The effect of Treasury debt on bank lending and the economy

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Abstract

What is the impact of a permanent increase in government debt on the financial sector and the economy? To answer this question, we use a VAR analysis to show that a higher debt-to-GDP ratio (i) reduces bank liabilities and bank lending, (ii) has no effect on non-bank lending, and (iii) reduces GDP and investments. We then present a simple model that rationalizes these findings and allows us to derive some implications for policy. The crowding out of bank lending and the reduction in GDP triggered by higher government debt imply that government revenues fall even if tax rates remain constant. The current scenario in which the government can borrow at low or negative real rates does not necessarily imply that higher government debt is beneficial.

1 Introduction

The COVID crisis and its response have accelerated the growth of government debt both in the US and around the world. In the US, federal government debt was 54% of GDP in 2001, 108% in early 2020, and 129% at the end of 2020. In addition, there are currently no plans to significantly decrease the debt-to-GDP ratio in the coming years, so that a significant part of this increase is likely to be long-lasting.

Motivated by these facts, the objective of this paper is to identify the effects of a permanent increase in the debt to GDP ratio, where "permanent" refers to a change that is long-lasting and,

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absent further shocks, will not be reversed. To address this question, we argue that it is important to understand the effects that higher government debt produces on the financial sector and how these effects are then transmitted to the macroeconomy. In particular, we build on and contribute to a growing literature showing that Treasury securities might crowd out banks' liabilities (Krishnamurthy and Vissing-Jorgensen, 2015; Greenwood, Hanson, and Stein, 2015; Li, 2019; Li, Ma, and Zhao, 2020). We do this using a novel approach that allows us to push the analysis further by asking whether and how the reduction in liabilities is transmitted to bank lending, the provision of credit to firms, firms' investments, and production.

Whether an increase in government debt affects bank lending and the economy is, a priori, ambiguous. Even if government debt crowds out bank liabilities, banks might adjust their balance sheet in the long-run without altering lending. For instance, they could tilt their capital structure toward having more equity or reducing holdings of other assets. Or, even if bank lending drops, firms could obtain more credit from non-bank lenders by e.g. issuing more corporate bonds, commercial paper, or equity. Despite these outcomes are possible, we find that an increase in debt to GDP not only crowds out of bank liabilities but also reduces lending to firms and, ultimately, leads to a contraction in investments and GDP. Because we analyze long-lasting and low-frequency changes in debt to GDP, our focus is mostly on the long-term impact they produce on the financial system and the economy.

We begin by providing evidence about the causal effect of a permanent increase in Treasury debt on bank liabilities, bank and non-bank lending, and macro outcomes using a structural VAR. The approach is novel — in the context of public debt and macro-finance outcomes — and complementary to those used in the classic macro literature (e.g., Elmendorf and Mankiw, 1999), international economics and cross-country comparisons (e.g., Rogoff and Reinhart, 2010) and finance (e.g., Greenwood, Hanson, and Stein, 2015). We then present a simple dynamic model to rationalize the results, explain the intuition behind the identification of our empirical results, and derive some implications. The model is so far only qualitative, but we plan to extend the paper by adding a quantitative analysis.

In the empirical analysis, we use a structural VAR to estimate the long-term effects of a permanent increase in debt to GDP using a sample that spans the period 1897-2020 for financial sector data and goes back to 1793 for macroeconomic data. On the financial sector, higher debt to GDP leads to a reduction in bank liabilities and bank lending, but we find no effect on non-bank lending (i.e., corporate debt and commercial paper). On the macroeconomy, a higher debt to GDP reduces GDP and investments, but these effects are significant only in peacetime periods. When we instead add war periods to the sample (i.e., the Civil War and World War I and II), the effects on GDP and investments become not significant.

The identification scheme of the VAR is based on long-run restrictions (Blanchard and Quah, 1989). This approach allows us to identify the effects of changes in government debt that are (i) long lasting (i.e., permanent) and (ii) are exogenous with respect to a large set of financial and macroeconomic shocks. We interpret the movements in debt-to-GDP that we identify to be driven by changes in the stance of policymakers over the long-run debt-to-GDP target. An example of such a change is the transition from the Regan-Bush-Clinton period — with low deficits and a strong focus on fiscal conservatism — to the Obama-Trump-Biden era — with large deficit spending and large increases in debt to GDP. A key element of our approach is that permanent changes in debt to GDP identified by the VAR with long-run restrictions are orthogonal to temporary changes. If business cycle fluctuations driven by macro and financial shocks produce only temporary changes in government debt, our approach identifies movements in debt to GDP that are exogenous with respect to short-run fluctuations in economic activity. In this case, we can recover both the short- and long-run effects of a permanent change in the debt-to-GDP ratio. However, we can still recover the long-term effects even under much weaker assumptions, that is, if (i) government policy does not systematically respond to secular changes in the financial sector and (ii) we focus on macro and financial variables measured as a fraction of GDP. More generally, the novel use of long-run restrictions in the analysis of government debt can be applied to study the impact of public finances on other aspects of the economy, opening up several avenues for future research.

The model builds on the macro-finance literature by including a banking sector in a standard macro setting. In particular, we build on Gertler and Kiyotaki (2010), in which banks are subject to an agency friction that limits the leverage they can take. As in Krishnamurthy and Vissing-Jorgensen (2012, 2015), both deposits and Treasury debt provide liquidity services.

In the current draft, we perform a qualitative analysis using numerical examples. An increase in the debt to GDP target crowds out bank deposits. With fewer deposits, banks contract lending. Whether non-bank credit increase or decrease depends on the degree of substitutability between bank and non-bank credit, and this result is in line with the empirical evidence which finds no significant effect on non-bank lending.

With respect to investments and GDP, we find in our numerical examples that an increase in the debt to GDP target reduces both. Investments drop because the substitution from bank to non-bank lending, if present, is only partial. And with lower investments, GDP drops too.

Finally, we explore the effects of an increase in government debt when the real rate on government debt is low or negative. A recent policy discussion (Blanchard, 2019) highlights that if "r<g" (i.e., if the real rate on government debt is less than the growth rate of the economy), the government earns seigniorage-like revenues on government debt, so that issuing public debt and rolling it over can reduce fiscal costs. We show that this is not necessarily the case. Because higher debt to GDP reduces GDP through the reduction in bank lending, the government collects lower tax revenues if tax rates remain constant. This effect might not be entirely offset by the higher seigniorage-like revenues, especially if the difference between "r" and "g" is small. In other words, the growth rate of the economy, "g," is endogenous and affected by the change in public debt, so that comparing "r" and "g" does not provide enough information to derive adequate policy implications. In particular, an analysis of public debt that abstracts from the interaction between Treasury securities, deposits, and bank lending will underestimate the costs of a fiscal expansion.

1.1 Additional comparison with the literature

On the empirical side, a growing literature emphasizes the link between government and intermediaries' debt due to their role in the provision of safety and liquidity. The closest paper is Krishnamurthy and Vissing-Jorgensen (2015), who also study long-run variations in debt to GDP and their impact on intermediaries. They show how an increase in government debt is associated with a reduction in banks' short term liabilities. A key difference is that our VAR approach allows us to provide a causal identification, whereas Krishnamurthy and Vissing-Jorgensen (2015) state explicitly that their analysis "cannot definitively rule out omitted variables or reverse causality concerns." In addition, on the empirical side, we also document the effects of Treasury debt on bank lending and the economy as a whole. Greenwood, Hanson, and Stein (2015) provide an instrument for Treasury fluctuations, but the instrument applies only to short-term variations. To our knowledge, our paper is the first one that provides a model-free identification of low-frequency variation in debt to GDP. Complementary approaches to study the substitution between Treasury debt and bank deposits are used by Li (2019) (who uses a structural model) and Li, Ma, and Zhao

(2020) (who use cross-sectional variations in banks' market power).[1]

On the theoretical side, several other papers study the effects of government liabilities and their interaction with the financial sector. Holmström and Tirole (1998) show that public liquidity is needed when the economy is subject to aggregate risk, but there are no negative effects of large public liquidity on financial intermediation. In Greenwood, Hanson, and Stein (2015), public liquidity crowds out the financial sector too, and this effect is positive in their model because of an externality generated by private intermediaries and modeled along the lines of Stein (2012).

