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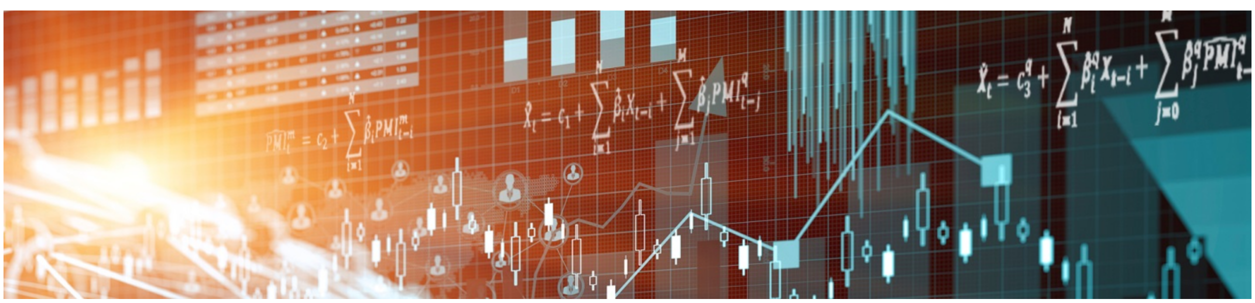
Staff Working Paper/Document de travail du personnel 2019-5

Corporate Debt Composition and Business Cycles



by Jelena Zivanovic

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Bank of Canada Staff Working Paper 2019-5

January 2019

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ISSN 1701-9397

Acknowledgements

I am indebted to Lutz Weinke. For helpful comments and suggestions, I would also like to thank Michael Burda, Frank Heinemann, Timothy Kehoe, Johanna Krenz, Maarten de Ridder, Felix Strobel, Tommy Sveen and Jaume Ventura. This work further benefited from discussions and comments by participants at the Money, Macro and Finance conference, the Dynare conference, the Workshop on Dynamic Macroeconomics in Vigo, Brown Bag seminar at Humboldt-Universitaet zu Berlin and the Bank of Canada seminar. The views expressed in this paper are those of the author and do not necessarily reflect the views of the Bank of Canada. All errors are my own.

Abstract

Based on empirical evidence, I propose a dynamic stochastic general equilibrium model with two financial sectors to analyze the role of corporate debt composition (bank versus bond financing) in the transmission of economic shocks. It is shown that in the presence of monetary and financial shocks, cyclical changes in corporate debt composition significantly attenuate the effects on investment and output. An additional result of the theoretical model is that a bank-dependent economy is more affected by financial shocks, which is in line with empirical results by Gambetti and Musso (2016), who report stronger real effects of loan supply shocks in Europe (with an excessive reliance on bank debt) than in the US.

Bank topics: Business fluctuation and cycles; Financial markets; Financial institutions; Recent economic and financial developments
JEL codes: E32, E44

Résumé

En me basant sur des données empiriques, je propose un modèle d'équilibre général dynamique et stochastique à deux volets qui permet d'analyser comment la composition de la dette des sociétés (financement bancaire et financement obligataire) joue dans la transmission des chocs économiques. Le modèle montre qu'en présence de chocs monétaires et financiers, les changements cycliques dans la composition de la dette atténuent considérablement les effets de ces chocs sur les investissements et la production. Autre résultat du modèle : les chocs financiers touchent plus durement une économie qui dépend des banques. Cette observation concorde avec les résultats empiriques de Gambetti et Musso (2016), qui révèlent que les chocs touchant l'offre de prêts ont des effets réels plus marqués en Europe, où les pays dépendent excessivement du financement bancaire, qu'aux États-Unis.

Sujets : Cycles et fluctuations économiques; Marchés financiers; Institutions financières; Évolution économique et financière récente
Codes JEL : E32, E44

Non-technical summary

Motivation and question

Recent empirical evidence documents that economic downturns in the US are associated with shifts from bank loans to corporate bonds, indicating that the composition of corporate debt (the use of bank versus bond finance) changes over the business cycle. This paper attempts to understand the role of this composition in the transmission of economic shocks.

Methodology

First, I use US data from 1973 to 2010 to estimate a structural vector autoregressive (SVAR) model with sign restrictions to analyze the effects of structural shocks on the composition of corporate debt. Second, I develop a theoretical framework with bank and bond financing, which is consistent with the SVAR model, to study to which extent the bank lending channel and the bond market channel affect macroeconomic dynamics.

Key contributions

First, I provide new evidence on the dynamics of the composition of corporate debt. Second, I integrate bank and bond financing in a tractable way in a macroeconomic model to assess the role of the composition of corporate debt for the real economy. Third, I use the model to compare the effects of structural economic shocks in the bank-dependent economy with those in the economy in which both bank and bond financing are available.

Key findings

My theoretical model predicts that the bank lending channel amplifies the effects of economic disturbances on the real economy, whereas the bond market channel attenuates these effects. A quantitative analysis with this model shows that contractions in output and investment are three times smaller in an economy with bank and bond financing than in an economy with only bank credit.

Future work

This work suggests that the composition of corporate debt is relevant for the propagation of economic shocks. In this sense, it would be interesting to explore the optimal policy design for segmented debt markets in order to better understand how the stabilization of bank and bond markets contribute to overall macroeconomic and financial stability.

1 Introduction

How do changes in corporate debt composition (bank versus bond financing) affect the propagation of macroeconomic and financial shocks? It is well documented that corporate debt composition varies over the business cycle (see, e.g., Adrian et al., 2013; Becker and Ivashina, 2014). The variation in the external debt financing mix seems to matter quantitatively for the dynamic consequences of the monetary policy shock (see empirical evidence by Kashyap et al., 1993; Oliner and Rudebusch, 1996). Therefore, it is important to understand to which extent cyclical variations in corporate debt affect the transmission of aggregate economic shocks.

To address this question, I first provide additional empirical evidence on the dynamics of real output, investment and corporate debt composition based on a structural vector autoregression (SVAR) with sign restrictions.[1] I show that the ratio of bank to bond finance falls conditional on adverse monetary and financial shocks, whereas it increases following adverse supply shocks. Second, I develop a financial dynamic stochastic general equilibrium (DSGE) model featuring bond and bank financing in order to analyze the role of debt composition in the propagation of macroeconomic and financial shocks. I show that changes in corporate debt composition dampen business cycle fluctuations by reducing the amplification of investment up to 70%. When bank credit is the only source of external financing (bank-dependent economy), financial shocks have stronger contractionary effects on real output and investment than in an economy with bank and bond finance. This result is in line with the empirical findings by Gambetti and Musso (2016), who report stronger real short-term effects of loan supply shocks in Europe than in the US. Note that the ratio of bank to bond finance is almost eight times higher in Europe than in the US (see DeFiore and Uhlig, 2011).

In the theoretical model, bank-dependent firms obtain loans, whereas mutual funds underwrite bond securities of firms with access to the bond market, which is consistent with the empirical finding by Colla et al. (2013) on debt specialization of large and small US firms. The differentiation between firms in the banking and bond sector is meant to reflect the segmentation of firms in their access to bank and bond markets, respectively. As in the model by Gertler and Karadi (2011), banks face a leverage constraint, which determines the amount of loans granted to bank-dependent firms. A tightening of bank capital constraints causes a decrease in bank supply of loans and, therefore, it captures to what extent the bank lending channel adversely affects the financing and investment decisions of firms. To model debt financing in the bond market, I use optimal debt contracts (cf. Bernanke et al., 1999) between perfectly competitive mutual funds and firms with access to corporate bond markets. The bond market channel indicates to what extent balance sheet conditions and default risks of these firms affect bond finance.

To study the dynamics of corporate debt over the business cycle, the DSGE model features supply (technology) and demand (monetary policy) shocks together with two financial shocks

[1] The sign restrictions are imposed to identify supply, monetary policy and financial shocks. Imposed sign restrictions are compatible with the predictions from a wide range of financial dynamic stochastic general equilibrium models.

that cause a disruption in the process of financial intermediation. The first one is a banking shock, which brings about a confidence loss in banks, inducing a tightening in bank credit supply and an increase in the bank spread. The second financial shock affects both bank and bond markets, causing an increase in respective credit spreads. All the shocks are calibrated to match the empirical evidence documented in the SVAR.

Two main sets of results arise from a tractable DSGE model, in which both the bank lending channel and the bond market channel operate. First, the model predicts that changes in corporate debt composition matter for the real economy regardless of economic shocks. The bond market channel reduces the amplification of investment by 10% to 70% in comparison to the model economy without this channel. The nutshell intuition for this result is the following: The functioning of the bond market is not as disrupted as that of the bank market following adverse economic shocks. In particular, the process of bank intermediation is substantially impaired, resulting in a decline in bank lending and a rise in bank spreads. The tightening of bank credit adversely affects investment projects of firms, which are dependent on bank finance (c.f., Gertler and Karadi, 2011). On the other hand, unrestricted mutual funds provide financing to firms as long as they are accordingly compensated for their default risks. As a result, firms with access to bond markets face lower costs of financing and do not divest as much as bank-dependent firms. In the aggregate, changes in corporate debt composition transmit via differential impacts on investments of bank and bond finance-dependent firms on the real economic activity. Second, following financial shocks, the monetary policy stance needs to be more aggressive in order to mitigate an economic downturn in the bank-dependent economy than in the economy that relies predominantly on bond finance. Abstracting from bond markets, the standard DSGE model with one financial (banking) market, such as Gertler and Karadi (2011) or Gerali et al. (2010), would predict a deeper recession following adverse financial shocks.

In the counterfactual experiment, in which I shut down the bond market channel, the negative effects of financial and monetary policy shocks on real output and investment are intensified through the workings of the bank lending channel. Hence, the result gives support to the view that bond (capital) markets can act as a spare tire, which was highlighted by Greenspan (1999). Disentangling the bond market channel from the bank lending channel has been achieved through the segmentation of firms in their access to bank and bond markets. The magnitude of attenuating effects associated with the bond market channel will be diminished if the model captures the reliance of large firms on bank finance. To the extent that the dependence of large firms (bond finance firms) on bank finance is limited in the US (c.f., Colla et al., 2013), the main results of the paper continue to hold.

While the theoretical results are in line with numerous empirical findings (c.f., Kashyap et al., 1993; Gambetti and Musso, 2016, including herewith provided findings), the model offers one economic mechanism to explain the role of corporate debt composition in the propagation of shocks. I do not dispute alternative explanations that address the aggregate implications of changes in corporate debt. Adrian et al. (2013) were among the first to document the change in the US corporate debt composition during the Great Recession, which they rationalize in a model with procyclical bank leverage. Crouzet (2018) shows that the ease of bank debt restructuring in firm debt choices has macroeconomic implications. Chang et al. (2017) analyze an interplay of bank and bond finance in the transmission of shocks in the open economy in order to account for the empirical evidence on the debt dynamics in emerging economies. Closest to this paper, DeFiore and Uhlig (2015) address a decline in the ratio of bank to bond finance and the relatively higher costs of bond finance during the financial crisis of 2008–09 in the euro area in the context of the DSGE model, in which firms' access to bank and bond finance depends on the risk of default. They show that the shift from bank to bond finance mitigates the negative effects of financial shocks on the real economy. Using the US data, my SVAR evidence, together with the evidence from Kashyap et al. (1993) and Oliner and Rudebusch (1996), shows that the change in the external financing mix is not only associated with financial shocks, as suggested by DeFiore and Uhlig (2015). Furthermore, estimated financial shocks generate higher bank spreads than bond spreads. In my DSGE model I allow for leveraged banks to affect credit supply conditions, whereas DeFiore and Uhlig (2015) do not explicitly model the role of banks. Therefore, my theoretical setup quantifies changes in the composition of corporate debt by analyzing the extent to which the bank lending channel and the bond market channel interact and affect macroeconomic dynamics.

Furthermore, my model suggests that financial frictions associated with bank finance à la Gertler and Karadi (2011) provide a stronger amplification mechanism than those associated with the model by Bernanke et al. (1999). This is related to work by Villa (2016), who assesses the empirical relevance of each model with financial frictions using data from the US and euro area. The Bayesian estimation of the model for the euro area favors the propagation of shocks through the bank lending channel, along the lines of Gertler and Karadi (2011). This finding is consistent with my results on the stronger amplification mechanism in the bank-dependent economy than in the economy featuring changes in the composition of corporate debt.

