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# On the firm-level implications of the Bank Lending Channel of monetary policy

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ABSTRACT

Standard models of the Bank Lending Channel are unable to yield predictions on the differential impact of monetary policy shocks over heterogeneous borrowers. This inability has made researchers doubt about the role played by bank credit as a transmission mechanism of monetary policy. Moreover, it has made them reject those models in favor of the Balance Sheet Channel as a transmission mechanism. In this paper we show that an "augmented" version of the Bank Lending Channel that allows for firm heterogeneity (but without any role for firms' balance sheets) reproduces well the dynamics of firm-level data. Our contribution is to show that it is not clear that the Bank Lending Channel should be rejected in favor of alternative theories on the basis of its inability to reproduce firm-level data. Thus, there is additional room for econometric tests that can provide support to the Bank Lending Channel.



## 1. Introduction

The theory of the *Bank Lending Channel* holds that the transmission mechanism of monetary policy shocks operates through adjustments to the assets side of banks' balance sheets (Bernanke and Blinder, 1988; see also Kashyap and Stein, 1993; Stein, 1998). The fall in bank reserves that follows a monetary policy contraction directly limits banks' access to loanable funds, which makes the supply of bank credit fall. Two necessary conditions must be met for this channel to be operative. First, banks must find it costly to use alternative non-reservable sources of funds and/or to re-balance their asset portfolio after the change in reserves. Second, bank borrowers must not be able to perfectly substitute bank loans with alternative financing methods.

There are important reasons to believe that these two conditions hold in the US economy.[2,3] However, some authors have raised the concern that the Bank Lending Channel hypothesis—in its standard formulation—cannot account for the

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[2] Kashyap and Stein (1993, 2000) offer evidence showing that although banks have access to alternative sources of loanable funds such as CDs, this is not enough for them to be able to completely overcome the liquidity shock caused by a monetary policy tightening. For that to be the case, banks should face a perfectly elastic supply of non-deposit funding. Bernanke and Gertler (1995) show that the interest rate spread between CDs and T-bills rises during a monetary policy contraction, which means that the marginal cost of funds must be increasing as banks start accessing the market for CDs (i.e. they show that the supply of non-deposit funding is not perfectly elastic).

[3] Among others, Bernanke and Gertler (1995) contend that this mechanism is likely to have decreased in importance in the US after the 1980s. Financial deepening has increasingly allowed companies to access open-market credit at the same time that it has made easier for banks to raise non-deposit financing, such as certificates of deposit, not subject to reserve requirements. However, Kashyap and Stein (1993) show that in spite of the rapid

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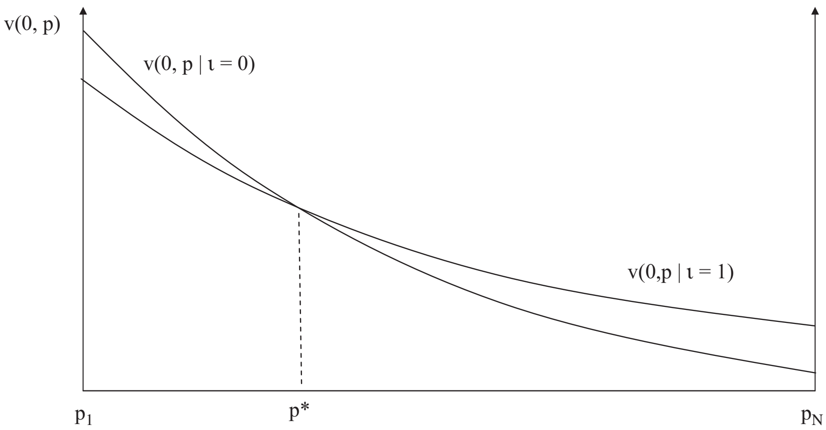


**Fig. 1.** Firms' choice of financing method. *Note*: $v$ denotes the firms' value function as in Eq. (1). $v(0,p|\iota=0)$ is the value of the firm when it chooses bond financing; $v(0,p|\iota=1)$ is the value of the firm in the case of bank financing.

rich dynamics of firm-level data (see Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1995, 1996a). This standard formulation of the bank lending channel (as in Bernanke and Blinder, 1988; Stein, 1998 and the literature that followed) assigns a role to banks'/lenders' heterogeneity, but not to borrowers' heterogeneity in the transmission of monetary policy.

On the contrary, an alternative credit-based explanation of the real effects of monetary policy, the *Balance Sheet Channel*, has been shown to match well the dynamics of firm-level data on sales, short-term debt and financing choices between open-market credit and bank credit (see Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1996a, 1996b; Bernanke et al., 1996).

Therefore, the empirical literature on the credit channels of monetary policy transmission has recently changed its focus of attention towards the Balance Sheet Channel. This theory assigns no special role to bank credit in the transmission of monetary policy. Rather, it is borrowers' balance sheets that limit their access to external financing. Due to informational asymmetries between borrowers and lenders, borrowing usually requires the former to pledge their net worth as collateral. As a result, a contractionary monetary policy that adversely affects firms' balance sheet positions also limits their access to all forms of credit.

Furthermore, if one believes that small firms have a weaker net worth position in their balance sheets compared to larger firms, then the following key predictions of the Balance Sheet Channel have been confirmed in the data:

1. The financing mix used by firms (defined as the ratio of bank credit to total short-term external financing) does not respond to monetary policy shocks, for neither small nor large firms (see Oliner and Rudebusch, 1996a, Fig. 1, p. 306 and Gertler and Gilchrist, 1994, Fig. 3, p. 322).
2. The financing mix for the economy as a whole does change after a monetary policy shock, but only due to compositional effects: small firms that rely disproportionately more on bank credit are more severely affected by the policy shock than large firms (see Oliner and Rudebusch, 1996a, Fig. 1, p. 306).
3. After a monetary contraction there is a "Flight to Quality", i.e. a general redirection of all forms of credit from small firms towards large firms (see Gertler and Gilchrist, 1994, Fig. 5, p. 330; Bernanke et al., 1996, Fig. 1, p. 8).
4. The "Flight to Quality" phenomenon holds even within the group of bank-dependent borrowers (Gertler and Gilchrist, 1994; Oliner and Rudebusch, 1995).
5. There is an asymmetric response over the business cycle of small firm variables to a monetary policy contraction, with a stronger effect during recessions. Large firm variables do not display such an asymmetry (see Gertler and Gilchrist, 1994, Fig. 4, p. 333).

To summarize, the criticism to the Bank Lending Channel is that, in its standard formulation, it cannot account for the dynamics of firm-level data described in 1–5 above.

However, the argument we pursue in this paper is that with the Bank Lending Channel being *silent* about the dynamics of firm-level variables, it would be misleading to use firm-level evidence to reject it. That is, the empirical evidence summarized in 1–5 would provide a test to the bank lending view only in relation to an appropriate falsifiable hypothesis of the Bank Lending Channel that can yield predictions on the dynamics of firm-level variables. Since the lending view

(*footnote continued*)
pace at which the disintermediation process has been unfolding during the last years, bank credit still accounts for a significant share of firms' total external financing. In US around 60% of firms external financing is represented by bank loans, while the rest is bonds and stocks. Moreover, approximately half of the bonds and almost all of the stock are sold to some kind of financial intermediary (Dewatripont and Tirole, 1994). During the 1990's this share has remained around 80% for Germany and close to 90% for Japan (Mishkin, 2007). These overall averages still mask the real importance of bank credit for small and medium sized companies that cannot easily access direct financing.

amounts to a supply-side shock in the market for bank credit, the standard story has little to say about how this shock impacts over different types of borrowers.

Our goal in this paper is to build a model suitable to study this falsifiable hypothesis. We augment a general equilibrium model of the Bank Lending Channel with firm heterogeneity, but still without any role for firms' balance sheets. We then use the model to study the impact of a monetary policy shock over heterogeneous firms. Specifically, the model allows us to study the qualitative dynamics of disaggregated-level variables such as firms sales or production, capital stock, short-term debt and the financing mix.

Our model can reproduce the differential effects of monetary policy on heterogeneous borrowers for two main reasons. First, the model features heterogeneous firms that make endogenous investment and financing decisions. Because of financial frictions that make the costs of borrowing vary across financing sources, companies are not indifferent between bank credit and alternative financing sources. Specifically, small high-risk firms tap bank credit, while large low-risk companies can access direct finance. Second, a loan supply shock that increases the marginal cost of funds for banks makes bank-dependent borrowers change their optimal investment and financing strategies, with some of them switching into bond financing. In a general equilibrium setting, this endogenously affects interest rates in all credit markets in the economy, such that monetary policy has real effects not only on small bank-dependent borrowers (i.e. on the ones initially hit by the shock), but also on larger firms that use alternative financing sources.

Our main contribution is to show that the qualitative predictions of this ''augmented'' model of the Bank Lending Channel are mostly in line with the real effects of monetary policy on small and large firms summarized in 1–5. Thus, we show that there is additional room for econometric tests that can provide support to the Bank Lending Channel, and that it is not clear that it should be rejected in favor of alternative mechanisms of monetary policy transmission. Worthy of note, it is by no means our goal to challenge the validity of the alternative Balance Sheet Channel, or to suggest problems in the empirical research on this topic.

Following this introduction, the structure of the paper is as follows. Section 2 contains a brief background literature review of the work on the Bank Lending Channel. Section 3 presents a partial equilibrium model of firms' investment and financing decisions. Section 4 embeds this model into an otherwise standard dynamic general equilibrium model of a closed economy with heterogeneous borrowers. Section 5 simulates the model numerically to study the response to a monetary policy tightening of both macroeconomic aggregates and firm-level variables. Section 6 concludes. The appendix presents the details on the treatment of idiosyncratic risk in the model.

## 2. Background literature

Without attempting to do an exhaustive review of the vast literature on the Bank Lending Channel of monetary policy, in this section we aim to present what is the state of the art in this field reached after the initial contribution of Bernanke and Blinder (1988).

Bernanke and Blinder (1988) develop what can be considered the first model of the credit channel. They extend a standard IS-LM model to have three assets: money, bonds and loans. Because banks can finance special activities that cannot be financed in bond markets, bank loans acquire a special status. Therefore, if financial intermediation is reduced, both aggregate demand and aggregate supply can suffer. Even though it introduces the credit channel, this paper does not introduce a role for cross-sectional heterogeneities across banks in the transmission mechanism of monetary policy.

Stein (1998) develops a model of the Bank Lending Channel where informational asymmetries make it difficult for banks to raise funds with instruments other than insured deposits. When the monetary authority drains reserves from the economy through a monetary contraction, it forces banks to substitute away from deposits into adverse selection prone forms of non-deposit finance. This raises the cost of loanable funds for banks and leads them to curtail bank lending. In this paper there is still no reference to any bank-specific characteristics that may make some banks more subject to informational asymmetries problems than others.

Ehrmann et al. (2001) extend the model in Bernanke and Blinder (1988) to study the role of heterogeneity in bank characteristics in the transmission mechanism of monetary policy. Specifically, they allow for the impact of deposit changes on loan supply to be lower the larger bank size and/or the higher banks' liquidity and capitalization.[4]

The empirical literature also explores the evidence for cross-sectional bank heterogeneities in the transmission of monetary policy. Limiting ourselves to mentioning only some of these studies, Kashyap and Stein (1995) study the role of bank size in the transmission of monetary policy; Kashyap and Stein (2000) focus on the role of liquidity; and Peek and Rosengren (1995a), Ashcraft (2001), Jayaratne and Morgan (2000) and Kishan and Opiela (2000) study the role of capitalization.

Gambacorta and Mistrulli (2004) study the cross-sectional differences in the response of lending to monetary policy owing to differences in bank capitalization. They better control the riskiness of banks' portfolios by using the excess capital-to-asset ratio, and disentangle the effects of the ''Bank Lending Channel'' from those of the ''bank capital channel''

[4] Ehrmann et al. (2001) find evidence for liquidity effects in the response of loans supply to monetary shocks. However, they fail to find evidence for size or capitalization to explain a bank's lending reaction.

as in Van den Heuvel (2007, 2008). For Italian banks they find that heterogeneities in bank capital matter for the transmission of monetary policy.

They find results consistent with the ''Bank Lending Channel'', indicating that well-capitalized banks can better shield their lending from monetary policy shocks. They also find evidence for a ''bank capital channel'' that has a stronger effect on small banks whose balance sheets contain a larger maturity mismatch between assets and liabilities. Gambacorta and Mistrulli (2004) also confirm Ehrmann et al. (2001) results that liquidity is an important factor in enabling banks to attenuate the effect of a decrease in deposits on lending.

To summarize, this literature has reached the consensus that the response of banks to monetary policy shocks through the bank lending channel should be different depending on their individual characteristics (such as size, liquidity, and capitalization) as a proxy for financial strength in banks' balance sheets. In particular, the consensus now is that these characteristics help to better identify the effects of monetary policy working trough the supply-side Bank Lending Channel from those of the demand-side interest rate channel. It is worth highlighting that although by now it has become standard to look at the role of heterogeneities in banks' financial constraints in the transmission mechanism of monetary policy, none of the reviewed papers assign any special role to heterogeneities across borrowers in this transmission mechanism. This is the task that we undertake in this paper.

By focusing on the Bank Lending Channel in this paper we abstract from other transmission mechanisms of monetary policy, namely, the bank capital channel as in Van den Heuvel (2007, 2008),[5] the asset price channels and other channels within the credit view (i.e. those working through the effects of monetary policy shocks on borrowers' balance sheets, borrowers' cash flows, the unanticipated price level and household liquidity) as in Mishkin (2007).[6] These other channels are interesting per se because they directly affect components of GDP other than investment (consumption and net exports, for example). In this paper we ignore these other channels since we need to isolate the Bank Lending Channel. In future work it would be interesting to apply the same methodology to some of these alternative channels of monetary policy transmission.

## 3. Firms' investment and financing decisions

The production sector of the economy is composed of a large number of firms of each different type. A firm's type is represented by an index $p_k \in \{p_1, \ldots, p_N\}$, $p_1 < \cdots < p_N < 1$. The index $p_k$ could be interpreted as the probability of a firm of that type exiting the market and not repaying its loans (i.e. bankruptcy). By the Law of Large Numbers, this is also the proportion of each type of firms that ''die'' in each period and the proportion of non-performing loans in each lender's assets portfolio. Then, the firm is liquidated and its assets are used to start up a new business. That is, new firms start out with the same capital stock as the ''dying'' firms.

Our choice of this particular form of heterogeneity is guided by our goal of assessing whether an ''augmented'' version of the bank lending channel model can account for the dynamics of firm-level data in response to monetary policy shocks. In particular, we need a heterogeneity that will endogenously reproduce the relationship between firm sizes, default risk and financing choices that has been well documented by the empirical literature (see Petersen and Rajan, 1994, 1995; Cantillo and Wright, 2000, among others). We refer the reader to Section 5.1 below for more details on this relationship. We get this desired feature of the model by assuming heterogeneity in the default probabilities $p$. Although we could have had other forms of heterogeneity (such as idiosyncratic productivity across firm types), we are not interested in the source of heterogeneity per se, and our choice brings heterogeneity into the model in a numerically tractable way.[7]

All firms produce the same good and their production technology features decreasing returns to scale (DRS). The DRS technology is justified by the presence of a factor of production in fixed supply, such as managerial talent.[8]

[5] Van den Heuvel (2007, 2008) develops a model where banks are subject to risk-based capital requirements and there is a maturity mismatch in banks' balance sheets. Because of this mismatch, the rise in short-term interest rates caused by a monetary policy contraction increases banks' interest costs by more than it increases their interest revenues, lowering both their profits and bank capital. A reduction in bank capital raises the probability of a binding capital requirement, so that on average banks curtail their lending. This transmission mechanism has been labeled the ''bank capital channel'' of monetary policy.

[6] There are three *asset price channels*. The first works through the effects of interest rate changes on exchange rates and net exports. The second asset price channel works through the effects of interest rate changes on the Tobin's $q$ and the demand for investment spending. The third asset price channel works through the wealth effects of stock price movements on aggregate consumption. Through a reduction in stock prices, a contractionary monetary policy also triggers a *balance sheet channel*, which strengthens moral hazard and adverse selection problems in borrowing for these firms, and leads to lower investment spending. An increase in interest rates also triggers a *cash flow channel*, lowering firms' cash flows and leading to a reduction in investment. Another effect of a monetary contraction works through *unanticipated changes in the price level*, which raise the real value of firms' liabilities with no effects on the asset side, they lower firms' net worth in real terms, tightening borrowing constraints, and leading to a reduction in investment spending. The last channel impacts *consumer spending*. Lower stock prices make consumers feel less secure financially, which makes them lower their consumption spending, in particular on durables and housing.

[7] The assumption that new firms start out with the same capital stock as the ''dying'' firms implies that the mass of firms of each type is of size 1 at all times. This is a standard assumption typically introduced to avoid having to keep track of a time-varying distribution of firms, which would compromise the numerical tractability of the model.

[8] With CRS, the lowest $p$ firm, for which financial markets charge the lowest risk premium on its borrowing, would incur lower marginal costs than the rest and thus, it could undercut prices driving the other firms out of business. We assume that the total endowment of managerial talent is equally allocated among the $N$ firm types.

Firms in this economy need to borrow to finance new investment projects and to replace depreciated capital. They can borrow directly by issuing bonds or they can sign a loan contract with a bank. There are three different frictions in financial markets.

First, although there is full information on firm types, verifying firms' cash flows in each state of nature is costly to bondholders (as in Townsend, 1979; Gale and Hellwig, 1985). It is assumed that all bond issuers pay an expected verification cost *ex ante*, as an origination cost of the issue. Using $\varphi$ to denote the verification cost per unit of loan, each borrower of type $p_k$ pays $p_k\varphi$ per unit of borrowing.

Second, as in Gomes (2001) and Smith (2002), there are transaction costs in bond financing (underwriting fees and other flotation costs associated with new issues of public debt). Based on empirical evidence presented by Altinkiliç and Hansen (2000) and Lee et al. (1996), we model transaction costs per unit of loan that are increasing in the size of the issue and decreasing in the size of the firm. Thus, there is a second term in the origination cost of bond issues of the form $\phi(iv/k)$, where $iv/k$ is the firm's investment rate (i.e., its financing needs relative to its size as measured by its capital stock) and $\phi'(\cdot)>0$.[9] Therefore, total origination costs associated to bond financing are given by $\vartheta(p,iv/k)=p\varphi+\phi(iv/k)$ per unit of loan. In Section 5.4 we perform a robustness check on the model by imposing an alternative specification for these origination costs.

Third, bank borrowers pay an intermediation cost $c^L$ per unit of loan at the moment of signing a credit contract with a bank.[10] These costs may be related to regulations or to administrative expenses that banks incur as they lend to companies.

The dynamic optimization problem for a perfectly competitive firm of type $p$ that takes both investment and financing decisions can then be outlined as follows:

$$\max_{\{iv_p\}} v_p(0)=\int_0^\infty z_p(t)\pi_p^{firm}(t)\,dt$$

*s.t.*

$$\pi_p^{firm}(t)=AF[k_p(t)]-w_p(t)-i_p^L(t)l_p(t)-i_p^b(t)b_p(t)-iv_p(t)\left[1+\imath_p(t)c^L+(1-\imath_p(t))\vartheta\left(p,\frac{iv_p(t)}{k_p(t)}\right)\right]+\dot{b}_p(t)+\dot{l}_p(t) \quad (1)$$

$$\dot{k}_p(t)=iv_p(t)-\delta k_p(t) \quad (2)$$

$$\dot{l}_p(t)=\imath_p(t)iv_p(t)-\delta\beta(t)k_p(t) \quad (3)$$

$$\dot{b}_p(t)=[1-\imath_p(t)]iv_p(t)-\delta[1-\beta(t)]k_p(t) \quad (4)$$

$$\lim_{t\to\infty} k_p(t)z_p(t)\geq 0 \quad (5)$$

$$k_p(0)=l_p(0)+b_p(0) \quad (6)$$

$$\imath_p(t)=\underset{\{0,1\}}{\operatorname{argmax}}\left(\max_{iv_p(t)} v_p(t)\right) \quad (7)$$

where $z_p(t)\equiv\exp(-\int_0^t[\rho+p]\,dt$ is the discount factor; Eq. (1) defines the cash flow for a firm of type $p$; $k_p(t)$ is the capital stock for a firm of type $p$; $w_p$ is the rent paid to the manager; $i_p^L$ is the default risk-adjusted interest rate on loans; $i_p^b$ is the interest rate on bonds; $\imath_p(t)$ takes a value of 1 if the firm chooses bank lending financing rather than bonds, and of 0 otherwise; $iv_p(t)$ is type $p$ firm's gross investment; $l_p(t)$ is bank loans outstanding; $b_p(t)$ is bonds outstanding; $\beta(t)=l_p(t)/l_p(t)+b_p(t)$ is the fraction of bank loan financing relative to total external financing and $k_p(0)$ is type $p$ firm's initial capital stock. Finally, $\vartheta(p,iv_p(t)/k_p(t))\equiv\phi(iv_p(t)/k_p(t))+p\varphi$, with $\vartheta_1(\cdot)>0$ and $\vartheta_2(\cdot)>0$.