A growing body of literature analyzes government finances and its implications on the financial system. In Li (2017), public liquidity reduces liquidity premia and creates an incentive for intermediaries to take on more risk, which amplifies credit cycles and lengthens the duration of crises. Bolton and Huang (2017) study public liquidity in a framework in which domestic and foreign money provides liquidity. Liu, Schmid, and Yaron (2019) highlight the negative effects on corporate financing of a large supply of Treasury debt. Jiang et al. (2020) analyze the trade-off between insuring taxpayers and bondholders, and Jiang et al. (2021) emphasize the importance of considering risk when computing the government's funding cost.

2 Treasury debt, the financial sector, and the economy: Empirical evidence

This section provides an empirical analysis of the effects of government debt on financial intermediation and the macroeconomy. Before detailing our data and empirical approach, we provide the key element of the theoretical framework that we use to guide our empirical analysis. We then present the full model after deriving the empirical results.

We find that higher debt to GDP reduces banks' liabilities and bank lending. With respect to the real economy, the result is a contraction of investments and GDP. The effect on GDP, however, is significant only in peacetime periods, and becomes not significant if we add the Civil War and World War I and II to our sample.

[1] Other studies such as Infante (2020) and Amaral, Corbae, and Quintin (2020) study the effects of an increase in the demand for safe assets on the supply of government and intermediaries' liabilities.

2.1 A simple framework to guide the analysis

To guide our analysis and clarify the approach we follow, we begin by outlining the equations that describe the evolution of Treasury debt and government policies. In this section, we provide a very general formulation that fits a large class of models. A more detailed specification is provided later when we present our full model.

Consider a government that issues debt, faces expenditures and must pay transfers to the private sector, and collects taxes. The government budget constraint is given by

$$B_t + (\text{tax revenues}) \leq B_{t-1} + (\text{government expenses and transfers})\,. \tag{1}$$

On the right-hand side, the government must finance the government debt B_{t-1} issued in previous periods, as well as government expenses and transfers. The government can finance these expenses by issuing new debt B_t or collecting taxes.

The key equation related to our empirical analysis is the the one that govern the evolution of Treasury debt B_t:

$$\frac{B_t}{GDP_t} = \left(1 - \rho^B\right) \left[\frac{B}{GDP}\ target\right] + \rho^B \frac{B_{t-1}}{GDP_{t-1}} + \varepsilon_t^B, \tag{2}$$

where $\rho^B \in (0, 1)$. The term in square brackets on the right-hand side of Equation (2) is the long-run target for the debt-to-GDP ratio. Debt to GDP, B_t/GDP_t, can fluctuate around the target. The term ε_t^B represents the various factors that could affect the short-run evolution of debt to GDP around its target, such as business cycle and financial fluctuations, or temporary policies. Once debt to GDP is away from its target, and absent further shocks, the government will bring it back to its long-run target over time. The debt-to-GDP target does not have to be explicitly chosen by the government but could be implicitly determined by other policies, as we discuss in more details below.

In our empirical analysis, we want to understand how a change in the debt-to-GDP target affects banking and macroeconomic variables in the long term. The target could change because of a time-varying stance of policymakers over the "right" long-run average debt to GDP. While we analyze our identification assumptions in more details in Section 2.3, we note here that the main results we focus on are valid even if changes in the debt-to-GDP target are correlated with temporary shocks that cause booms and recessions, and even if the changes are correlated to permanent shifts in productivity that cause long-run growth. For instance, if movements in the debt-to-GDP target are correlated to booms or recessions (e.g., because the government effectively increases the target in response to recessions), we might not necessarily estimate the correct effects on impact, that is, in the first few years after the change in the target. However, we are able to identify the long-run effect of the change in the target — which is our main goal — as long as we focus on variables as a ratio of GDP (e.g., investments to GDP, bank lending to GDP, and so on). A more detailed discussion is provided in Section 2.3.

When the debt-to-GDP target changes, the budget constraint implies that the government will also adjust some of its other policies. For instance, if the government increases the debt-to-GDP target, it can spend more or cut taxes as debt to GDP moves toward the new level. At this point, we do not specify what other fiscal policy variable adjusts when the government changes $\overline{B}$. We will return to this point when presenting the model, in Section 3.

2.2 Data and empirical specification

Our data draws from the following sources. For debt to GDP, we use the series constructed by Henning Bohn which covers the period 1791-2012 and update it to 2020. Debt denotes Treasury debt held by the public (i.e., not held by government agencies and not held by the Federal Reserve). For investments and real GDP, we use Henning Bohn' data, the Jordà-Schularick-Taylor Macrohistory Database, and the Flow of Funds. Financial sector data is based on All Bank Statistics, Banking and Monetary Statistics, and the Flow of Funds.

To understand if there is a causal link between changes in the debt-to-GDP ratio and changes in financial sector and macro variables, we need to identify exogenous movements in debt to GDP. We do this using a VAR with long-run restrictions. Let $Y_t = \left[\Delta \log\left(debt/GDP\right)_t, \ \Delta \log \boldsymbol{x}_t\right]'$ where $\boldsymbol{x}_t$ includes variables related to the financial sector or the macroeconomy, and consider the reduced-form VAR

$$Y_t = AY_{t-1} + \boldsymbol{\varepsilon}_t. \tag{3}$$

We first estimate the coefficients A and then construct the impulse response to an exogenous shock identified using long-run restriction. This approach identifies two types of shocks: a shock that has permanent effects on the *level* of debt to GDP, and shocks that have transitory effects on the *level* of debt to GDP and are orthogonal to the first one. Long-run restrictions have been proposed by Blanchard and Quah (1989) and have been applied to both macro and finance questions. In the macro literature, for example, they have been used to study the effects of technology shocks on hours worked (Gali, 1999; Fisher, 2006). In finance, for example, they have been employed by Hansen, Heaton, and Li (2008) to study the pricing of risk exposure in the long run.

If the government has a target for the debt-to-GDP ratio that should be reached in the long run (i.e., in steady state), the shock with permanent effects corresponds to an exogenous increase in this target. This approach is consistent with numerous models that include such a target; see, for instance, the general framework of Uhlig (2010) and the analysis of government debt and corporate financing of Liu, Schmid, and Yaron (2019). An increase in the target debt to GDP could be due, for instance, to changes in the stance of policymakers over the "right" long-run average for the debt-to-GDP ratio.

2.3 Identification

The long-run identification scheme and the structure of the VAR that we use have the advantage of making sure that we focus on changes in the debt-to-GDP ratio that are not temporary and, thus, are likely not driven by business cycle fluctuations or financial shocks. Indeed, business cycle fluctuations and financial crises alone (i.e., without changes in the long-run target for the debt-to-GDP ratio) give rise to temporary changes in government debt. In the VAR, such changes are captured by shocks that have transitory effects on the level of debt to GDP. Instead, we focus on the shock that has permanent effects on debt to GDP and, by construction, is *orthogonal* to temporary shocks.

If shocks that move the long-run target of debt to GDP are uncorrelated with any other shock in the economy, our approach would clearly work well. That is, we would identify the shocks that move the long-run target of debt to GDP and their effects on macro and financial variables.