The remainder of the paper is organized along the following lines. Section 2 presents the empirical evidence. Section 3 describes the model setup. Section 4 discusses the main results. Section 5 concludes.

2 Empirical evidence on corporate debt composition

Earlier empirical work found that monetary contractions were associated with changes in the corporate financing mix in favor of capital market finance (see Kashyap et al., 1993, 1996; Oliner and Rudebusch, 1996). Developments in corporate credit markets during the recent financial crisis spurred renewed research interest in bank finance and capital market finance. Adrian et al. (2013) document that the Great Recession has featured a surge in corporate bond issuance and a decline in bank lending in the US. The similar empirical fact has been established by DeFiore and Uhlig (2015) for the euro area. Both works demonstrate not only that corporate debt composition changed in favor of corporate bonds but also that bond market debt got more expensive than bank debt during the Great Recession. Using the US micro-level firm data, Becker and Ivashina (2014) find that substitutions from bank loans to corporate bonds occur in times of tight bank lending standards and tight monetary policy. By analyzing a sample of advanced and emerging countries, Grjebine et al. (2018) find that economies with high dependence on corporate bond markets and strong substitution toward bond finance recover faster from recessions.

By revisiting the dynamic behavior of bank and bond finance, I address the role of corporate debt composition through the lens of the structural model. The identification of supply, monetary policy and financial shocks follows the approach by Gambetti and Musso (2016), who use a set of mutually exclusive sign restrictions to obtain a sharp identification of multiple shocks.[2] The authors focus on the real effects of loan supply shocks in the US, euro area and UK. To study the dynamics of corporate debt composition in the US, I include further credit market variables: credit, bank loans, corporate bonds, the ratio of bank finance (bank loans) to bond finance (corporate bonds), the bond spread (i.e., the GZ credit spread) and the bank spread (i.e., the difference between the bank prime rate and the federal funds rate).[3] Both corporate debt volumes and costs of debt finance are included in the empirical analysis. The ratio of bank to bond finance represents a measure of the corporate debt composition. The GZ credit spread index is constructed by Gilchrist and Zakrajšek (2012) in order to measure corporate bond financing costs of non-financial firms. For bank finance, the bank spread is supposed to capture the costs of short-term business loans.[4] Additionally, I focus on investment dynamics conditional on structural shocks because New Keynesian models or financial accelerator models propagate through the investment demand channel.

Figure 1 displays median impulse responses of macroeconomic variables based on the estimated model from 1973:Q1 to 2010:Q3. All variables are for the US and specified in logs, except for the spreads and the federal funds rate, which are expressed in percentage points. It should be noted that not every impulse response is statistically significant; however, it gives the general tendency of the variable. The respective credible sets are computed and reported in appendix A.

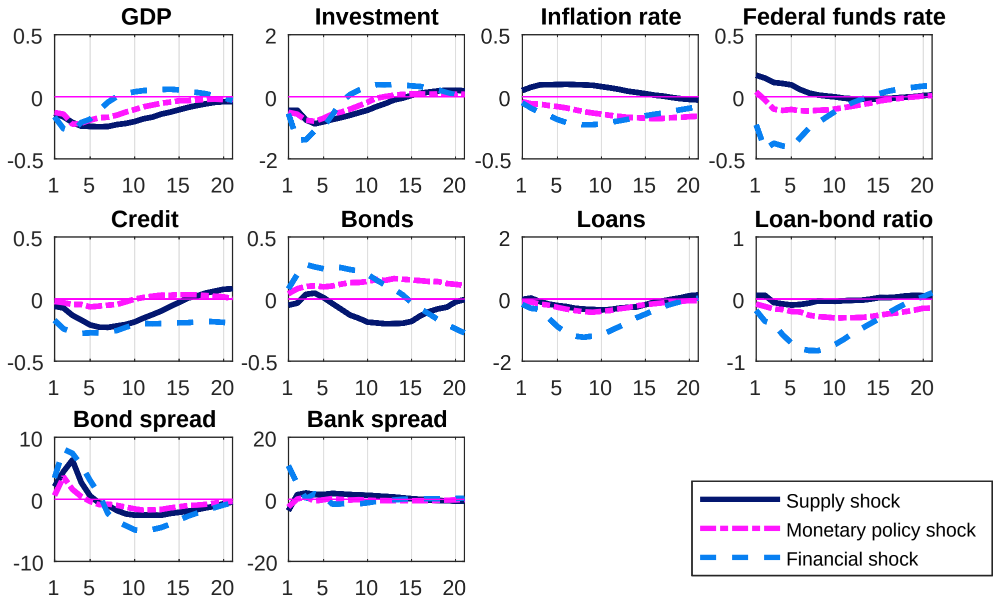
The estimated financial shock represents an exogenous disturbance to the bank spread, which increases the bank spread and decreases the credit volume. Similar to the findings by Gilchrist and Zakrajšek (2012), I show that investment and real output fall significantly in response to the adverse financial shock. The estimated adverse shock generates a decline in bank loans and an increase in corporate bonds, inducing a shift from bank to bond finance. Also, the estimated bank spread is almost three times higher than the bond spread in response to the structural financial shock. This result is at odds with the empirical observation associated with the Great

[2]See Table 2 in appendix A. The authors argue that the imposed sign restrictions comply with the predictions from a large class of New Keynesian models with financial frictions.

[3]Both spreads are assumed to represent proxies of respective finance premia or credit spreads in the theoretical model.

[4]Additionally, alternative indicators for bank spreads are available for a limited time period and, therefore, the analysis assumes that the bank spread, as a proxy, represents a lower bound on the costs of bank finance paid by firms.

Figure 1: SVAR evidence



Note: The lines denote the median of the impulse responses, which are estimated from a Bayesian VAR with 1000 draws. The impulse responses are related to an adverse one-standard deviation shock.

Recession, which is documented by Adrian et al. (2013) and DeFiore and Uhlig (2015). It suggests that higher costs of bond finance seem to be only a distinctive feature of the last financial crisis. The theoretical model can shed some light on the channels that are consistent with my evidence.

Contractionary monetary policy shocks reduce aggregate demand and prices. Conditional on the realization of the negative monetary policy shock there is an increase in bond issuance, whereas bank loans start declining after one year. Unexpected monetary tightening is associated with a decline in the ratio of bank to bond finance. This result corroborates the earlier findings by Kashyap et al. (1993) and Oliner and Rudebusch (1996). Unlike the earlier evidence, the estimated model predicts that the bond spread is higher than the bank spread following the monetary tightening.

Negative supply shocks cause a persistent decline in investment, output and debt financing (loans, bonds). Over the medium term, the bank spread rises more than the bond spread. The estimated shock causes an increase in the ratio of bank loans to corporate bonds on impact.

To summarize, the cyclical variation of the corporate debt composition differs depending on the type of shock. The structural financial shock and monetary policy shock produce a change in the corporate debt composition in favor of corporate bonds, whereas the supply shock triggers the development in the opposite direction. Bank spreads increase more in reaction to financial shocks than bond spreads. In the following, the model is proposed to study economic mechanisms and channels in the transmission of macroeconomic shocks.

3 The model

In this section, I present a medium-scale DSGE model that is able to qualitatively match the conditional dynamics of corporate debt following the economic shocks reported in section 2. To motivate the analysis of corporate debt composition, the model features two types of debt financing – bank and bond financing. I differentiate between firms that rely on bank lending and firms that have access to the bond market. The differentiation between the bank and bond sector is supposed to match the empirical notion of debt specialization of small and large US firms.[5] The reduced-form approach to the segmentation of firms in their access to bank and bond markets has been largely used in the literature (see, e.g., Bolton and Freixas, 2000, 2006; Holmstrom and Tirole, 1997; Repullo and Suarez, 2000).

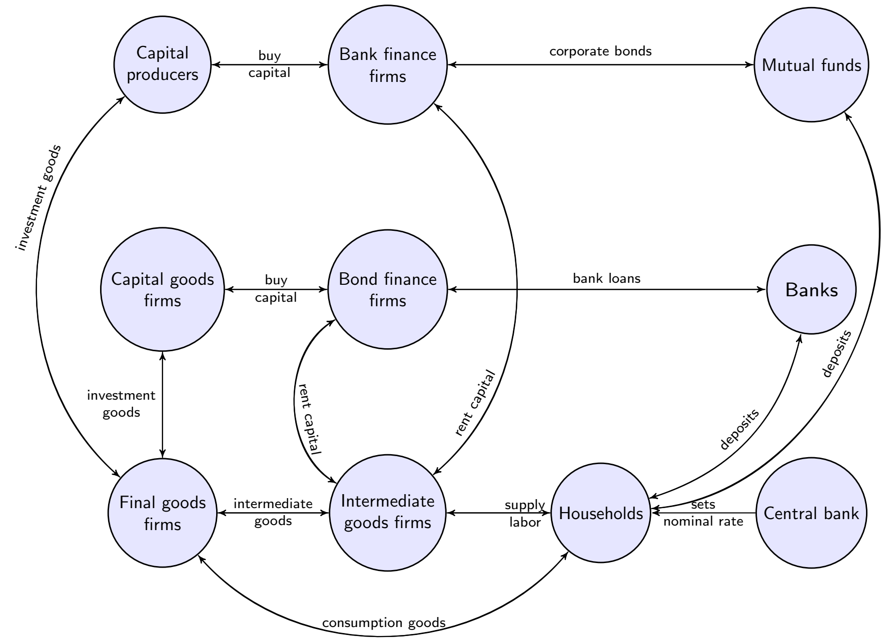
Specifically, I follow the modeling framework by Gertler and Karadi (2011), but allow for financial intermediation by mutual funds. Due to a moral hazard problem between banks and depositors, banks can supply only as much credit to bank-dependent firms as indicated by their leverage constraint. Mutual funds (or, equivalently, non-bank financial institutions such as money market funds, investment banks, etc.) are modeled as perfectly competitive financial institutions[6] along the lines of Bernanke et al. (1999). They offer underwriting services to firms with access to bond markets and help them issue corporate bond securities. The terms of the optimal bond contract specify the amounts of bonds as well as bond spreads.

The model economy is populated by seven different types of agents: households, bank and bond finance firms, intermediate firms, final goods firms, capital goods firms, lending banks and mutual funds. The bird's eye view of the model economy is given in Figure 2. Households consume, supply labor and save via depositing resources with financial intermediaries. Two types of corporate finance firms make financing decisions regarding bank loans and corporate bonds, respectively, in order to finance their investments in physical capital. Monopolistically competitive intermediate goods firms combine the physical capital from two sectors with the labor to produce differentiated products and set prices. Capital goods firms make investment decisions. Final goods producers combine all the intermediate goods and make them available to households. The central bank conducts the policy by following a Taylor-type monetary policy rule.

[5] Cantillo and Wright (2000) show that large firms use bond financing, whereas smaller firms rely only on bank financing. Colla et al. (2013) and Rauh and Sufi (2010) find that the majority of US firms tend to concentrate on one type of debt. However, a certain degree of heterogeneity in debt structure is found among the large rated firms, whereas the small unrated firms tend to specialize in bank financing.

[6] Wahal and Wang (2011) examine the market structure of mutual funds and find that the market for mutual funds is a competitive market.

Figure 2: Model overview



3.1 Households

There is a continuum of households with a unit mass. As in Gertler and Karadi (2011), I assume that a fraction f of households are workers, whereas a fraction $1-f$ manage banks. Workers earn their wage income every period, whereas bankers reinvest their profits from bank loans until they exit the banking sector. The accumulated profits are then transferred to their family. To ensure that both fractions of the households face the same consumption stream, perfect consumption insurance within the household family is assumed. The household consumes, works and saves in the form of riskless short-term government bonds (deposits), which are issued by banks and mutual funds.[7] In short, the household solves the following intertemporal maximization problem:

$$\max_{C_t, D_t, L_t} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left(\ln(C_t - hC_{t-1}) - \frac{\psi_L}{1+\phi_L} L_t^{1+\phi_L} \right)$$

subject to a sequence of constraints:

$$C_t + D_t = R_{t-1} D_{t-1} + w_t L_t + \mathit{\Pi}_t, \quad \text{for } t \in 0, 1, 2...$$

where $0 < \beta < 1$ and $\psi_L, \phi_L > 0, 0 < h < 1$ denote, respectively, the household's discount factor, the weight on the disutility of labor, the inverse of the labor supply elasticity and the degree

[7] Households do not make a portfolio choice, as both financial intermediaries pay the same return, the real interest rate, on deposits.

of habit formation. C_t denotes real consumption, w_t real wage rate, D_t holdings of one-period risk-free debt, R_t risk-free gross return between $t-1$ and t, L_t hours worked, Π_t profits from the ownership of financial and non-financial firms, net the transfers that the household gives to its members entering the financial system in t and lump-sum receipts from the cost of monitoring by mutual funds.