The production technology $AF(k)$ has the usual properties: $F_k>0$; $F_{kk}<0$, Inada conditions hold and $A$ is the TFP index. Both capital and managerial talent are inputs in the production process, but the latter exists in fixed supply. Thus, the production function features DRS. Managerial talent has not been explicitly included in the production function, but the assumption is that each firm needs it to operate. In equilibrium $w_p$, the rent earned by the managerial talent factor, is determined by the representative firm's zero-profit condition $\pi_p^{firm}=0\forall p$. Thus, for each firm type it equals the difference between the firm's output and its payments to the other inputs.

[9] It will become clear later that these costs are needed in the model as a type of "financial" adjustment costs to investment that help to obtain a well defined dynamic path for investment even with an exogenous interest rate.

[10] One way to rationalize the assumption that banks do not have to engage in costly state verification of borrowers is to think that they are endowed with an information technology that puts them at an advantage over other lenders. Alternatively, the assumption of an informational advantage can be rationalized with the existence of a costly verification technology that features economies of scale in the volume of funds audited. If banks' assets are large in relation to the size of the projects financed, then banks can exploit these scale economies driving their average verification costs close to zero. Bondholders may have access to this verification technology, but they cannot exploit the economies of scale since they can finance just a fraction of a single project. This is in the spirit of Diamond (1984).

Eq. (2) is the equation of motion for the capital stock with $\delta$ being the depreciation rate. Eq. (3) is the law of motion for bank loan financing and Eq. (4) is the law of motion for bond issuance. These two equations arise from the constraint on gross investment being financed externally.[11] At each point in time a fraction of the stock of outstanding bank credit as well as a fraction of the outstanding bonds are paid back. These fractions equal the amount of the depreciation weighted by the share of each financing source in total external financing.

The firm's choice of financing method at time $t$ is represented by the dichotomous choice variable $\imath_p(t) \in \{0,1\}$. This financing decision is determined by condition (7).

The Hamiltonian, conditional on the value of $\imath_p$ is

$$H_p = z_p\left\{AF[k_p] - w_p - i_p^L l_p - i_p^b b_p - iv_p\left[\imath_p c^L + (1-\imath_p)\vartheta\left(\frac{iv_p}{k_p}\right)\right] - \delta k_p + q_p(iv_p - \delta k_p)\right\} \quad (8)$$

where we have omitted the time index $t$ for convenience. The FOCs for the optimal control problem for type $p$ firms are

$$H_{iv,p} = q_p - \imath_p c^L - (1-\imath_p)\vartheta(x_p) - (1-\imath_p)x_p\vartheta'(x_p) = 0 \quad (9)$$

$$H_{k,p} = -\dot{\mu}_p; \quad \mu_p = z_p q_p \Rightarrow AF_{k,p} + (1-\imath_p)x_p^2\vartheta'(x_p) - [\beta i_p^L + (1-\beta)i_p^b] - \delta - \delta q_p = (r+p)q_p - \dot{q}_p \quad (10)$$

where $x_p \equiv iv_p/k_p$ denotes the investment rate.

It can be shown that firms' characteristics will play a key role in determining the value of $\imath_p$. Fig. 1 plots the net present value of the firm for all types $\{p_1,\ldots,p_N\}$ assuming that each firm remains in its steady-state path of investment. As a result, firms of type $p < p^*$ find it optimal to use bond financing and those of type $p > p^*$ use bank lending. We assume that $p_1$ and $p_N$ are such that bond financing and bank lending coexist in this economy.

It is worth noting that the interest rates $i_p^L$ and $i_p^b$ are exogenously given in this partial equilibrium setting. In order to study the feedback between investment and financing decisions and the real effects of monetary policy on firms of all types, these prices must be made endogenous variables of the model by moving to a general equilibrium analysis. We pursue this task in Section 4.

## 4. The dynamic general equilibrium model

This section embeds the partial equilibrium model of firms' financing decisions presented before into an otherwise standard dynamic general equilibrium model of a closed economy.

There are three agents in this economy: households, firms and financial intermediaries (hereafter called banks).

### *4.1. Households*

The setting is one of the infinitely lived representative households that maximize lifetime utility derived from consumption goods ($C$). Households are endowed with a fixed amount of managerial talent. This factor of production is supplied inelastically to the firms and its total endowment is normalized to 1. Households saving decisions consist on allocating resources between two assets: corporate bonds issued by firms ($B$) and bank deposits ($D$). Households are the owners of both firms and banks, which distribute their profits if any ($\pi_p^{firm}$ and $\pi^{bank}$, respectively,) in a lump-sum fashion.

$$\max_{\{\alpha,C\}} \int_0^\infty e^{-\rho t} U(C)\,dt$$

$$C + \dot{a} \leq \sum_{p=p_1}^{p_N} w_p + a[\alpha r^d + (1-\alpha)r^b] + \pi^{bank} + \sum_{p=p_1}^{p_N} \pi_p^{firm} \quad (11)$$

$$D = \alpha a$$

$$B = (1-\alpha)a$$

$$C \geq 0$$

where $\rho$ is the rate of time preference; $w_p$ is the payment to the fixed factor by type $p$ firms and $\alpha$, a choice variable, is the share of bank deposits in total assets. The time index $t$ has been dropped again for convenience.[12]

[11] An alternative could be just to assume that net investment is financed with debt while depreciation is paid out of the firm's cash flow at every moment of time. In fact, if there were no financial frictions there would be no difference between these two schemes. However when there are costs of issuing debt, the two settings differ in that only the former gives a continuous function for the "financial" adjustment cost to investment as long as gross investment is positive (i.e. irreversibility of investment). With the alternative setting there would be a discontinuity in that function at the steady-state value of investment, since it would jump discontinuously to zero. Thus, it would be impossible to derive the marginal condition for capital.

[12] An implicit assumption in this model is that there is a securitization firm that undertakes a risk-pooling function. Therefore, the risk premium $p$ does not enter the households' budget constraint. A perfectly competitive securitization firm charges $i_p^b = (r^b + p)/(1-p)$ for every dollar of bond financing and it earns $(1-p)i_p^b - p = r^b$. Thus, households hold loan-backed securities which earn $r^b$ in all states of nature. Please refer to the appendix for more details on this assumption.

The Hamiltonian function and the corresponding FOCs are given by

$$H = e^{-\rho t}\left[U(C)+\lambda\left(\sum_{p=p_1}^{p_N} w_p + a[\alpha r^d+(1-\alpha)r^b]+\pi^{bank}+\sum_{p=p_1}^{p_N}\pi_p^{firm}-C\right)\right]$$

$$H_C = U'(C)-\lambda = 0 \quad (12)$$

$$H_\alpha = \lambda a(r^d-r^b)=0 \Rightarrow r^d = r^b \quad (13)$$

$$H_a = -\dot{\mu}, \quad \mu = \lambda e^{-\rho t} \Rightarrow \dot{\lambda} = \lambda\{\rho-[\alpha r^d+(1-\alpha)r^b]\} \quad (14)$$

### 4.2. Banks

Banks are perfectly competitive. At each moment of time they choose lending to each firm type ($l_p$), deposits ($D$) and holdings of excess reserves (R) to maximize profits.[13] With probability $(1-p)$ they receive interest payments on outstanding loans, and with probability $p$ firms go bankrupt and banks lose both the interest and the principal. Also, banks pay interest for the balances held by households at the bank. They receive payments of loan origination fees made by the firms that find it optimal to use bank financing ($\imath_p c^L i\nu_p$), and they incur those costs ($\Omega(\varepsilon,R)$). These costs are modelled as a function of an exogenous monetary policy shock $\varepsilon$ and of the amount of excess reserves $R$. In Section 4.2.1 we provide more details on how these costs are modelled and their role in the transmission mechanism of monetary policy.

The representative bank optimization problem is given by

$$\max_{l_p,D,R}\pi^{bank} = \sum_{p=p_1}^{p_N}(1-p)i_p^L l_p - \sum_{p=p_1}^{p_N} p l_p - r^d D + \sum_{p=p_1}^{p_N}\imath_p c^L i\nu_p - \Omega(\varepsilon,R) \quad (15)$$

$$p \in \{p_1,\ldots,p_N\}$$

$$\sum_{p=p_1}^{p_N} l_p + R = D$$

The loan pricing equation corresponding to a borrower of type $p$ is given by

$$i_p^L = \frac{r^d+p}{1-p} \quad (16)$$

This equation implies that banks never make any losses. Since banks can perfectly observe firms' types, they can charge a fair credit-risk premium, perfectly pooling risk and eliminating any source of uncertainty.

The FOC which governs the bank's optimal choice of excess reserve holdings is

$$(1-p)i_p^L - p = -\frac{\partial\Omega(\varepsilon,R)}{\partial R} \quad (17)$$

#### 4.2.1. Banks intermediation costs and the Bank Lending Channel

Monetary policy is introduced in our model as a shock to banks' reserves ($\varepsilon$) induced by the Central Bank. Thus, in a real model with no currency in circulation, the monetary base $M_0$ is given by banks' holdings of reserves, as described by Eq. (18).

$$M_0 \equiv R \quad (18)$$

Therefore, the stance of monetary policy is defined as $\Delta M_0 = \Delta R = \varepsilon$, with $\varepsilon < 0$ ($\varepsilon > 0$) representing contractionary (expansionary) monetary policy shocks.