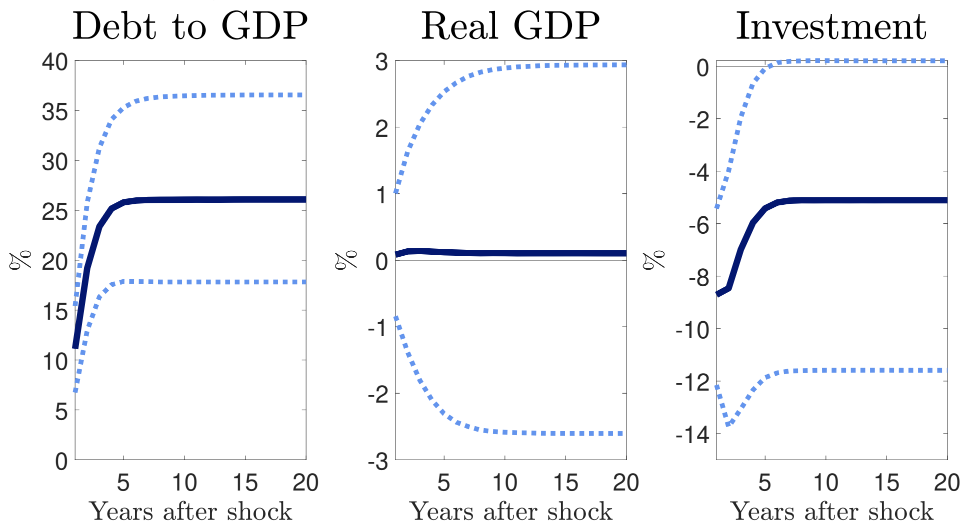
Importantly, our main results remain valid under much weaker assumptions. In particular, we argue that the impulse responses might be biased on impact, but they nonetheless allow us to recover the correct effects that a change in the debt-to-GDP target produce (i) *in the long run* and (ii) *on variables normalized by GDP* (e.g. investments to GDP, bank lending to GDP, ...), under weaker assumptions. We explain the rationale of this result with a few examples.

Consider, for instance, the case in which movements in the long-run debt-to-GDP target are correlated with transitory shocks that determine business cycle or financial fluctuations. This would be the case if, for instance, the government increases its debt-to-GDP target when it enters a recession. On impact, our impulse responses will be biased because they will capture the effects of both the new debt-to-GDP target as well as the effects of the recession. But as we look at the impulse response over a longer horizon, the results will be valid. As the recession is temporary, its effect will eventually vanish, and the effects that are left can be attributed to the change in the debt-to-GDP target. This logic applies not only to shocks that create temporary booms and recessions, but to any shock that might temporarily affect the economy.

Our most important results remain valid even if changes in the debt-to-GDP target are correlated with changes that are responsible for the long-term growth of an economy (i.e., permanent technology shocks). As economies grow over time (i.e., as they are hit by permanent technology shocks), it is well-documented that several aggregate macro and financial variables remain constant as a fraction of GDP — the so-called Kaldor facts. In Section 3, we sketch a model that builds on standard growth theory and replicates these stylized facts. In the model, a shock that permanently improve productivity produces no long-run changes in several aggregate ratios such as investments to GDP, deposits to GDP, and bank lending to GDP. Thus, if the permanent productivity shock is coupled with a shock to the debt-to-GDP target, any long-run effect on ratios such as investments to GDP, deposits to GDP, and bank lending to GDP can be attributed to the movement in the debt-to-GDP target. Similar to the previous case, the VAR results on impact will be biased, but this will not prevent us from correctly estimating the long-run effect of a change in debt-to-GDP target. As this logic applies only to variables measured as a fraction of GDP, we are unable to correctly estimate the effects on GDP itself in this case.

Ultimately, we believe that the only case in which even our long-term estimates would be biased is a scenario in which movements in the debt-to-GDP target are systematically correlated with permanent shocks that affect the ratio of aggregate macro and financial variables to GDP. With respect to macro variables, we believe that this possibility is not relevant. While the economic growth literature has highlighted the role of permanent shocks that affect the importance of certain sectors in comparison to others, these shifts typically do not alter the ratio of aggregate macro variables to GDP. With respect to financial variables, we need shocks that generate long-term trends in the financial sector to be uncorrelated with permanent changes in the debt-to-GDP target.

Figure 1: Macro variables. Sample: 1871-2020



The solid line is the median impulse-response and the dotted lines denote the 90% confidence bands. The right panel denotes investments to GDP.

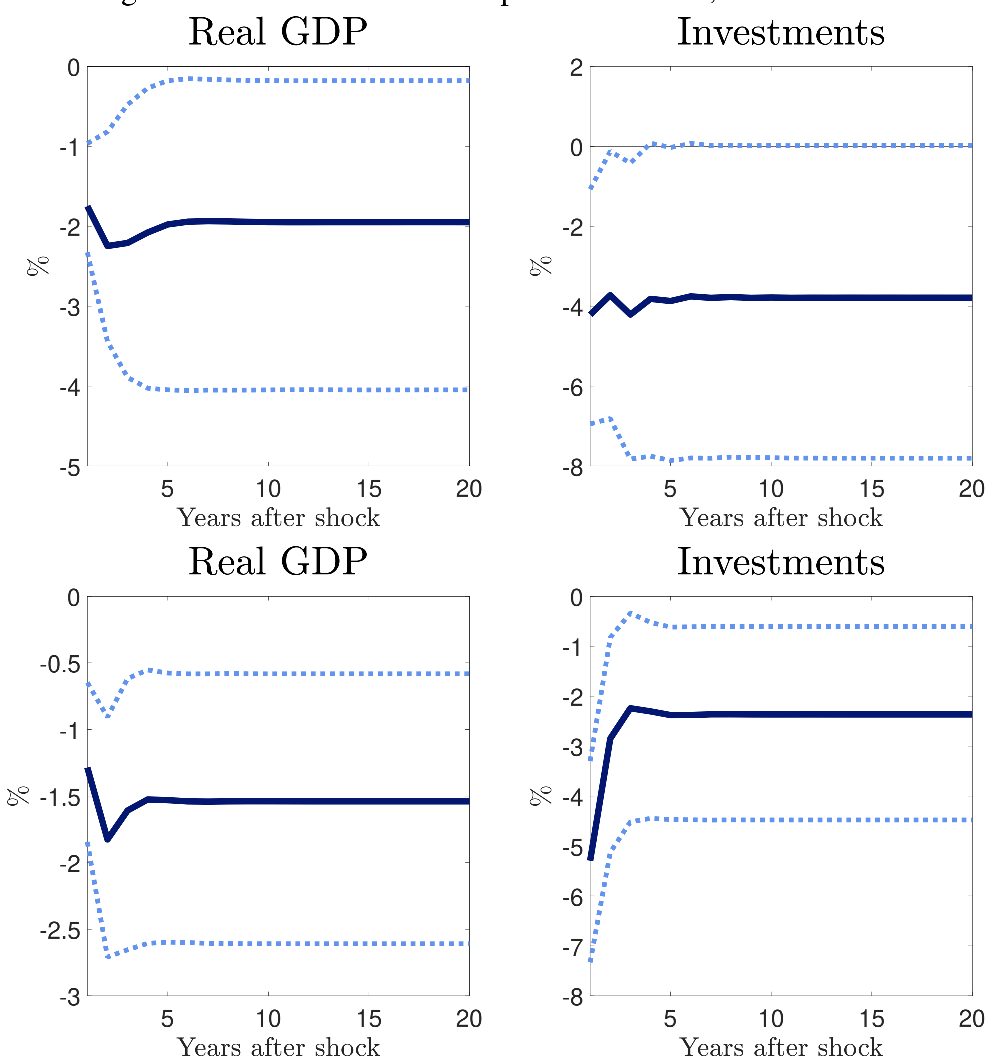
We think this is the case because we view it as unlikely that government policies that determine the long-run level of revenues, taxes, expenditures, and deficits are changed in response to secular trends in the financial sector.

2.4 Results: effects on macro variables

We begin by studying the effects of changes on debt to GDP on macro variables. Our sample includes debt to GDP and GDP for the period 1793-2020, and investments for the period 1871-2020. Our baseline macro-variable VAR includes debt to GDP, real GDP, and investments to GDP, and thus we estimate it for the period 1871-2020. The main takeaway is that the effect is crucially affected by whether we look at peacetime periods or if we include major wars (i.e., the Civil War and World War I and II).

Figure 1 shows the results of higher debt to GDP on macro variables estimated using the full sample available. All the figures plots the cumulative effects on the variable of interests. In response to a permanent increase in debt to GDP, there are no significant effects on real GDP and investments — the solid line denotes the median impulse response and the dotted lines are the 90% confidence bands. Similar results are obtained if we run the VAR by including only debt to GDP and GDP for the period 1793-2020.

Figure 2: Macro variables. Samples: 1871-1913, and 1948-2020



The solid line is the median impulse-response to a permanent increase in debt to GDP, and the dotted lines denote the 90% confidence bands. The top panels refer to the VAR estimated for the period 1871-1913, and the bottom panels refer to the VAR estimated for the period 1948-2020. Investments is defined as the ratio of investments to GDP.

The results are very different if we restrict the analysis to peacetime periods. To do so, we estimate two different VARs — one until World War I and another one after World War II. The results, shown in Figure 2, show that higher debt to GDP reduces both real GDP and investments to GDP, and the effects are statistically significant. The results are similar if we run a VAR that omits investments and begin the first subsample in 1866, that is, after the end of the civil war.

2.5 Results: effects on the financial sector

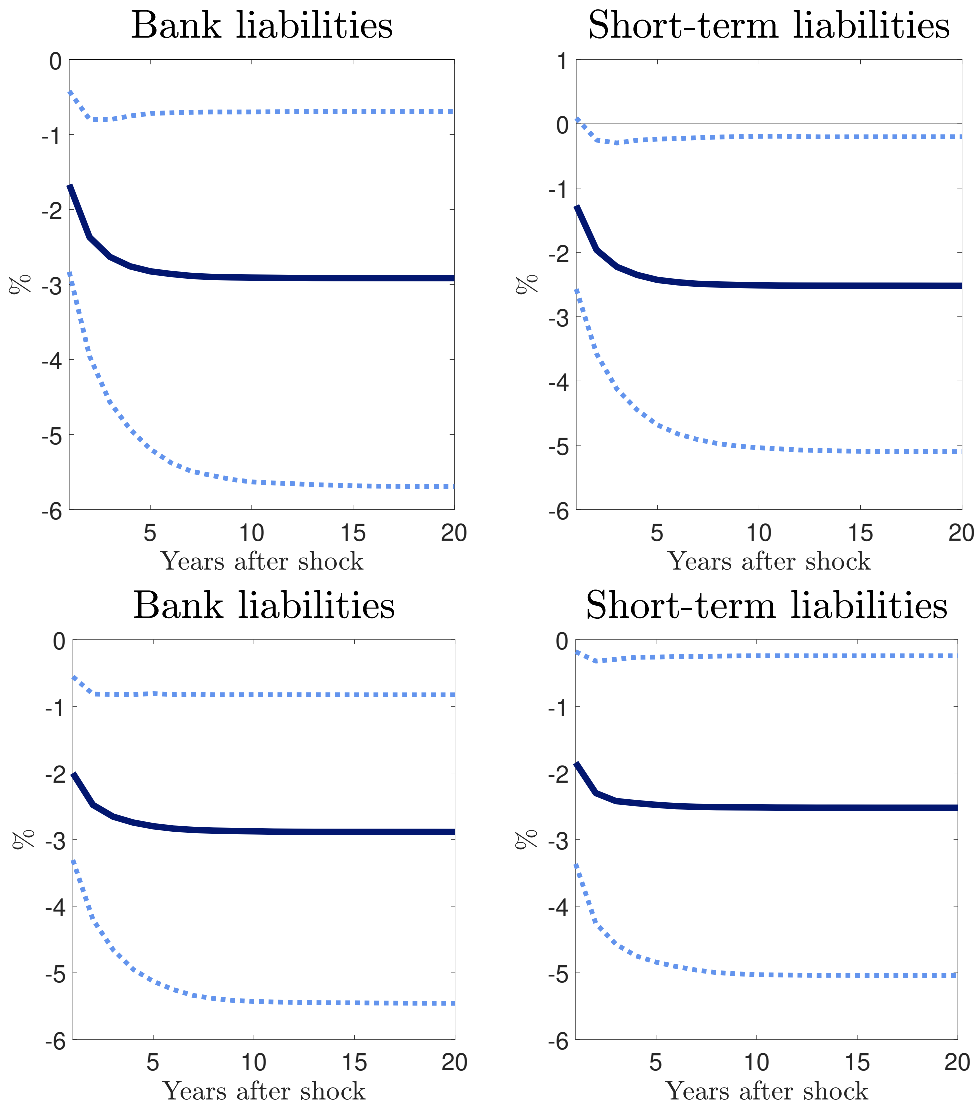
We now turn to the analysis of the effects of debt to GDP on the financial sector. In particular, we analyze two main set of financial variables: bank liabilities and bank lending. We also run a VAR that includes the spread between AAA bonds and long-term Treasury to compare our results with Krishnamurthy and Vissing-Jorgensen (2012).

Figure 3 plots the effects of debt to GDP on bank liabilities, measured in two different ways: all liabilities and short-term liabilities — the latter, defined as non-government deposits plus financial commercial paper. Overall, an increase in debt to GDP reduces both measures of bank liabilities. The top panels of Figure 3 focus on the years 1897-2007, that is, we exclude 2008 and later years in which the Federal Reserve implemented quantitative easing and increased its reserves dramatically. If we extend our sample to 2020, we find no significant effects, but we argue that the result is the byproduct of the increase in central bank reserves. Indeed, in the bottom panels of Figure 3, we control for reserves by including reserves to GDP in the VAR and ordering them first. With this ordering, we identify a shock with permanent effects to debt to GDP that does not alter reserves to GDP in the long run, and the results are essentially identical to those obtained for the sample period 1897-2007. The bottom panels are based on a sample that starts in 1915 because of data availability about central bank reserves — the Federal Reserve was indeed established at the end of 1913. In all subsequent VARs, we include reserves to GDP as well.

Next, we turn to bank lending. We begin by using all bank lending as a fraction of GDP and include that in the VAR together with non-bank lending as a fraction of GDP. Non-bank lending is the sum of corporate bonds and commercial paper and, starting in 1945, other non-real estate related loans on the balance sheet of non-financial firms. We observe a significant and negative effect of debt to GDP on bank lending but no effects on non-bank loans.

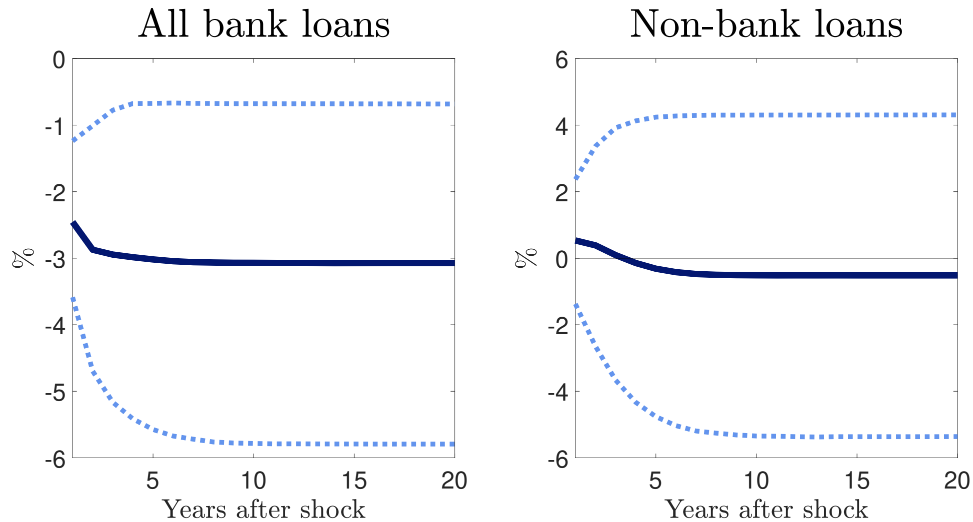
We then repeat our analysis for the post-World War II period. This subsample analysis creates

Figure 3: Bank liabilities. Samples: 1897-2007 and 1915-2020



The solid line is the median impulse-response to a permanent increase in debt to GDP, and the dotted lines denote the 90% confidence bands. The top panels refer to the 1897-2007 sample, and the bottom panel to the 1915-2020 sample. The bottom panel includes reserves to GDP in the VAR, ordered first. All variables are measured as a fraction of GDP.

Figure 4: Bank lending. Sample: 1919-2020

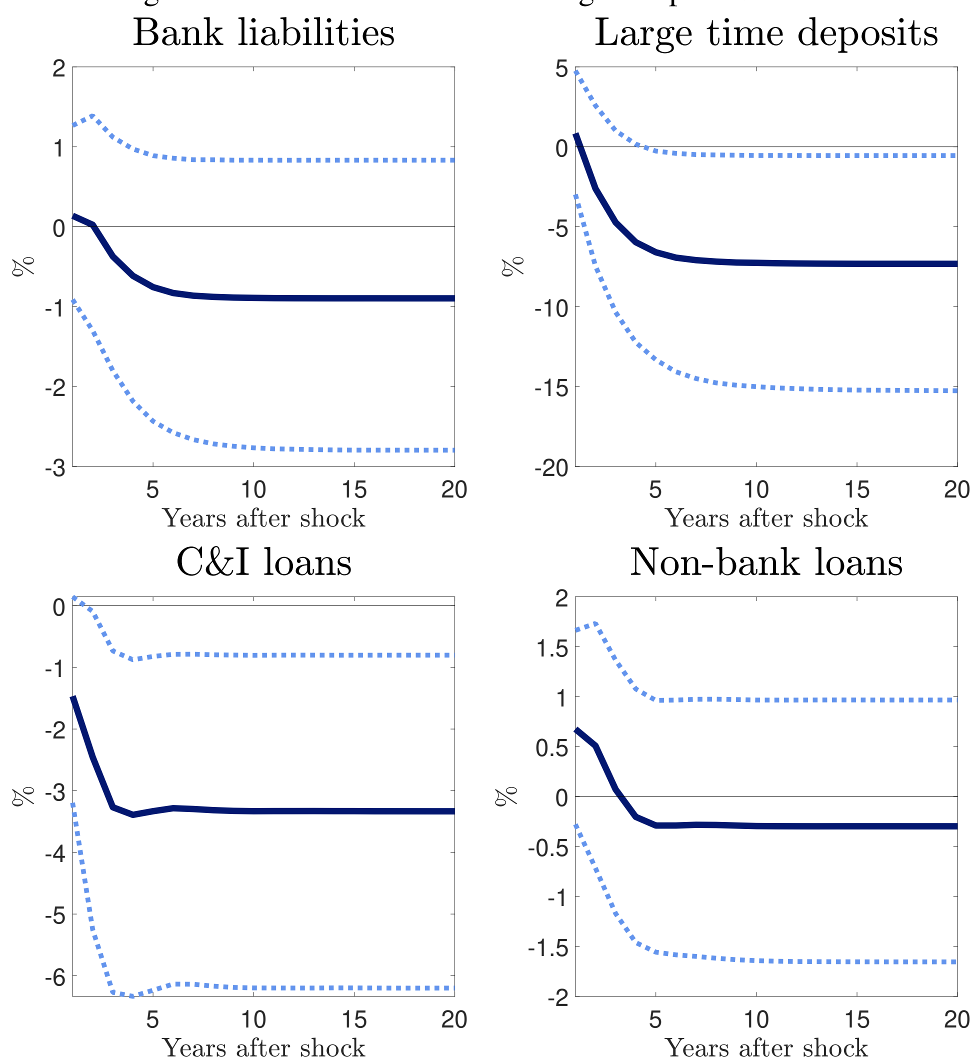


The solid line is the median impulse-response to a permanent increase in debt to GDP, and the dotted lines denote the 90% confidence bands. The VAR includes reserves to GDP, ordered first. All variables are measured as a fraction of GDP.

challenges because the long-run identification uses low-frequency variations in the data and, thus, requires either long samples or data with low noise (or both) to work well. To overcome this problem, we exploit the fact that, in the post-war period, more detailed data is available than in the full sample. In particular, we show that our results are robust when we include, in the VAR, selected bank liabilities and loans that are likely to have less noise than total liabilities or total total loans.

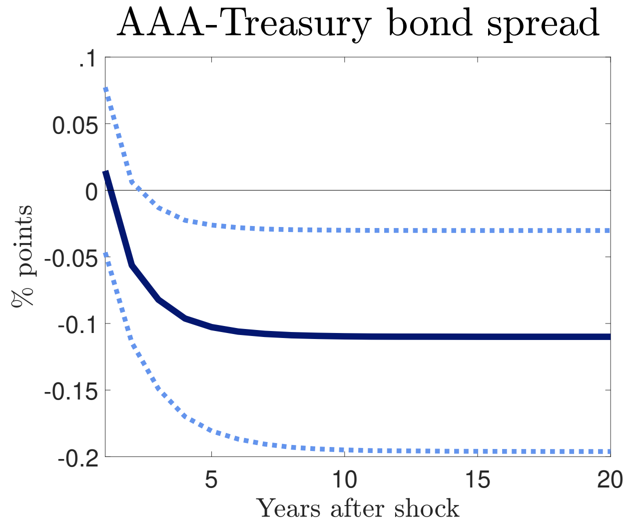
In particular, we focus on the effects of debt to GDP on wholesale financing and commercial and industrial loans. Figure 5 show that higher debt to GDP reduces both wholesale funding — measured as large time deposits over GDP, in line with Li, Ma, and Zhao (2020) — and commercial and industrial (C&I) loans. As in the full sample, we do not find an effect on non-bank lending. We note that we do not find significant effects on bank liabilities and total bank lending, in contrast to the full sample. However, in light of the effects on wholesale funding and C&I loans, we believe that this result is the byproduct of a very demanding specification that uses a very short sample period. Let us elaborate more, beginning with bank liabilities. In the 1960s and 1970s, ceilings on deposit rates created a disconnect between the choice of most depositors and macroeconomic dynamics, as pointed out by Drechsler, Savov, and Schnabl (2020). This disconnect was likely less pronounced for wholesale funding, which is typically provided by large firms or wealthy

Figure 5: Bank liabilities and lending. Sample: 1948-2020



The solid line is the median impulse-response to a permanent increase in debt to GDP, and the dotted lines denote the 90% confidence bands. The VAR includes reserves to GDP, ordered first. All variables are measured as a fraction of GDP.

Figure 6: Spread between AAA corporate bonds and long-term Treasury bonds. Sample: 1920-2020



The solid line is the median impulse-response to a permanent increase in debt to GDP, and the dotted lines denote the 90% confidence bands. The VAR includes reserves to GDP, ordered first.

households who have direct access to Treasury securities and thus are — not surprisingly — more sensitive to changes in Treasury supply. On the bank lending side, C&I loans are a cleaner measure than total loans as they include loans unrelated to real estate. In contrast, real estate lending in the post-war period have been significantly influenced by government policies aiming at encouraging home ownership. Overall, these effects create a noise that is filtered out by the VAR in the full sample but not in the post-war periods. Focusing on large time deposits and C&I loans allows us to filter out such a noise and produces results that are consistent with the full-sample VAR and the literature.

As a final step, we run a VAR that includes the spread between AAA corporate bonds and long-term Treasury bonds. Krishnamurthy and Vissing-Jorgensen (2012) show the existence of a demand for Treasury debt as a function of such a spread. The objective of running a VAR with such a spread is to verify that the long-run restrictions that we use are indeed identifying movements in the supply of debt to GDP, which should result in changes in the AAA-Treasury spread with the opposite sign (i.e., a movement along the demand curve). The results suggest that this is indeed the case, as shown in Figure 6. The sample starts in 1920 because of data availability, similar to Krishnamurthy and Vissing-Jorgensen (2012).

2.6 Interpretation of the results

The previous sections have documented that higher debt to GDP (i) reduces GDP and investments to GDP, (ii) reduces bank liabilities, in line with the results previously established in the literature, (iii) reduces bank lending but has no effect on non-bank lending. Taken together, these results suggest a negative impact of debt to GDP that is transmitted through the financial sector, similar to the channel described in Krishnamurthy and Vissing-Jorgensen (2015). That is, government debt and bank liabilities are substitutes, at least in part, because they both are valued by households for their liquidity value. An increase in government debt crowds out bank liabilities, and banks respond by cutting lending and reducing overall investments.