The first order conditions with respect to C_t, L_t and D_t are given by:

$$\lambda_t = \frac{1}{(C_t - hC_{t-1})} - \frac{\beta h}{(E_t C_{t+1} - hC_t)}, \tag{1}$$

$$1 = \beta E_t \{R_t \Lambda_{t,t+1}\}, \tag{2}$$

$$w_t = \frac{\psi_L L_t^{\phi_L}}{\lambda_t}, \tag{3}$$

where λ_t denotes the Lagrange multiplier and $\Lambda_{t,t+1} \equiv \frac{\lambda_{t+1}}{\lambda_t}$.

3.2 Intermediate goods firms

There are infinitely many monopolistic firms on the interval $[0,1]$, which produce differentiated intermediate goods. A representative firm i produces output $Y_{i,t}^m$ using labor $L_{i,t}$ and capital input $K_{i,t}$:

$$Y_{i,t}^m = A_t K_{i,t}^{\alpha} L_{i,t}^{1-\alpha}, \tag{4}$$

with $0 < \alpha < 1$, and A_t represents aggregate technology. The capital input is a composite of two types of capital, $K_{i,t}^S$ and $K_{i,t}^B$, provided by bank and bond finance firms, which are indicated by the respective superscripts S and B. This modeling construct facilitates the introduction of market segmentation or the presence of heterogeneous sectors into the representative agent model (see, e.g., Bernanke et al., 1999; Verona et al., 2013). The capital composite is given by:[8]

$$K_{i,t} = \left[\eta (K_{i,t}^S)^{\rho} + (1-\eta)(K_{i,t}^B)^{\rho}\right]^{\frac{1}{\rho}}, \tag{5}$$

where ρ is the degree of substitutability between the two types of capital services and η the share of bank finance firms.

The intermediate firm minimizes its costs by optimally choosing labor and capital inputs:

$$\min_{\{L_{i,t}, K_{i,t}^S, K_{i,t}^B\}} \quad C(\cdot) = w_t L_{i,t} + K_{i,t}^S r_{k,t}^S + K_{i,t}^B r_{k,t}^B$$

$$\text{subject to} \quad (4) \text{ and } (5).$$

[8]Note that after solving the cost minimization problem of intermediate firms and assuming symmetry, index i drops. All the individual members are identical within each group, i.e., $K_t^{S,a} = \eta K_t^S$ and $K_t^{B,a} = (1-\eta)K_t^B$, whereby $K_t^{S,a}$ and $K_t^{B,a}$ represent the sector-specific bundles of capital.

where w_t denotes the real wage and $r^S_{k,t}$ and $r^B_{k,t}$ are real rental rates of capital in the respective sector. After substituting the optimal choices back into the cost function and using symmetry, since all firms face the same input prices, the optimality condition yields the following real marginal cost s_t:

$$s_t = \frac{r^j_{k,t}}{\alpha A_t \left(\frac{L_t}{K_t}\right)^{1-\alpha} \left(K^j_t\right)^{\rho-1} \left[\eta \left(K^S_t\right)^{\rho} + (1-\eta)\left(K^B_t\right)^{\rho}\right]^{\frac{1}{\rho}-1}}, \tag{6}$$

which states that the real marginal cost equals the ratio of the rental rate of capital to the marginal product of capital of firms for each type of capital services $j \in (S, B)$.

The minimization problem also yields the optimality condition for the choice of capital services and labor hours, respectively:

$$\frac{r^{k,B}_t}{r^{k,S}_t} = \left(\frac{K^B_t}{K^S_t}\right)^{\rho-1}, \tag{7}$$

$$w_t = s_t \frac{\alpha Y^m_t}{L_t}. \tag{8}$$

Intermediate goods firms set their prices à la Calvo (1983) in order to maximize the present value of the expected future nominal profits:

$$\begin{aligned} &\max && E_t \sum_{\tau=0}^{\infty} (\beta\theta)^{\tau} \Lambda_{t,t+\tau} [(\frac{P^*_t}{P_{t+\tau}} \prod_{k=1}^{\tau} \Pi^{\iota}_{t+k-1} - S_{t+\tau}) Y_{i,t+\tau}] \\ &\text{subject to} && Y^m_{i,t+\tau} = \left(\frac{P_{i,t+\tau}}{P_{t+\tau}}\right)^{-\epsilon} Y_{t+\tau}. \end{aligned}$$

where S_t represents firms' nominal marginal costs. Parameters $\epsilon > 0, 0 < \theta < 1$ denote, respectively, the price elasticity of demand and the degree of price stickiness. The firms that cannot change prices in a given period adjust them according to the indexation rule:

$$P_{i,t} = P_{i,t-1} \Pi^{\iota}_{t-1},$$

where $\Pi_{t-1} = P_{t-1}/P_{t-2}$ is the gross inflation rate in $t-1$, and the parameter $0 \leq \iota \leq 1$ controls the degree of backward-lookingness in prices.

First order condition for optimal price setting reads:

$$E_t \sum_{i=0}^{\infty} (\beta\theta)^{\tau} \Lambda_{t,t+\tau} \left\{ \frac{P^*_t}{P_{t+\tau}} \prod_{k=1}^{\tau} \Pi^{\iota}_{t+k-1} - \frac{\varepsilon - 1}{\varepsilon} S_{t+\tau} \right\} \left(\frac{P^*_t}{P_{t+\tau}}\right)^{-\epsilon} Y_{t+\tau} = 0. \tag{9}$$

The solution of the maximization problem equates the newly set price, P^*_t, to the weighted average of all future expected marginal costs, i.e., taking into account the possibility that the newly set price could remain active forever. Using symmetric equilibrium and the law of large numbers, the aggregate price index evolves as follows:

$$P_t = \left\{(1-\theta)P_t^{*1-\epsilon} + \theta(P_{t-1}\Pi_{t-1}^{\iota})^{1-\epsilon}\right\}^{\frac{1}{1-\epsilon}}. \tag{10}$$

3.3 Corporate finance firms and debt financing

The financial sector is composed of two types of financial intermediaries: a) banks that accept deposits and lend to bank finance firms and b) mutual funds that underwrite corporate bonds issued by bond finance firms and thereby channel the funds by households (see the graphical representation in Figure 2). Each group of corporate finance firms, which are equivalent to entrepreneurs in setups by Repullo and Suarez (2000) and Verona et al. (2013), relies only on one form of finance. The modeling approach is supported by the recent findings by Colla et al. (2013) and Rauh and Sufi (2010) who show, using different samples, that the majority of US firms tend to concentrate on one type of debt. Since the share of firms in each sector is assumed to be fixed in the model, the change in the composition of corporate debt happens along the intensive margin by altering the ratio of loans to bonds in response to shocks.

Before turning to the description of debt financing in each sector, I define the ex-post return on capital. A representative (corporate finance) firm of type j makes revenues by providing capital services to intermediate producers and selling the non-depreciated capital to capital goods producers, which yields the following ex-post return on capital:

$$R_{k,t+1}^{j} = \frac{r_{k,t+1}^{j} + (1-\delta)Q_{t+1}^{j}}{Q_t^{j}}, \tag{11}$$

where Q_t^j denotes the price of capital in the respective sector. Parameter $0 < \delta < 1$ denotes the depreciation rate.

3.4 Bond financing: Optimal debt contract

Firms with access to bond markets, which are equivalent to entrepreneurs in Bernanke et al. (1999) and Christiano et al. (2010, 2014), engage in a one-period debt contract with mutual funds, convert the raw capital into the effective capital and rent it to intermediate firms. The capital purchase is financed partly by the firm's net worth, N_t^B, and partly by debt financing in the form of corporate bonds, B_t^B:[9]

$$B_t^B \equiv Q_t^B K_t^B - N_t^B. \tag{12}$$

[9] The maximization problem refers to a representative B-th bond finance firm in the B-sector; however, to simplify the notation, I will only use a "B"-superscript to refer to the variables related to the bond sector. After solving for the optimal contract, it can be shown that the solution does not depend on any individual characteristics of the firm and that all the firms in the respective sector are identical and symmetric.

An idiosyncratic shock ω_t^B affects each bond finance firm and determines how much of the raw capital turns into the effective capital. If $\omega_t^B > \bar{\omega}_t^B$, the mutual fund receives the full payment, $Z_{t+1}^B B_t^B$, where Z_{t+1}^B is the agreed rate to be paid one period later and ω_t^B follows log normal distribution, with $E(\omega_t^B) = 1$ and $Var(\ln \omega_t^B) = \sigma_\omega{}^2$. The debt contract is settled between a firm with access to bond markets and a mutual fund as follows:

$$\max_{\{\bar{\omega}_{t+1}^B, K_t^B\}} E_t \left\{ \left[1 - \Gamma_t(\bar{\omega}_{t+1}^B)\right] R_{k,t+1}^B Q_t^B K_t^B \right\} \tag{13}$$

$$\text{s.t. } E_t \left\{ \left[\Gamma_t(\bar{\omega}_{t+1}^B) - \mu G_t(\bar{\omega}_{t+1}^B)\right] R_{k,t+1}^B Q_t^B K_t^B \right\} = R_t(Q_t^B K_t^B - N_t^B), \tag{14}$$

where $1 - \Gamma_t(\cdot)$ denotes the share of average firm earnings in the bond sector. The following definitions hold: $\Gamma_t(\bar{\omega}_{t+1}^B) \equiv \bar{\omega}_t^B(1 - F_t(\bar{\omega}_{t+1}^B) + \int_0^{\bar{\omega}_{t+1}^B} \omega dF_t(\omega^B)$ and $G_t(\bar{\omega}_{t+1}^B) \equiv \int_0^{\bar{\omega}_{t+1}^B} \omega^B dF_t(\omega^B)$, where $F_t(\bar{\omega}_{t+1}^B)$ is a cumulative distribution function (and the probability of default) of ω^B. $\Gamma_t(\cdot)$ and $\mu G_t(\cdot)$ denote, respectively, the share of firm earnings received by the mutual fund and the expected monitoring costs. Perfect competition among mutual funds leads to the equalization of the expected return from the bond contract on the left-hand-side of equation 14 to the return from the riskless asset (i.e., households' deposits). Combining the first order conditions, I obtain the following relationship: $E_t R_{k,t+1}^B = E_t[\rho(\bar{\omega}_{t+1}^B) R_t \Xi_t]$, where

$$\rho(\bar{\omega}_{t+1}^B) = \frac{\Gamma_t'(\bar{\omega}_{t+1}^B)}{[(\Gamma_t(\bar{\omega}_{t+1}^B) - \mu G_t(\bar{\omega}_{t+1}^B))\Gamma_t'(\bar{\omega}_{t+1}^B) + (1 - \Gamma_t(\bar{\omega}_{t+1}^B))(\Gamma_t'(\bar{\omega}_{t+1}^B) - \mu G_t'(\bar{\omega}_{t+1}^B))]} \tag{15}$$

represents the bond finance premium or the bond spread. For the sake of comparability with the bank sector, I will use two terms interchangeably.[10] Ξ_t denotes a shock to the bond finance premium, which is modeled along the lines of Kaihatsu and Kurozumi (2014).

Defining the leverage ratio $\phi^B = \frac{Q_t^B K_t^B}{N_t^B}$ and using equation 14, one can show that there is a one-for-one relationship between the leverage ratio and the bond spread, $\phi^B = \phi(\rho(\bar{\omega}^B))$. Each bond finance firm chooses a combination of $(\bar{\omega}^B, K^B)$ or equivalently $(\bar{\omega}^B, \phi^B)$ to solve the maximization problem in (13). Since the initial net worth position does not affect the optimality condition, the leverage ratio is the same across firms in the bond sector and they pay the same bond spread.

