The impact of Treasury supply on financial sector lending and stability

Arvind Krishnamurthy,[a,b] Annette Vissing-Jorgensen[b,c,d]

[a] Graduate School of Business, Stanford University, 655 Knight Way, Stanford, CA 94305, USA
[b] National Bureau of Economic Research
[c] Haas School of Business, University of California, Berkeley, 545 Student Services Building #1900, CA 94720, USA
[d] Center for Economic Policy Research

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 nonfinancial 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 them. 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 with US data from 1875 to 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: G12, G2, E4.

Keywords: Treasury supply, Monetary economics, Financial stability, Banking.

Corresponding author: Annette Vissing-Jorgensen. Tel.: 510 643 8013. *E-mail address:* vissing@haas.berkeley.edu.
We thank Hui Chen, Dean Corbae, Martin Ellison, Bjorn Eraker, Robin Greenwood, Richard Grossman, Sam Hanson, Michael Jansson, Jiacui Li, Thomas Phillipon, participants at the National Bureau of Economic Research (NBER) Summer Institute, Third Advances in Macro-Finance Tepper-Laboratory for Aggregate Economics and Finance Conference, London Business School Safe Assets Conference, Wharton Conference on Liquidity and Financial Crises, American Economic Association meeting, NBER Understanding Capital Structure conference, Fourth Macroeconomics and Finance conference in Paris, France, Ninth Asset Pricing Retreat at University of Oxford, Western Finance Association meeting, European Finance Association meeting, and Econometric Society meeting, and participants in seminars at Copenhagen Business School, Emory University, University of California at Berkeley (Haas School of Business), University of California at Berkeley (Department of Economics), Northwestern University (Kellogg School of Management), University of California at Davis, Federal Reserve Bank of New York, Federal Reserve Bank of San Francisco, Bank of Canada, European University Institute, Einaudi Institute for Economics and Finance, International Monetary Fund, University of Illinois at Urbana-Champaign, University of California at San Diego, Stanford University, and University of Texas at Austin.

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 that on average the ratio of financial sector short-term debt to gross domestic product (GDP) is 0.58. Financing from long-term debt and equity funding is small, averaging 0.08 relative to GDP. These funds are used mainly to fund long-term investments that 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 (1991) 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 (2009), 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 nonfinancial sector. This paper provides evidence in favor of this third view of banking and short-term debt. We show that investors have

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

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 show that Treasury securities are money-like in several respects. We establish 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 and 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, in which banks own loans and securities and fund these 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 yield 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 and illiquid loans and safe and liquid assets brought about by an increase in Treasury supply makes it less profitable for banks to take in deposits to invest in riskier, less liquid loans. Prior theoretical work, in particular by Holmstrom and Tirole (1998, 2011), also draws the connection between the government supply of liquid securities and the private supply of such securities. Holmstrom and Tirole (2011) show that when a shortage exists 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 US financial sector and the supply of US government securities from 1875 to 2014. 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, when the Treasury issued currency), and by metal-backed supply we mean Treasury issues of gold and silver coins and gold and silver certificates. We subtract foreign official holdings of government securities from this sum as we are interested in the privately held supply of US government issues. We study the relation between government supply and the US financial sector's net supply of short-term debt. The latter 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., nongovernment) 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 and illiquid assets and Treasuries (representing safe and 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 and liquid debt. The picture that emerges from the data is that of a financial sector that is active in transforming risky and illiquid loans into liquid and 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 might not be driven by safety and liquidity effects but instead by the standard mechanism taught in macroeconomics 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 demonstrating that the crowding-out of net short-term debt by government supply is robust to including these control variables. Moreover, our model of safety and liquidity-induced crowding-out 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, 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 might not be causal and instead are driven by either omitted variables or reverse causality. Treasury supply is affected by wars and the business cycle, and these factors could independently affect the financial sector's use of short-term debt and the financial sector's lending to the nonfinancial 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 could 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 crises, where the financial sector contracts and the associated recession causes an increase in government debt.

Second, we isolate two episodes in which 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 to 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 unlikely that the US trade deficits that underlie this build-up of foreign Treasury holdings would 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 represents 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 (when 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 National Income and Product Accounts (NIPA) categories Durable goods plus Housing and utilities, and we 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, the Deaton and Muellbauer (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 a standard generally agreed upon framework exists 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 compare the impact of financial development on the relative growth rate of industries that have different dependence on external finance to identify the impact of financial development on growth.

Section 2 lays out a model for understanding the relations between government supply, private demand for liquid and safe debt, and the private supplies of such debt. Section 3 describes how we empirically measure government supply and how to construct an overall balance sheet for the financial sector going back 140 years. In Section 4, we present our empirical results linking government supply and private supply. This section also discusses institutional changes over our long sample period and how these changes could have affect our results. Section 5 concludes.

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 and 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 and business capital and is funded by equity and deposits.

2.1. Government bonds

Both the household sector and the financial sector own government bonds. Bonds are issued at date 0 and retired at date 1. Proceeds from the issue are transferred in a lump-sum fashion to the households at date 0 and retired at date 1 using lump-sum 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 basic model has only one maturity of bond, when, in practice, there are different maturities of bonds. We extend the model to consider multiple bond maturities 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 are determined in equilibrium). Finally, households receive lump-sum transfers or taxes of T_0 and T_1.

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

- 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, and
- 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 notes 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) show that a demand exists from investors for extremely safe assets [above and beyond what can be rationalized by a consumption-based capital asset pricing model (CCAPM)], which can 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. 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 when we consider several maturities of government debt.

The household date 0 budget constraint gives

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

and date 1 consumption is

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

We define

$$\begin{aligned} s &= \frac{S}{y_1}, && (7) \\ C_0 &= c_0, && (8) \end{aligned}$$

and

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

The first order condition (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

$$1 + r_E = \frac{Dividend_1}{E - Dividend_0},$$

where $E - Dividend_0$ 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 or 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 with an economic function that is to make loans to households and to issue deposits, D, to satisfy households' demand for safe and 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. We assume that only the financial sector has access to this investment technology.

An example is helpful to understand a simplifying assumption we make. In practice, a bank may make an \$80 loan against a home worth \$100 (i.e., 80% loan-to-value ratio). The bank can 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 $D = 60$. In this example, 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. We explicitly model the first haircut, but this is without loss of generality. Our model is isomorphic to one in which 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 approach 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., to create short-term debt up to $\lambda_K K$ of home or 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

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

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

$$Dividend_1 = \lambda_K K + \theta^F - D. \quad (19)$$

The value of bank equity is then

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

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

The bank always chooses to saturate the deposit constraint of Eq. (17) as long as $v'(s) > 0$ (and $v'(s)$ is always strictly positive as we assume 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 $\frac{\delta}{1+r_E}$. Because $r_E > r_D$, the bank gains $\frac{\delta}{1+r_D} - \frac{\delta}{1+r_E} > 0$.

Substituting 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

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

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.

Because $r_D = r_T$ 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. Also, 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 can appear problematic, 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, $\lambda_K = 0$ (because $\phi'(0) = 0$). 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. Because 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 Eq. (16). $\square$

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. An increase in government bond supply could also reduce 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 and 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. Also, 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 Eq. (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 profitable only when funded by debt, as debt is cheap because it offers special services to households. If a bank made loans financed purely with money from shareholders, the bank would lose money because $r_K = r_E$ and lending suffers the screening cost of $\phi(\lambda_K) K > 0$.

If we consider 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 and Mollerus (2014). Our model is different from Barro's because it has a single representative household. If we modeled heterogeneity along the lines of Barro and Mollerus, then 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 in which government bond supply affects quantities via prices because we have elsewhere (Krishnamurthy and Vissing-Jorgensen, 2012) shown price effects of Treasury supply.

To test our model, we consider 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 Eq. (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 the Corollary 1 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 also show 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 it 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, changes in Treasury supply could affect the banking sectors' lending funded by short-term debt in two ways. First, consider the bank deposit constraint, $D = \lambda_K K + \theta^F$. Consider an extreme case in which 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 in which the increase in Treasury supply is fully absorbed by the households. In this case, households decrease their demand for bank deposits at every interest rate, which leads to a decrease in the equilibrium value of D. Banks then reduce lending, $\lambda_K K$, given that fewer bank deposits need backing. We refer to this as a household debt substitution effect.

The bank portfolio substitution effect implies no relation between Treasury supply and D, and the household substitution effect leads to a negative relation between Treasury supply and D. Regardless of these differing effects, Net-ST always falls with increases in Treasury supply.

2.6. Extension: short and long-term Treasury bonds

In this subsection, we consider a variant of the model 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

[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.

attributes they offer households and banks. Short-term government bonds are assumed to be perfect substitutes for deposits:

$$S = D + \theta^H_{ST}. \tag{24}$$

That is, short-term government debt (θ^H_{ST}) and bank deposits satisfy the safety and liquidity demand of households. In addition, the bank's deposit constraint is

$$D \leq \lambda_K K + \theta^F_{ST} + \lambda_{LT}\theta^F_{LT}, \tag{25}$$

so that banks can write deposits one-for-one against their holdings of short-term government bonds. Short-term government bonds are modeled exactly as we model all government bonds in the basic model. The deposit constraint has a new term, $\lambda_{LT}\theta^F_{LT}$, 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

$$u(c_0) + u\left(c_1 + y_1 \times v\left(\frac{S}{y_1}\right) + y_1 \times \mu\left(\frac{\lambda_{LT}\theta^H_{LT}}{y_1}\right)\right). \tag{26}$$

We include a new term, $\mu(\cdot)$, which assigns a special value to the safety and liquidity value of holdings of long-term government bonds, $\lambda_{LT}\theta^H_{LT}$. This function can be motivated as in Krishnamurthy and Vissing-Jorgensen (2012) as capturing households' desire for a safe long-term store of value. We assume that banks cannot issue long-term bonds to satisfy households' demand for a long-term store of value, as in Stein (2012). For simplicity, we 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 one part that is worse collateral, which we 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 and liquidity differences between these bonds.

Instead of resolving agents' decisions problems and deriving equilibrium, deriving the equilibrium as the solution to the planner's problem is easier. That is, given that no externalities are present, this solution gives the competitive equilibrium (this is easy to verify). The only resource cost is $\phi(\lambda_K) K$ to be paid at date 0. Thus,

$$
\begin{aligned}
c_0 &= y_0 - \phi(\lambda_K) K, && (27)\\
c_1 &= y_1 + K, && (28)\\
C_0 &= c_0, && (29)\\
C_1 &= c_1 + y_1 v\left(\frac{S}{y_1}\right) + y_1 \mu\left(\frac{\lambda_{LT}\theta_{LT}^H}{y_1}\right), && (30)
\end{aligned}
$$

and

$$S = \lambda_K K + \Theta_{ST} + \lambda_{LT}\theta_{LT}^F, \tag{31}$$

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

$$\max_{\lambda_K, \theta_{LT}^H} u(C_0) + u(C_1). \tag{32}$$

This gives a pair of first order conditions:

$$v'\left(\frac{\lambda_K K+\Theta_{ST}+\lambda_{LT}\theta_{LT}^{F}}{y_1}\right)=v'(s)=\frac{u'(C_0)}{u'(C_1)}\phi'(\lambda_K) \tag{33}$$

and

$$v'\left(\frac{\lambda_K K+\Theta_{ST}+\lambda_{LT}\theta_{LT}^{F}}{y_1}\right)=v'(s)=\mu'\left(\frac{\lambda_{LT}\theta_{LT}^{H}}{y_1}\right). \tag{34}$$

The first of these conditions is the same as in our basic model. That is, because $v'(s)=\frac{r_K-r_D}{1+r_D}=\phi'(\lambda_K)\,(1+r_K)$ 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_{LT}^{H}, and thus bank holdings of long-term government bonds $\theta_{LT}^{F}=\Theta_{LT}-\theta_{LT}^{H}$, where Θ_{LT} is the total supply of long-term government bonds.

We rewrite the first order conditions as

$$v'\left(\frac{\lambda_K K+\Theta_{ST}+\lambda_{LT}\Theta_{LT}-\lambda_{LT}\theta_{LT}^{H}}{y_1}\right)=\frac{u'(C_0)}{u'(C_1)}\phi'(\lambda_K) \tag{35}$$

and

$$v'\left(\frac{\lambda_K K+\Theta_{ST}+\lambda_{LT}\Theta_{LT}-\lambda_{LT}\theta_{LT}^{H}}{y_1}\right)=\mu'\left(\frac{\lambda_{LT}\theta_{LT}^{H}}{y_1}\right). \tag{36}$$

These two conditions determine the values of λ_K and θ_{LT}^{H} as a function of Θ_{ST} and Θ_{LT}. We note that Θ_{ST} and $\lambda_{LT}\Theta_{LT}$ enter symmetrically everywhere in Eqs. (35) and (36). Thus, it follows that an equal increase in Θ_{ST} and $\lambda_{LT}\Theta_{LT}$ has the same effect on the equilibrium, crowding out Net-ST the same. Because $\lambda_{LT}<1$, 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 fall more with an increase in Θ_{ST} than an increase in Θ_{LT}. We examine this differential crowding-out prediction in the data, although 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*

An extensive literature examines the transaction demand for money, which includes non–interest bearing deposits (checking deposits) at banks (e.g., see Goldfeld and Sichel, 1990). Our analysis has been silent on any transaction 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

$$u\left(c_0 + y_0 \times \psi\left(\frac{M}{y_0}\right)\right) + u\left(c_1 + y_1 \times v\left(\frac{S}{y_1}\right)\right) \tag{37}$$

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

$$S = M + NTD + \theta^H. \tag{38}$$

Consider the household problem first. The FOC for NTD is:

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

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 to 2011). The FOC for checkable deposits gives

$$\frac{1 + v'(s)}{1 - \psi'(m)} = \frac{u'(C_0)}{u'(C_1)}, \tag{40}$$

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

$$\psi'(m) = \frac{r_D}{1 + r_D}. \tag{41}$$

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

$$m = \psi'^{-1}\left(\frac{r_D}{1 + r_D}\right), \tag{42}$$

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:

$$M + NTD \leq \lambda_K K + \theta^F. \tag{43}$$

The bank maximizes the date 0 dividend,

$$\max_{\lambda_K} \left(M + \frac{NTD}{1 + r_D} - \frac{\lambda_K K}{1 + r_K} - \frac{\theta^F}{1 + r_T}\right) - \phi(\lambda_K)K, \tag{44}$$

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, $m = \psi'^{-1}(r_D/(1 + r_D))$.

Because 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:

$$\phi'(\lambda_K) = \frac{r_K - r_D}{(1 + r_D)(1 + r_K)}. \tag{45}$$

Thus, the predictions of the model under Proposition 1 and Corollary 1 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 that pay interest rate r_D, which then allows the bank to capture a profit $r_K - r_D$ on the intermediation service.[3]

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 government bonds, $r_K - r_T$, and short-term private safe and 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 focus on testing the quantity predictions regarding bank lending.

We acknowledge at the outset an important shortcoming of our empiri-

[3]The logic we offer carries through in cases in which checking deposits can effectively pay interest. Consider the realistic case in which banks compete for checking deposits by offering transaction services at a cost. Banks would provide transaction services up to 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.

cal 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, and Stein (2015) propose 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 eight 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 to 2014, which is the longest time span for which we can construct a reliable time series for our main variables of interest. Subsection 3.1 explains our data definition of government debt. Subsection 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 to scale it by the size of the US economy. Our definition of government supply is as follows, with 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

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

and

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

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 US 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. By 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 backing the coin and certificates could not be used with equal safety or liquidity in place of coins or certificates had the Treasury not issued them.[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 Fed-issued currency or reserves, we are thus effectively considering the Fed as having a net zero impact on the supply of safe 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 2008 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 affected by excluding the period from 2008 to 2014.

Our data sources for implementing the government supply variable are as follows. We obtain data on Treasury unbacked supply and on GDP for 1875 to 2012 from Henning Bohn's web page (www.econ.ucsb.edu/∼bohn/data.html). Bohn's debt series, which for the early years come 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 to 2014,

[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.

the Debt/GDP series can be adjusted by a market-to-book adjustment using data from the Center for Research in Security Prices (CRSP) bond database as done in Krishnamurthy and Vissing-Jorgensen (2012). This make very little difference to our results. Therefore, because 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% of Treasuries in 1952, they have held about one-third of Treasuries in recent years. We are interested in the amount of Treasuries available to be held by private US 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 *Financial Accounts of the United States*, Table L.106, line 11. We obtain 1945 to 1951 data from the annual data available in *Financial Accounts*, Table L.106, for those years.[5] We set foreign Treasury holdings to zero prior to this, as 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

[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.

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 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 (US official reserve assets).

Fig. 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 US GDP. The Treasury unbacked supply to GDP is what is commonly called Debt-to-GDP. Our government 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.

[INSERT FIG 1 HERE]

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

3.2.1. 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 that is a supplier of short-term debt backed by loans and government bonds. We therefore include all parts of the financial sector with 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 because 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, Government Sponsored Enterprises (GSEs), Agency- and GSE-Backed Mortgage Pools, and Equity Real Estate Investment Trusts.[6]. Appendix A provides table and release information for the *Financial Accounts* and explains how to implement this financial sector construct in the pre-1952 period.

3.2.2. 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 various types of interbank markets means that financial sector participants also write safe and liquid claims with each other. It is well understood that there are chains of safe and liquid assets and liabilities that financial sector participants write

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

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 to 2014 of the ratio (Assets-Liabilities)/GDP. By subtracting cross-holdings within the financial sector, our reported measure of the size of the financial sector is smaller than what the raw dollar value of the sum of the assets (or liabilities) of the financial sector would suggest. Systemic risk could be 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, we are unable to use an aggregated balance sheet for the nonfinancial 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 nonfinancial 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 and liquid debt to the nonfinancial sector is much smaller than the value of the amount of money market mutual fund shares outstanding.

3.2.3. Defining categories of financial instruments

We classify the instruments that appear as an asset 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. Appendix A provides additional detail on the categories that are not self-explanatory.

[INSERT TABLE 1 HERE]

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. For example, note 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. We estimate regressions relating the average interest rate on savings and time deposits to a constant maturity Treasury yield. We use data from 1986 to 2013 since deposit rates on savings and time deposits were fully deregulated in 1986 (see subsection 4.6 regarding institutional changes over our sample). We consider Treasury yields for three months and one, two, five and ten years and we find that rates on savings and time deposits move the closest (based on R^2 values of the regressions) with yields on three-month bills, suggesting that these deposits are of less than one year duration.[7]

Less detail is available in sources prior to 1952, 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% over the 1875 to 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% over our entire sample, but it has trended up over time, peaking at 133.8% 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 increased issuance by Asset-Backed Security (ABS) issuers.

[7] These regressions are available upon request. We obtain data on interest rate paid on savings and time deposits and amount of such deposits from the Federal Deposit Insurance Corporation (FDIC) web page, https://www2.fdic.gov/hsob/SelectRpt.asp?EntryTyp=10&Header=1, and obtain 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.

3.2.4. Mapping the categories to the model concepts

Consider how the assets and liabilities in Table 1 map into the model. Our main objective is to measure the quantity of risky and 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 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 (as it is unlikely that most long-term financial sector debt satisfies the household's special demand for safe and liquid 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 and liquid private bank 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 and 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. 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, and net equity is the part of net long-term investments financed with equity.

[INSERT TABLE 2 HERE]

Our main object of interest is net short-term debt, i.e., the amount of risky and illiquid assets that is financed with short-term debt. Fig. 2, Panel A, graphs the series for net long-term investments, net short-term debt, and net equity. 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.

[INSERT FIG. 2. HERE]

4. Results

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

Fig. 2, Panel A, provides visual evidence consistent with our model of financial crowding out. A strong negative relation exists between Net short-term debt/GDP and Government supply/GDP, and it seems to be consistently present over the full 140-year period. Fig. 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 to 2014 period. Regressions are estimated by ordinary least squares (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

$$y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t \tag{46}$$

and

$$\varepsilon_t \quad = \quad \rho\varepsilon_{t-1} + v_t, v_t \; i.i.d. \tag{47}$$

It is well documented as far back as Kendall (1954) that AR(1) coefficients estimated based on OLS regressions are downward-biased (away from one). 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 therefore develop 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 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 ten annual lags rejects with probability 23.3%.