We also note that firms' non-bank financing does not respond to changes in debt to GDP. There are two possible explanations for this result. First, this could be a sign that the drop in investments is in part due to a reduction in demand, possibly related to the distortionary effects of the higher taxes associated with the policy change. Alternatively, if a change in debt to GDP is compensated by changing fiscal policies other than taxes (e.g., cutting spending), the result is a sign that bank and non-bank lending are not perfect substitute.

3 Model

This section presents a model that rationalizes the empirical findings presented above, provides insights into the impact of government liabilities on the economy, and can be used for policy analysis. In the current draft, our analysis is qualitative and we illustrate the functioning of the model using numerical examples. We plan to extend our analysis to include a quantitative analysis.

The model has three building blocks: households, banks, firms, and the government. Households value the deposits and government debt not only because of their return but also because of the liquidity they provide. As in Krishnamurthy and Vissing-Jorgensen (2012), we model this feature using a Sidrausky-type model in which deposits and Treasury debt enter the utility function. Banks are modeled as in Gertler and Kiyotaki (2010), in which bankers face an agency problem that constrains their ability to borrow using deposits. Firms are similar to standard business cycle models, except for the fact that they use credit from both banks and non-banks. We model this feature using a very general specification and then explore implications of different parameter values.

Finally, the government section extends and details the general framework outlined in Section 2.1. The government faces a budget constraint, and sets a target for Treasury debt as well as other policies that determine taxes and expenditures.

Because we analyze long-run changes in government policies and financial variables, it is important that our model is consistent with key stylized facts of the economic growth literature. More specifically, our model builds on a neoclassical growth framework with a balanced growth path, and thus is consistent with the Kaldor facts of economic growth (Kaldor, 1961), that is, the long-run constancy of the growth rate, the capital-output ratio, the share of income attributable to labor and capital, and the real interest rate.

After presenting the model, we study the effects of unanticipated shocks, and in particular, of technology shocks and of a change in the debt-to-GDP target of government debt.

3.1 Households

Households have utility

$$\mathbb{E}_0 \sum_t \beta^t \left[-h\left(L_t\right) + u\left(C_t\right) + v\left(\frac{D_t + B_t}{C_t}\right) \right]$$

where L_t are hours worked, C_t is consumption, D_t are bank deposits, and B_t is government debt. The function $v\left(\cdot\right)$ is increasing and concave and captures the fact that households derive liquidity benefits from bank deposits and government debt.

Households maximize their utility subject to the budget constraint

$$C_t + K_t^{nb} + q_t^d D_t + q_t^b B_t \leq K_{t-1}^{nb}\left[1 + \left(r_t^{nb} - \delta\right)\left(1 - \tau_t^k\right)\right] + \left(D_{t-1} + B_{t-1}\right) + w_t L_t\left(1 - \tau_t^l\right) + \Pi_t + T_t.$$

In each period, households purchase consumption goods C_t and decides their portfolio of investments. Households can provide credit directly to firms by investing in capital K_t^{nb} (where nb stands for "nonbank"), they can deposit D_t at banks, and can purchase government debt B_t. Deposits and government debt are modeled as zero-coupon securities with unitary face value and price q_t^d and q_t^b, respectively.

Households finance their consumption expenditures and investments by drawing on several resources. First, the investments in capital K_{t-1}^{nb} made at $t-1$ pay a return r_t^{nb}, net of depreciation

δ and taxes τ_t^k. Second, households have access to bank deposits and investments in Treasury debt made at $t-1$, that is, D_{t-1} and B_{t-1}. Third, households earn labor income $w_t L_t$ (where w_t is wage), net of taxes τ_t^l. Fourth, households get lump-sum dividends Π_t from banks and lump-sum transfers T_t from the government.

The problem of households can be expressed recursively as

$$V_t(X_t) = \max \left\{ -h(L_t) + u(C_t) + v\left(\frac{D_t + B_t}{C_t}\right) + \beta \mathbb{E}_t V_{t+1}(X_{t+1}) \right\}$$

s.t.

$$C_t + K_t^{nb} + q_t^d D_t + q_t^b B_t \leq X_t + w_t L_t \left(1 - \tau_t^l\right)$$

$$X_{t+1} = K_{t-1}^{nb} \left[1 + \left(r_t^{nb} - \delta\right)\left(1 - \tau_t^k\right)\right] + (D_{t-1} + B_{t-1}) + \Pi_t + T_t.$$

The first-order conditions with respect to labor L_t, consumption C_t, capital K_t^{nb}, deposits D_t, and government debt B_t imply:

$$h'(L_t) = V_t'(X_t)\, w_t \left(1 - \tau_t^l\right)$$

$$u'(C_t) - v'\left(\frac{D_t + B_t}{C_t}\right) \frac{D_t + B_t}{C_t^2} = V_t'(X_t)$$

$$V_t'(X_t) = \beta \mathbb{E}_t \left\{ V_{t+1}'(X_{t+1}) \left[1 + \left(r_{t+1}^{nb} - \delta\right)\left(1 - \tau_{t+1}^k\right)\right] \right\}$$

$$v'\left(\frac{D_t + B_t}{C_t}\right) \frac{1}{C_t} + \beta \mathbb{E}_t \left\{ V_{t+1}'(X_{t+1}) \right\} = q_t^d V_t'(X_t)$$

$$q_t^d = q_t^g.$$

In our numerical simulations, we use the following functional form for the utility benefits provided by deposits and government debt:

$$v\left(\frac{D_t + B_t}{C_t}\right) = \psi \frac{\left(\frac{D_t + B_t}{C_t}\right)^{1-\gamma_d}}{1 - \gamma_d}.$$

3.2 Banks

Banks work as in Gertler and Kiyotaki (2010). There is a mass of bankers, and each of them faces a probability $1 - \psi$ of exiting and becoming an household member. Every banker that exits is replaced by a new one, so that the mass of bankers remain constant. The setup of Gertler and Kiyotaki (2010) is very tractable and allows to combine together the choices of all the bankers, without the need to keep track of the distribution of their net worth.

Consider a representative banker with net worth N_t. The banker chooses capital (i.e., bank lending) K_t^b and deposits D_t to maximize

$$v_t^b\left(N_t\right) = \max_{K_t^b, D_t} \mathbb{E}_t \left\{ \Lambda_{t+1} \left[\left(1-\psi\right) \tilde{N}_{t+1} + \psi \, v_{t+1}^b\left(N_{t+1}\right) \right] \right\}$$

subject to the budget constraint

$$K_t^b \leq N_t + q_t^d D_t$$

and a constraint that originates from an agency friction:

$$\theta K_t^b\left(n_t\right) \leq v_t^b\left(N_t\right),$$

and where

$$\tilde{N}_{t+1} = \left(1 + \left(r_{t+1}^b - \delta\right)\left(1 - \tau_{t+1}^k\right)\right) K_t^b - D_t.$$

Bankers collect deposits D_t (issued at price q_t^d) and invest in capital K_t^b. After the investment is made, the banker can divert a fraction θ of the resources invested, leaving nothing for the depositors. To avoid misbehavior, the continuation value of running the bank, $v_t^b\left(N_t\right)$, must be at least as large as the resources θK_t^b that can be diverted by the banker. If this incentive constraint holds — as it is the case in equilibrium — the banker does not divert any resource.

Bankers discount the future using the discount factor Λ_{t+1} of households. With probability $1-\psi$, the banker will exit and will give the accumulated net worth N_{t+1} as a dividend to his household. Otherwise, the banker keeps being a banker. When a banker will exist, a member of the household who is currently not a banker will replace him. Therefore, the measure of bankers and workers in the household is constant.