Within one period, the bond finance firm sells the undepreciated capital to capital producers, collects the proceeds from capital rented to the intermediate goods producers and settles the debt obligation with the mutual fund. A random fraction $1 - \gamma^B$ of net worth is transferred to the household. The net worth of the firm gets accumulated with the constant lump-sum transfers of households, W^B, and the remaining γ^B fraction of the share of the bond finance firm's earnings:

$$N_t^B = \gamma^B(1 - \Gamma_{t-1}(\bar{\omega}_t)) R_{k,t}^B Q_{t-1}^B K_{t-1}^B + W^B. \tag{16}$$

[10] The bond finance premium represents a wedge between the cost of the financing firm's capital and costs of funds from the lender. In the absence of monitoring costs and the possibility of default, $(F(\bar{\omega}^B) \to 0)$, $\rho \to 1$. With costly state verification in place, monitoring arises to verify the success of a firm's projects, implying $\rho > 1$.

3.5 Bank financing

As in Gertler and Karadi (2011), banks are depository institutions that channel funds from households to bank finance firms.[11] In this process, they increase their net worth by earning return on loans:

$$\begin{aligned} N_t^S &= R_{k,t}^S Q_{t-1}^S B_{t-1}^S - R_t D_{t-1}^S, \\ &= (R_{k,t}^S - R_t) Q_{t-1}^S B_{t-1}^S + R_t N_{t-1}^S, \end{aligned}$$

where Q_t^S is the real price of the loan claim, B_t^S, N_t^S is the bank's equity capital and D_t^S denotes deposits the bank obtains from households. Due to bank misbehavior, the banker may divert a fraction λ_t^S of total assets back to his own family in the form of large bonuses. The cost to the banker is that depositors can force the intermediary into bankruptcy and recover the remaining fraction $1 - \lambda_t^S$ of assets. For depositors to give funds to the banker, the following incentive constraint must hold:

$$V_t \geq \lambda_t^S Q_t^S B_t^S,$$

which indicates that the value of diverted assets cannot exceed the terminal value of the bank.

To motivate the introduction of the banking shock, I assume that λ_t^S is time-varying. An unexpected increase in λ_t^S can be interpreted as a loss of trust in banks (see, e.g., Dedola et al., 2013). The worsening of bank mismanagement induces a reduction in funds managed by banks and subsequent credit tightening.

Following Gertler and Karadi (2011), a banker's expected terminal wealth can be rewritten as:

$$V_t = \nu_t^S Q_t^S B_t^S + \eta_t^S N_t^S,$$

whereby

$$\nu_t^S = E_t \left\{ (1-\gamma^S)\beta\Lambda_{t,t+1}(R_{k,t+1}^S - R_{t+1}) + \beta\Lambda_{t,t+1}\gamma^S \chi_{t,t+1}, \nu_{t+1}^S \right\}, \tag{17}$$

$$\eta_t^S = E_t \left\{ (1-\gamma^S) + \beta\Lambda_{t,t+1}\gamma^S z_{t,t+1}\eta_{t+1}^S \right\}. \tag{18}$$

The variable ν_t can be interpreted as the marginal gain of expanding bank assets, while η_t^S is the marginal gain of having another unit of net worth. $\chi_{t,t+i} \equiv \frac{Q_{t+i}^S B_{t+i}^S}{Q_t^S B_t^S}$ and $z_{t,t+i} \equiv \frac{N_{t+i}^S}{N_t^S}$ denote growth rates of assets and net worth, respectively. Parameter γ^S is the survival probability of bankers.

Furthermore, the agency problem restricts the bank leverage ratio to the point where the incentive to divert funds is exactly balanced by the costs of engaging in this activity. Hence, the

[11] Bank finance firms represent a veil, as they costlessly channel funds from banks to intermediate firms. There is no friction in this process. The financial friction arises in the relationship between banks and households.

amount of assets that the bank can manage will depend positively on its net worth as follows:

$$
\begin{aligned}
Q_t^S B_t^S &= \frac{\eta_t^S}{\lambda_t^S - \nu_t^S} N_t^S, && (19)\\
&= \phi_t^S N_t^S. && (20)
\end{aligned}
$$

Net worth is accumulated from revenues of bank operations and a start-up transfer from the household, $\omega^S Q_{t-1}^S B_{t-1}^S$.

$$
N_t^S = \gamma^S [(R_{k,t}^S - R_{t-1})\phi_{t-1} + R_{t-1}] N_{t-1}^S + \omega^S Q_{t-1}^S B_{t-1}^S, \tag{21}
$$

where $R_{k,t}^S - R_{t-1}$ denotes the bank spread. Note that bank loans are used to finance purchases of the productive capital:

$$
Q_t^S K_t^S = Q_t^S B_t^S.
$$

3.6 Capital goods firms

The investment decision is conducted by capital goods firms, which are owned by households. In order to account for different investment patterns of large and small firms (see, e.g., Gertler and Gilchrist, 1994), two types of capital goods firms coexist. In the perfectly competitive environment capital goods firms employ the undepreciated capital together with investment goods of type j to produce new capital of the same type. The old capital can be transformed costlessly into the new capital, whereas the convex adjustment costs are entailed in the conversion of the investment into new capital:

$$
\begin{aligned}
&\max_{I_t^j} \quad E_t \sum_{t=0}^{\infty} \beta^{t+k} \Lambda_{t,t+k} \left[q_{t+k}^j \left(1 - f\left(\frac{I_{t+k}^j}{I_{t+k-1}^j} \right) \right) I_{t+k}^j - I_{t+k}^j \right] \\
&K_t^j = \left\{ (1-\delta) K_{t-1}^j + \left(1 - f\left(\frac{I_t^j}{I_{t-1}^j} \right) \right) I_t^j \right\},
\end{aligned}
$$

with I_t^j denoting investment of type j.

The first order condition for optimal investment reads:

$$
Q_t^j = \frac{1 - \beta E_t \left\{ \Lambda_{t,t+1} f'\left(\frac{I_{t+1}^j}{I_t^j} \right) \frac{{I_{t+1}^j}^2}{{I_t^j}^2} \right\}}{1 - f\left(\frac{I_t^j}{I_{t-1}^j} \right) - f'\left(\frac{I_t^j}{I_{t-1}^j} \right) \frac{I_t^j}{I_{t-1}^j}}. \tag{22}
$$

Note that $f\left(\frac{I_t^j}{I_{t-1}^j} \right) = \frac{\xi^j}{2} \left(\frac{I_t^j}{I_{t-1}^j} - 1 \right)^2$. Parameter ξ^j measures the degree of curvature of investment adjustment cost.

3.7 Monetary policy and resource constraint

The central bank sets the nominal interest rate according to the following Taylor-type policy rule:

$$\frac{R_t^n}{R^n} = \left(\frac{R_{t-1}^n}{R^n}\right)^{\rho_r} \left(\frac{\Pi_t}{\Pi}\right)^{\alpha_\pi(1-\rho_r)} \varepsilon_t^{MP}, \tag{23}$$

where R^n and Π denote the steady-state values for nominal interest rate and inflation, R_t^n and Π_t, respectively. ε_t^{MP} is an unexpected monetary policy shock. The parameter α_π is the weight on inflation and ρ_r measures the degree of the interest rate smoothing. Note also that the Fisher relation holds, i.e., $R_t = \frac{R_t^n}{E_t \Pi_{t+1}}$. To complete the model, the aggregate resource constraint is given by:

$$Y_t = C_t + I_t,$$

where the aggregate investment is given by $I_t = \eta I_t^S + (1-\eta) I_t^B$. The market clearing for the rental market for capital, the bond and bank market implies:

$$\int_0^\infty K_{i,t}^S di = K_t^{S,a} = \eta K_t^S, \tag{24}$$

$$\int_0^\infty K_{i,t}^B di = K_t^{B,a} = (1-\eta) K_t^B, \tag{25}$$

$$B_t^{tot} = B_t^{tot,B} + B_t^{tot,S}, \tag{26}$$

where B_t^{tot} represents total credit, $B_t^{tot,S} \equiv \eta Q_t^S B_t^S$ and $B_t^{tot,B} \equiv (1-\eta)(Q_t^B K_t^B - N_t^B)$ total values of bank loans and corporate bonds, respectively. I define Υ_t as the ratio of bank to bond finance:

$$\Upsilon_t = \frac{B_t^{tot,S}}{B_t^{tot,B}}. \tag{27}$$

Finally, the goods market clearing requires that the total aggregate demand equals the total aggregate production:

$$Y_t = A_t (K_t)^\alpha (L_t)^{1-\alpha}. \tag{28}$$

The shocks follow autoregressive processes given by:

$$\ln A_t = \rho_a \ln A_{t-1} + e_{t,A}, \tag{29}$$

$$\ln \lambda_t^S = (1-\rho_G) \ln \lambda^S + \rho_G \ln \lambda_{t-1}^S + e_{t,S}, \tag{30}$$

$$\ln \Xi_t = (1-\rho_G) \ln \Xi + \rho_G \ln \Xi_{t-1} + e_{t,B}, \tag{31}$$

where $\rho_A, \rho_G \in (0,1)$ and $e_{t,x}, \sim iid(0, \sigma_x^2)$, whereby $x = \{A, S, B\}$. $e_{t,S}$ and $e_{t,B}$ denote, respectively, shocks in the banking and bond market. In the following, I consider the banking shock and the economy-wide financial shock, which is a combination of shocks originating in both markets. λ^S and Ξ represent the steady-state values of λ_t^S and Ξ_t.

4 Results

4.1 Calibration

The time unit is one quarter. Standard model parameters are calibrated in the vein of Gertler and Karadi (2011). The discount factor β is calibrated to 0.99. In the household utility function, ψ_L is chosen so that steady-state labor is one third, whereas ϕ_L, the inverse of the labor supply elasticity, is set to 0.276. In the aggregate production function, the labor share, $1-\alpha$, is 0.67. The depreciation rate δ is set at 2.5 percent. The degree of monopolistic competition ε is calibrated at 4.167. The Calvo parameter θ, giving the probability that a firm does not change price, is calibrated at 0.779. The degree of price indexation, ι, is 0.241. As far as monetary policy is concerned, the autoregressive parameter, ρ_r, is set to 0.8 and the coefficient on inflation rate, α_π, to 1.5. Similar to Gertler and Karadi (2011), I set the curvature of investment adjustment cost for both types of capital goods producers, ξ^j, to 1.728. The degree of substitutability between the two types of capital services, ρ, is set to 0.6, which is taken from Verona et al. (2013).

Table 1: Calibration

Parameter	Value	Description	Target
η	0.270	share of small firms	$\frac{Loans}{Bonds} = 0.66$
γ_S	0.959	survival probability of banks	Leverage: 4
γ_B	0.981	survival probability of large firms	Leverage: 2
λ^S	0.574	fraction of divertible bank capital	bank spread: 232bp. (annualized)
μ^B	0.060	monitoring cost (mutual funds)	GZ credit spread: 158bp. (annualized)
$F(\omega^B)$	0.0134	default probability	SG-debt: 5.37% (annualized)

The calibration of parameters related to the two sector corporate debt market captures the characteristics of the US economy, and it is presented in Table 1. The share of firms that use bank financing, η, is set so that the ratio of bank to bond finance in the US is exactly matched (0.66). The value is reported by DeFiore and Uhlig (2011). I use the GZ credit spread as a proxy for the bond spread. I calculate the bank spread as the difference between the bank prime rate and the federal funds rate.[12] The bank spread (232 basis points) is higher than the bond

[12] Alternative proxies for costs of bank finance are available for the shorter time horizon.

spread (158 basis points). Note that DeFiore and Uhlig (2011) also report that the bank spread is higher than the bond spread in the US data. Following Bernanke et al. (1999), I calibrate the leverage ratios (the ratio of total assets to equity) to 2 for the firm sector using bond finance, whereas the bank leverage is calibrated to 4, as in Gertler and Karadi (2011), who argue that the corporate sector is less leveraged than the financial sector. Together with the spreads, the leverage ratios are used to pin down the survival probabilities of large firms and banks, γ_S and γ_B, respectively. The default probability $F(\omega^B)$ is set to match the default rate on the US speculative grade debt (similar to DeFiore and Uhlig, 2011). The idiosyncratic shocks ω^B follow the log-normal distribution with $E\omega^B = 1$. Evaluating the optimality conditions of large firms in the steady-state, I obtain a value for μ^B of 0.06, which is smaller than the value of 0.19 reported by Bernanke et al. (1999). A smaller value for the calibrated parameter reflects a less severe asymmetric information problem between mutual funds and bond finance firms, as the former incur lower costs to recover firms' returns. Note that both the steady-state value of λ^S of 0.574 and the banker's survival probability of 0.959 differ from the proposed values by Gertler and Karadi (2011). This comes as a result of the higher bank spreads I used to match the data on bank loans. The steady-state values of transfers from households to bond finance firms and bankers, W^B and ω^S, are set to 0.005 and 0.002, based on Christiano et al. (2014) and Gertler and Karadi (2011), respectively.