[INSERT TABLE 3 HERE]

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% 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

$$y_t - y_{t-d} = \gamma d + \beta \left(x_t - x_{t-d}\right) + \underbrace{\varepsilon_t - \varepsilon_{t-d}}_{u_t}. \tag{48}$$

If ρ is close to one, then the error term u_t in the difference specification is approximately MA(d-1), or MA(d) 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 one-year, two-year, three-year, five-year and ten-year differences with standard errors based on the Newey-West approach with the same number of lags as the differencing, e.g., five lags for five-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 five-year or ten-year differences. The relations are again statistically significant at the 1% level in the differencing approach.

[INSERT TABLE 4 HERE]

A potentially important issue with respect to inference is that both the Government supply/GDP and the Net short-term debt/GDP series could be nonstationary. Bohn (1998) argues that while one cannot reject that Debt/GDP is nonstationary [I(1)], evidence exists 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

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

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 nonstationarity 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 and one of the financial sector net variables). We use Stata's varsoc function to test for the appropriate lag order of the vector error correction model (VECM). This function implements various lag selection methods, and in all cases the various methods suggest two or three lags. We therefore test for cointegration using VECMs with three 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 nonstationary, then it is very unlikely to observe a negative relation between Government supply/GDP and Net short-term debt/GDP (and between Government supply/GDP and Net long-term investments/GDP) that is as tight as the one seen in the data. The crowding-out coefficients in the cointegrating relations are similar to those in the OLS regressions.

Our various specifications all suggest that the 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 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. Because 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 reduces the net short-term debt issued by the financial sector by between 51 and 57 cents, depending on the approach used, and reduces net long-term lending of the financial sector by between 57 and 59 cents.

4.2. Alternative hypotheses

A number of plausible alternative explanations can be made for our results. We present a series of approaches to address some of these alternatives, although because we lack an instrument for government supply, we cannot definitively rule out alternatives.

4.2.1. 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 this literature 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, when 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 six 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). We use the rate on three-month Bankers Acceptances (a predecessor to commercial paper) from 1946 to 1990 [from the Federal Reserve Economic Data (FRED) database] and the rate on three-month repo contracts backed by Treasury collateral from 1991 to 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 to 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, not the inclusion of the real short rate. In

[9] Below we use this nominal rate series back to 1918, with data from FRED going back to 1941 and data from the National Bureau of Economic Research Macrohistory Database for 1918–1940.

Column 3, 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 (nonresidential and residential) and consumer durable goods, at current prices, with data available back to 1925 from the Bureau of Economic Analysis Fixed Assets Table 1.1. In Column 2 and 3 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. Fig. 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.

[INSERT FIG. 3 AND TABLE 5 HERE]

4.2.2. 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

Tables 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. Including the growth control has almost no effect on the size and significance of the crowding-out coefficient. The reason is likely that government supply moves at a slower frequency than the business cycle. From Fig. 2, Panel A, the Government supply/GDP series (and the series for Net short-term debt/GDP) changes slope only about ten 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 affects 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 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, as Deficits/GDP and Government supply/GDP are positively correlated. Consistent with this, we find slightly stronger crowding-out in this specification.

4.2.3. Dropping financial crises

Table 5, Panel A, Column 6 drops years in which reverse causality is likely, namely, years following a financial crisis when 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

4.3.1. Gold inflows as an exogenous supply shock

From 1933 to 1940, the Federal Reserve's balance sheet grew by about \$16 billion. The asset side of the Fed balance sheet was driven by an increase in Fed holdings of gold certificates of \$16 billion, 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 \$11 billion and Federal Reserve notes in circulation increased by \$3 billion (the discrepancy 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.

The well-known Romer (1992) paper discusses the causes of the gold inflows. It 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 U.S. 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 in which foreign investors bring in gold and increase bank deposits 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 debt+long-term debt+equity) declines

[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 not have been driven by the subsequent economic recovery in the U.S..

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).

Fig. 4, Panel A, traces the dramatic increase in gold certificates (which are part of Treasury metal-backed supply) during the 1933 to 1940 period. During this period, net short-term debt falls significantly despite this being the period of recovery from the Great Depression. Importantly, Treasury unbacked supply, as a ratio to GDP, is virtually unchanged during this period. That is, if one considers only 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.

[INSERT FIG 4 HERE]

4.3.2. Exogenous demand shock by foreign official investors

In our model, a demand shock for safe and 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 seems unlikely that 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 trade deficits to decrease corporate loan demand in the US as more is produced abroad).

The potential importance of foreign demand is visually apparent from Fig. 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 and 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 short-term debt/GDP. The literature on global safe-asset imbalances (see Bernanke, 2005; Caballero and Krishnamurthy, 2009; Caballero, 2010) posits that the demand for US safe assets has grown over the last few decades.

Panel A and Panel B of Fig. 4 clearly show 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 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 on 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) has statistically significant effects. We find the expected signs for both 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.

4.3.3. Rajan-Zingales identification: expenditure share for credit goods

We argue 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 lowers 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 for which widespread agreement exists 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, showing 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 the sum of NIPA categories Durable goods and Housing and utilities. Expenditure data are from NIPA Table 2.3.5 and price data are 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 durable goods 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 with 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 factor. 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 that for technical reasons are often bought 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 factor (wars, financial crises, tax policy, etc.). Following the comments on Rajan and Zingales, it may seem that this identification works only 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, because 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. Fig. 5 illustrates the relation between the budget share for credit goods and government supply. A clear negative relation exists between the two series (the correlation is -0.78). The World War II 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 10% level even if we drop 1942–1951.

[INSERT FIG. 5 HERE]

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 Section 2.5: a bank portfolio substitution and a 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 toward 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 Fig. 6, Panel A.

[INSERT TABLE 5 AND FIG 6 HERE]

Consider next the household debt substitution channel. If households view Treasury securities and financial sector short-term debt as substitutes, then we can expect to see that an increase in Treasury supply (and thus government supply) reduces households holdings of short-term financial sector debt. From Table 6, Column 1, the liability side, such household debt substitution 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. Treasuries could be 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 to 2014 sample. From Fig. 6, Panel A and Panel B, however, it is clear that the relative importance of

[11] The bank portfolio substitution channel is likely present for non-banks as others also have an incentive to reallocate toward Treasuries in response to changing spreads. 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.

the bank portfolio substitution channel and the household debt substitution channel changes over time. Since the end of World War II, 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 Columns 2 and 3 of Table 6. For the period since 1970 (picked based on the graphical impressions), government supply crowds in financial sector holdings of Treasuries with a coefficient of 0.131, compared with 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 with only -0.086 pre-1970, driven by increased crowd-out of non-checkable short-term debt. Thus, while the overall crowding-out of net short-term debt is fairly stable across these two subperiods (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, a robust empirical relation exists between Treasury supply and net short-term debt. From our theoretical model, it is not obvious which of these substitution effects should be most present in the data because 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 in 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 one year remaining maturity) and long-term Treasury supply is strongly positively correlated (around 0.5 based on the data we describe in this subsection). Thus, little independent variation exists 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. 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). Most publicly held debt is marketable (i.e., can be resold by the initial buyer), whereas most intragovernmental holdings are non-marketable. However, one important category of non-marketable debt is included in publicly held debt, namely, savings bonds. According to the US 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

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

no duration risk. Savings bonds thus seem like an ideal security for households that 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 or less attractive features, we show in Table 7 the separate effects of three subcomponents 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 to 2014. We calculate the amount of marketable Treasury securities with remaining maturity of one year or less as follows. For 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] For 1949–2014 we calculate the amount of marketable Treasury securities with remaining maturity of one year or less using the CRSP Monthly Treasury Masterfile (prior to 1949, the amounts outstanding are missing for many Treasuries in this source). For savings bonds, we get data for 1935–1970 from *Banking and Monetary Statistics* (1914–1941, Table 146; 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 Fig. 7. The positive correlation of short and long supply is visible

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

in the graph. Savings bonds increase with overall debt as a way to fund World War II and then decline gradually in importance over time (relative to GDP).

[INSERT TABLE 7 AND FIG 7 HERE]

In Table 7, we provide regressions both for the full 1916 to 2014 period and for a sample that excludes the World War II years. As discussed in Section 4.6 these years were special in that the Fed had large holdings of Treasury bills, which could 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 (Columns 1 and 3) even when the sum is significant (Columns 2 and 4). While short and long marketable Treasury supply have about equal crowding-out coefficients, 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 (2015) 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 crowds out short-term bank debt more strongly. In their model, this is desirable because of externalities from short-term bank debt. They provide empirical evidence that quantities of financial commercial paper are crowded out by T-bill supply, but not by non-bill supply, over the period since 1952. Our evidence based on all financial sector debt and 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 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 many economic and institutional changes have occurred. 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, and 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 subsection we discuss particular periods and institutional changes of concern.

4.6.1. World War II

During World War II, banks were large buyers of government debt, with the Federal Reserve providing incentives to purchase such debt. The Fed promised to buy (or sell) Treasury bills at 3/8% (substantially below typical peacetime rates of 2% to 4%). It effectively pegged short-term Treasury bill rates and enhanced the liquidity of Treasury bills, because 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 II in financial sector Treasury holdings/GDP is apparent in Fig. 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% from 1942 to 1945 (NIPA Table 2.1). This enabled households both to directly buy a large fraction of the Treasury debt issued to fund the war and to increase their bank deposits and thereby facilitate bank purchases of Treasuries without an ensuing crowding-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-related enterprises. See Coleman (1952). Third, it is likely 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 (2012) find that safety and liquidity spread measures are at their historical lows during the World War II period. If $v'(s)$ is zero, then the safety and 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 in which 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 more negative, consistent with less crowding-out during World War II.

4.6.2. World War I

Some of the actions taken by the government in World War II were also taken in World War I but on 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 little formal evidence exists on this point.

4.6.3. 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 three-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 three-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% at the start of 1966 to almost 78% 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 attracted savers 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 overcomes many of the issues raised by Regulation Q. We analyze whether Regulation Q appears to have been binding at the level of the overall financial sector by including a dummy variable for the 1966 to 1986 period in our regressions in Table 3, Panel A for the 1875 to 2014 sample. For each of the two regressions, the coefficient on the Regulation Q dummy is negative but small (-0.06 or closer to zero) and never statistically significant, and its inclusion has little effect on the coefficient on our Government supply/GDP variable (we omit the regressions with this dummy from the table for brevity).

4.6.4. 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 II years dropped for the post-1934 period). We do not find evidence of increased crowding-out post-1934, implying that FDIC insurance is not the central driver of the safety and liquidity feature of bank deposits.

4.6.5. 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 US Treasury) Treasury securities equal to 111% of bank note issuance (Friedman and Schwartz, 1970). This requirement was relaxed in 1900 to 100% 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 only a small effect (a reduction of 11% of the value of national bank notes outstanding) prior to 1900. We find, over the period from 1875 to 1933, 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 it exceeds the pre-1900 mechanical 0.11 crowding-out.

4.6.6. 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 purchased 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 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 nonfinancial sector to hold. If one were to assign different weights to different instruments (e.g., using Barnett weights), this would change. We experiment with including the size of the Fed's balance sheet as an additional regressor (for the 1914–2014 subsample), 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 nonfinancial sector's willingness to pay a premium on safe and 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 and 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 decade that preceded the 2008 financial crisis (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 ten 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 and 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 macroeconomics textbooks in which government supply crowds out private capital formation by raising real interest rates.

Appendix A. Data descriptions

A.1. Data sources and timing

Our sources for data on the US financial sector are as follows. For years 1952–2014, we use *Financial Accounts of the United States* (formerly known as Flow of Funds Accounts). For years 1896–1951 we use data from *All-Bank Statistics* [accessible via the Federal Reserve Archival System for Economic Research (FRASER), https://fraser.stlouisfed.org/]. 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 US 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 US government debt data).

A.2. Defining the financial sector

For 1952–2014, we use data from the December 11, 2014 release of *Financial Accounts*. The table numbers for the sectors we include 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 US that accept deposits from the general public or that mainly are engaged in fiduciary business. This source 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 *Financial Accounts* (numbers for total assets in 1952 are almost identical across *All-Bank Statistics* and Table L.110 in *Financial Accounts*). Furthermore, in 1952, the first year for which we use *Financial Accounts*, Table L.110 accounts for about 92% 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 covered only from 1887 (at which point their assets represent about 3% 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 worse than that in *All-Bank Statistics*, with total assets of the financial sector in 1896 in the former source amounting to about 93% of total assets in the latter source. We experiment 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.

A.3. Categories of instruments

Some categories of instruments require additional explanations.

A.3.1. 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 subsection 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 *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 data sources: "National bank notes"in *All-Bank Statistics* and (various wordings of) "Circulation outstanding" and "State bank notes" in *Annual Report of the Comptroller of the Currency.* There are no currency and coin categories as liabilities in the *Financial Accounts* because there are no national bank notes on bank balance sheets after 1935.

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

A.3.2. Net interbank liabilities to domestic banks

We use this to refer to what is denoted "Net interbank liabilities to domestic banks" in *Financial Accounts*, "Cash items in process of collection," "Banker's balances," and "Interbank deposits" in *All-Bank Statistics*, and (various wordings of) "Due to banks," "Due from banks," and "Cash items"

[14]For savings banks and for private banks, *Annual Report of the Comptroller of the Currency* does not break down the category "Cash on hand" into subcomponents. We assume the majority of cash on hand is currency and coin.

(for state banks and for loan and trust companies) in *Annual Report of the Comptroller of the Currency.*

A.3.3. Foreign deposits, Trade credit, Other loans and advances, US direct investment abroad, Mutual fund shares

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

A.3.4. Miscellaneous

In *Financial Accounts*, this refers to various line items with content that is not clarified. They are called "Miscellaneous" or "Other" (when detail is given that identify what they are, we code them accordingly so this category captures only unidentified items). The line items for assets are 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; and L.129, line 17. The line items for liabilities are 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; and L.130, line 22.

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

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

A.3.5. Checkable deposits and currency

We borrow this label from *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 item in *Financial Accounts* this item cannot include currency liabilities since no bank-issued currency was outstanding during the 1952–2014 period).

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

A.3.6. Commercial paper

This is referred to as "Open market paper" or "Commercial paper" in *Financial Accounts*. There is no corresponding category in *All-Bank Statistics* or *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*.

A.3.7. Financial sector equity

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 *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).

A.3.8. Investment by holding companies, parent companies and funding corporations (in other parts of the financial sector)

This category is defined in *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 toward the end of the sample (over 20% of GDP), making this the most important category to account for in terms of cross-holdings within the financial sector. The line items for assets are L.129, lines 11+14+15+16 and L.130, lines 10+11. The line items for liabilities are L.110, line 50; L.111, line 28; L.126, line 20; and L.128, line 28.

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.

We assume the data generating process is

$$y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t \tag{49}$$

$$\varepsilon_t = \rho\varepsilon_{t-1} + v_t,\ v_t\ i.i.d. \tag{50}$$

B.1. Why not just use AR(1) standard errors?

The simplest approach to estimate this model would be to estimate Eq. (49) by OLS and then use the residuals to estimate Eq. (50). Based on this, the standard error of the OLS estimates in Eq. (49) could be estimated based on the usual formula for the variance of OLS estimates $\widehat{\delta}' = \left[\begin{array}{ccc} \widehat{\alpha} & \widehat{\beta} & \widehat{\gamma} \end{array}\right]'$

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 Eq. (50). We are interested in testing whether $\widehat{\beta}$ is different from zero. Consider using the t-statistics based on the OLS estimate of Eq. (49) 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 Eq. (50) is downward biased.

The objective of our bootstrap-after-bootstrap approach is to construct more precise standard errors for the OLS estimates in Eq. (49) 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 on 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 ten lags in annual data. We also consider 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 Fig. 2 of MacKinnon and Smith (1998)] we conduct a separate Monte Carlo study (available upon request) that shows that 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 intuitive because 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]

[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

B.2. Our bootstrap-after-bootstrap approach

The basic idea of our approach is simple. We first estimate Eq. (49) and Eq. (50) 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 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 vector auto regression (VAR) estimation, whereas our case is a linear regression with an AR(1) error term. 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 Eq. (50)].[16]

The detailed steps of our approach are as follows.

Step 1. Initial estimation.

Estimate Eq. (49) 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 Eq. (50) by OLS to get $\widehat{\rho}$ and $\widehat{v}_1, ..., \widehat{v}_T$.

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 Eq. (49) and Eq. (50) 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 and use it as ε_0^*.
- Draw values of $\widehat{v}$ with replacement and use them as $v_1^*, ..., v_T^*$.

the residuals from a cointegrating regression is I(1) (Engle and Yoo (1987)).

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

- Use ε_0^*, $v_1^*, ..., v_T^*$ and $\widehat{\rho}$ to construct a bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ using Eq. (50).
- Use $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$ from Step 1, the actual values of the x_ts, and the bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ to generate a bootstrap sample $y_1^*,..., y_T^*$.
- Estimate Eq. (49) by OLS using $y_1^*,..., y_T^*$ and $x_1, ..., x_T$. Use the residuals to estimate Eq. (50) 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 $\widehat{\rho}^{\text{Bias-corrected}}$. 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 one when it would otherwise be above one imposes a belief that the true data generating process in Eq. (50) 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 Eq. (49) and Eq. (50) 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 and 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 $\varepsilon_0^*, ...,$ ε_T^* using Eq. (50).
- Use $\widehat{\alpha}$, $\widehat{\beta}$, $\widehat{\gamma}$ from Step 1, the actual values of the x_ts, and the bootstrap sample $\varepsilon_0^*, ..., \varepsilon_T^*$ to generate a bootstrap sample $y_1^*,..., y_T^*$.
- Estimate Eq. (49) 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 procedure in this step but that this is likely to have little effect. We also do not find that iterating substantially improves 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 $\mathrm{SE}(\widehat{\alpha})$, $\mathrm{SE}\left(\widehat{\beta}\right)$, and $\mathrm{SE}(\widehat{\gamma})$, respectively. The t-statistic for $\widehat{\beta}$ is then $t_{bootstrap-after-bootstrap} = \widehat{\beta}/\mathrm{SE}\left(\widehat{\beta}\right)$ (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 $I = 2,000$ bootstrap estimations in each of Steps 2 and 3.

B.3. Monte Carlo evidence on the quality of our bootstrap-after-bootstrap approach

Assume the data generating process is

$$y_t = \alpha + \beta x_t + \gamma t + \varepsilon_t, \tag{51}$$

$$\varepsilon_t = \rho \varepsilon_{t-1} + v_t, \ v_t \text{ i.i.d. } N\left(0, \sigma_v^2\right), \tag{52}$$

and

$$x_t = \rho x_{t-1} + w_t, \ w_t \text{ i.i.d. } N\left(0, \sigma_w^2\right). \tag{53}$$

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 $\alpha = \beta = \gamma = 0$, and $\sigma_u^2 = \sigma_v^2 = \sigma_w^2 = 1/\left(1 - \rho^2\right)$, 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.

Table B.1. below is based on two thousand 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 with that of OLS [incorrectly assuming independent, identically distributed (i.i.d.) errors], Newey-West standard errors with ten 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., $(X'X)^{-1} X'\Omega X (X'X)^{-1}$ 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 Eq. (49) and Eq. (50). 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 if you use the Newey-West approach with ten 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]

[INSERT TABLE B1 HERE]

[18]The AR(1) approach with the Kendall adjustment performs in between the AR(1) approach and our approach, having a rejection rate of 6.8% in the case just discussed.

Table B1

	$\rho = 0.6$	$\rho = 0.8$	$\rho = 0.9$	$\rho = 0.95$	$\rho = 0.99$
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

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

To assess how much the results of the Monte Carlo simulation change 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 values in Table B1 of 0.519, 0.233, 0.104, and 0.038 for $T = 140$ to 0.432, 0.245, 0.126, and 0.045 for $T = 70$.

References

Admati, A., Hellwig, M., 2013. The Bankers' New Clothes: What's Wrong with Banking and What to Do about It. Princeton University Press, Princeton, NJ.

Barro, R., Mollerus, A., 2014. Safe assets. Unpublished working paper 20652. National Bureau of Economic Research, Cambridge, MA.

Berkowitz, J., Kilian, L., 2000. Recent developments in bootstrapping time series. Econometric Reviews 19 (1), 1–48.

Bernanke, B., 2005. The global saving glut and the US current account deficit. Sandridge Lecture, Virginia Association of Economics, Richmond, Virginia.

Bohn, H., 1998. The behavior of U.S. public debt and deficits. Quarterly Journal of Economics, 113 (3), 949–963.

Caballero, R., 2010. The 'other' imbalance and the financial crisis. Unpublished working paper 15636. National Bureau of Economic Research, Cambridge, MA.

Caballero, R., Krishnamurthy, A., 2009. Global imbalances and financial fragility. American Economic Review: Papers and Proceedings 99 (2), 584–588.

Calomiris, C., Kahn, C., 1991, The role of demandable debt in structuring optimal banking arrangements. American Economic Review, 81(3), 497–513.

Dang, T., Gorton, G., Holmstrom, B., 2009. Opacity and the optimality of debt for liquidity provision. Unpublished working paper, Yale University and Massachusetts Institute of Technology, New Haven, CT, and Cambridge, MA.

Deaton, A., Muellbauer, A., 1980. An almost ideal demand system. American Economic Review 70 (3), 312–326.

Diamond, D. W., Dybvig, P., 1983. Bank runs, deposit insurance, and liquidity. Journal of Political Economy 91, 401–419.

Diamond, D. W., Rajan, R. G., 2000, A theory of bank capital, Journal of Finance, 55, 2431–2465.

Elmendorf, D. W., Mankiw, N. G., 1999. Government debt. In: Taylor, J. B., Woodford, M., (Eds.), Handbook of Macroeconomics, Elsevier Science, Amsterdam, Chapter 25.

Engle, R. F., Yoo, B. S., 1987. Forecasting and Testing in Co-Integrated Systems. Journal of Econometrics, 35, 143–159.

Feinman, J. N., 1993. Reserve requirements: history, current practice, and potential reform. Federal Reserve Bulletin, 569–589.

Fisher, I., 1933. The debt-deflation theory of great depressions. Econometrica 1 (4), 337–357.

Friedman, M., Schwartz, A. J., 1970. Monetary statistics of the United States. National Bureau of Economic Research, New York.

Gilbert, R. A., 1986. Requiem for Regulation Q: what it did and why it passed away. Federal Reserve Bank of St. Louis Review (February), 22–37.

Goldfeld, S. M., Sichel, D. E., 1990. The demand for money. In: Friedman, B. M., Hahn, F. H., (Eds.), Handbook of Monetary Economics, Volume 1, Elsevier Science, Amsterdam, 299–356.

Gorton, G., Lewellen, S., Metrick, A., 2012, The safe asset share. American Economic Review: Papers and Proceedings, 102 (3), 101–06.

Gorton, G., Pennacchi, G., 1990, Financial intermediaries and liquidity creation. Journal of Finance 45 (1), 49–72.

Greenwood, R., Hanson, S. Stein, J., 2015. A comparative-advantage approach to government debt maturity. Journal of Finance, 70 (4), 1683-1722.

Holmstrom, B., Tirole, J., 1998. The private and public supply of liquidity. Journal of Political Economy 106, 1–40.

Holmstrom, B., Tirole, J., 2011. Inside and Outside Liquidity. MIT Press, Cambridge, MA.

Kendall, M. G., 1954, A note on bias in the estimation of autocorrelation, Biometrika, 41, 403–404.

Kilian, L., 1998. Small-sample confidence intervals for impulse response functions. Review of Economics and Statistics 80 (2), 218–230.

Krishnamurthy, A., Vissing-Jorgensen, A., 2012. The aggregate demand for treasury debt. Journal of Political Economy 120 (2), 233–267.

Lucas, R. E., Asset Prices in an Exchange Economy, Econometrica, 46 (6), 1429–1445.

MacKinnon, J. G., Smith, A. A. Jr., 1998. Approximate bias correction in econometrics. Journal of Econometrics 85, 205–230.

Nagel, S., 2014. The liquidity premium of near-money assets. Unpublished working paper 1242. University of Michigan, Ann Arbor, MI.

Rajan, R. G., Zingales, L., 1998. Financial dependence and growth. American Economic Review, 88 (3), 559–586.

Romer, C. D, 1992. What ended the Great Depression? Journal of Economic History 52, 757–784.

Schularick, M., Taylor, A. M., 2012. Credit booms gone bust: monetary policy, leverage cycles, and financial crises, 1870–2008, American Economic Review, 102 (2), 1029–1061.

Stein, J., 2012, Monetary policy as financial stability regulation. Quarterly Journal of Economics 127 (1), 57–95.

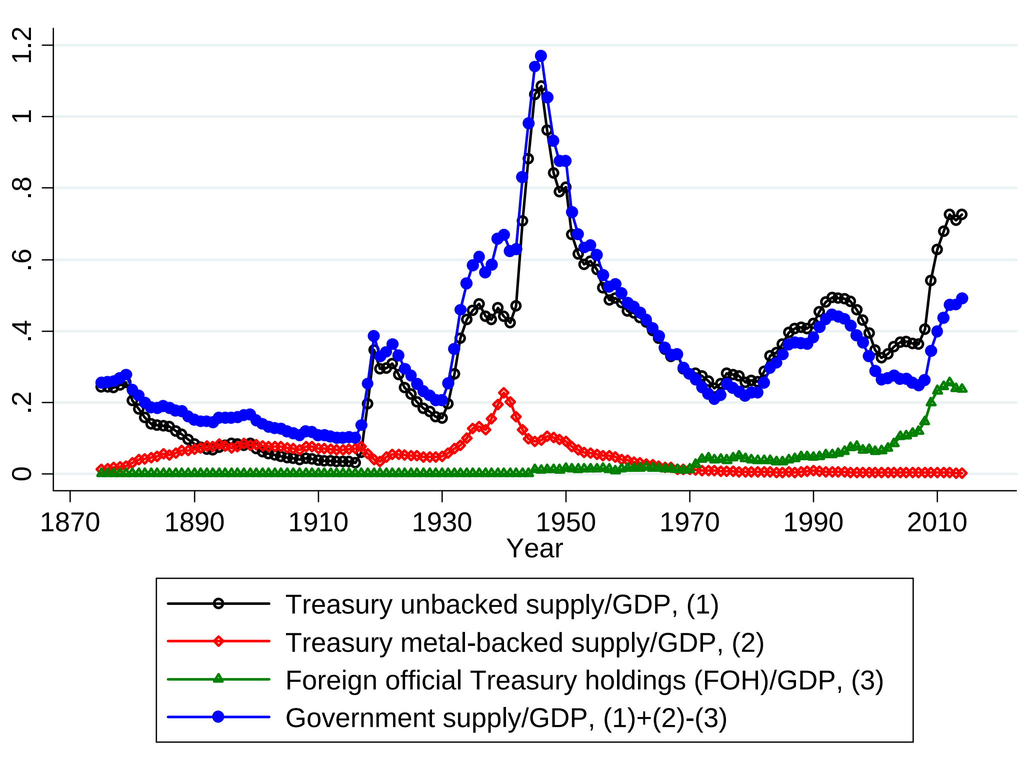
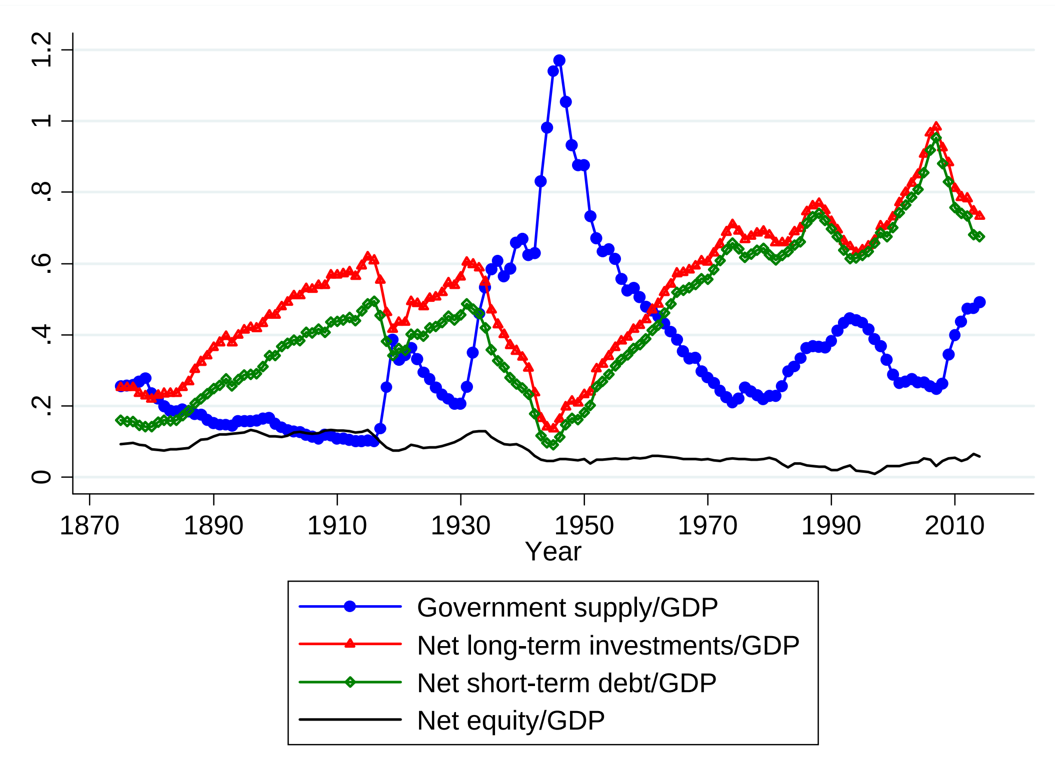


Fig. 1. The three components of the government supply variable (Treasury unbacked supply, Treasury metal-backed supply, and Foreign official Treasury holdings) are plotted along with the government supply variable. The sample is from 1875 to 2014. GDP = Gross Domestic Product.

Panel A: Time series graph



Panel B: Scatter plot of financial sector Net short-term debt/GDP against Government supply/GDP

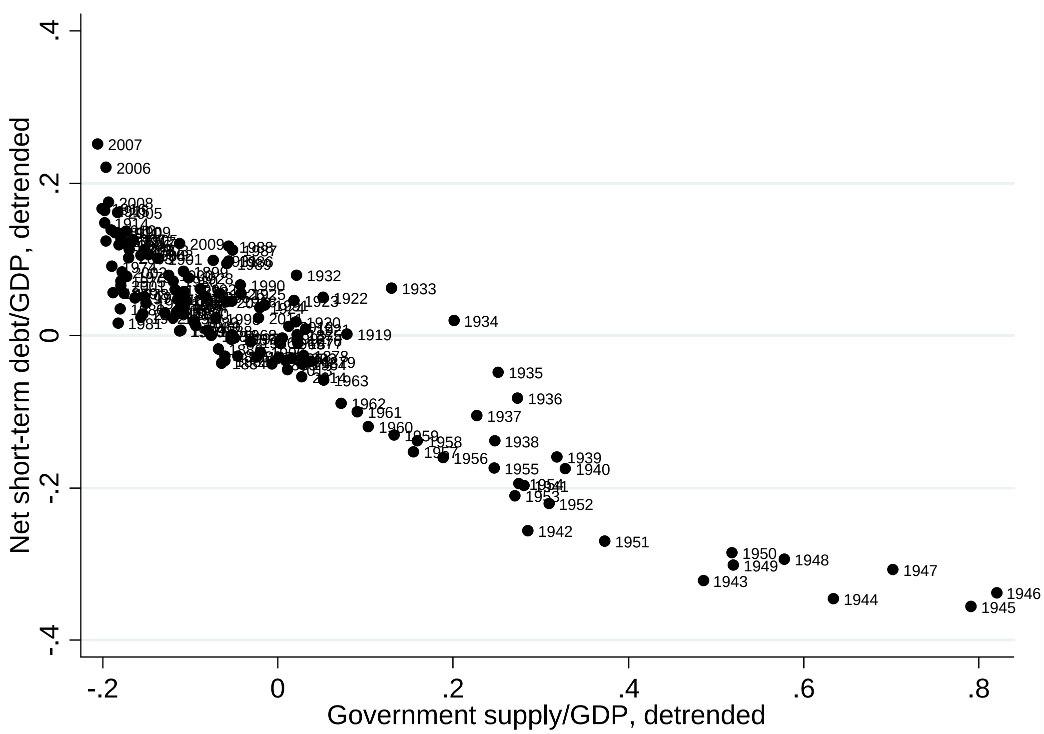
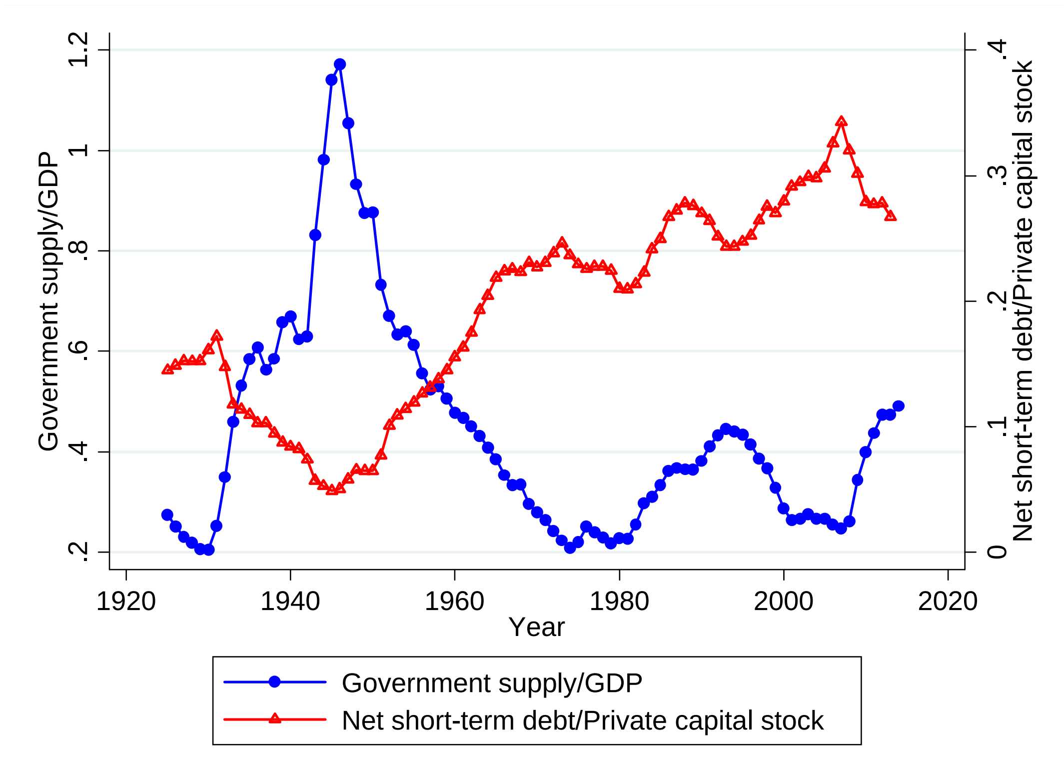


Fig. 2. The relation between Government supply, financial sector lending (Net long-term investments), and financial sector short-term debt (Net short-term debt), 1875 to 2014. GDP = Gross Domestic Product. In Panel B, the scatter plot is of the residuals from detrending by regressing the time series on year.

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



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

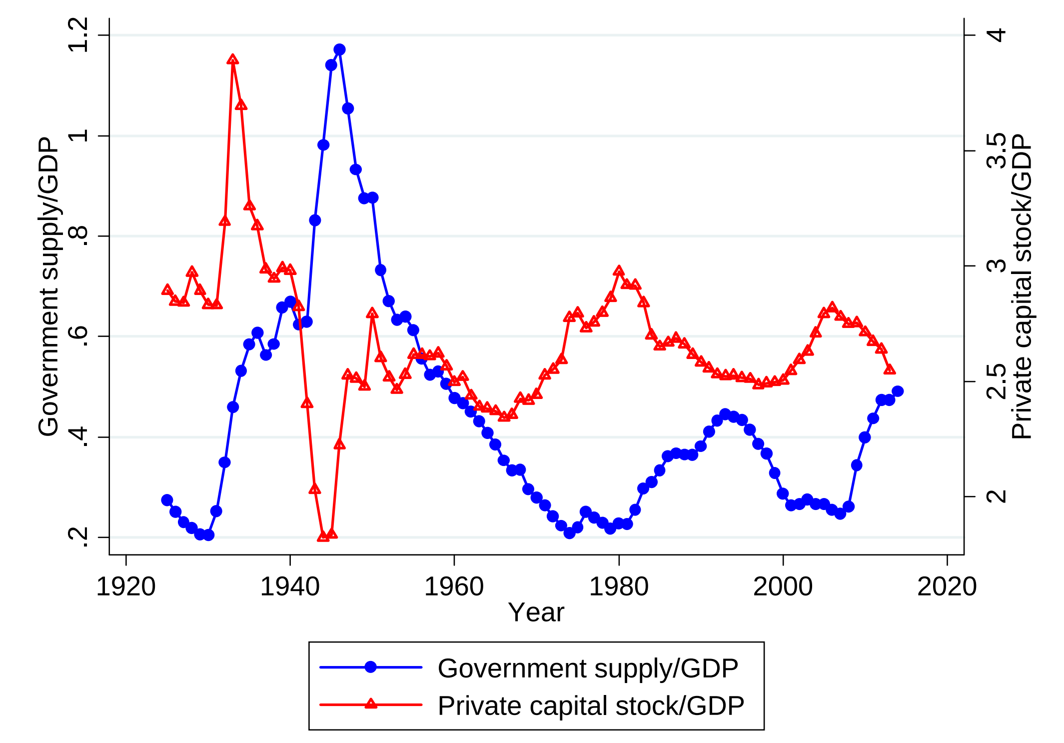
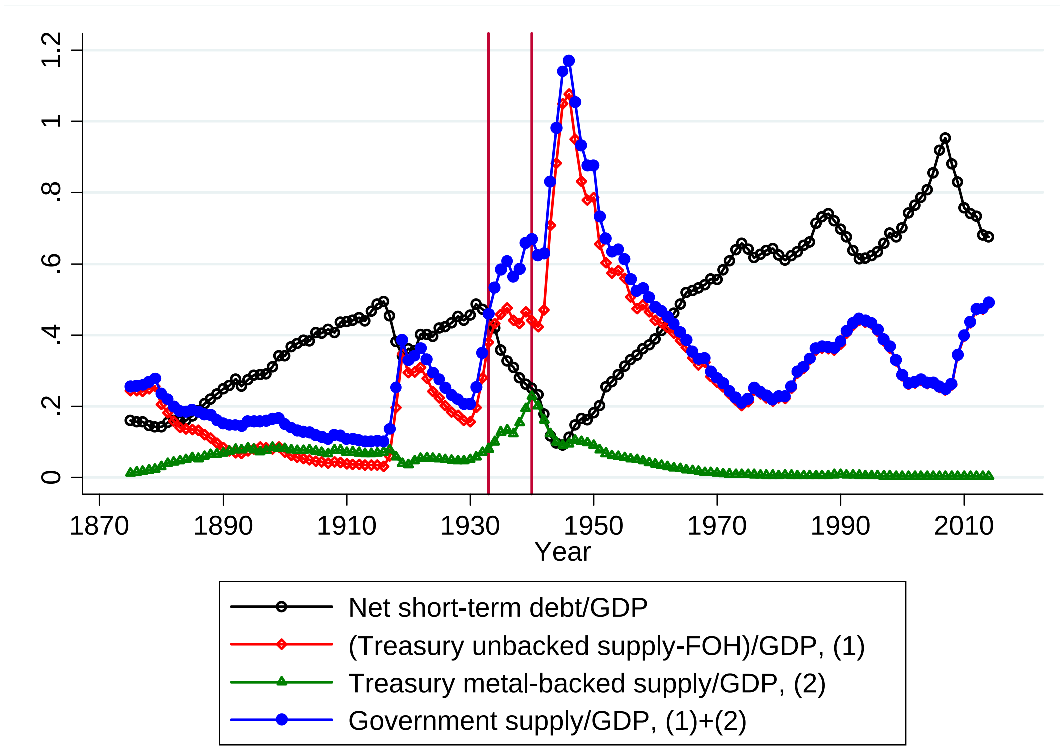


Fig. 3. Net short-term debt/Private capital stock and Private capital stock/GDP, 1925 to 2013. We define the private capital stock as the sum of private fixed assets (non-residential and residential) and consumer durable goods, at current prices. GDP = Gross Domestic Product.

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



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

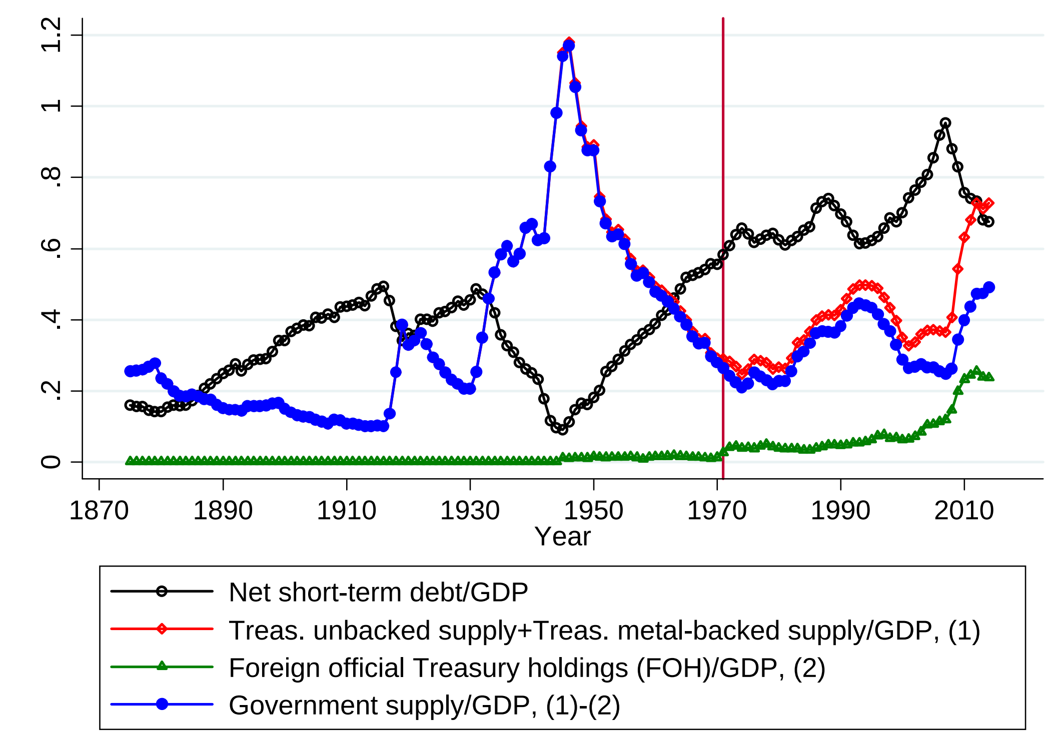


Fig. 4. Shocks to supply and demand. For Panel A, the vertical lines are at year 1933 and 1940. For Panel B, the vertical line is at 1971. The US ended convertibility of the dollar to gold in August 1971. GDP = Gross Domestic Product. FOH=Foreign official Treasury holdings.

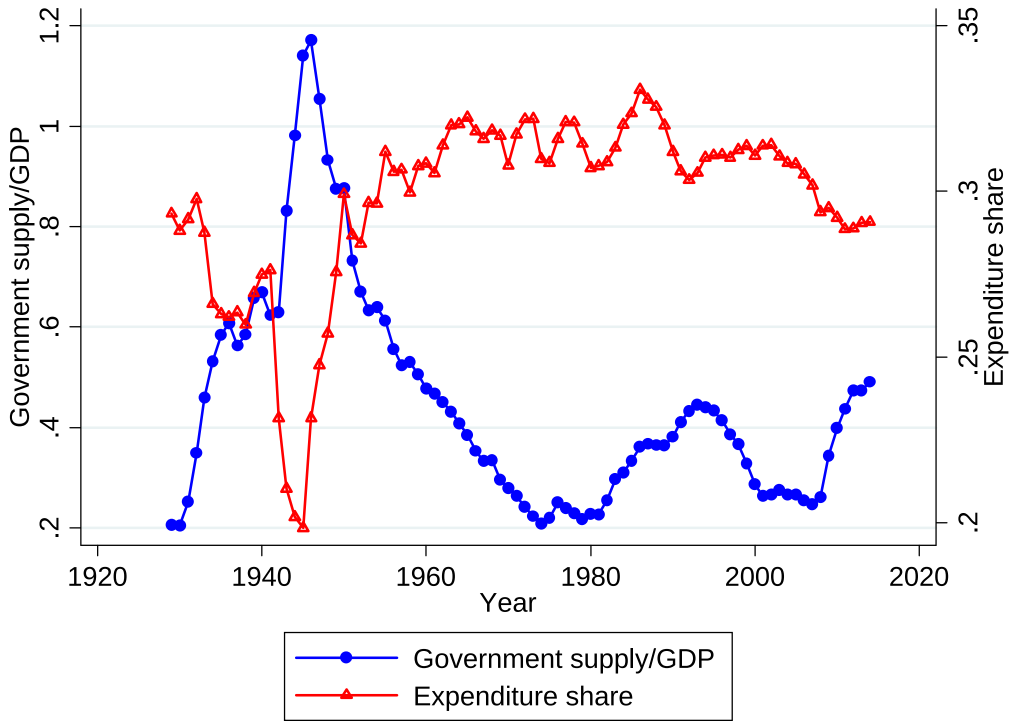
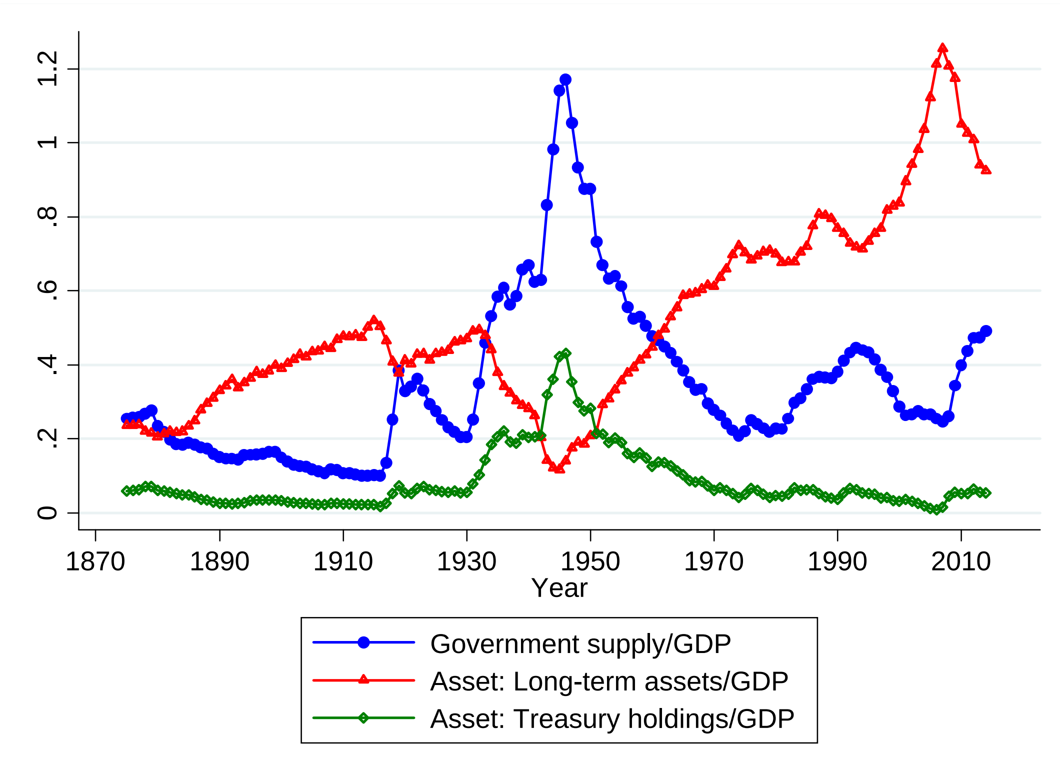


Fig. 5. Expenditure share for credit goods, 1929–2014. We define credit goods as National Income and Products Acounts categories durable goods plus housing and utilities. GDP = Gross Domestic Product.

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

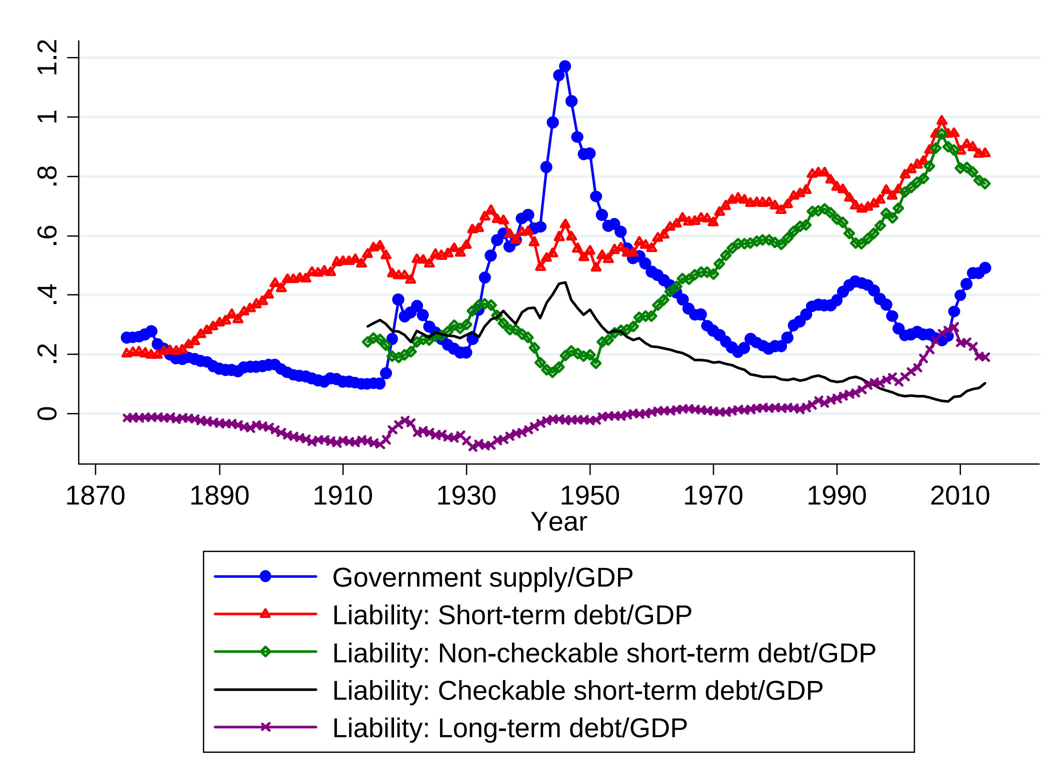


Fig. 6. Subcomponents of the financial sector balance sheet, 1875 to 2014. GDP = Gross Domestic Product.

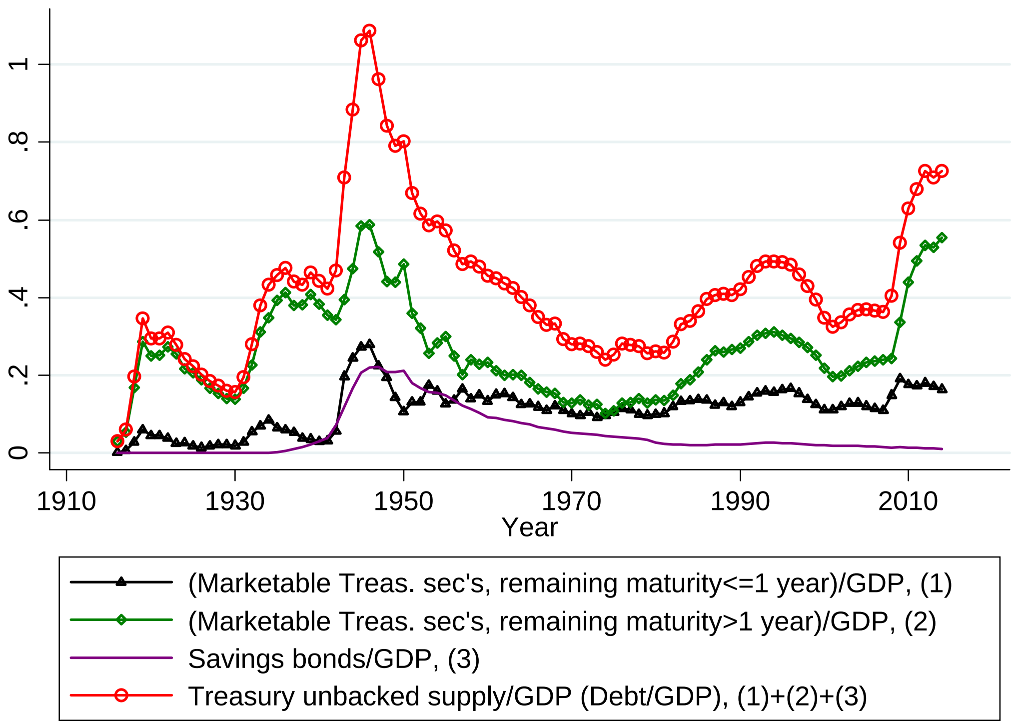


Fig. 7. The Treasury unbacked supply/GDP (i.e., Debt/GDP) is decomposed into three parts: marketable Treasury bonds with less than one year maturity, marketable Treasury bonds with greater than one year maturity, and savings bonds. The series are plotted from 1916 to 2014. GDP = Gross Domestic Product.

Table 1. Financial sector balance sheet, 1875–2014

Panel A: Instruments that are net assets on average across the full sample period

	(Assets-Liabilities)/GDP					Assets	Liabilities	Assets-Liabilities
	Averages							
Instrument	1875–2014	1875–1913	1914–2014	Value in 2007:Q3	Value in 2014:Q3	Value in 2007:Q3 (billions of dollars)		
Treasury securities	8.6	3.8	10.5	1.7	5.3	230	0	230
Short-term assets								
Positions with the Federal Reserve (Assets: Reserves. Liabilities: Float, borrowing from Fed)	2.5	0.0	3.4	0.2	14.4	23	-1	24
Currency and coin (Assets: Government issued money, gold, silver. Liabilities: 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 government sponsored enterprise-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 (including 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	(Liabilities-Assets) /GDP: Averages 1875–2014	Averages 1875–1913	Averages 1914–2014	Value in 2007:Q3	Value in 2014:Q3	Assets: Value in 2007:Q3 (billions of dollars)	Liabilities	Assets-Liabilities
Short-term debt								
Savings and time deposits	51.8[a]	35.0	37.8	52.4	54.5	335	7,601	7,266
Checkable deposits and currency	N/A	N/A	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
Asset-backed security issuers	2.3	0.0	3.2	27.5	7.5	0	3,808	3,808
Other financial institutions	-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

[a] From 1875 to 1913 we only have data for overall deposits (i.e., do not know the split into Checkable deposits and currency and Savings and time deposits). We report the overall deposit data in the row for Savings and time deposits.

Table 2. Financial sector balance sheet with short, long, and equity categories netted, 1875–2014.
GDP = Gross Domestic Product.

	Averages				
	1875–2014	1875–1913	1914–2014	Value in 2007:Q3	Value in 2014:Q3
(1) Net long-term investments/GDP =(Long-term assets/GDP)-(Long-term debt/GDP)	51.7	39.3	56.4	98.3	73.4
(2) 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
(3) 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
(1)=(2)+(3)					

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

Linear regressions estimated by ordinary least squares, with *t*-statistics calculated using bootstrap-after-bootstrap standard errors. *t*-statistics are in parentheses. Regressions include a constant (not reported for brevity). The cutoff for significance for a two-sided test using the normal distribution is 2.58 at the 1% level, 1.96 at the 5% level, and 1.65 at the 10% level. GDP=Gross Domestic Product.

	Government supply/GDP	Year	R^2	Partial R^2 of Government supply/GDP	Bootstrap biased corrected AR(1)-coefficient for OLS residual
Panel A: 1875 to 2014					
Net long-term investments/GDP	-0.570	0.0044	0.902	0.383	0.963
	(-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 to 2014, excluding 1942 to 1951 (World War II)					
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 to 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 to 2014, excluding 1942 to 1951 (World War II)					
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)			

Table 4. The negative relation between government supply and financial sector lending financed by short-term debt (net short-term debt), estimated using alternative approaches.

t-statistics are in parenthesis. Regressions include a constant (not reported for brevity). Regressions in Panel A are estimated by ordinary least squares with standard errors calculated using the Newey-West method with *d* lags for regressions using *d*-year differenced data. GDP=Gross Domestic Product.

Panel A: Estimations using differenced data, 1875–2014

	One-year differences	Two-year differences	Three-year differences	Five-year differences	Ten-year differences
Net long-term investments/GDP regressed on Government supply/GDP					
β	-0.296	-0.357	-0.388	-0.460	-0.574
t-statistic	(-4.91)	(-4.98)	(-4.96)	(-5.91)	(-7.41)
Net short-term debt/GDP regressed on Government supply/GDP					
β	-0.287	-0.337	-0.370	-0.419	-0.511
t-statistic	(-5.64)	(-5.26)	(-5.13)	(-6.09)	(-8.22)

Panel B: Estimated cointegrating relations, 1875–2014

	Government supply/GDP	Year
Net long-term investments/GDP	-0.594	+0.0043
	(-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.

t-statistics are in parentheses. Estimations are by ordinary least squares, with *t*-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). In Panel B, the sample starts in 1925 for data availability reasons. In Panel C, the partial R^2 is with respect to all three supply variables. Foreign holdings are set to zero before 1952. In Panel D, 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. GDP=Gross Domestic Product.

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
	(-5.99)	(-3.07)	(-4.64)	(-5.71)	(-5.37)	(-6.05)
Real short rate		0.072				
		(0.17)				
Nominal short rate			-0.438			
			(-0.51)			
Real GDP_t/Real GDP_{t-5}				-0.093		
				(-1.95)		
Federal deficit/GDP, average 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

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

	Net short-term debt/GDP (1)	Net short-term debt/ Private capital stock (2)	Private capital stock/GDP (3)
Government supply/GDP	-0.453	-0.173	-0.667
	(-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)
R^2	0.951	0.953	0.251
Partial R^2 of Government supply/GDP	0.148	0.191	0.204

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

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
	(-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

Table 6. The relation between government supply and subcomponents of the financial sector balance sheet, 1875–2014.

t-statistics are in parentheses. 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 available only for 1914–2014. Regressions for those separate categories thus omit the 1875–1913 period. Estimations are by ordinary least squares, with *t*-statistics calculated using bootstrap-after-bootstrap standard errors. GDP = gross domestic products.

Dependent variable	1875–2014 (1)	1875–1970 (2)	1971–2014 (3)
Net short-term debt/GDP	-0.536	-0.524	-0.625
	(-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)

Table 7. Separate effects of the subcomponents of Treasury unbacked supply, 1916–2014.

t-statistics in parentheses. Estimations are by ordinary least squares, with *t*-statistics calculated using bootstrap-after-bootstrap standard errors. Regressions include a constant (not reported for brevity). The partial R^2 is with respect to all four supply variables. The sample starts in 1916 for data availability reasons. GDP=Gross Domestic Product.

	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		-0.426	
	(-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)
R^2	0.952	0.952	0.946	0.946
Partial R^2	0.332	0.332	0.240	0.240