

# Bank finance versus bond finance: what explains the differences between US and Europe?\*

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## Abstract

We present a DSGE model with agency costs, where heterogeneous firms choose among two alternative instruments of external finance - corporate bonds and bank loans. We characterize the financing choice of firms and the endogenous financial structure of the economy. The calibrated model is used to address questions such as: What explains differences in the financial structure of the US and the euro area? What are the implications of these differences for allocations? We find that a higher share of bank finance in the euro area relative to the US is due to lower availability of public information about firms' credit worthiness and to higher efficiency of banks in acquiring this information. We also quantify the effect of differences in the financial structure on per-capita GDP.

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# 1 Introduction

This paper looks at the composition of the corporate sector's external finance as an important dimension through which credit imperfections affect the macroeconomy. In the presence of agency costs, the main role of financial intermediaries is to provide contractual arrangements that reduce the effects of information asymmetries between lenders and borrowers. This is achieved by offering alternative financing instruments that best fit the needs of individual borrowers. Each instrument differs in the cost imposed to lenders and borrowers and in the ability to reduce the macroeconomic effects of information asymmetries.

Empirical evidence suggests substantial differences in the financial structure across countries. For instance, the traditional distinction between bank-based and market-based financial systems applies to the euro area and the US. