*$ and $\widehat{\rho}$ to construct a bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ using (46).
- Use $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$ from step 1, the actual values of the x_t's and the bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ to generate a bootstrap sample y_1^*,..., y_T^*.
- Estimate (45) by OLS using y_1^*,..., y_T^* and $x_1, ..., x_T$. Use the residuals to estimate (46) by OLS.
- Record the value of the estimate of ρ for this bootstrap iteration, $\widehat{\rho}_i^*$.

Then calculate the average value of $\widehat{\rho}_i^*$ across the I bootstrap iterations and denote it $\overline{\widehat{\rho}^*}$. Estimate the bias of the initial OLS estimator $\widehat{\rho}$ as $\widehat{Bias} = \overline{\widehat{\rho}^*} - \widehat{\rho}$. Use $\min(1, \widehat{\rho} - \widehat{Bias})$ as the bias-adjusted estimate of ρ and denote it by $\widehat{\rho}^{\text{Bias-corrected}}$. Note that this implicitly assumes that the bias is the same for ρ values near the true value ρ.[17] Furthermore, setting the bias-adjusted estimate of ρ to 1 when it would otherwise be above one, the method imposes a belief that the true data-generating process in (46) does not have an explosive value of ρ.

Step 3. Bootstrap to assess statistical significance of $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$.

Each iteration i of this bootstrap is a parametric bootstrap based on the assumed model in (45) and (46) and works as follows (where * refers to a bootstrap sample and there are I bootstrap iterations in total):

- Draw one of the residuals $\widehat{\varepsilon}_t$ at random. Use it as ε_0^*.
- Draw values of $\widehat{v}$ with replacement and use them as $v_1^*, ..., v_T^*$.
- Use ε_0^*, $v_1^*, ..., v_T^*$ and $\widehat{\rho}^{\text{Bias-corrected}}$ to construct a bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ using (46).
- Use $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$ from step 1, the actual values of the x_t's and the bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ to generate a bootstrap sample y_1^*,..., y_T^*.
- Estimate (45) using y_1^*,..., y_T^* and $x_1, ..., x_T$.
- Record the value of the estimates of α, β, and γ, $\widehat{\alpha}_i^*$, $\widehat{\beta}_i^*$, $\widehat{\gamma}_i^*$.

[17] Kilian (1998) suggests that one could iterate the bias-estimation proceedure in this step but that this is likely to have little effect. We have also not found iterating to substantially improve the properties of the resulting estimator of ρ.

The standard errors of $\widehat{\alpha}$, $\widehat{\beta}$ and $\widehat{\gamma}$ is then estimated as the standard deviations of $\widehat{\alpha}_i^*$, $\widehat{\beta}_i^*$ and $\widehat{\gamma}_i^*$ across the I bootstrap iterations. Denote these standard errors by $\text{SE}(\widehat{\alpha})$, $\text{SE}\left(\widehat{\beta}\right)$ and $\text{SE}(\widehat{\gamma})$ The t-statistic for $\widehat{\beta}$ is then $t_{bootstrap-after-bootstrap} = \widehat{\beta}/\text{SE}\left(\widehat{\beta}\right)$ (and similarly for $\widehat{\alpha}$ and $\widehat{\gamma}$) and the null of $\beta = 0$ is rejected if $|t_{bootstrap-after-bootstrap}| > z_{\alpha/2}$ where α is the nominal significance level of the test.

We use I =2000 bootstrap estimations in each of step 2 and 3.

Monte-Carlo evidence on the quality of our bootstrap-after-bootstrap approach:

Assume the data generating process is

$$y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t \tag{47}$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + v_t, \ v_t \text{ i.i.d. } N\left(0, \sigma_v^2\right) \tag{48}$$

$$x_t = \rho x_{t-1} + w_t, \ w_t \text{ i.i.d. } N\left(0, \sigma_w^2\right) \tag{49}$$

This is as assumed above with the addition of a process for x_t and the assumption that v_t and w_t are normally distributed (these assumptions are not needed for the bootstrap approach itself but are needed for the Monte-Carlo study assessing the quality of the bootstrap approach). We set the true values as $\alpha = \beta = \gamma = 0$, $\sigma_u^2 = \sigma_v^2 = \sigma_w^2 = 1/\left(1-\rho^2\right)$, where we consider a few different values of ρ. Setting $\sigma_u^2 = \sigma_v^2 = \sigma_w^2 = 1/\left(1-\rho^2\right)$ ensures that the unconditional variances of y and x do not change as we change ρ.

The table below is based on 2000 Monte-Carlo iterations and is done for $T = 140$ observations. It shows the mean of the OLS estimator of ρ along with the mean of our bias-adjusted estimator. It then states the rejection rates for t-tests of $H_0 : \beta = 0$ for two-sided tests with nominal significance levels of 5%, 1% and 0.1%, respectively (when the null is in fact true). We compare the properties of t-tests based on our bootstrap-after-bootstrap approach to that of OLS (incorrectly assuming i.i.d. errors), Newey-West standard errors with 10 lags and AR(1) standard errors. By AR(1) standard errors we mean the square root of diagonals of the variance of the OLS estimator conditional on X, i.e. $\left(X'X\right)^{-1} X'\Omega X \left(X'X\right)^{-1}$ with $\Omega_{i,j} = \frac{\sigma_v^2}{1-\rho^2}\rho^{|i-j|}$ and where ρ and σ_v^2 are estimated based on OLS estimation of (45) and (46). From the table it is clear that there is still some over-rejection in our bootstrap approach but that this approach is substantially better than the other approaches listed. For example, for $\rho = 0.95$ (close to what we find in the actual data in Table 3 Panel A) and a nominal significance level of 1%, our approach rejects the null with probability 3.8%, the AR(1) approach rejects with probability 10.4%, and the Newey-West approach rejects with probability 23.3% (meaning that when using the Newey-West approach with 10 lags and a critical value of $z_{0.995} = 2.576$ you incorrectly reject the null when it is true with probability 23.3%, far above the nominal significance level of 1%).[18]

[18] The AR(1) approach with the Kendall-adjustment performes in between the AR(1) approach and our approach, having a

	$\rho = 0.6$	$\rho = 0.8$	$\rho = 0.9$	$\rho = 0.95$	$\rho = 0.99$
Mean of $\widehat{\rho}$	0.560	0.747	0.837	0.877	0.901
Mean of $\widehat{\rho}^{\text{Bias-corrected}}$	0.599	0.797	0.894	0.937	0.958
		Nominal significance level=5%			
$\Pr(\lvert t_{OLS}\rvert) > z_{0.975}$	0.177	0.363	0.526	0.601	0.695
$\Pr(\lvert t_{NW,\text{ 10 lags}}\rvert) > z_{0.975}$	0.111	0.178	0.271	0.361	0.443
$\Pr\left(\lvert t_{AR(1)}\rvert\right) > z_{0.975}$	0.075	0.110	0.166	0.218	0.297
$\Pr(\lvert t_{Bootstrap-after-bootstrap}\rvert) > z_{0.975}$	0.062	0.074	0.082	0.094	0.125
		Nominal significance level=1%			
$\Pr(\lvert t_{OLS}\rvert) > z_{0.995}$	0.081	0.233	0.410	0.519	0.610
$\Pr(\lvert t_{NW,\text{ 10 lags}}\rvert) > z_{0.995}$	0.048	0.091	0.156	0.233	0.328
$\Pr\left(\lvert t_{AR(1)}\rvert\right) > z_{0.995}$	0.022	0.036	0.066	0.104	0.174
$\Pr(\lvert t_{Bootstrap-after-bootstrap}\rvert) > z_{0.995}$	0.012	0.022	0.028	0.038	0.056
		Nominal significance level=0.1%			
$\Pr(\lvert t_{OLS}\rvert) > z_{0.9995}$	0.027	0.141	0.292	0.419	0.529
$\Pr(\lvert t_{NW,\text{ 10 lags}}\rvert) > z_{0.9995}$	0.015	0.039	0.082	0.142	0.224
$\Pr\left(\lvert t_{AR(1)}\rvert\right) > z_{0.9995}$	0.002	0.009	0.023	0.044	0.082
$\Pr(\lvert t_{Bootstrap-after-bootstrap}\rvert) > z_{0.9995}$	0.002	0.003	0.010	0.017	0.031

Note: z denotes a percentile of the standard normal distribution. $z_{0.975} = 1.960$, $z_{0.995} = 2.576$, $z_{0.9995} = 3.291$.

To assess how much the results of the Monte-Carlo simulation changes for smaller sample size we redid the simulation for $\rho = 0.95$ and nominal significance level=1% for $T = 70$. The rejection rates for the four approaches changes from the above values of 0.519, 0.233, 0.104, and 0.038 for $T = 140$ to 0.432, 0.245, 0.126 and 0.045 for $T = 70$.

rejection rate of 6.8% in the case just discussed.

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Figure 1. Government supply and its three components, 1874 to 2014.

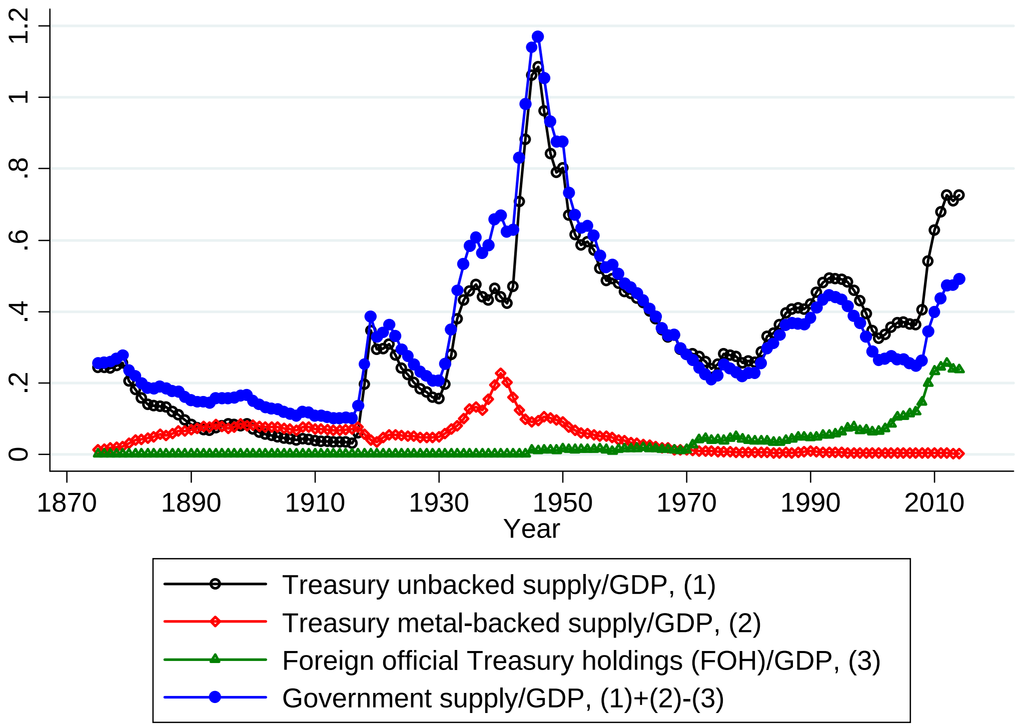
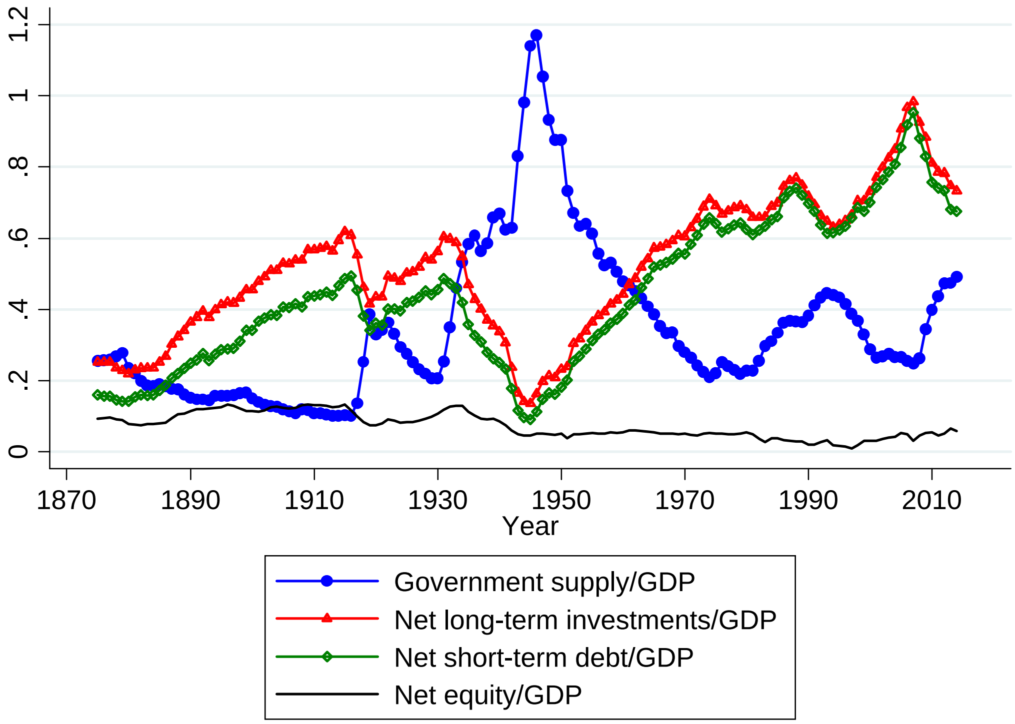


Figure 2. The relation between government supply, financial sector lending (net long-term investments), and financial sector lending financed with short-term debt (net short-term debt), 1875-2014

Panel A. Time series graph



Panel B. Scatter plot of financial sector net short-term debt/GDP against government supply/GDP.

The scatter plot is of the residuals from detrending by regressing the time series on year.

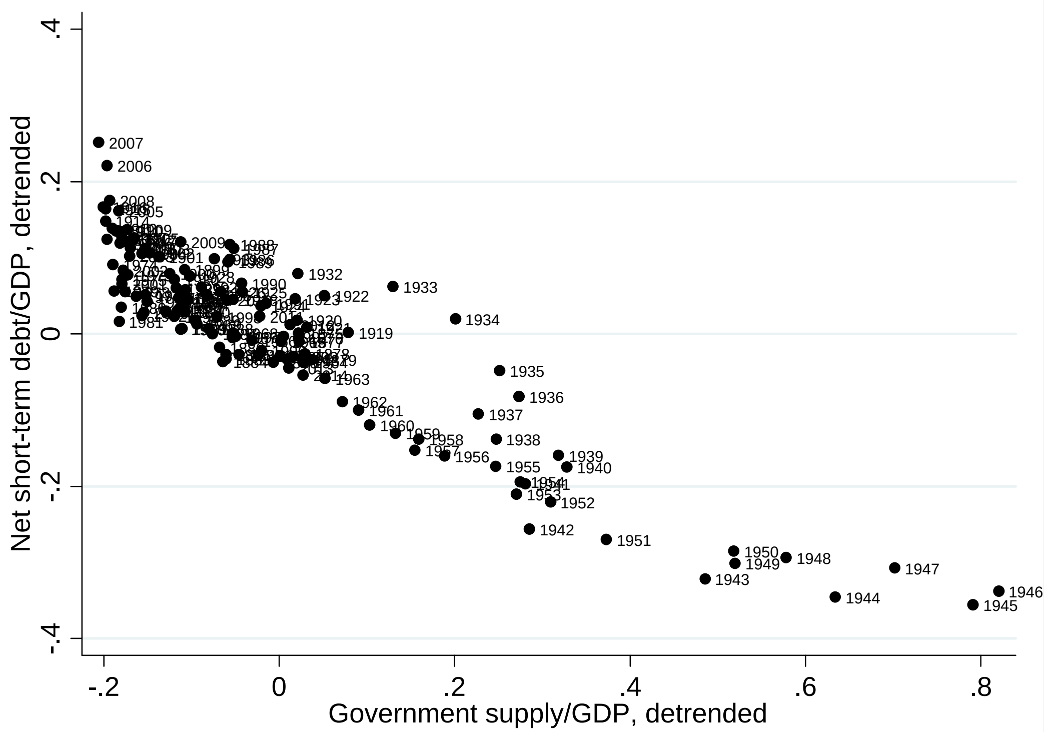
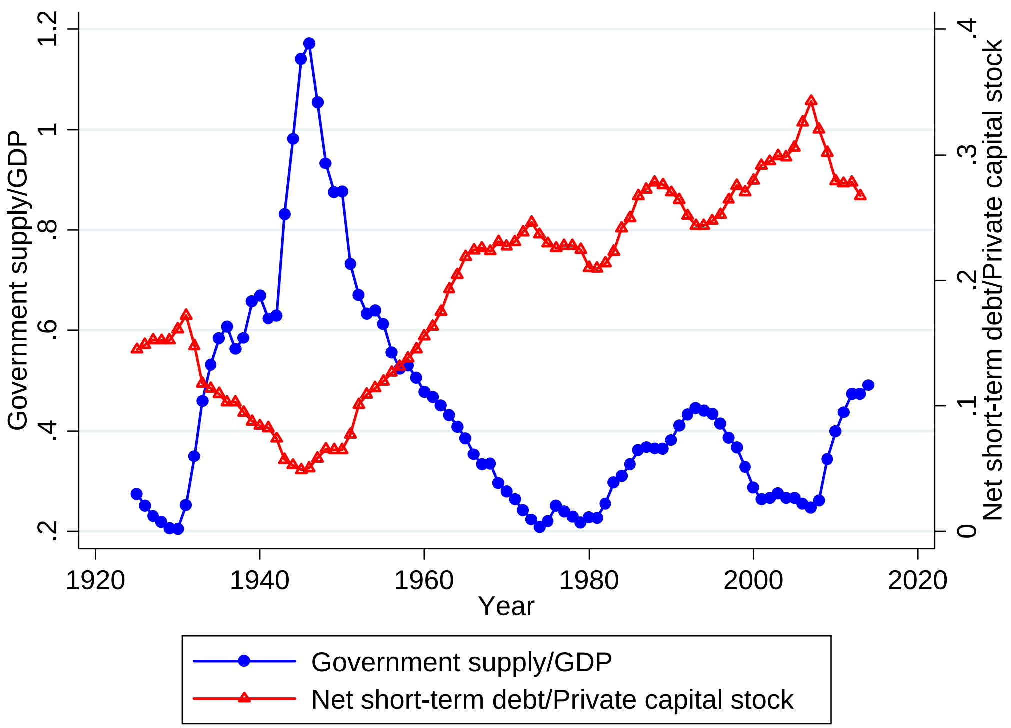


Figure 3. Net short-term debt/Private capital stock and Private capital stock/GDP, 1925-2013

We define the private capital stock as the sum of private fixed assets (non-residential and residential) and consumer durable goods, at current prices.

Panel A. Net short-term debt/Private capital stock and Government Supply/GDP



Panel B. Private capital stock/GDP and Government Supply/GDP

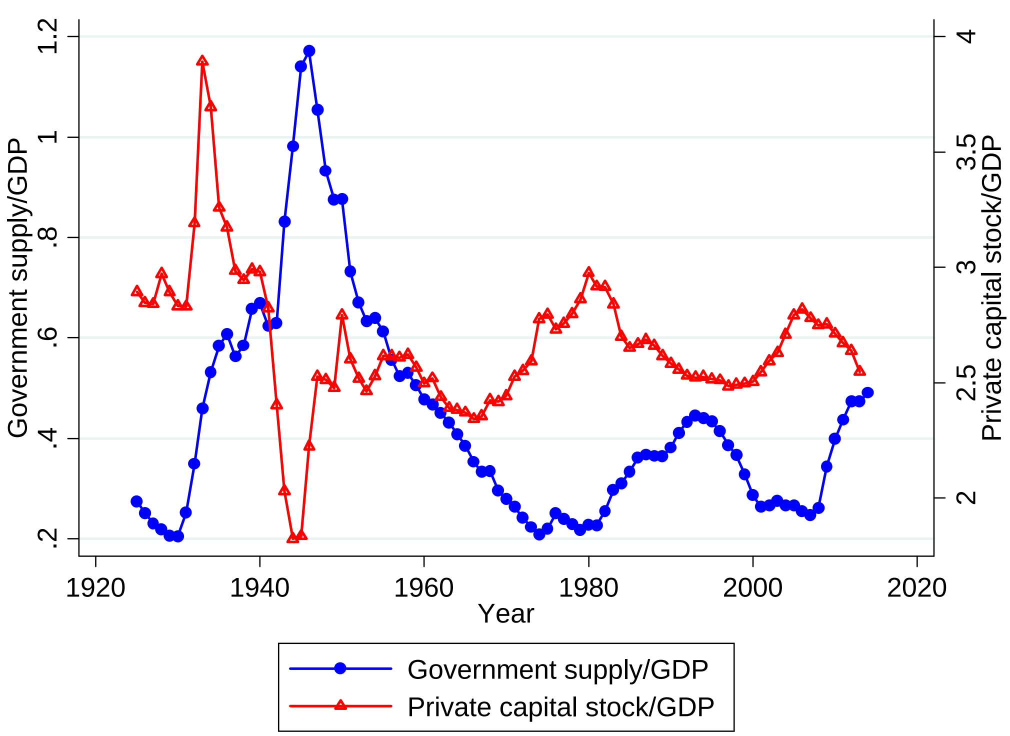
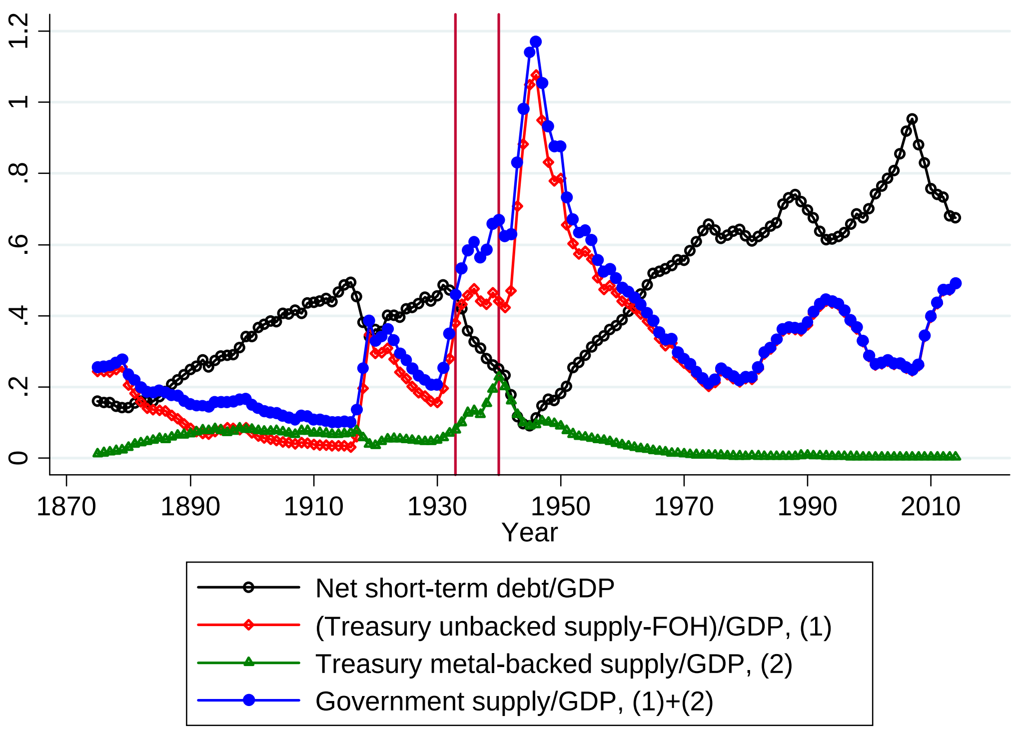


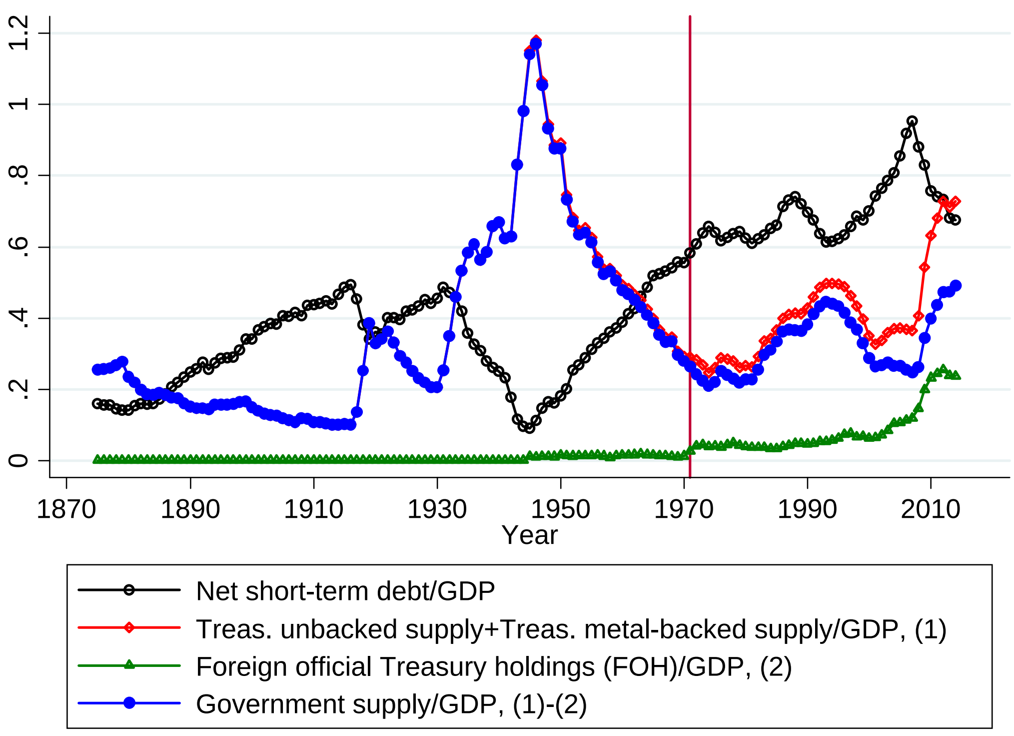
Figure 4. Shocks to supply and demand

Panel A. Gold inflows during 1934-1940 (positive shock to Treasury metal-backed supply/GDP)



Note: The vertical lines are at year 1933 and 1940.

Panel B. Increased foreign official holdings post Bretton-Woods (positive shock to Treasury demand)



Note: The vertical line is in 1971. The US ended convertibility of the dollar to gold in August 1971.

Figure 5. Expenditure share for ``credit goods'', 1929-2014.

We define credit goods as NIPA categories "durable goods" plus "housing and utilities".

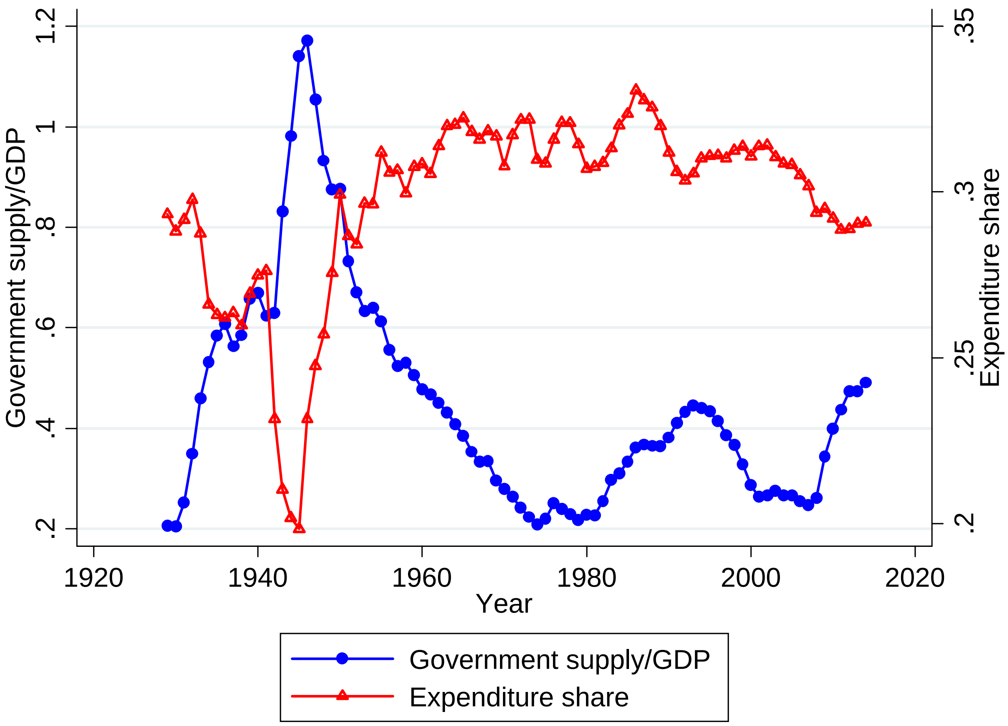
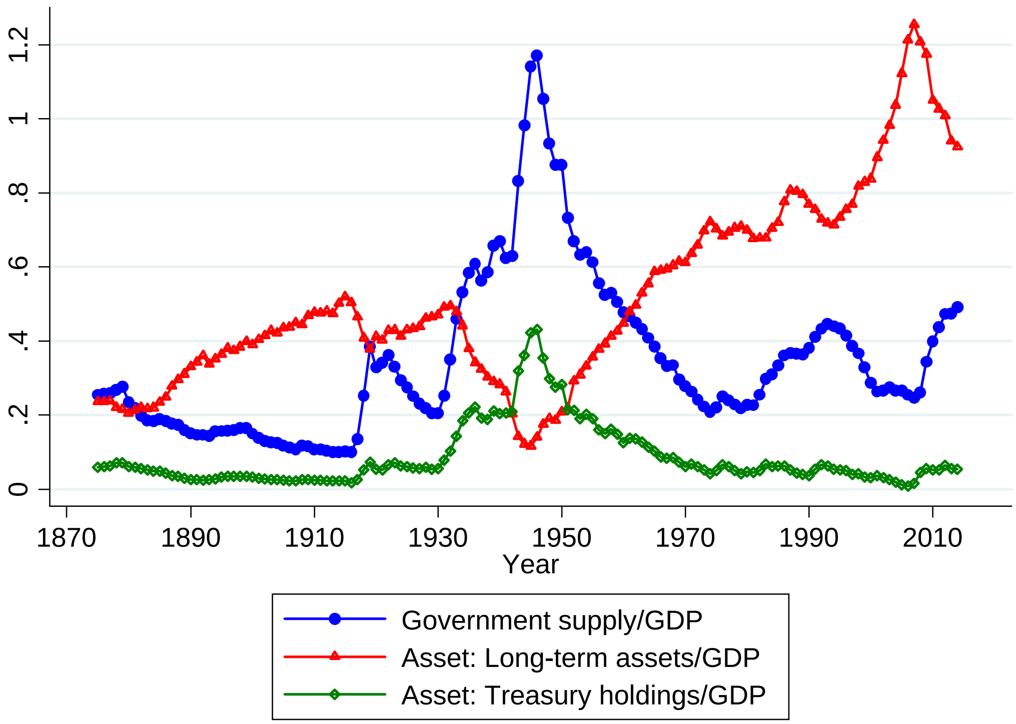


Figure 6. Sub-components of the financial sector balance sheet, 1875-2014

Panel A. The long-term assets of the financial sector, principally corporate and mortgage loans, and the financial sector's Treasury holdings



Panel B. The financial sector's liabilities

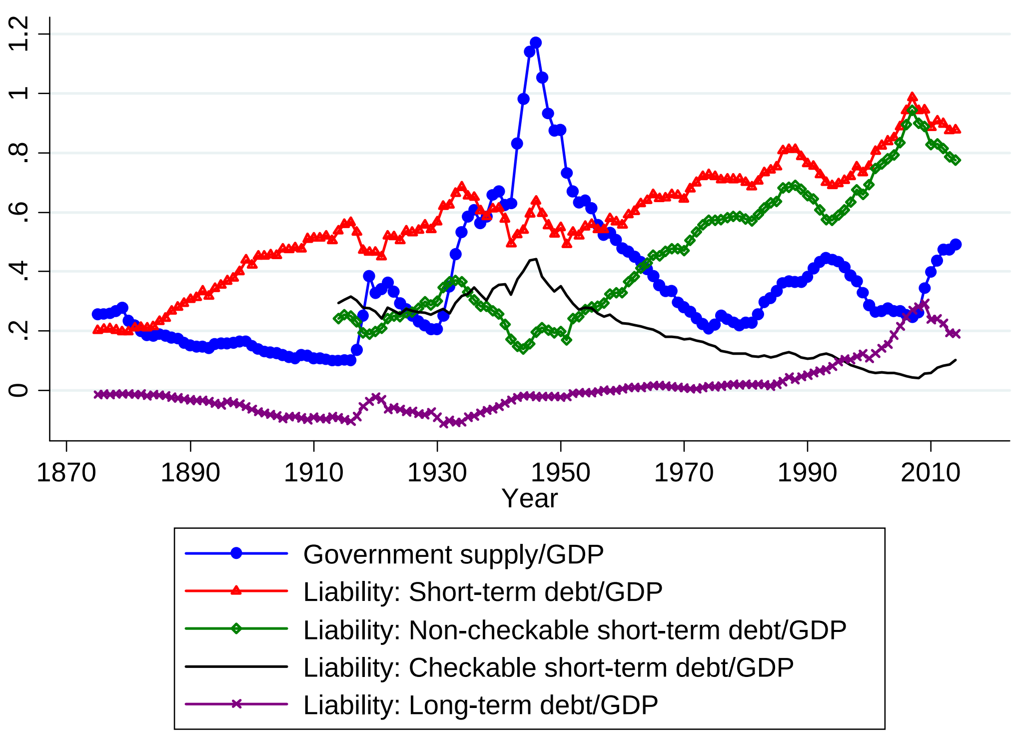


Figure 7. Decomposition of Treasury unbacked supply/GDP (Debt/GDP) into three parts: Marketable Treasury bonds with less than one year maturity, marketable Treasury bonds with greater than one year maturity and savings bonds. The series are plotted from 1916 to 2014.

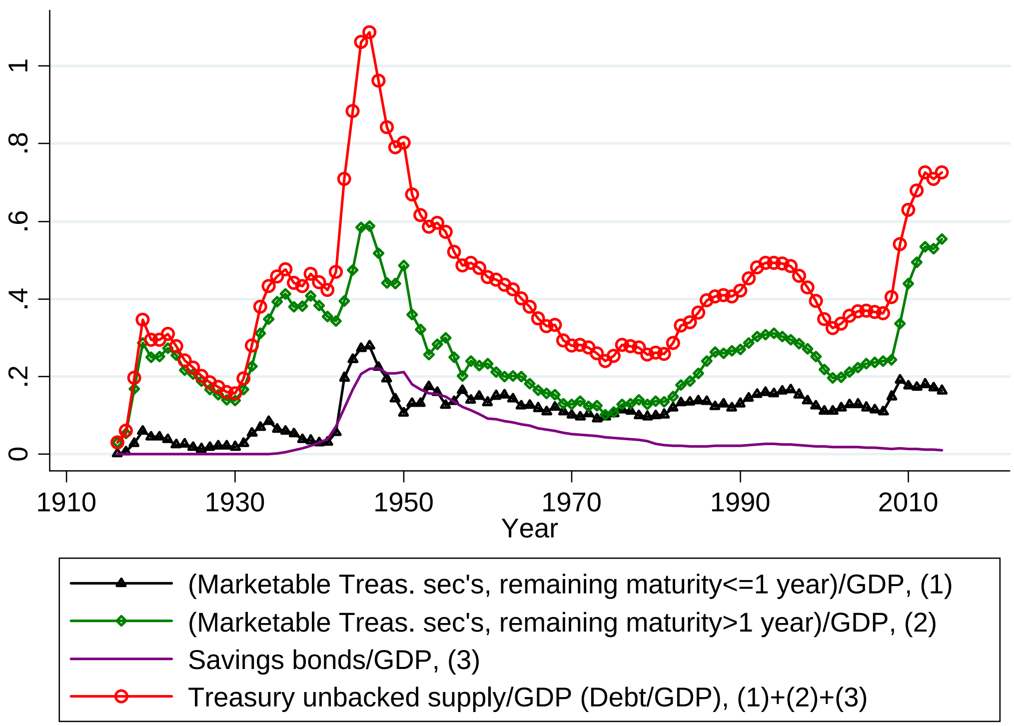


Table 1. Financial sector balance sheet, 1875-2014
Panel A. Instruments that are net assets on average across the full sample period

Instrument		(Assets-Liabs.) /GDP					Assets ($B)	Liabs. ($B)	Assets-Liabs. ($B)
		Avg for 1875-2014	Avg for 1875-1913	Avg for 1914-2014	End of 2007	End of Q3 2014	End of 2007		
Treasury securities	Sum	8.6	3.8	10.5	1.7	5.3	230	0	230
Short-term assets									
Assets at/liabilities to the Federal Reserve (asset: reserves, liabs: float+borrowing from Fed)		2.5	0.0	3.4	0.2	14.4	23	-1	24
Currency and coin (assets: govt. issued money, gold, silver, liabs: national and state bank notes)		0.8	1.5	0.6	0.3	0.4	41	0	41
Net interbank liabilities to domestic banks		1.1	1.4	1.0	0.4	-0.1	0	-57	57
Foreign deposits		0.1	0.0	0.2	0.6	0.1	80	0	80
Trade credit		0.0	0.0	0.1	0.3	0.1	105	62	42
	Sum	4.6	2.8	5.2	1.8	14.9	249	4	245
Long-term assets									
Depository institution loans		18.2	25.7	15.3	12.5	13.5	1,993	258	1,734
Mortgages		17.9	3.9	23.4	62.7	34.0	8,694	0	8,694
Consumer credit		5.6	0.0	7.8	16.6	13.2	2,304	0	2,304
Municipal securities		3.8	2.9	4.1	5.1	4.2	708	0	708
Agency- and GSE-backed securities		3.6	0.0	5.0	15.2	15.4	2,111	0	2,111
Miscellaneous		1.8	1.9	1.8	12.5	11.0	2,888	1,160	1,728
Other loans and advances		0.9	0.0	1.2	0.8	1.1	912	796	116
	Sum	51.9	34.4	58.6	125.5	92.5	19,609	2,215	17,394
Equity									
Corporate equities (incl. life insurance reserves)		0.4	0.2	0.5	3.4	2.7	475	0	475
U.S. direct investment abroad		0.3	0.0	0.4	1.2	2.1	453	280	173
Mutual fund shares		0.0	0.0	0.0	0.2	0.4	31	0	31
	Sum	0.7	0.2	0.9	4.9	5.2	959	280	679
	Overall sum	65.8	41.2	75.3	133.8	117.9	21,048	2,499	18,549