The variable $\tilde{N}_{t+1}$ denotes the net worth in $t+1$ of the representative banker with net worth N_t. The net worth includes the gross proceeds earned from bank lending (i.e., the return r_{t+1}^b net of depreciation δ and taxes τ_{t+1}^k) minus the repayment D_t to depositors. Note that $\tilde{N}_{t+1}$ is not the same as the total net worth of the economy in $t+1$, which accounts for the entry and exit of bankers. The law of motion of aggregate net worth is

$$
\begin{aligned}
N_{t+1} &= \underbrace{\psi \left[\left(1+\left(r^b_{t+1}-\delta\right)\left(1-\tau^k_{t+1}\right)\right)K^b_t - D_t\right]}_{\text{net worth of bankers that do not exit}} \\
&\quad + \underbrace{(1-\psi)}_{\text{bankers that enters}} \underbrace{\omega \left[\left(1+\left(r^b_{t+1}-\delta\right)\left(1-\tau^k_{t+1}\right)\right)K^b_t - D_t\right]}_{\text{endowment of wealth for new bankers}} \\
&= \left[\psi + (1-\psi)\,\omega\right]\left[\left(1+\left(r^b_{t+1}-\delta\right)\left(1-\tau^k_{t+1}\right)\right)K^b_t - D_t\right].
\end{aligned}
$$

As in Gertler and Kiyotaki (2010), we assume that new bankers that enter at $t+1$ receive an endowment of net worth equal to a fraction $\omega < 1$ of the the net worth of the average banker that does not exit. Because ω is less than one, the term $\psi + (1-\psi)\,\omega < 1$ essentially parametrizes the dividends that are paid by banks to households. In addition, because $\psi + (1-\psi)\,\omega$ is constant, banks' net worth responds relatively slowly to macroeconomic shocks, as it is the case in practice.

The problem of bankers can be solved by guessing and verifying that their value function is proportional to net worth:

$$v^b_t\left(N^b_t\right) = \alpha_t n_t.$$

The verification steps allows us to solve for α_t, which is given by

$$\alpha_t = \frac{\left(1/q^d_t\right)\mathbb{E}_t\left\{\left[\Lambda_{t+1}\left(1-\psi+\psi\,\alpha_{t+1}\right)\right]\right\}}{1-\mathbb{E}_t\left\{\left[\Lambda_{t+1}\left(1-\psi+\psi\alpha_{t+1}\right)\frac{1}{\zeta}\left[\left(1+\left(r^b_{t+1}-\delta\right)\left(1-\tau^k_{t+1}\right)\right)-1/q^d_t\right]\right]\right\}}.$$

3.3 Firms

Firms are modeled as static players that get credit from households and banks, hire workers, and produce. The production function is given by

$$Y_t = \left(K_{t-1}\right)^{\alpha}\left(A_t L_t\right)^{1-\alpha}$$

where A_t is aggregate TFP, K_{t-1} is capital, and L_t is labor. Firms' choose capital K_{t-1} at time t, but because capital in the overall economy is predetermined at time $t-1$, we follow the notation used before and index it by $t-1$. Capital K_{t-1} used by firms is a composite of capital rented from households, K^{nb}_{t-1}, and capital rented from banks, K^{b}_{t-1}:

$$K_{t-1} = \left[\gamma^K \left(K^{nb}_{t-1}\right)^{\nu} + \left(1-\gamma^K\right)\left(K^{b}_{t-1}\right)^{\nu}\right]^{\frac{1}{\nu}}. \tag{4}$$

This specification is very flexible and allows us to consider very different cases. For instance, as $\nu \to 1$, K^{nb}_{t-1} and K^{b}_{t-1} are perfect substitutes. We interpret this scenario as the case in which firms can very easily substitute bank credit with non-bank credit, and vice versa. At the opposite case, in which $\nu \to -\infty$, K^{nb}_{t-1} and K^{b}_{t-1} are perfect complement. This case would arise, for instance, if firms face a collateral constraint of the form $K^{b}_{t-1} \leq \theta K^{nb}_{t-1}$, that is, if banks require the assets K^{nb}_{t-1} as collateral.

Our choice of considering a labor-augmenting TFP (i.e., to raise A_t to the power of $1-\alpha$) is motivated by our objective of building a model that produces a balanced growth path. That is, this specification is necessary to obtain a model in which a permanent technology shock does not alter the ratio of aggregate variables to GDP in the long run.

Firms' profits are given by

$$\Pi^{nb}_t = \left(K_{t-1}\right)^{\alpha}\left(A_t L_t\right)^{1-\alpha} - r^{nb}_t K^{nb}_{t-1} - r^{b}_t K^{b}_{t-1} - w_t L_t$$

and their first-order conditions with respect to K^{nb}_{t-1}, K^{b}_{t-1}, and L_t are

$$\left(A_t L_t\right)^{1-\alpha} \alpha \left(K_{t-1}\right)^{\alpha-1} \frac{\partial K_{t-1}}{\partial K^{nb}_{t-1}} = r^{nb}_t$$

$$\left(A_t L_t\right)^{1-\alpha} \alpha \left(K_{t-1}\right)^{\alpha-1} \frac{\partial K_{t-1}}{\partial K^{b}_{t-1}} = r^{b}_t$$

$$\left(1-\alpha\right)\left(K_{t-1}\right)^{\alpha} A_t^{1-\alpha} \left(L_t\right)^{-\alpha} = w_t.$$

Productivity A_t evolves according to the law of motion

$$A_t = \left(1-\rho^A\right)\overline{A} + \rho A_{t-1} + \varepsilon^A_t$$

where $\overline{A}$ is the average productivity and ε^A_t is a productivity shock.

3.4 Government

The government faces the budget constraint

$$q_t^b B_t + \tau_t^l w_t L_t + \tau_t^k \left[\left(r_t^{nb} - \delta \right) K_{t-1}^{nb} + \left(r_t^b - \delta \right) K_{t-1}^b \right] = B_{t-1} + G_t + T_t.$$

Government outlays include the repayment of bonds issued in $t-1$, the purchase of goods and services G_t, and lump-sum transfers to households T_t. The government finances these expenditures by issuing new debt B_t and raising taxes. Taxes are levied on labor income and capital income. Labor income $w_t L_t$ is taxed at rate τ_t^l. Capital income $\left(r_t^{nb} - \delta \right) K_{t-1}^{nb} + \left(r_t^b - \delta \right) K_{t-1}^b$ is taxed at rate τ_t^k.

Government debt evolves according to the law of motion

$$\frac{B_t}{Y_t} = \left(1 - \rho^B\right) \bar{b} + \rho \frac{B_{t-1}}{Y_{t-1}} + \varepsilon_t^B$$

where Y_t is GDP. The long-run target for Treasury debt is $\bar{b}$. Thus, to replicate the empirical analysis in the context of the model, we need to study the effects of a permanent increase in $\bar{b}$.

To complete the description of the government, we need to specify three additional equations. This is because the government chooses five policy instruments (i.e., τ_t^l, τ_t^k, G_t, T_t, and B_t) and we have already provided two equations (i.e., the budget constraint and the law of motion of B_t). The three remaining equations specify the dynamic of three of the four policy instruments τ_t^l, τ_t^k, G_t, T_t, with the fourth being residually determined by the government budget constraint. In what follows, we provide equations that specify τ_t^l, τ_t^k, and G_t, so that transfers T_t are residually determined by the budget constraint. We assume taxes to be constant:

$$\tau_t^l = \bar{\tau}^l, \qquad \tau_t^k = \bar{\tau}^k$$

and government expenditure to be given by

$$\frac{G_t}{Y_t} = \left(1 - \rho^G\right) \bar{g} + \rho^G \frac{G_{t-1}}{Y_{t-1}} + \varepsilon_t^G$$

where $\bar{g}$ is the target of public expenditure as a fraction of GDP.

The choice to have transfers T_t residually determined by the budget constraint is not inconsequential, but it produces the cleanest results. Because transfers T_t enters in a non-distortionary way in the households' budget constraint. In contrast, taxes on labor and capital are distortionary, and government expenditure G_t enters the resource constraint. In the next section, we argue that some results are even stronger when taxes are allowed to adjust. We will discuss the effects of letting G_t adjust in future drafts of the paper.