Following the intuition in the model of Stein (1998), a contractionary monetary policy shock drains reserves from the banking system. Banks react having to substitute deposits with alternative sources of finance that are more prone than deposits to asymmetric information problems. The costs of dealing with these informational asymmetries typically make these alternative liabilities more expensive for banks. Banks react by curtailing lending, and borrowers see an increase in the cost of borrowing. That is the gist of the Bank Lending Channel as a transmission mechanism of monetary policy.[14]

To model this story, although admittedly not from first principles, we model the banks' cost $\Omega$ in Eq. (15) as an increasing function of the negative shock $\varepsilon$ that drains reserves from the banking system.

Also, we want to allow for the effects of monetary policy to be weakened by the presence of excess reserves. The idea is that when a bank has relied more on excess reserves prior to the monetary policy shock, these larger reserves can act as a stronger buffer to the shock, which should weaken the Bank Lending Channel. To account for this possibility, we model the

[13] For simplicity we assume the required reserve ratio to equal zero.

[14] This same intuition is present in Kashyap and Stein (1993) and Bernanke and Gertler (1995), among others.

cost $\Omega$ as decreasing in the amount of bank reserves $R$. Thus, intuitively, condition (17) equates the marginal cost of reserves (given by forgone default-adjusted interest earnings) to their marginal benefit (given by the cost-saving effect of increased reserves).

Specifically, the cost function we use is

$$\Omega = \left(\frac{\Lambda - \varepsilon}{R}\right)^{\omega} \tag{19}$$

such that the parameter $\omega$ governs how much banks rely on excess reserves as a buffer against potential future negative shocks to their reserves.

Having presented the functional form assumed for the cost function, we can use some analytical expressions to discuss the intuition on how monetary policy operates.

$$\frac{\partial \Omega}{\partial \varepsilon} = -\omega R^{-\omega}(\Lambda - \varepsilon)^{\omega - 1} < 0 \tag{20}$$

This equation tells that a contractionary monetary policy shock (a drop in $\varepsilon$) raises operational costs for banks.

Imposing a zero-profit condition for banks, such that $\pi^{bank} = 0$ and using the bank's pricing Eq. (16), yields $\sum_{p=p_1}^{p_N} \imath_p c^L i v_p = \Omega(\varepsilon, R)$. Therefore, banks shift the increase in $\Omega$ to the borrowers that will now pay a larger origination cost $c^L$.

However, this effect will be weaker the larger $R$ as shown by Eq. (21):

$$\frac{\partial^2 \Omega}{\partial \varepsilon \partial R} = \omega^2 R^{-\omega - 1}(\Lambda - \varepsilon)^{\omega - 1} > 0 \tag{21}$$

### *4.3. Decentralized economy equilibrium*

Eqs. (22) and (23) impose market clearing in asset markets.

$$a = \sum_{p=p_1}^{p_N} k_p \tag{22}$$

$$\alpha = \frac{\sum_{p=p_1}^{p_N} l_p}{\sum_{p=p_1}^{p_N} k_p} \tag{23}$$

The resource constraint in the market for goods is given by

$$C + \sum_{p=p_1}^{p_N} i v_p [1 + \imath_p c^L + (1 - \imath_p)\vartheta(x_p)] = \sum_{p=p_1}^{p_N} AF(k_p) \tag{24}$$

Eqs. (13), (15) and (16) together with the assumption of perfect risk-pooling in the bonds market by a securitization firm[15] imply $i_p^b = i_p^L$, and $r^b = r^d \equiv r$. Using this result in (10) and working with (9) to eliminate $q_p$, we obtain

$$AF_{k,p} + (1 - \imath_p)x_p^2 \vartheta'(x_p) = \left(\frac{(r+p)}{(1-p)} + \delta\right) + (r + p + \delta)[\imath_p c^L + (1 - \imath_p)\vartheta(x_p) + (1 - \imath_p)x_p \vartheta'(x_p))] - (1 - \imath_p)(2\vartheta'(x_p) + x_p \vartheta''(x_p))\dot{x}_p \tag{25}$$

Re-writing the law of motion of capital (2) in terms of $x_p$,

$$\dot{k}_p = k_p(x_p - \delta) \tag{26}$$

Eqs. (25) and (26) form a well-behaved dynamic system for firms that use bond financing, i.e. $\imath_p = 0$. That is, for each type $p$ that uses bond financing, and given the interest rate $r$, we can pin down the dynamic path of investment, bond financing and the capital stock. The resource constraint (Eq. (24)) together with the Euler equation for consumption (Eq. (14)) must be used to jointly solve for the equilibrium paths of interest rates, investment and the capital stock for firms that use bank financing, i.e. $\imath_p = 1$.

Using $p^*$ to denote the marginal firm type such that for all $p \le p^*, \imath_p = 0$ ($N^*$, firm types: $\{p_1, \ldots, p_{N^*}\}$), while for all $p > p^*, \imath_p = 1$ ($N - N^*$ firm types: $\{p_{N^*+1}, \ldots, p_N\}$), then the equilibrium path for this economy is determined by the following system:

$$\dot{x}_p = \frac{\left(\frac{(r+p)}{(1-p)} + \delta\right) + (r + p + \delta)[\vartheta(x_p) + x_p \vartheta'(x_p)] - AF_{k,p} - x_p^2 \vartheta'(x_p)}{2\vartheta'(x_p) + x_p \vartheta''(x_p)} \quad p \in \{p_1, \ldots, p_{N^*}\} \tag{27}$$

$$AF_{k,p} = \left(\frac{(r+p)}{(1-p)} + \delta\right) + (r + p + \delta)c^L \quad p \in \{p_{N^*+1}, \ldots, p_N\} \tag{28}$$

[15] See footnote 11.

$$\dot{k}_p = k_p(x_p - \delta) \quad \forall p \tag{29}$$

$$C + \sum_{p=p_1}^{p_N} k_p x_p [1 + \imath_p c^L + (1-\imath_p)\vartheta(x_p)] = \sum_{p=p_1}^{p_N} AF(k_p) \tag{30}$$

$$\dot{C} = -\frac{U'(C)}{U''(C)}(r - \rho) \tag{31}$$

$$k_p(0) = \kappa_p, \quad \lim_{t\to\infty} k_p(t) z_p(t) \geq 0 \quad \forall p$$

The strategy to solve this system relies on using Eqs. (28) and (29) to reduce the dimensionality of the system. This is achieved by eliminating $k_p$ and $x_p$ for $p \in \{p_{N^*+1}, \ldots, p_{N-1}\}$ from the problem (i.e. all firms that use bank financing but one). First, using Eq. (28), $k_p = f_p(k_{pN})$ and $\dot{k}_p = f_p' \dot{k}_{pN}$ can be found for $p \in \{p_{N^*+1}, \ldots, p_{N-1}\}$, where $f_p(\cdot)$ is some known function. Second, Eq. (29) can be used to derive $x_p = g_p(k_{pN}, \dot{k}_{pN})$ for $p \in \{p_{N^*+1}, \ldots, p_{N-1}\}$, where $g_p(\cdot)$ is another known function. Using these expressions into the resource constraint given by (24) yields

$$x_{pN} = h(k_{pN}, f_{pN^*+1}, \ldots, f_{pN-1}, g_{pN^*+1}, \ldots, g_{pN-1}, k_{p1}, \ldots, k_{pN^*}, C)\dot{k}_{pN}$$

where $h(\cdot)$ is some known function. Finally, plugging this expression for $x_{pN}$ into $\dot{k}_{pN} = k_{pN}(x_{pN} - \delta)$ (from Eq. (29) for $p = p_N$), an equation of motion for $k_{pN}$ is obtained:

$$\dot{k}_{pN} = m(k_{pN}, h(\cdot))$$

where $m(\cdot)$ is some known function. Finally, Eq. (28) can be used to eliminate the interest rate throughout: $r = r(k_{pN}, p_N)$. Therefore, the system in Eqs. (27)–(31) can be re-expressed as a new system given by Eqs. (32)–(36):

$$\dot{x}_p = \frac{\left(\frac{(r(k_{pN}, p_N) + p)}{(1-p)} + \delta\right) + (r(k_{pN}, p_N) + p + \delta)[\vartheta(x_p) + x_p \vartheta'(x_p)] - AF_{k,p} - x_p^2 \vartheta'(x_p)}{2\vartheta'(x_p) + x_p \vartheta''(x_p)}$$

$$p \in \{p_1, \ldots, p_{N^*}\} \tag{32}$$

$$\dot{k}_p = k_p(x_p - \delta) \quad p \in \{p_1, \ldots, p_{N^*}\} \tag{33}$$

$$\dot{k}_N = m(k_{pN}, f_{pN^*+1}, \ldots, f_{pN-1}, g_{pN^*+1}, \ldots, g_{pN-1}, k_{p1}, \ldots, k_{pN^*}, C) \tag{34}$$

$$\dot{C} = -\frac{U'(C)}{U''(C)}(r(k_{pN}, p_N) - \rho) \tag{35}$$

$$k_p(0) = \kappa_p, \quad \lim_{t\to\infty} k_p(t) z_p(t) \geq 0 \quad p \in \{p_1, \ldots, p_{N^*}\} \cup \{p_N\} \tag{36}$$

The solution consists of the functions describing the time paths for $x_p$ and $k_p$ for the subset of $N^*$ firm types that use bond financing, $k_{pN}$ and $C$.[16]

## 5. Monetary policy shocks and the Bank Lending Channel

In this section we find the solution to the boundary value problem stated in Eqs. (32)–(36). Due to the dimensionality of the system, using a phase diagram to study the dynamics of this economy does not provide enough insight, and a numerical approximation to the exact solution is needed. We use Miranda and Fackler (2002) *CompEcon Toolbox* to solve boundary value problems. This numerical method relies on a polynomial approximation to the unknown solution functions, where the coefficients of the polynomial are found by the collocation method.[17]

In carrying out this numerical implementation, we constrain the number of firm types $N$ to 3. With the goal of our paper being to reproduce the qualitative (not necessarily quantitative) dynamics of firm-level data, having only three different types of agents: those that are more likely to use bank lending (firm type $p_3$), those that are more likely to choose bond financing (firm type $p_1$) and those that can potentially choose one or the other depending on the model's parameters (firm type $p_2$) is enough to summarize the heterogeneity among borrowers. Therefore, in our parametrization $p_1 < p_2 < p_3$.

Tables 1 and 2 present the functional forms and the parameter values used in the numerical solution to the model. The parameter $\rho$ is set to match a 3% annual real interest rate on deposits in steady state. Based on data on factor shares, capital

[16] This is a system of $2N^*+2$ equations in $2N^*+2$ unknowns, with $2N^*+2$ boundary conditions.

[17] For a system of dimension $d$, the collocation method finds the $n \times d$ coefficients of the $n$-degree polynomial by requiring the approximation to the solution function to satisfy the system of differential equations at $n-1$ prescribed time nodes. This yields $d \times (n-1)$ nonlinear equations. The boundary conditions, that must also be satisfied by the approximated solution function, add $d$ equations for a total of $n \times d$ equations. The $n \times d$ nonlinear system can be solved by standard nonlinear solvers such as the Newton method or the more computationally efficient Broyden method. See Miranda and Fackler (2002, Chapter 6).

**Table 1**
Functional forms.

| | |
|---|---|
| $AF(k) = Ak^{\gamma}$ | Firms' production function |
| $U(C) = \frac{C^{1-\sigma}}{1-\sigma}$ | Households' utility function |
| $\vartheta(x) = \varphi p + \phi x^{\theta}$ | Total origination costs of bond financing |
| $\vartheta(x) = \varphi p x^{\theta}$ | Alternative specification for robustness check |

**Table 2**
Parameter values.

| | |
|---|---|
| $\gamma = 0.33$ | Capital share of output |
| $\rho = 0.03$ | Annual households' discount rate |
| $\sigma = 2$ | Intertemporal elasticity of substitution |
| $\delta = 0.11$ | Annual capital depreciation rate |
| $A$=1 | Steady-state value of TFP |
| $\varphi = 0.405$ | Verification costs in capital markets |
| $\phi = 0.1$ | Origination costs (level) of bond issues in capital markets |
| $\theta = 2$ | Origination costs (slope) of bond issues in capital markets |
| $p_1$=0.03 | Probability of exiting the market (i.e. bankruptcy) for firms of type 1 |
| $p_2$=0.05 | Idem for firms of type 2 |
| $p_3$=0.07 | Idem for firms of type 3 |
| $\omega = 3$ | Parameter in bank's cost function $\Omega = f(\varepsilon, R)$ |

to output ratios and investment to output ratios, we set $\delta$ to be 2.75% per quarter (i.e. $\delta = 0.11$ for our annual parametrization of the model), and $\gamma = 0.33$. In doing so we follow the standard as in Hansen and Wright (1992) and Romer (2006), among others. Regarding the parameter $\sigma$ which governs the elasticity of intertemporal substitution for households, the standard has become to set it anywhere between 2 and 20. We choose the most conservative approach of setting it to 2. Our choice is in line with Mankiw (1981), Prescott (1986) and references therein. It is worth highlighting that all results are robust to the choice of these parameter values.

The parameter $\Lambda$ in the cost function $\Omega$ is set to match a cost of 2% per unit of bank loans.

The exponent $\theta$ for the costly state verification cost was set to 2 to work with a quadratic function in line with the adjustment costs to investment literature. Given the values of $p_1$, $p_2$, $p_3$, $\delta$ and $\theta$ and bank loan origination costs of 2%, the cost of bond financing as a percentage of those loans and total financing costs as a percentage of GDP are pinned down by the parameters $\phi$ and $\varphi$. These were chosen to match a cost of bond financing of 1.35% for the largest firms in the economy and total financing costs of 0.3% of GDP. With this parametrization and the chosen value for $p_2$, in steady-state the optimal financing choice for medium-sized firms is, initially, bank financing (i.e. $\imath_{p2} = 1$). This allows us to study how the financing method used by these firms of type $p_2$ changes after a monetary policy shock.

Several sensitivity analyses were run on these parameter values without changes to the qualitative results. These results are available from the authors upon request.

### 5.1. *Firm size and firm financing decisions*

Eq. (25) implies that the steady-state level of the capital stock is decreasing in the firm type $p$. A higher $p$ means a higher probability of default and thus, it implies a higher interest rate on loans charged by both banks and the securitization firms. Higher interest rates lead to lower investment and smaller firms' sizes, as measured by their capital stock. Thus, high-risk firms that must use bank lending (i.e. firms of the $p_3$ type) are the smallest, while low-risk firms that can undercut financing costs by issuing direct debt (i.e. firms of the $p_1$ type) are the biggest.

Several other papers use this same type of relationship among firm size, default risk and firm financing decisions (Bolton and Freixas, 2000; Oliner and Rudebusch, 1996a, 1996b; Gertler and Gilchrist, 1994; Bernanke et al., 1996).

### 5.2. *Effects of an unexpected monetary policy tightening*

The simulation exercise performed here consists of a temporary negative shock to $\varepsilon$ such that the bank intermediation costs $\Omega$ rise by one percentage point. This intends to capture a shock to bank loan supply schedules after a monetary tightening. $\Omega$ is kept at this higher value during some period of time, after which it returns to its original value.

We choose $p_2$ such that a small temporary shock to $\varepsilon$ is enough for a firm of type $p_2$ to immediately find it profitable to switch to bond financing, which makes the aggregate financing mix $\sum_p l_p / \sum_p k_p$ fall. This choice is made to be consistent with the empirical evidence first presented by Kashyap et al. (1993), by which borrowers seek alternative financing sources as bank intermediation costs increase. Fig. 2 displays the time paths of aggregate consumption, investment and output after the monetary tightening, and Fig. 2(b) shows the corresponding individual variables at the firm-type level. The recessionary impact

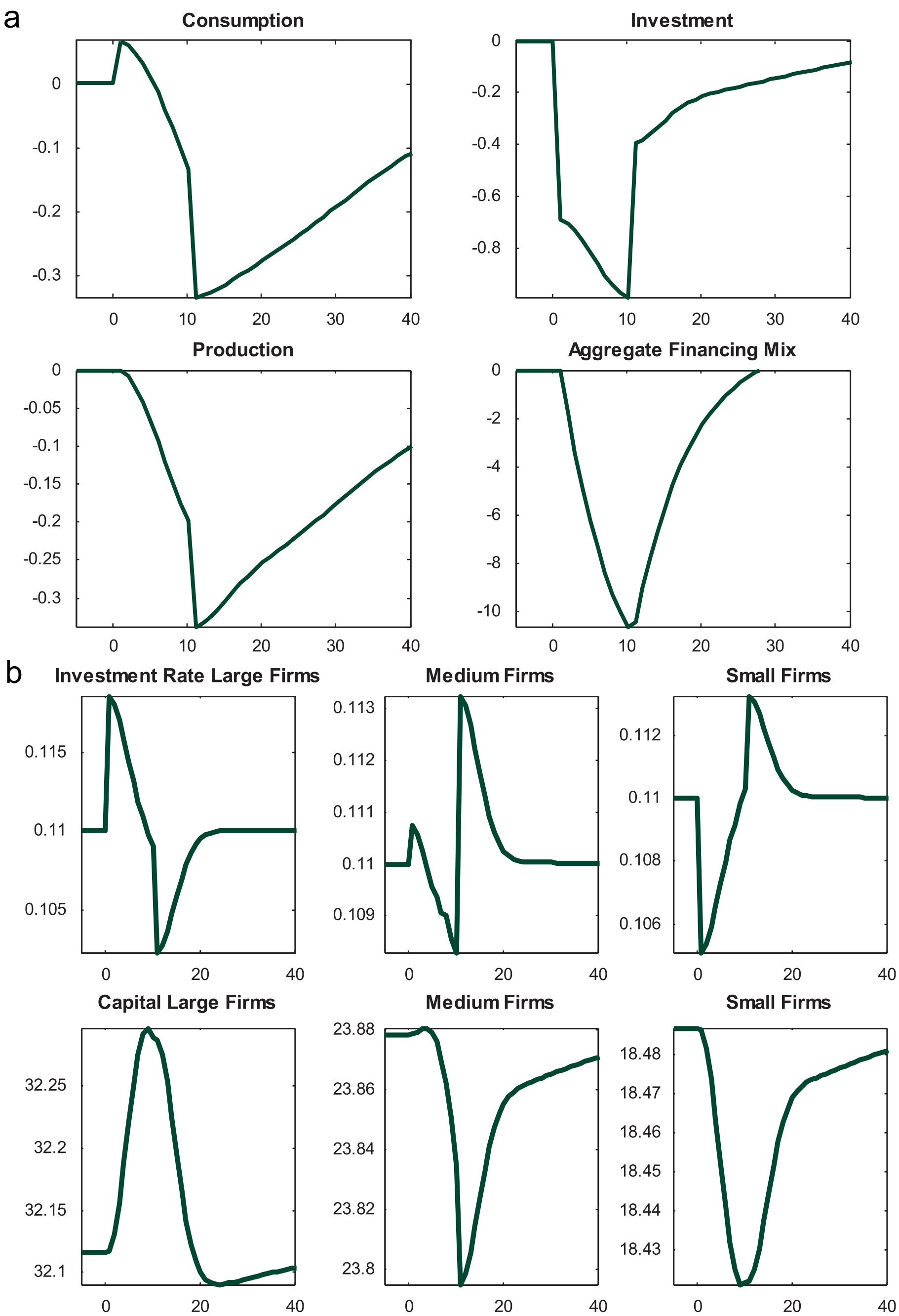


**Fig. 2.** (a) The aggregate financing mix and the Bank Lending Channel. *Note*: figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are percentage deviations from the steady state. The aggregate financing mix is the ratio of bank credit to total short-term external financing. (b) Firm-level variables. *Note*: figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are in levels.

of the monetary policy described in this figure is also in line with Kashyap et al. (1993) empirical estimation of the negative effects of a monetary tightening. As in their model, here these real effects arise as a consequence of alternative financing sources being imperfect substitutes for firms. After a monetary tightening a borrower that previously found it optimal to use bank lending, cannot overcome the shortage of bank credit without incurring in higher financing costs. It is worth noting that consumption increases on impact, but then it falls and remains below its steady-state value for several periods. The initial small increase in consumption is a result of the reduction in investment, which frees up resources towards consumption uses.

Next we perform exercises that show, qualitatively, that some of the arguments that the literature has posed against the Bank Lending Channel in favor of the alternative Balance Sheet Channel should be revised. Our thesis is formulated based on our "heterogeneous firms-augmented" model of the Bank Lending Channel (with no role for firms' balance sheets) being able to match the firm-level data. The inability of a benchmark model of the Bank Lending Channel to reproduce these data has been used in the past to reject the Bank Lending Channel.

One argument opposed to the empirical findings in Kashyap et al. (1993) has been that the firms do not actually switch after a monetary policy contraction. Oliner and Rudebusch (1996a) present some evidence showing that although the aggregate financing mix falls, the choice of financing method does not change for each firm size group. They explain this apparent contradiction between results from aggregate and disaggregated data resorting to a compositional effect that drives the aggregate behavior of the financing mix. Their reasoning is that if monetary policy affects firms *through a mechanism other than the Bank Lending Channel* (which would constrain access to all sources of credit equally), and if small (bank-dependent) firms happen to be hit more severely than large firms, then aggregate bank lending will fall disproportionately more than total external financing. This will generate the observed behavior of the aggregate financing mix, even with individual firms not switching from bank to bond financing.

Kashyap et al. (1996) contend that Oliner and Rudebusch's evidence of no switching only shows that looking at the aggregate financing mix is not a good identification strategy, but that this does not necessarily challenge the Bank Lending Channel. Kashyap et al. (1996) argue that many small firms that have no access to alternative sources of funds other than bank credit never switch. However, the lack of switching would actually reinforce the Bank Lending Channel.

Fig. 3 shows the behavior of aggregate consumption, investment and production with the purpose of illustrating the point made by Kashyap et al. (1996).[18] The exercise performed is the same as in Fig. 2, but now $p_2$ has been increased to a level that guarantees no switching for the marginal firm. Thus, after the monetary policy shock, there is no change in the financing choices of the individual firms for either of the three firm types. As Oliner and Rudebusch (1996a) suggest, there is still a negative effect on the aggregate financing mix, due entirely to a disproportionate effect of the policy shock on small firms. However, as Kashyap et al. (1996) argue, the explanation for this differential response of small firms lays precisely on the Bank Lending Channel. That firms are affected by a different mechanism that would constrain all sources of credit equally is not a requirement.

There is a second argument against the Bank Lending Channel rooted in the evidence presented by Gertler and Gilchrist (1994), Oliner and Rudebusch (1996a, 1996b) and Bernanke et al. (1996). These authors find a re-direction of all forms of credit from small firms towards large firms after a monetary contraction. This observation is independent of the financing choice of each type of firm, and it is consistent with no changes in the financing mix at the level of the firm. This is the "Flight to Quality" story (Bernanke et al., 1996) that provides strong support to a Balance Sheet Channel of monetary policy in which banks play no special role, and where the collateral/balance sheet constraint is less binding the larger and less risky the firm. In their view the Bank Lending Channel cannot provide an equally satisfactory explanation of the facts.

However, Fig. 4 shows that our "augmented" version of the Bank Lending Channel produces qualitative dynamics of firms' variables in line with this "Flight to Quality" story. Fig. 4 displays the dynamics of firm-level variables after a temporary negative shock to $\varepsilon$. The figure shows a shift of business (i.e. sales, investment and credit) away from small firms and towards large firms.

The driving force for this result is the response of the endogenous interest rate in a general equilibrium setting. As small firms cut back on production and financing after being affected by higher intermediation costs, they free-up resources that can then be used by other production units not initially affected by the monetary contraction. Higher intermediation costs also imply lower wealth and thus lower consumption by households, which makes even more resources available for investment in larger firms. As more resources are made available, the relative price of current period goods in terms of future goods (i.e. the real interest rate) decreases. Large firms, which are not directly affected by the policy shock, take advantage of the lower financing costs and they increase production.[19] From this exercise we conclude that the empirical evidence on "Flight to Quality" should not be used to make a case against the Bank Lending Channel. In fact, the predictions of this "heterogeneous-borrower-augmented" version of the Bank Lending Channel (with no role for firms' balance sheets) are also in line with this evidence.

Finally, a prediction of the Balance Sheet Channel with strong support in the data is the asymmetric response over the business cycle of small-firm variables (investment in particular) to a monetary policy contraction (see Gertler and Gilchrist, 1994). A monetary policy tightening worsens the balance sheet positions of small credit-constrained firms, their net worth decreases, informational problems worsen and agency costs increase. Thus, the external financing premia for these firms rise, increasing their financing costs. The idea is that this mechanism should be stronger during downturns, when firms net worth is already low. During a boom, monetary policy is not likely to have such a strong impact on the external finance premium of small firms because their credit constraints are not likely to bind in good times. Large firms, on the other hand, should not experience such an asymmetric effect since their credit constraints are rarely binding after a monetary shock, even during bad times. The common wisdom is that the simple story behind the Bank Lending Channel cannot account for

[18] Fig. 3(b) shows the corresponding individual variables at the firm-type level.

[19] This result is clearly in contrast with the traditional interest rate channel of monetary policy. In the traditional view, a positive shock to nominal interest rates generates an increase in real rates due to price rigidities. There are, however two pieces of evidence that back the idea of falling real rates during a policy tightening. First, King and Watson (1996) and Seppala and Xie (2005) show that real interest rates are countercyclical, so countercyclical monetary policy generates real interest rate responses in line with those observed in this model. Second, Mishkin (2007) argue that even nominal rates could decline after a slowdown in the growth rate of money supply due to income, price level and expected inflation effects.

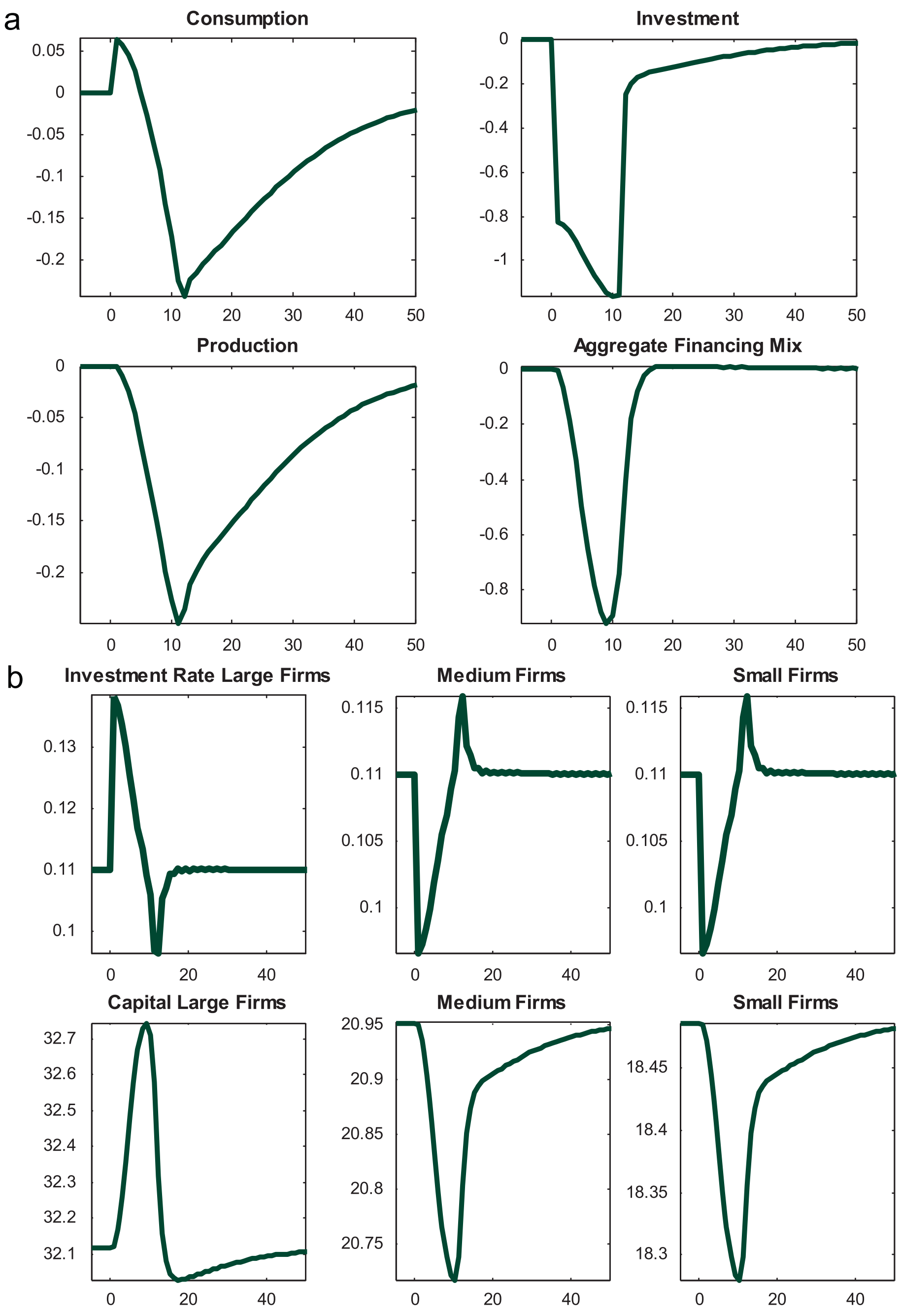


**Fig. 3.** (a) Compositional effects versus switching. *Note*: same exercise as in Fig. 2, but the value of $p_2$ has been raised to guarantee no switching for the marginal firm. Figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are percentage deviations from the steady state. The aggregate financing mix is the ratio of bank credit to total short-term external financing. (b) Firm-level variables. *Note*: same exercise as in Fig. 2(b), but the value of $p_2$ has been raised to guarantee no switching for the marginal firm. Figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are in levels.

these rich dynamics of disaggregated level variables over the business cycle. However, as we show in Fig. 5, the predictions of our augmented model are also consistent with this asymmetric response over the cycle.

The exercise in Fig. 5 consists of comparing the response to a monetary tightening in two possible states of the economy: a high and a low growth state. High (low) growth states are represented with a $+(-)1\%$ temporary TFP shock.[20] Since there is no growth in this model, positive or negative TFP shocks correspond to states in which the economy is above

[20] The magnitude of this shock (1%) is the standard deviation of the TFP index over the business cycle commonly used by the RBC literature.

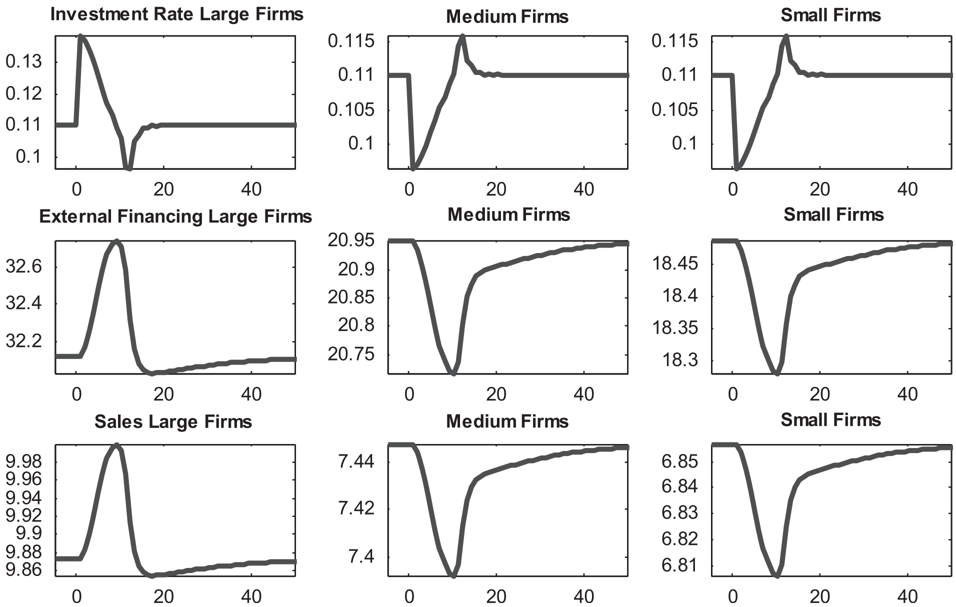


**Fig. 4.** Differential impact of monetary policy across firm sizes and the 'Flight to Quality" hypothesis. *Note*: figures display the dynamics of firm-level variables after a temporary negative shock to $\varepsilon$; they show a shift in business away from small firms and towards large firms, "Flight To Quality". The investment rate $x$ equals $x = iv/k$. Values shown are in levels.

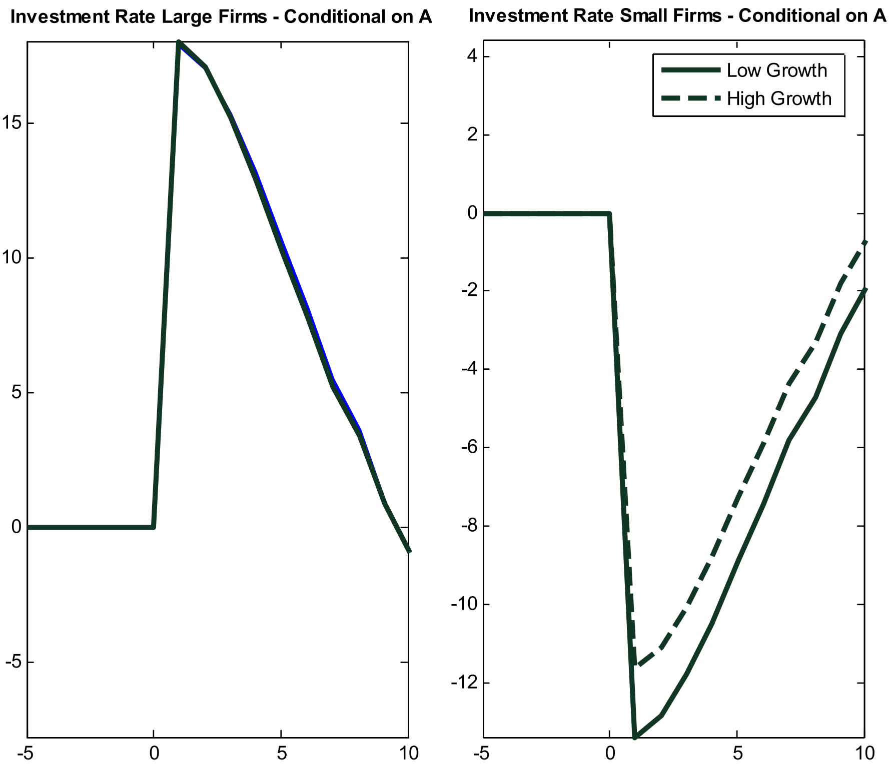


**Fig. 5.** Asymmetric effects of monetary policy over the business cycle. *Note*: figures show impulse response functions to a monetary tightening in two possible states of the world: a high and a low growth state. Values shown are percentage deviations from the steady state.

or below trend, respectively. Fig. 5 displays the time paths for the investment rate conditional on the state of the economy (i.e. controlling for the level of the TFP index) after a temporary monetary policy shock under the two growth regimes. The solid (dashed) line corresponds to a monetary policy shock in a low (high) growth state.

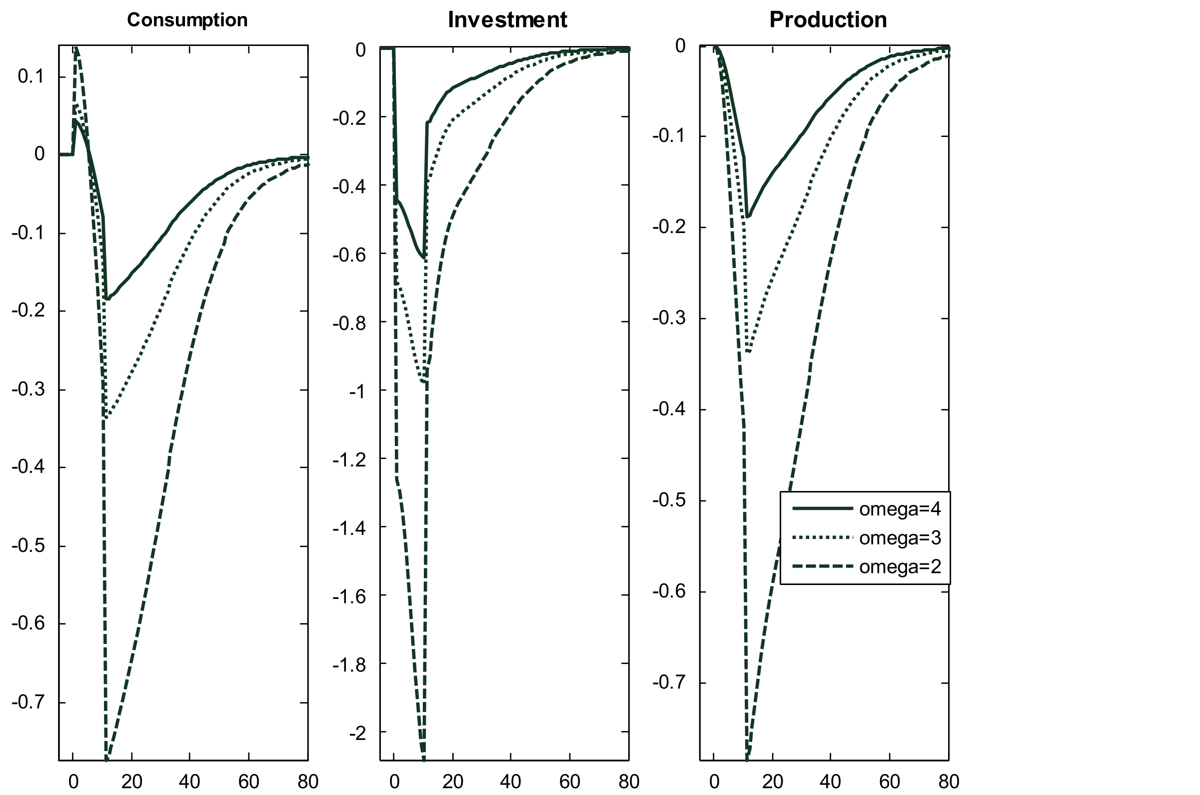


**Fig. 6.** The macroeconomic effects of monetary policy through the lending channel for alternative levels of excess reserves in banking. *Note*: figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are percentage deviations from the steady state.

Investment for small firms (i.e. $p_3$ type) display a marked asymmetry in their response to a monetary tightening, with the reduction being significantly smaller in the high-growth state (even after controlling for the level of economic activity). The story is different for large firms: investment follows the same pattern in good and bad times. The feature of the model that generates this result is that for this specific exercise we allow for bank intermediation costs to move countercyclically over the economy's business cycle, assuming $\Omega = ((\Lambda - \varepsilon)/R)^{\omega_1} A^{-\omega_2}$ such that $\Omega_A < 0$. We do so building on the empirical evidence presented by Chen et al. (2005) and Aliaga-Díaz and Olivero (2010a, b) for the United States[21] and by Olivero (2010) for a cross-section of OECD countries. Notice that this feature is completely unrelated to endogenously varying borrowers balance sheets. In a model of the Bank Lending Channel countercyclical costs reinforce the effects of a monetary policy tightening during recessions, while they tend to ameliorate them during booms. Therefore, concluding that this asymmetric response provides evidence in favor of the Balance Sheet Channel (and against the Bank Lending Channel) seems premature.

In the following subsections we present the results of two robustness checks performed on the model.

### 5.3. A first robustness check: The macroeconomic effects of monetary policy under different levels of banks' excess reserves holdings

In this section we want to look at the aggregate effects of monetary policy under different alternative scenarios concerning excess reserves holdings by the banking sector. This exercise is interesting because excess reserves can act as a buffer against monetary contractions. Banks can use these reserves to make up for the lost insurable sources of finance (i.e. deposits) without having to resort to uninsured sources of finance that are more prone to asymmetric information problems. Doing so, banks can partially avoid the increase in their costs, and therefore they can afford to curtail their lending by less, weakening the effects of monetary policy.