Panel B. Instruments that are net liabilities on average across the full sample period

Instrument	(Liabs.-Assets) /GDP					Assets ($B)	Liabs. ($B)	Liabs.-Assets ($B)
	Avg for 1873-1913	Avg for 1873-1913	Avg for 1914-2014	End of Q3:2007	End of Q3:2014	End of Q3:2007		
Short-term debt								
Savings and time deposits	51.8	35.0	37.8	52.4	54.5	335	7,601	7,266
Checkable deposits and currency			20.5	4.3	10.1	113	708	595
Money market fund shares	2.6	0.0	3.6	15.9	12.5	570	2,780	2,210
Federal funds and security repos	1.2	0.0	1.7	9.8	1.5	2,888	4,244	1,356
Securities loaned, security credit	1.0	0.0	1.4	13.9	7.0	353	2,276	1,924
Commercial paper	0.7	0.0	1.0	1.9	-0.7	1,031	1,300	269
Net interbank liabilities to foreign banks	0.2	0.0	0.3	0.2	2.9	0	25	25
Taxes payable	0.1	0.0	0.1	0.3	-0.1	0	38	38
Sum	57.6	35.0	66.3	98.7	87.8	5,290	18,971	13,681
Long-term debt								
Corporate and foreign bonds	0.2	-4.9	2.1	27.1	19.1	2,306	6,069	3,763
ABS issuers	2.3	0.0	3.2	27.5	7.5	0	3,808	3,808
Other fin. inst's	-2.1	-4.9	-1.0	-0.3	11.6	2,306	2,261	-46
Sum	0.2	-4.9	2.1	27.1	19.1	2,306	6,069	3,763
Equity								
Financial sector equity	8.0	11.1	6.8	8.2	11.0	0	1,130	1,130
Investment by holding companies, parent companies and funding corporations (in other parts of the financial sector)	0.0	0.0	0.0	-0.2	0.0	2,360	2,335	-26
Sum	8.0	11.1	6.8	8.0	11.0	2,360	3,465	1,104
Overall sum	65.8	41.2	75.3	133.8	117.9	9,957	28,506	18,549

Table 2. Financial sector balance sheet with short, long, and equity categories netted, 1875-2014

	Avg for 1875-2014	Avg for 1875-1913	Avg for 1914-2014	End of Q3:2007	End of Q3:2014
Net long-term investments/GDP					
=(Long-term assets/GDP)-(Long-term debt/GDP)					
Overall sum	51.7	39.3	56.4	98.3	73.4
Net short-term debt/GDP (long-term investments financed with short-term debt/GDP)					
=(Short-term debt/GDP)-(Short-term assets/GDP)-(Treasuries/GDP)					
	44.4	28.4	50.6	95.3	67.5
Net equity/GDP (long-term investments financed with equity/GDP)					
=(Equity on liability side/GDP)-(Equity on asset side/GDP)					
	7.3	10.9	5.8	3.1	5.8
Overall sum	51.7	39.3	56.4	98.3	73.4

Table 3. The negative relation between government supply and financial sector lending (net long-term investments) and financial sector lending financed by short-term debt (net short-term debt). Baseline OLS estimates.

Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors (developed in Appendix B).

	Government supply/GDP	Year	R2	Partial R2 of Government supply/GDP	Bootstrap biased corrected AR(1)-coefficient for OLS residual
	Panel A. 1875-2014				
Net long-term investments/GDP	-0.570	0.0044	0.902	0.383	0.963
	(t=-4.62)	(4.31)			
Net short-term debt/GDP	-0.536	0.0050	0.945	0.294	0.934
	(-5.99)	(7.92)			
	Panel B. 1875-2014, excluding 1942-1951 (WW2)				
Net long-term investments/GDP	-0.603	0.0044	0.886	0.208	0.992
	(-3.38)	(3.05)			
Net short-term debt/GDP	-0.575	0.0051	0.943	0.154	0.961
	(-4.13)	(6.47)			
	Panel C. 1875-1933				
Net long-term investments/GDP	-0.648	0.0071	0.908	0.174	0.996
	(-2.49)	(2.35)			
Net short-term debt/GDP	-0.491	0.0067	0.947	0.119	0.907
	(-3.58)	(7.13)			
	Panel D. 1934-2014, excluding 1942-1951 (WW2)				
Net long-term investments/GDP	-0.488	0.0049	0.880	0.100	0.940
	(-2.83)	(3.52)			
Net short-term debt/GDP	-0.507	0.0055	0.923	0.094	0.938
	(-2.99)	(4.06)			

Note: t-statistics in parenthesis. Regressions include a constant (not reported for brevity). The cutoff for significance for a 2-sided test using the normal distribution is: 2.58 at the 1 percent level, 1.96 at the 5 percent level, and 1.65 at the 10 percent level.

Table 4. The negative relation between government supply and financial sector lending (net long-term investments) and financial sector lending financed by short-term debt (net short-term debt). Alternative estimation approaches.

Panel A. Estimations using differenced data, 1875-2014

		1-year differences	2-year differences	3-year differences	5-year differences	10-year differences
Net long-term investments/GDP	β	-0.296	-0.357	-0.388	-0.460	-0.574
regressed on Govt. supply/GDP	t-statistic	(-4.91)	(-4.98)	(-4.96)	(-5.91)	(-7.41)
Net short-term debt/GDP	β	-0.287	-0.337	-0.370	-0.419	-0.511
regressed on Govt. supply/GDP	t-statistic	(-5.64)	(-5.26)	(-5.13)	(-6.09)	(-8.22)

Note: t-statistics in parenthesis. Regressions include a constant (not reported for brevity). Regressions are estimated by OLS with standard errors calculated using the Newey-West method with d lags for regressions using d-year differenced data.

Panel B. Estimated cointegrating relations, 1875-2014

	Government supply/GDP	Year
Net long-term investments/GDP=	-0.594	+0.0043
	(t=11.00)	(15.03)
Net short-term debt/GDP=	-0.567	+0.0050
	(-13.91)	(22.87)
Net equity/GDP	No cointegrating relation	

Table 5. Addressing endogeneity concerns

Panel A. Adding controls for loan demand and dropping years after financial crisis.