Regarding the calibration of shock processes, I use the results from section 2 to empirically discipline my theoretical model. In particular, I specify the standard deviation and the persistence of shocks so that the theoretical response of output exactly matches the median of the empirical counterpart on impact and falls within the estimated credible set afterwards. The impulse response matching leads to the following values of parameters: $\rho_A = 0.70$, $\rho_G = 0.70$, $\sigma_A = 0.015$ and $\sigma_S, \sigma_B = 0.05$.[13]

4.2 Model comparison: Does the corporate debt composition matter?

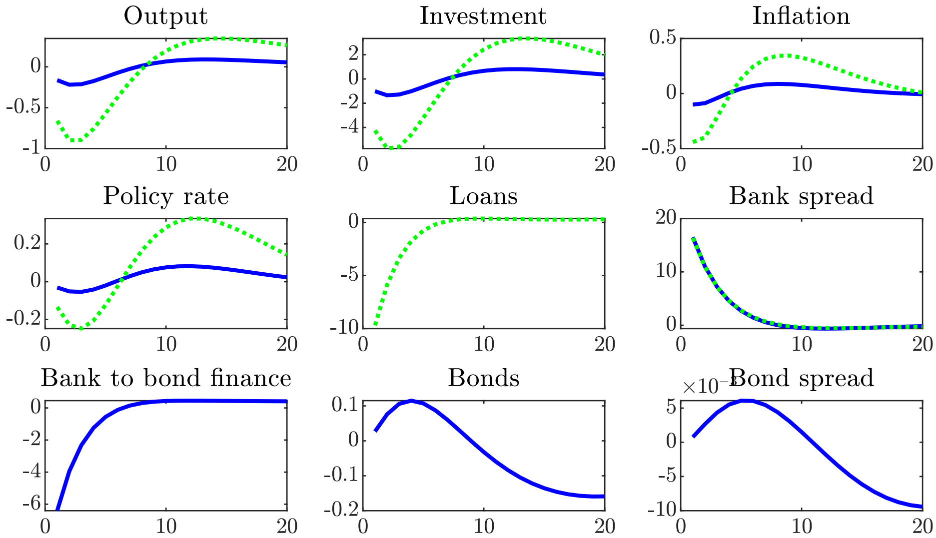
To understand how the composition of corporate debt affects the propagation of the shocks, I compare the model economy with both bond and bank markets (benchmark case) with an economy relying only on bank credit.[14] In the counterfactual experiments, I set the share of the bond market to 0, which results in one source of capital and one financial (banking) market. Both model economies are buffeted by a shock process of the same size.

Figure 3 displays the responses of the two model economies with financial markets to the banking shock (as a shock to λ^S). The theoretical counterpart of the empirical loan supply shock estimated in section 2 can be a result of a confidence loss in the banking sector (as described by

[13]For two financial shocks, the standard deviation is chosen to match a rise in the credit spread(s), in addition to matching the response of output on impact. In the case of the banking shock, its standard deviation is calibrated to 0.11.

[14]The alternative exercise can refer to the comparison of an economy with a stronger reliance on bank credit (European-type economy) to an economy with a predominance of bond markets (US). The calibrated value for the ratio of bank loans and corporate bonds can be adjusted, so that it reflects the debt composition in Europe. The European-type model economy would fall in between the two model economies considered above.

Figure 3: Adverse banking shock



Note: Green dashed lines refer to the dynamics of the model economy with the banking sector. Blue lines refer to the benchmark model economy. Nominal interest rate, the ratio of bank to bond finance and spreads are reported in absolute deviations; the remaining variables are expressed in percentage deviations. Interest rates and spreads are reported in annualized terms. Horizontal axes display quarters after the shock.

Dedola et al., 2013) and leads to tightening in lending standards. The shock increases the incentive of bankers to divert assets, which induces a disruption in the bank intermediation process. As a result, bank spreads need to increase to make bank operations profitable.[15]

It might not be surprising that the tightening of bank credit standards results in stronger real effects in the model economy, which relies on bank credit, than in the benchmark economy. The latter economy features a change in corporate debt composition in favor of bonds (c.f., a decline in the ratio of bank to bond finance in figure 3). The model predictions suggest that the bond market channel acts as a spare tire in the banking crisis (Greenspan, 1999). To quantify the effect of this channel in the presence of the banking shock, I find that the decline in output and investment is almost three times smaller in the benchmark economy. In the absence of the attenuating effect of the bond market channel, the model predicts that an aggressive monetary policy stance is necessary in order to mitigate a disruption in the bank intermediation process. Hence, the model seems to suggest that an economy with well-developed capital markets seems to be shielded from negative effects of shocks originating in the banking market. Furthermore, the model generates an increase in bond issuance and a decline in bank loans conditional on the realization of financial shock, which is consistent with my SVAR evidence documented in appendix B. These predictions are also in line with the unconditional evidence on the sources of

[15]The theoretical model does not generate any change in the bond spread, which does not match the empirical evidence on rising costs of bond finance. In the following, I will also consider the shock to the bond market.

the US corporate debt financing reported by Adrian et al. (2013).

It is worth mentioning that the model offers one theoretical mechanism that explains the propagation of banking shocks, which is in line with the empirical evidence by Gambetti and Musso (2016). The authors document that real short-term effects of loan supply shocks[16] are stronger in Europe than in the US. Note that European firms rely predominantly on bank debt, whereas bond (capital) markets are an important source of US firm financing. The ratio of bank to bond finance is nine times higher in the euro area than in the US (see DeFiore and Uhlig, 2011).

The propagation of the banking shock is effective mainly through the bank lending channel. Since bank finance firms rely only on bank loans, they curtail their investment spending as a result of loan supply restrictions. Lower capital demand leads to a decline in the price of capital and investment of these bank-dependent firms. On the other hand, firms with access to bond markets are not affected by the shock, i.e., the determinants of the bond spreads (the leverage ratio and the default threshold) remain unaltered. Hence, these unconstrained firms can issue bonds to finance capital purchases, as depicted in Figure 3. Good financing conditions of firms using bond market financing affect their investment activities favorably, which in turn dampens the overall response of investment and output in the benchmark economy.

Figure 3 also highlights a recovery in the banking sector in both economies. In the context of high bank spreads, bank profitability improves rapidly and trust in the banking system is restored. As a consequence, bank balance sheet conditions stabilize and banks are willing to extend loans to firms.[17]

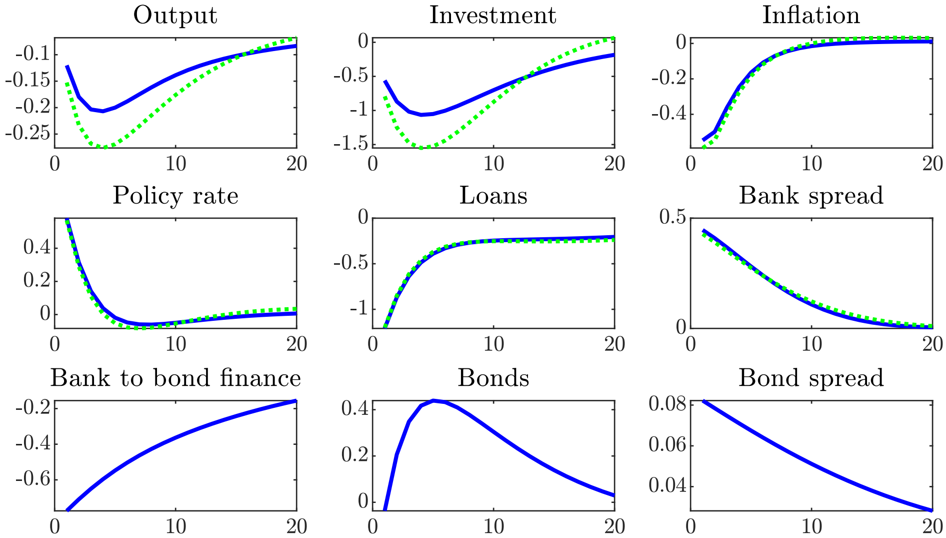
Next, I compare the economy's response to the monetary policy shock if the corporate debt market features the heterogeneous financial structure (banks and mutual funds) with the economy in which firms rely only on bank finance. Figure 4 depicts the dynamics of two model economies.

Model predictions suggest that the bank lending channel is an important part of the monetary transmission mechanism. For example, bank loans decline by 1.2% on impact in both economies in response to unexpected monetary tightening. Leveraged banks reduce credit to firms in order to meet their capital requirements, which causes a substantial decline in investment of bank-dependent firms. In the benchmark model version, bond issuance increases by 0.4%, which is in line with my SVAR evidence. The availability of bond financing subdues the adverse effects of shocks since bond finance firms can issue corporate bonds to maintain their capital purchases. Unconstrained mutual funds are willing to accommodate the demand for external finance as long as they are compensated for possible default risks, captured by an increase in the bond spread. A

[16]The dynamic consequences of the loan supply shock, identified by an increase in the lending rate and a decline in the credit volume on impact in SVAR by Gambetti and Musso (2016), are consistent with the reactions of respective variables in my theoretical setup.

[17]The recovery of real output and bank profitability following the banking shock echoes a narrative associated with the recovery of the US banks after the financial crisis of 2007–2009 in The Economist (2017, "American banks have recovered well; many European ones much less so") in terms of the recapitalization of banks and charging profitable margins.

Figure 4: Adverse monetary policy shock

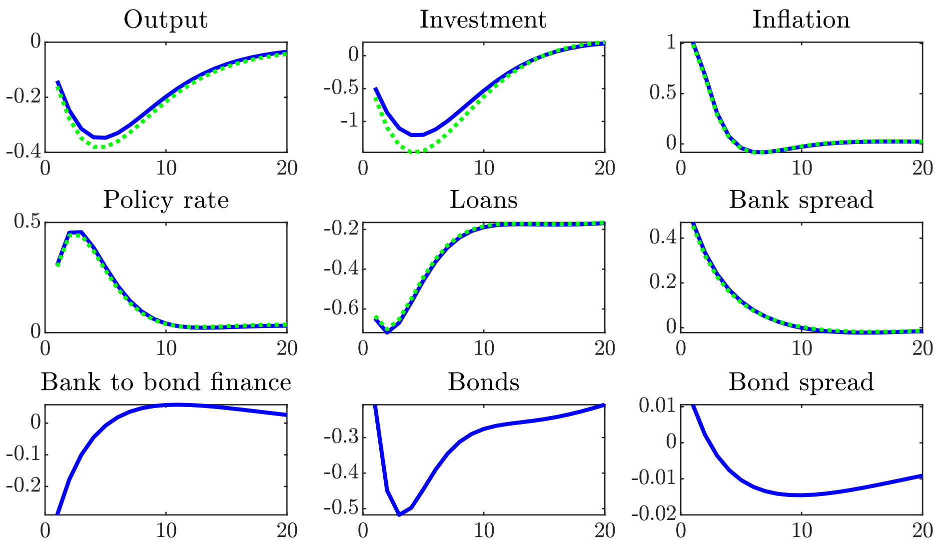


Note: Green dashed lines refer to the dynamics of the model economy with the banking sector. Blue lines refer to the benchmark model economy. Nominal interest rate, the ratio of bank to bond finance and spreads are reported in absolute deviations; the remaining variables are expressed in percentage deviations. Interest rates and spreads are reported in annualized terms.

modest rise in bond issuance does not eliminate the credit squeeze present in the banking sector; however, it indicates that the economy's change in corporate debt composition helps mitigate the effects of this shock. The reason is that firms with access to bond markets do not divest as strongly as the bank-dependent firms. As a result, the maximum reactions of investment and output in the benchmark economy are 30% lower than in the bank-dependent economy. This result echoes the empirical findings on the shift from bank loans to capital market finance and its repercussions for investment following tight monetary policy (see Kashyap et al., 1993). Using the VAR framework, Ciccarelli et al. (2015) study the bank lending channel and the firm borrower's channel in the transmission of monetary policy in the euro area and the US. They find support for the stronger propagation of monetary policy shocks through the bank lending channel in the euro area, whereas the firm borrower's channel is more important in the US. The amplification of the monetary policy shock in the bank-dependent economy is in line with these empirical findings.

The dynamic consequences of a technology shock are shown in Figure 5. Both model versions generate roughly the same effects on output, investment and nominal interest rate. The technology shock affects mainly the production capability of the intermediate goods producers, who reduce capital demand in the face of lower productivity. This induces a fall in external financing, with slight differences between the sectors and two different model economies with financial markets. In the absence of the bond market channel, the reduction in investment spending would be

Figure 5: Adverse technology shock



Note: Green dashed lines refer to the dynamics of the model economy with the banking sector. Blue lines refer to the benchmark model economy. Nominal interest rate, the ratio of bank to bond finance and spreads are reported in absolute deviations; the remaining variables are expressed in percentage deviations. Interest rates and spreads are reported in annualized terms.

10% more pronounced. As the needs for external financing in bond and bank markets develop similarly, the composition of corporate debt changes only slightly and does not matter for the real output.[18]

Note that the changes in spreads following the technology shock are much smaller than the reactions of spreads in the banking shock scenario. Similarly, the other financial variables are much less responsive to the technology shock. Therefore, the propagation of the shock through the financial sector is rather negligible. On impact, banks reduce provision of loans relatively less compared to the bond issuance volumes, which can be seen in an initial decrease of the ratio of bank to bond finance. This stands in contrast to the empirical model, which generates an increase in the ratio of bank to bond finance on impact in response to the aggregate supply shock (see appendix B). The ratio increases in the theoretical model over the medium term. The reason for this is that the bank market gets stabilized faster than the bond market.

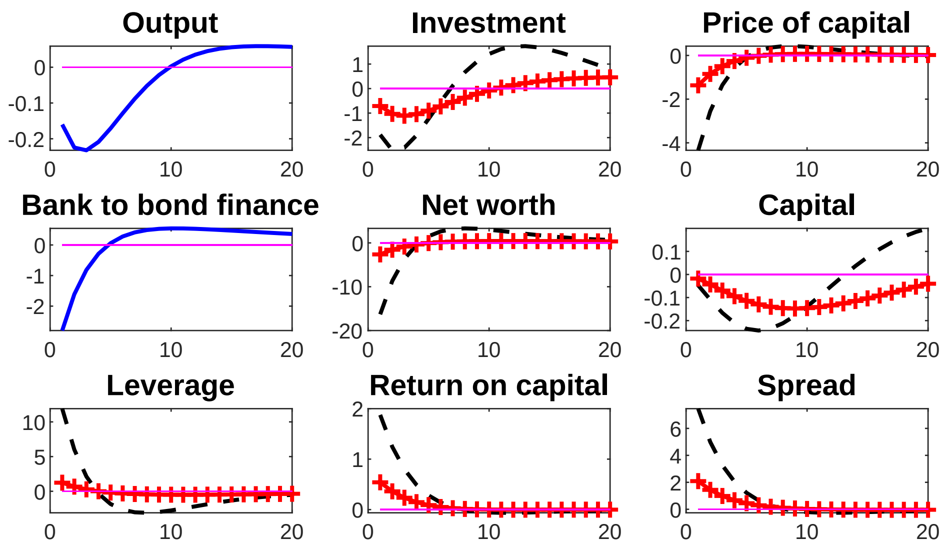
4.3 Inspecting the mechanism: Financial and monetary policy shocks

In order to gain further intuition about the relevance of variations in the corporate debt for the real economy, I examine monetary and financial shocks in more detail because these shocks

[18]The effects of the technology shock in the benchmark economy are discussed in appendix C.

generate changes in corporate debt that matter for the real activity. Figure 6 displays the impulse responses of some key real and financial variables to an adverse financial shock affecting the bank and bond market simultaneously in the benchmark economy. In particular, this economy-wide financial shock leads to an increase in distrust of the banking sector and an increase in bond financing costs. The reason for this specification is to further empirically discipline the model using my SVAR evidence with respect to bank and bond spreads.[19]

Figure 6: Adverse financial shock



Note: Blue lines refer to the variables associated with the banking sector, whereas the red lines refer to the bond sector. Black dashed lines refer to the aggregates. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations.

The unexpected confidence loss in banks makes bank balance sheets deteriorate, reducing the amount of intermediated credit and bank net worth. Banks start the process of deleveraging, which comes to an end after five periods. The bank lending channel highlights how the decline in bank loan supply adversely affects investment outcomes of firms that rely on bank finance. As bank-dependent firms reduce their investment demand initially, the price of capital falls, inducing a rise in the expected return on capital. The buildup of capital and the rebound in the price of capital is associated with the higher investment demand after ten periods, which is then financed through recapitalized banks.

Interestingly, the model predicts a fast recovery of the banking sector. The reason is that banks can rather quickly restore their profitability by charging high bank spreads. As a conse-

[19] Both the banking shock and the economy-wide financial shock (i.e., the shock to both financial sectors) result in a disproportionately higher increase in the bank spread relative to the bond spread, as documented in the SVAR evidence. The specification of the economy-wide financial shock additionally generates a rise in the bond spread.

quence, banks stabilize their balance sheet positions and start extending loans to firms. Once banks are well-capitalized, they intermediate loans that bank-dependent firms use for financing capital purchases.

Despite an increase in the bond spread following a shock to the bond sector, firms with access to bond markets are not affected as much as bank-dependent firms. The model economy tends to shift towards relatively cheaper sources of financing and employs more capital financed by bond finance firms. The economic rationale behind this result is the following: Since the leverage and net worth of bond finance firms are not strongly altered, the default risks associated with bond finance are maintained low, resulting in a small increase in the bond spread. As a result, the aggregate corporate debt composition changes in favor of corporate bonds. It follows that the investment demand of firms using bond finance does not decline as strongly as the sector relying on bank finance.

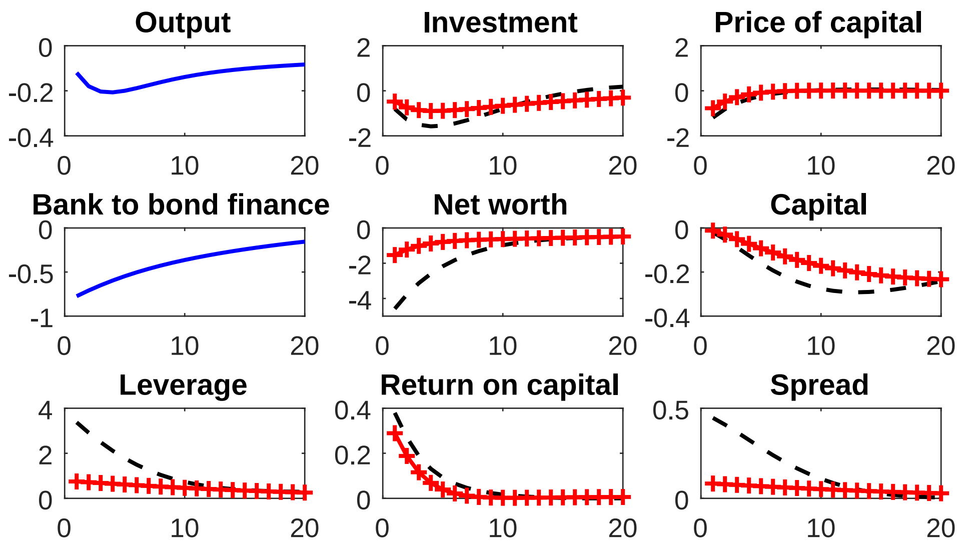
Model predictions suggest that the bond sector acts as an absorber of negative financial shocks. The decline in output and investment is 40% smaller than in the economy that relies on the bank debt (not shown). To measure the differential impact of the shock to corporate bond markets, I compare the benchmark economy under the banking shock scenario and the financial shock scenario. In this counterfactual exercise, I find that the reductions of output and investment are two times more exacerbated than those arising in the absence of disturbances to the bond market. Put differently, the disturbance to the bond sector makes bond finance costlier, which in turn dampens the positive effect of the bond market channel on the real economy. Since I use my SVAR evidence to empirically discipline the DSGE model, the introduction of the disturbance to the bond intermediation process reproduces an increase in the bond spread, documented in the data.

The dynamic effects of the economy-wide financial shock on investment and corporate debt composition qualitatively match their empirical counterparts presented in figure 9 in appendix B. Note that the model replicates the trough and the rebound in investment documented in the SVAR model. It also generates a decline in the ratio of bank to bond finance, but it falls short of reproducing the persistence seen in the data.

Figure 7 presents the responses of key variables in the benchmark model following the negative monetary policy shock. An unexpected increase in the policy rate leads to a decline in aggregate demand. The lower demand for goods and capital depresses inflation and the price of capital. Low asset price valuations decrease bond finance firms' and banks' net worth, which worsens their balance sheet positions and leads to an increase in respective leverage ratios. As a result, both spreads increase after the contractionary monetary policy shock.

The benchmark model economy features a decline in the ratio of bank loans to corporate bonds as a result of different dynamics of the two markets. Bond issuance increases in order to close the gap between the capital purchases and the net worth of firms with access to bond markets. Unconstrained mutual funds accommodate the demand for external finance, since they are accordingly compensated for default risks of leveraged bond finance-dependent firms. The

Figure 7: Adverse monetary policy shock



Note: Black dashed lines refer to the variables associated with the banking sector, whereas the red lines refer to the bond sector. Blue lines refer to the aggregates. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations.

rise in the default threshold together with an increase in the leverage leads to a rise in the bond spread. The bond market channel attenuates the propagation of the monetary policy shock because the availability of bond financing helps firms to mitigate the reductions in investment spending. On the other hand, banks find that their balance sheets shrink as a result of lower asset valuations. This translates into a strong decline in their net worth and a tighter leverage constraint. To comply with their capital requirement, banks reduce the intermediation of loans, which negatively affects investment spending. The investment slump is aggravated as a result of bank leverage constraints and high bank spreads. The higher costs of bank finance translate into a stronger divestment of bank-dependent firms than bond finance firms, which matches the empirical evidence of Gertler and Gilchrist (1994) on the behavior of investment by large and small US manufacturing firms in periods of monetary tightening.

The change in corporate debt composition in favor of bonds matches well my SVAR evidence, as well as the evidence by Kashyap et al. (1993) and Oliner and Rudebusch (1996). However, the theoretical model falls short of reproducing a relatively stronger increase in the median bond spread documented in figure 11. While the model prediction might be at odds with the data, most of the theoretical impulse responses fall into the credible sets, implied by the structural model. It should be noted that the theoretical model generates a strong increase in the nominal interest rate in order to match a decline in the real activity. Furthermore, the DSGE model proposes a mechanism where bank finance and investment decisions are so costly that the bank lending channel intensifies a fall in the aggregate demand. During the monetary tightening, the corporate bond market acts a spare tire as it features a smaller contraction in financial intermediation and investment than the banking sector.

The model shows that the transmission of monetary policy shocks, as depicted in Figure 7, is altered if the heterogeneity of sectors relying on different types of financing is considered. The propagation of the monetary policy shock through the bank lending channel has already been documented in the literature (see, e.g., Gertler and Karadi, 2011). My model setup highlights the attenuating role of the bond market channel, and, hence, the relevance of corporate debt composition.

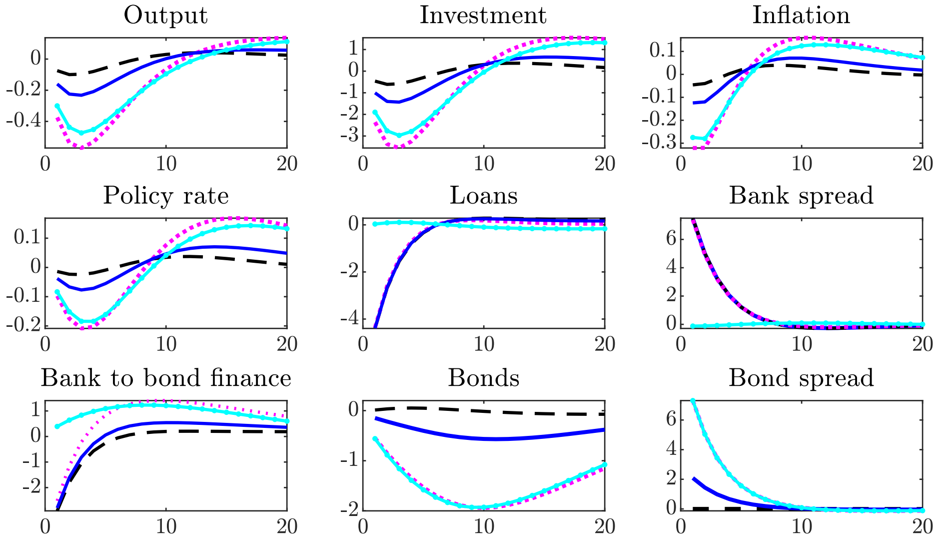
4.4 Sensitivity analysis

In this section, I evaluate macroeconomic implications of four different shocks: the shock to the banking sector, the shock to the bond sector and two economy-wide financial shocks. For comparability, shocks are calibrated so that credit spreads rise by the same amount. For example, the shock to the bond market is calibrated to generate an increase in the bond spread comparable to the one in the bank spread following the banking shock.[20] The first economy-wide financial shock, modeled as in figure 7, matches my SVAR evidence, while the second one is modeled so that the shock generates a comparable increase in both spreads. The dynamics of main economic variables are depicted in figure 8. The purpose of this exercise is to analyze how different types of financial disturbances affect the workings of the bank lending channel and the bond market channel.

Figure 8 provides some further perspective on the relevance of corporate debt composition. First, sources of financial disturbances are important for the propagation of shocks through the bank lending channel and the bond market channel. The attenuating effect of the latter channel is strong if the economy is affected by banking shocks or if the functioning of the bond market is not severely disrupted. Second, changes of the composition of corporate debt in favor of bank loans arise only if the economy is affected by shocks to the bond sector; however, this development cannot neutralize the effects of these shocks. The explanation for this result appears to be that a large fraction of firms is adversely affected by negative shocks to the bond sector, and favorable bank lending conditions cannot counteract an ensuing credit crunch in the bond market. Third, the model predicts that the bond market channel is considerably diminished if shocks generate a substantial rise in bond spreads. In particular, if financial shocks lead to comparable rises in bank and bond spreads, changes in corporate debt composition in favor of corporate bonds are not necessarily associated with an improvement in macroeconomic outcomes. By varying the extent to which the bond market is disrupted, I show that increasing costs of bond finance

[20]The shock to the bank market is calibrated so that the rise in the bank spread is equivalent to the one in the benchmark economy hit by the economy-wide shock. Hence, it does not generate as large an output contraction as implied by the banking shock presented in Figure 3.

Figure 8: Different types of financial shocks



Note: Black dashed lines refer to economy dynamics following the shock to the banking sector, blue lines refer to the economy if both bank and bond markets are affected by shocks. The model dynamics following the shock to the bond sector are depicted in cyan, whereas magenta dotted lines refer to the economy-wide financial shock, which increases bond and bank spreads by the same magnitude.

discourage the intermediation in the bond market, which in turn results in strong divestments of firms with access to bond markets. This leads to a stronger decline in the real economic activity in comparison to the model economy being perturbed only by banking shocks. Hence, the caveat applies that the source of financial disturbance appears to be relevant for aggregate implications of bank and bond finance.

5 Conclusion

The Great Recession featured a surge in corporate bond issuance and a decline in bank loans in the US, which indicates that corporate debt composition changes over the business cycle (c.f., Adrian et al., 2013). This work addresses the relevance of corporate debt composition for the aggregate economy in the following manner: First, I provide new empirical evidence on the conditional dynamics of corporate debt composition. Second, I develop a DSGE model with bank and bond finance to understand the role of the composition of corporate debt in the transmission of economic shocks.

My empirical results show that the ratio of bank to bond finance, i.e., the measure of corporate debt composition, falls conditional on financial and monetary policy shocks, whereas it rises following supply shocks. Estimated aggregate supply and monetary policy shocks generate a persistent decline in investment and a persistent variation in corporate debt, whereas the reactions of both variables are short-lived in response to financial shocks.

To what extent does the composition of corporate debt matter for output and investment? To understand how the availability of bank and bond finance affects the propagation of shocks, I compare an economy with both a bond market and a banking market (benchmark economy) to an economy relying only on bank credit. The results indicate that access to bond finance reduces the negative effects of adverse financial and monetary policy shocks on the real economy. The intuition is the following: Shocks that affect bank balance sheets in an adverse way lead to a reduction in funds intermediated by banks and a rise in bank spreads. The reason is that leveraged banks have to comply with capital requirements. The bank lending channel highlights how the unavailability of bank loans for bank-dependent firms adversely affects the investment spending of these firms. Mutual funds, which are not subject to any leverage constraints, are willing to underwrite bonds in return for higher bond spreads. The effective bond market channel attenuates the effects of contractionary shocks on the investment of firms with access to bond markets. The interplay of the bank lending channel and the bond market channel leads to the cyclical variation in the aggregate corporate debt composition. This is relevant for the propagation of financial and monetary policy shocks in the economy because the sector dependent on bank finance reduces investment much more than the sector dependent on bond finance. The model suggests that changes in the corporate debt composition in favor of bonds can help absorb some business cycle fluctuations. If bank credit is the only source of external finance, the contractions in real investment and output can be up to three times larger than in the case of the benchmark economy.

This paper shows that the bank lending channel amplifies the effects of economic disturbances on the real economy, whereas the bond market channel dampens these effects. In future work, it would be interesting to explore the optimal policy design for segmented debt markets in order to better understand how the stabilization of bank and bond markets contribute to the overall macroeconomic and financial stability.

References

Adrian, T., Colla, P., and Shin, H. S. (2013). Which financial frictions? Parsing the evidence from the financial crisis of 2007 to 2009. *NBER Macroeconomics Annual*, 27(1):159–214.

Becker, B. and Ivashina, V. (2014). Cyclicality of credit supply: Firm level evidence. *Journal of Monetary Economics*, 62:76–93.

Bernanke, B. S., Gertler, M., and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of Monetary Economics*, 1(C):1341 – 1393. Edited by John B. Taylor and Michael Woodford.

Bolton, P. and Freixas, X. (2000). Equity, bonds, and bank debt: Capital structure and financial market equilibrium under asymmetric information. *Journal of Political Economy*, 108(2):324–351.

Bolton, P. and Freixas, X. (2006). Corporate finance and the monetary transmission mechanism. *Review of Financial Studies*, 19(3):829–870.

Calvo, G. A. (1983). Staggered prices in a utility-maximizing framework. *Journal of Monetary Economics*, 12(3):383 – 398.

Cantillo, M. and Wright, J. (2000). How do firms choose their lenders? An empirical investigation. *Review of Financial Studies*, 13(1):155–189.

Chang, R., Fernández, A., and Gulan, A. (2017). Bond finance, bank credit, and aggregate fluctuations in an open economy. *Journal of Monetary Economics*, 85:90 – 109.

Christiano, L. J., Motto, R., and Rostagno, M. (2010). Financial factors in economic fluctuations. Working Paper Series 1192, European Central Bank.

Christiano, L. J., Motto, R., and Rostagno, M. (2014). Risk shocks. *American Economic Review*, 104(1):27–65.

Ciccarelli, M., Maddaloni, A., and Peydró, J.-L. (2015). Trusting the bankers: A new look at the credit channel of monetary policy. *Review of Economic Dynamics*, 18(4):979 – 1002.

Colla, P., Ippolito, F., and Li, K. (2013). Debt specialization. *Journal of Finance*, 68(5):2117–2141.

Crouzet, N. (2018). Aggregate implications of corporate debt choices. *The Review of Economic Studies*, 85(3):1635–1682.

Dedola, L., Karadi, P., and Lombardo, G. (2013). Global implications of national unconventional policies. *Journal of Monetary Economics*, 60(1):66 – 85.

DeFiore, F. and Uhlig, H. (2011). Bank finance versus bond finance. *Journal of Money, Credit and Banking*, 43(7):1399–1421.

DeFiore, F. and Uhlig, H. (2015). Corporate debt structure and the financial crisis. *Journal of Money, Credit and Banking*, 47(8):1571–1598.

Economist (2017). American banks have recovered well; many european ones much less so. Special report: A decade after the financial crisis, how are the world's banks doing?

Gambetti, L. and Musso, A. (2016). Loan supply shocks and the business cycle. *Journal of Applied Econometrics*, 32(4):764–782.

Gerali, A., Neri, S., Sessa, L., and Signoretti, F. M. (2010). Credit and banking in a DSGE model of the euro area. *Journal of Money, Credit and Banking*, 42:107–141.

Gertler, M. and Gilchrist, S. (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. *The Quarterly Journal of Economics*, 109(2):309–340.

Gertler, M. and Karadi, P. (2011). A model of unconventional monetary policy. *Journal of Monetary Economics*, 58(1):17–34.

Gilchrist, S., Yankov, V., and Zakrajšek, E. (2009). Credit market shocks and economic fluctuations: Evidence from corporate bond and stock markets. *Journal of Monetary Economics*, 56(4):471–493.

Gilchrist, S. and Zakrajšek, E. (2012). Credit spreads and business cycle fluctuations. *American Economic Review*, 102(4):1692–1720.

Greenspan, A. (1999). Do efficient financial markets mitigate financial crises? Remarks at the Financial Markets Conference of the Federal Reserve Bank of Atlanta, Sea Island, Georgia. https://www.federalreserve.gov/newsevents/speech/1999speech.htm.

Grjebine, T., Szczerbowicz, U., and Tripier, F. (2018). Corporate debt structure and economic recoveries. *European Economic Review*, 101:77 – 100.

Holmstrom, B. and Tirole, J. (1997). Financial intermediation, loanable funds, and the real sector. *The Quarterly Journal of Economics*, 112(3):663–691.

Kaihatsu, S. and Kurozumi, T. (2014). Sources of business fluctuations: Financial or technology shocks? *Review of Economic Dynamics*, 17(2):224 – 242.

Kashyap, A. K., Stein, J. C., and Wilcox, D. W. (1993). Monetary policy and credit conditions: Evidence from the composition of external finance: Reply. *American Economic Review*, 83(1):78–98.

Kashyap, A. K., Stein, J. C., and Wilcox, D. W. (1996). Monetary policy and credit conditions: Evidence from the composition of external finance: Reply. *American Economic Review*, 86(1):310–14.

Oliner, S. D. and Rudebusch, G. D. (1996). Monetary policy and credit conditions: Evidence from the composition of external finance: Comment. *American Economic Review*, 86(1):300–309.

Rauh, J. D. and Sufi, A. (2010). Capital structure and debt structure. *Review of Financial Studies*, 23(12):4242–4280.

Repullo, R. and Suarez, J. (2000). Entrepreneurial moral hazard and bank monitoring: A model of the credit channel. *European Economic Review*, 44(10):1931–1950.

Verona, F., Martins, M. M. F., and Drumond, I. (2013). (Un)anticipated monetary policy in a DSGE model with a shadow banking system. *International Journal of Central Banking*, 9:73–118.

Villa, S. (2016). Financial frictions in the Euro Area and the United States: A Bayesian assessment. *Macroeconomic Dynamics*, 20(5):1313–1340.

Wahal, S. and Wang, A. Y. (2011). Competition among mutual funds. *Journal of Financial Economics*, 99(1):40 – 59.

Appendices

Appendix A

A.1 Data and Sources

Real GDP: GDP (seasonally adjusted), divided by GDP deflator. Source: FRED.
Investment: Business equipment (seasonally adjusted), divided by GDP deflator. Source: FRED.
GDP deflator. Source: FRED.
Nominal short-term interest rate: effective federal funds (FF) rate (secondary market rate), expressed in annual units and in percent. Source: FRED.
Credit: sum of corporate bonds, bank loans and other loans and advances (non-financial corporate business). Source: FRED.
Loans: commercial and industrial loans. Source: FRED.
Bonds: corporate bonds (non-financial corporate business). Source: FRED.
Debt composition (the ratio of bank to bond finance): ratio of bank loans to corporate bonds. Source: FRED.
CB spread: GZ credit spread. Source: Gilchrist et al. (2009).
BP spread: bank prime rate - FF rate, expressed in annual units and in percent. Source: FRED.

A.2 SVAR model and empirical results

Table 2 summarizes the set of sign restrictions based on major financial (New Keynesian) models. The identification follows the approach by Gambetti and Musso (2016); however, within my model, I impose a restriction on the bank spread instead of the bank lending rate. The key variables of interest, the corporate debt composition (the ratio of bank to bond finance) and investment, are left unrestricted. The estimated model results are reported in the following section.

Table 2: Identification of the SVAR model

	Supply	Monetary	Financial
Real GDP	-	-	-
Investment	NA	NA	NA
GDP deflator	+	-	-
Federal funds rate	NA	+	-
Credit	NA	NA	-
Loans	NA	NA	NA
Bonds	NA	NA	NA
Bank to bond finance	NA	NA	NA
Bond spread	NA	NA	NA
Bank spread	NA	NA	+

Notes: A "+" indicates that the impact response is positive; a "-" indicates that the impact response is negative; "NA" indicates an impulse response can be either positive or negative. Restrictions are imposed only on impact. All the shocks represent adverse disturbances.

Appendix B

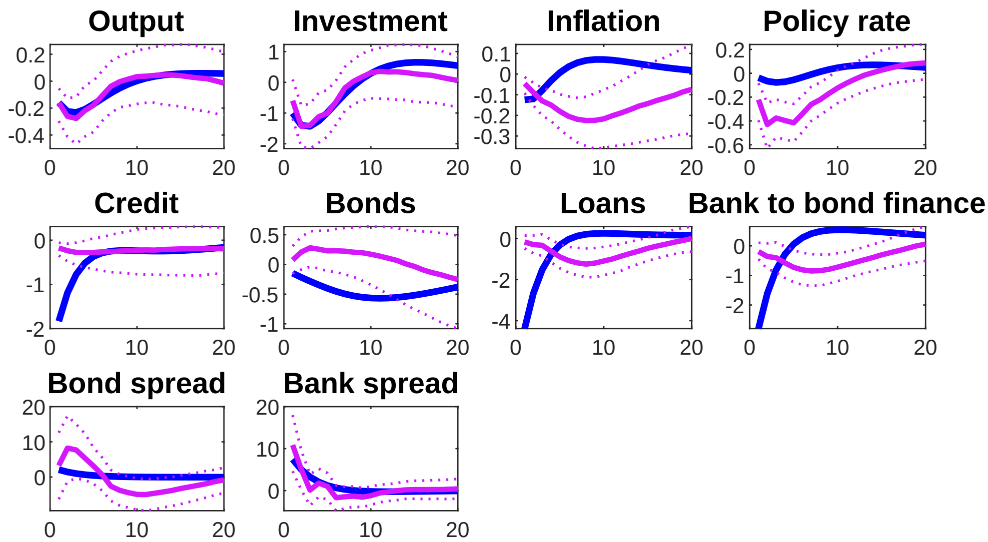
Impulse response functions: SVAR and DSGE model

Figures 9, 10 and 11 depict the estimated median impulse responses together with the respective credible sets. The median impulse responses are estimated from a Bayesian VAR with 1000 draws. The bounds are the 16th and 84th percentiles. I choose the size of shocks so that the median of the output response is matched on impact. The theoretical impulse responses qualitatively match their empirical counterparts. Most of the impulse responses fall into the 68% percent posterior probability regions of the estimated impulse responses.

The theoretical model generates a cyclical reaction of investment, which is consistent with its empirical counterpart. However, the impulse response of the ratio of bank to bond finance reacts more strongly than the empirical counterpart throughout the period considered. It should be emphasized that both the ratio of bank to bond finance and investment are left unrestricted in the identification.

The novel feature of the empirical model refers to the dynamics of corporate debt. Corporate bonds increase, whereas bank loans fall conditional on the realization of the structural financial

Figure 9: Adverse financial shock



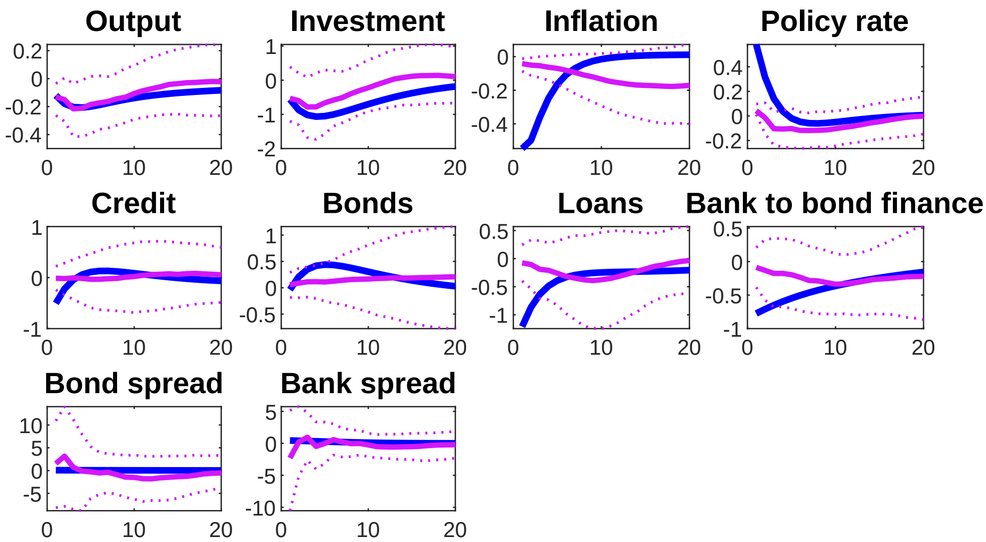
Blue lines refer to the impulse responses generated by the benchmark theoretical model following the financial shock that affects the banking market. Magenta lines refer to the estimated financial shock (the bank spread shock) from the SVAR model. The identification is specified in Table 2. The error bands represent 16% and 84% percentile of posterior distribution. The time period is 1973Q1–2010Q3. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations. The horizontal axis displays quarters after shock.

shock, which is in line with the unconditional empirical evidence documented by Adrian et al. (2013) and Becker and Ivashina (2014). The DSGE model is able to reproduce these features of the data, when the economy is hit by the banking shock. However, the economy-wide financial shock in the theoretical model generates a disruption in bond and bank markets, associated with a fall in external financing and a rise in spreads. Under this scenario, the theoretical model captures much higher bank spreads than the bond spreads, which match their empirical counterparts in Figure 9. The decline in the ratio of bank to bond finance is statistically significant. The initial reaction of the bank spread is statistically significant as well. It should be noted that most of impulse responses related to financial variables lack the persistence seen in the data.

Interestingly, similar to the SVAR evidence, the DSGE model predicts a fast recovery of the banking sector. The reason is that banks can rather quickly restore their profitability by charging high bank spreads. As a consequence, banks stabilize their balance sheet positions and start extending loans to firms. Once banks are capitalized, they intermediate loans, which the bank finance-dependent firm sector uses for financing capital purchases.

In order to match the output reaction in response to the monetary policy shock, the DSGE model generates a much stronger increase in the nominal interest rate than the one implied by

Figure 10: Adverse monetary policy shock

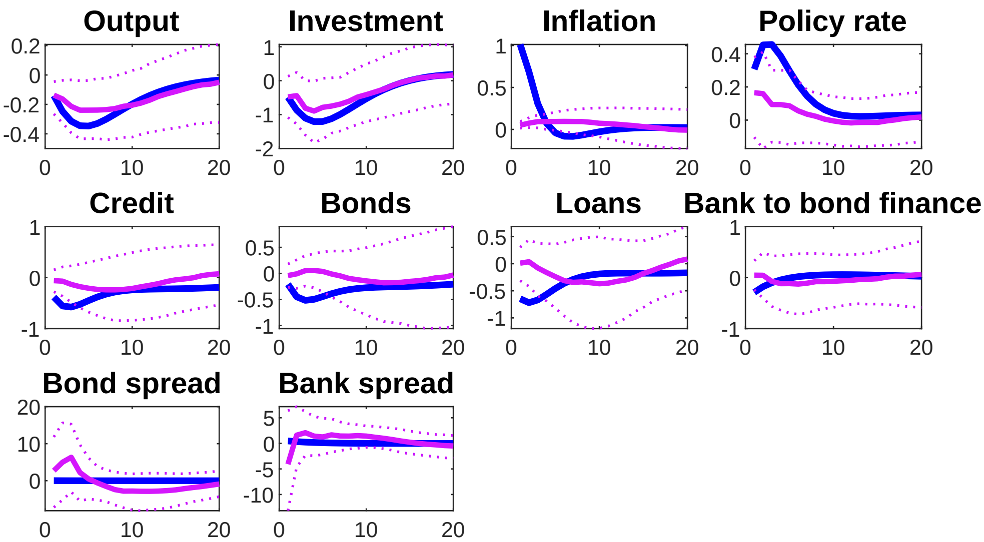


Blue lines refer to the impulse responses generated by the benchmark theoretical model following the technology shock. Magenta lines refer to the estimated aggregate supply shock from the SVAR model. The identification is specified in Table 2. The error bands represent 16% and 84% percentile of posterior distribution. The time period is 1973Q1–2010Q3. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations. The horizontal axis displays quarters after shock.

the SVAR with sign restrictions. Similarly, inflation declines substantially in the DSGE model. The initial reaction of loans and credit deviate from true responses, whereas the reactions of spreads are not as strong as their empirical counterparts. On the positive side, the model is able to qualitatively match the dynamics of bank loans and corporate bonds; reported by my SVAR model.

Following aggregate supply shocks, DSGE model predictions are consistent with the empirical evidence. In particular, the theoretical model reproduces the persistence in the responses of investment seen in the data and matches fairly well the dynamics of credit volumes. The reactions of both spreads seem to be negligible. The deviation of the ratio of bank to bond finance from its steady-state falls within the credible set of the empirical model.

Figure 11: Adverse supply shock



Blue lines refer to the impulse responses generated by the benchmark theoretical model following the technology shock. Magenta lines refer to the estimated aggregate supply shock from the SVAR model. The identification is specified in Table 2. The error bands represent 16% and 84% percentile of posterior distribution. The time period is 1973Q1–2010Q3. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations.The horizontal axis displays quarters after shock.

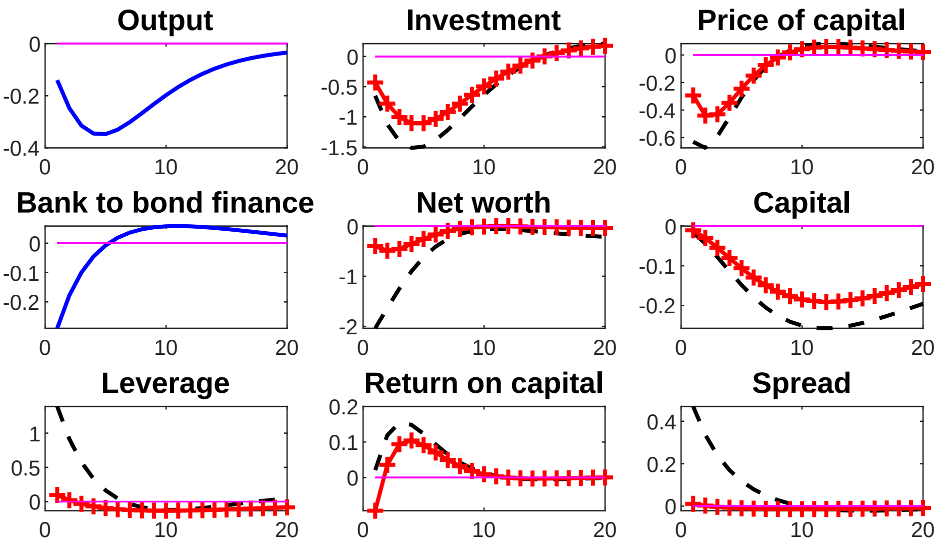
Appendix C

Technology shocks

Figure 12 depicts the responses of some key variables in the model following a negative technology shock in the benchmark economy. A decrease in aggregate productivity leads to a strong and persistent decrease in investment. Note that the propagation of a technology shock with respect to investment matches well the empirical evidence on the supply shock (c.f., Figure 11).

The technology shock has negligible effects on the financial variables (small changes in spreads and debt composition). Initially, bank loans do not change as much as bonds, which results in an increase in the bank to bond financing ratio. However, the banking sector is affected more by the shock since it is more leveraged. Declines in capital prices reduce the value of the bank's net worth, which makes bank spreads rise and leads to a further tightening of loan supply.

Figure 12: Adverse technology shock



Note: Black dashed lines refer to the variables associated with the banking sector, whereas the red lines refer to the bond sector. Blue lines refer to the aggregates. Credit spreads and the ratio of bank to bond finance are reported in absolute deviations; the remaining variables are expressed in percentage deviations.