What we do is to run the model for three alternative values of the parameter $\omega$ in the cost function $\Omega = f(\varepsilon, R)$. These results are shown in Fig. 6. They show that the larger the parameter $\omega$, the larger the incentive for banks to hold excess reserves, the larger the amount that they hold and the weaker the effects of monetary policy.

[21] Chen et al. (2005) show that banks operate with lower intermediation costs during booms. Aliaga-Díaz and Olivero (2010a, b) provide evidence on countercyclical price-cost margins in commercial banking.

When $\omega = 2$, consumption falls by 0.8% in response to a monetary tightening, investment falls by 2.2% and output falls by 0.85%. As $\omega$ increases towards 4, these drops change to 0.2%, 0.6% and 0.2%, respectively. We confirm our intuition that the effects of monetary policy through the lending channel are weakened as banks increase their reliance on excess reserves.

### 5.4. A second robustness check: Non-separable costs of bond financing

The verification cost and origination cost of bond financing are assumed to be separable in the benchmark version of our model. However, it makes sense to think of an alternative scenario in which if a borrower has a higher probability of

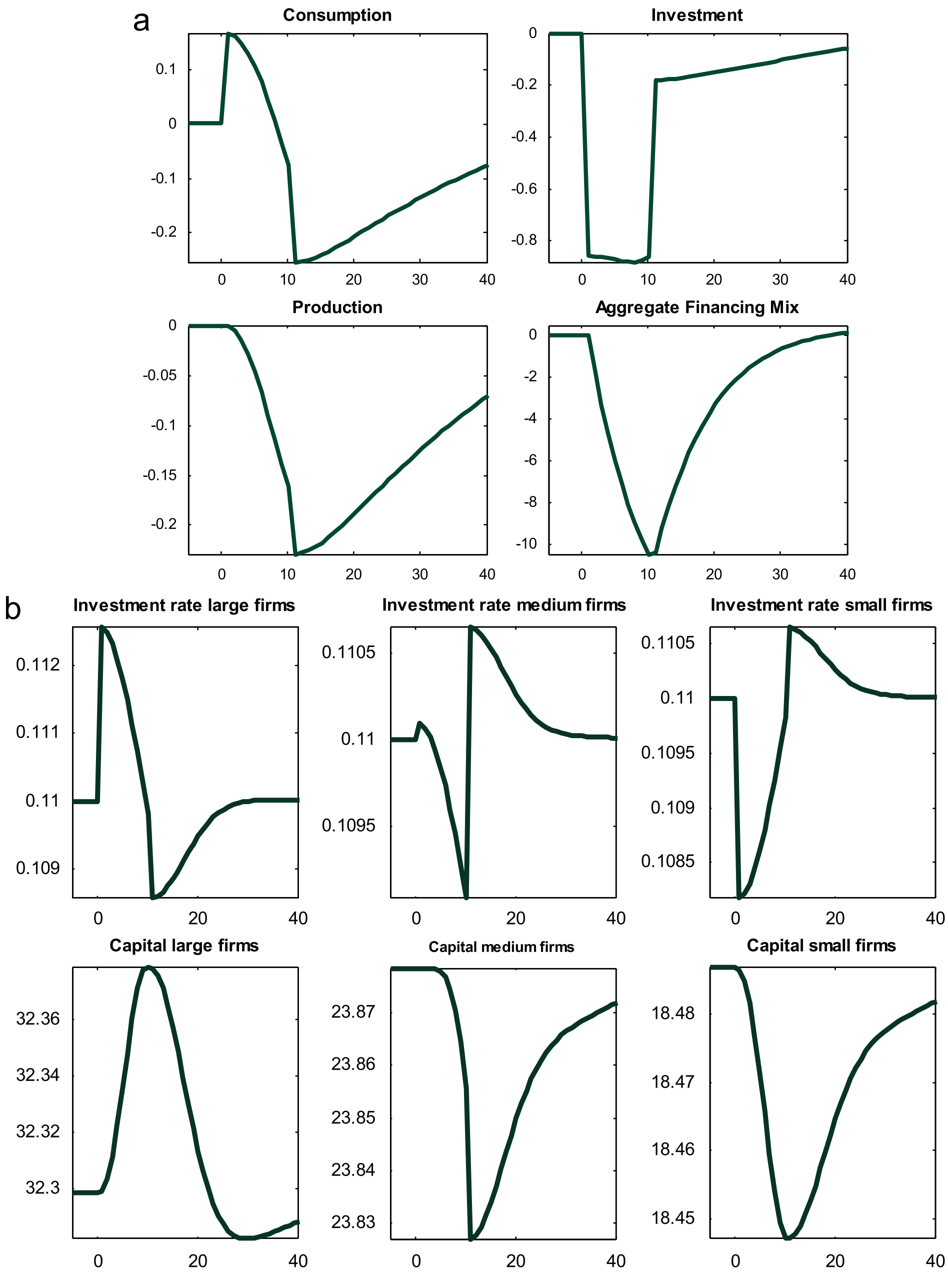


**Fig. 7.** (a) The aggregate financing mix and the Bank Lending Channel—non-separable costs of bond financing. *Note*: figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are percentage deviations from the steady state. The aggregate financing mix is the ratio of bank credit to total short-term external financing. (b) Firm-level variables—non-separable costs of bond financing. *Note*: figures show impulse response functions to a monetary tightening as measured by a negative shock to $\varepsilon$. Values shown are in levels.

bankruptcy (i.e. a higher $p$), then it should also incur higher origination costs. Thus, in this section we conduct a robustness check on the benchmark model and specify both types of costs as non-separable.

Total origination costs of bond financing are now given by $\vartheta(p,iv/k) = p\varphi(iv/k)^{\theta}$ per unit of loan. We still set $\theta = 2$ to work with a quadratic cost function, but $\varphi$ is now set so that these costs are still 1.35% of loans as in the benchmark parametrization of the model.

The results of this exercise are presented in Fig. 7. It is obvious from these charts that the results are quantitatively mildly different from the benchmark, but qualitatively robust to the parametrization of the cost function.

We expected this consistency in results for two reasons: First, we calibrate the two cost functions so that in steady-state costs as a percentage of loans are the same for each firm type. Second, the functional forms for $\vartheta(x_p)$, $\vartheta'(x_p)$ and $\vartheta''(x_p)$ that enter equilibrium condition (32) are unchanged.

## 6. Conclusions

The inability of a benchmark version of the Bank Lending Channel model to yield predictions in line with firm-level data has cast doubts among researchers about the role played by bank credit in the transmission of monetary policy. At the same time, an alternative mechanism, the Balance Sheet Channel, which relies on shocks to individual borrowers' net worth rather than on shifts of the aggregate supply of credit, has proven successful at replicating these data. It has been stressed that only the Balance Sheet Channel can account for the rich dynamics of several firm-level variables (see Oliner and Rudebusch, 1996b).

However, the main argument we make in this paper is that using firm-level data to judge the validity of the Bank Lending story is misleading because standard versions of the Bank Lending Channel are *silent* about the dynamics of firm-level variables. The existing empirical evidence could provide a test of the bank lending view only in relation to an appropriate falsifiable hypothesis. In this sense, the model we build in this paper provides an adequate framework to confront the Bank Lending Channel hypothesis to the firm-level evidence gathered by previous work. Our "heterogeneous borrower-augmented" version of the Bank Lending Channel embedded into an otherwise standard dynamic general equilibrium model (with no role for firms' balance sheets) allows us to study the qualitative dynamics of firm-level variables.

Our main contribution is to successfully reproduce the qualitative dynamics of firm-level data. Our model predictions can track well firms' financing choices, the differential access to credit markets across firm sizes and the compositional effects in changes of the financing mix after a monetary policy tightening, all of them empirical regularities attributed to the Balance Sheet Channel and the "Flight to Quality" hypothesis.

It is important to note that our goal was by no means to challenge the validity of the alternative Balance Sheet Channel, or to suggest identification problems in previous empirical research. Rather, the idea is to study the firm-level implications of monetary policy operating through the Bank Lending Channel, and to confirm the feasibility of bank lending as a transmission mechanism of monetary policy. Further empirical research is needed to formulate a rigorous econometric test that can provide support to this hypothesis, and possibly give an indication of the relative importance of the two alternative credit channels of monetary policy.

We believe the topic we study in this paper is specially relevant because despite the rapid pace at which the disintermediation process has been unfolding in the banking sector during the last three decades, bank credit still remains an important source of external financing for firms (particularly smaller ones). Thus, it is important to assess the extent to which even small shocks to the supply of bank loans can still provide an effective transmission channel of monetary policy.

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## Appendix A. Treatment of idiosyncratic risk

In spite of the idiosyncratic risk stemming from firms default risk, it is not necessary to use stochastic methods in this model. If lenders' total assets are large relative to the size of each of the investment projects that they finance, then lenders can achieve perfect diversification of their portfolio of assets. By the Law of Large Numbers, borrower types will indicate exactly the proportion of non-performing loans in each lender's assets portfolio. Thus, all that banks need to do is to charge a default risk-adjusted interest rate on their loans $i_p^L = f(r^d, p)$, where $r^d$ is the interest rate paid on deposits and $p$ is a default risk premium. This risk premium does not refer to the compensation for risk-aversion of the lender, but rather to a compensation for the probability of default.

For the case of bondholders we assume that there is a securitization firm that undertakes the risk-pooling function. The assumption of risk-pooling applies very naturally to the case of banks. However, it is more difficult to invoke risk-pooling for the case of small bondholders. In this model, the bondholder is the representative household, an atomistic unit.

Thus, we think of a setting in which households own loan-backed securities issued by a securitization firm which in turn undertakes the risk-pooling function. There are two reasons why the securitization firm and the bank are different institutions. First, the latter operates under perfect information. Second, there is no intermediation costs associated to the activities of this firm. This firm (in representation of households) will also charge $i_p^b = f(r^b, p)$ for the loan to a type $p$ firm, where $r^b$ is the opportunity cost of capital and $p$ is again a risk premium given by the probability of default.

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