3.5 Numerical examples

We use some numerical examples to illustrate the functioning of the model. Our ultimate objective is to have a fully quantitative analysis that disciplines the model and can be used for policy analysis, but we have not yet completed that step. The numerical examples are based on the effects of one-time unanticipated shocks that hit the economy in steady state.

We summarize the implications of the numerical examples by providing a series of result statements. The relevance of these results is just qualitative because our model is not fully calibrated; hence, we do not report quantitative results. The specific parameter values required for these results are not important, with two important exception. First, because we assumed that the utility of consumption and the disutility of labor are separable, we need to assume $u(C) = \log C$. This is a standard requirement to obtain a model with a balanced growth path. The requirement can be relaxed to have a more general risk aversion parameter or Epstein-Zin utility, as long as consumption and leisure utility are modeled with non-separable preferences. Second, we have solved the model under parameter values that imply that the incentive compatibility constraint of banks is binding in equilibrium.

3.5.1 Technology shocks

We begin by summarizing the effects of technology shocks. Because our model admits a balance growth path, neither temporary nor permanent technology shocks have an effect on the long-run value of aggregate variables as a fraction of GDP.

With respect to temporary shocks, the same result holds if we introduce a temporary shock that affects not only productivity but also any of the parameter of the model. Because temporary shocks are mean reverting, they do not affect the steady state of the economy and, thus, have no long-term effects.

Result 1. *The model admits a balanced-growth path. That is, from the initial steady state, and in response to a permanent shock to $\overline{A}$, the economy converges to a new steady state in which labor, government debt over GDP B/Y, investments over GDP $\delta\left(K^b + K^{nb}\right)/Y$, capital over GDP K^{nb}/Y and K^b/Y, and deposits over GDP D/Y are the same as in the initial steady-state.*

Result 2. *After a temporary shock, the economy reverts back to the original steady state. In particular, government debt over GDP B/Y, investments over GDP $\delta\left(K^b + K^{nb}\right)/Y$, capital over GDP K^{nb}/Y and K^b/Y, and deposits over GDP D/Y are the same as in the initial steady-state.*

3.5.2 Shocks to the debt-to-GDP target

Next, we study the effect of an increase in the debt-to-GDP target $\bar{b}$. We begin by letting transfers T_t adjusting in response to the change in $\bar{b}$.

Result 3. *A shock that permanently increases the debt-to-GDP target $\bar{b}$ produces the following effects:*

- *Bank deposits to GDP, D/Y, and bank lending to GDP, K^b/Y, decrease;*
- *The spread between the return on non-bank lending and government debt, $\left(r^{nb} - \delta\right) - \left(1/q_t^b - 1\right)$, decreases;*
- *Non-bank capital as a ratio to GDP, K^{nb}/Y, can increase or decrease;*
- *Investment to GDP, $\delta\left(K^b + K^{nb}\right)/Y$, decreases;*
- *GDP, Y, decreases;*
- *Transfers, T, and transfers to GDP, T/Y, could increase or decrease;*

The effect on bank deposits and bank lending follow from the substitution between deposits and government debt. Households value both deposits and government debt for their liquidity and, because of the substitutability between the two, an increase in government debt crowds out deposits. With fewer deposits, banks cut lending.

The spread between the return on non-bank lending and government debt, $\left(r^{nb} - \delta\right) - \left(1/q_t^b - 1\right)$, correspond to the spread between AAA corporate debt and Treasury debt. Krishnamurthy and Vissing-Jorgensen (2012) show that the demand for Treasury debt is downward sloping in this spread. As in the data, an increase in government debt reduces its liquidity premium and, thus, the spread.

The provision of non-bank credit to the economy (i.e., K^{nb}) can increase or decrease. This result crucially depends on the elasticity of substitution between bank capital K^b and non-bank capital K^{nb}, which is given by ν in the model (see Equation (4)). When ν is close to one, the two capital are highly substitutable. Hence, a reduction in bank lending is offset by an increase in K^{nb}. If instead ν is smaller and possibly negative, the two capital are more complements, and the reduction in bank lending triggers a reduction in K^{nb}.

The effects on investments and GDP is negative. Even if bank and non-bank capital are highly substitutable, we always assume that $\nu < 1$ in Equation (4) so that both bank and non-bank capital are used in equilibrium — as it is the case in practice. Hence, even if K^{nb} replaces K^b, the substitution is always partial, and investments drop. With the drop in investments, GDP is lower too.

The effects on fiscal variable is overall uncertain. Recall that transfers are the "residual category" in the sense that they adjust to satisfy the budget constraint. Hence, we will discuss the effects on transfers T and transfers to GDP, T/Y. Both transfers and transfers to GDP could increase or decrease, and this is related to two effects. One of this effect is in turn connected to the "r<g" in the current policy discussion, that is, the fact that empirically, the interest rate on government debt, denote by "r," is less then the growth rate of the economy, denoted by "g" (see e.g. Blanchard, 2019).

To understand the effects on transfers T, recall first that GDP drops as a result of an increase in $\bar{b}$. With a lower GDP, the government collects fewer tax revenues, and this effect reduces T. Second, if $q^b < 1$ (i.e., if the net return on government debt is positive), the government needs to get additional resources to pay the interest on higher debt, which also reduces transfers T. But if $q^b > 1$, which is the case when the liquidity premium of the government is so high that government debt earns a negative net real return, issuing additional debt allows the government to collect more revenues from the liquidity premium on government debt. This case is referred to as "r<g" in the policy discussion — in the model, "r" is $1/q^b - 1$ and in steady state, the growth rate "g" of the economy is zero. This second effect increases transfers and, if big enough, offsets the decrease in tax revenues implying that T might go up overall.

In connection to the current policy discussion, it is thus worth emphasizing that "r<g" is not a

sufficient condition that allows the government to generate more revenues by increasing government debt. The key point is that the growth rate “g” of the economy is affected by the change in the debt-to-GDP target $\bar{b}$. That is, an increase in $\bar{b}$ reduces GDP and, thus, the revenues collected through taxes. As a result, the gap between “r” and “g” needs to be sufficiently large to obtain an overall increase in government revenues associated with an increase in government debt. In this sense, it is particularly important to have derived this result in a model in which tax rates are fixed and non-distortionary transfers adjusts to satisfy the budget constraint. The result is even stronger if we fix T and allow the tax rate τ_t^l or τ_t^k to adjust to satisfy the budget constraint. That is, the revenue shortfall produced by the reduction in GDP needs to be compensated by higher tax rates, which in turn will reduce GDP even further because they increase distortions. The argument derived here complements the “r<g” analysis associated with risk (Liu, Schmid, and Yaron, 2019; Jiang et al., 2020, 2021).

4 Conclusions

Government debt is high and growing. What are its effects on the financial sector and the economy?

In the empirical evidence, we have documented the effects of higher Treasury debt to GDP on macroeconomic and financial variables. Higher debt to GDP reduces output and investments. It also reduces banks’ liabilities and bank lending, but has no effect on non-bank lending in the form of corporate bonds and non-financial commercial paper.

In the theoretical analysis, we have presented a simple dynamic model that rationalizes this result. A crucial element of the model is that government debt and bank deposits provide liquidity services to households and are substitute. Hence, an increase in government debt crowds out bank deposits and, as a result, bank lending. Investments and GDP drop, and the model can produce both an increase or decrease in non-bank lending, in line with the empirical results.

The model also provides some insights about the “r<g” policy discussion, that is, the effects of increasing government debt when liquidity premia on safe assets are high. In this case, the government essentially borrows at a negative rate, so increasing government debt boosts the seigniorage-like revenues that the government earn on its debt. But because the higher government debt crowds out bank lending and reduces GDP, total government revenues might fall. Hence, a negative real rate is not sufficient to justify additional borrowing by the government.

This paper is still a work in progress. We plan to extend our analysis to include a quantitative assessment of the model results and a policy analysis to determine the optimal level of public debt.

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