	Dependent variable: Net short-term debt/GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
Government supply/GDP	-0.536	-0.432	-0.573	-0.517	-0.620	-0.532
	(t=-5.99)	(-3.07)	(-4.64)	(-5.71)	(-5.37)	(-6.05)
Real short rate$_t$		0.072				
		(0.17)				
Nominal short rate$_t$			-0.438			
			(-0.51)			
Real GDP$_t$/Real GDP$_{t-5}$				-0.093		
				(-1.95)		
Federal deficit/GDP, avg. for year t-4 to t					0.775	
					(1.85)	
Year	0.0050	0.0065	0.0048	0.0049	0.0049	0.0046
	(7.92)	(2.82)	(3.68)	(7.82)	(8.28)	(5.03)
R^2	0.945	0.952	0.938	0.949	0.954	0.953
Sample	1875-2014	1946-2014	1918-2014	1875-2014	1875-2014	Drop year t to t+9 after financial crisis

Note: t-statistics in parenthesis. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity).

Panel B. Effect of Government supply/GDP on Net short-term debt/Private capital stock and on Private capital stock/GDP, 1925-2013

	Dependent variable:		
	Net short-term debt/GDP	Net short-term debt/ Private capital stock	Private capital stock/GDP
	(1)	(2)	(3)
Government supply/GDP	-0.453	-0.173	-0.667
	(t=-4.40)	(-5.30)	(-1.42)
Private capital stock/GDP	0.103		
	(1.75)		
Year	0.0055	0.0021	-0.0048
	(3.87)	(4.92)	(-0.90)
R2	0.951	0.953	0.251
Partial R2 of Government supply/GDP	0.148	0.191	0.204

Note: t-statistics in parenthesis. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). The sample starts in 1925 for data availability reasons.

Panel C. Separate impacts of each of the three main components of the government supply/GDP variable, 1875-2014

	Dependent variable: Net short-term debt/GDP
Treasury unbacked supply/GDP	-0.558
	(-5.59)
Treasury metal-backed supply/GDP	-0.304
	(-0.62)
Foreign Treasury holdings/GDP	0.701
	(1.26)
Year	0.0051
	(5.77)
R^2	0.947
Partial R^2	0.296

Note: t-statistics in parenthesis. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). The partial R2 is with respect to all three supply variables. Foreign holdings are set to zero before 1952.

Panel D. ``Rajan-Zingales identification'': Household expenditure shares for ``credit goods'', 1929-2013
Are expenditure shares for products often bought with borrowed money higher when government supply is smaller?

	Dependent variable: Expenditure share of products often bought with borrowed money	
	(1)	(2)
Government supply/GDP	-0.072	-0.051
	(t=-3.54)	(-1.84)
Log(real expenditure)	0.047	0.036
	(3.39)	(2.00)
Log(price of products often bought with borrowed money)	0.221	0.156
	(4.52)	(2.41)
R^2	0.822	0.602
Partial R^2 of government supply/GDP	0.232	0.131
Sample	1929-2013	1929-2013, excluding 1942-1951

Note: t-statistics in parenthesis. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). Expenditure on products often bought with borrowed money, or "credit goods," is defined as the sum of expenditure on durable goods and on housing and utilities.

Table 6. The relation between government supply and sub-components of the financial sector balance sheet, 1875-2014

	1875-2014	1875-1970	1971-2014
Dependent variable:	Government supply/GDP	Government supply/GDP	Government supply/GDP
	(1)	(2)	(3)
Net short-term debt/GDP	-0.536	-0.524	-0.625
	(t=-5.99)	(-5.38)	(-2.72)
Asset side:			
Treasuries/GDP	0.389	0.379	0.131
	(8.41)	(15.93)	(2.37)
Short-term assets/GDP	0.086	0.0579	0.144
	(1.58)	(1.61)	(1.57)
Long-term assets/GDP	-0.629	-0.537	-0.993
	(-3.78)	(-8.11)	(-3.23)
Equity/GDP	-0.012	-0.002	0.015
	(-0.89)	(-1.01)	(0.45)
Sum (size of financial sector/GDP)	-0.166	-0.102	-0.703
	(-0.90)	(-0.96)	(-2.23)
Liability side:			
Short-term debt/GDP	-0.061	-0.086	-0.350
	(-0.47)	(-0.72)	(-1.65)
Checkable deposits/GDP	0.226	0.222	0.185
	(9.60)	(6.77)	(3.44)
Non-checkable short-term debt/GDP	-0.309	-0.249	-0.535
	(-2.82)	(-2.31)	(-2.57)
Long-term debt/GDP	-0.059	0.041	-0.295
	(-0.88)	(1.16)	(-2.19)
Equity/GDP	-0.046	-0.057	-0.058
	(-1.15)	(-1.88)	(-0.89)
Sum (size of financial sector/GDP)	-0.166	-0.102	-0.703
	(-0.90)	(-0.96)	(-2.23)

Note: t-statistics in parenthesis. Each coefficient and corresponding t-statistic refers to the coefficient on Government supply/GDP in a regression of the dependent variable on Government supply/GDP, year and a constant. For readability, the coefficients on year and the constant are not reported. The division of short-term debt into checkable deposits and non-checkable deposits is only available for 1914-2014. Regressions for those separate categories thus omit the 1875-1913 period. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors.

Table 7. Separate effects of the sub-components of Treasury unbacked supply, 1916-2014

	Dependent variable: Net short-term debt/GDP			
	1916-2014		1916-2014, excluding 1942-1951	
	(1)	(2)	(3)	(4)
Components of Treasury unbacked supply/GDP (Debt/GDP):				
Marketable Treasury securities		-0.314		-0.441
		(-2.01)		(-2.97)
Remaining maturity ≤1 year/GDP	-0.397		-0.42	
	(-1.38)		(-0.88)	
Remaining maturity >1 year/GDP	-0.287		-0.445	
	(-1.17)		(-2.10)	
Savings bonds/GDP	-1.069	-1.105	-1.327	-1.319
	(-1.97)	(-1.91)	(-2.28)	(-2.13)
Treasury metal-backed supply/GDP	-0.868	-0.818	-0.582	-0.589
	(-1.54)	(-1.72)	(-1.24)	(-1.44)
Foreign official Treasury holdings/GDP	0.391	0.419	0.509	0.506
	(0.59)	(0.62)	(0.83)	(0.85)
Year	0.0042	0.0041	0.0045	0.0045
	(2.04)	(2.44)	(2.63)	(2.92)
R2	0.952	0.952	0.946	0.946
Partial R2	0.332	0.332	0.240	0.240

Note: t-statistics in parenthesis. Estimations are by OLS, with t-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). The partial R2 is with respect to all four supply variables. The sample starts in 1916 for data availability reasons.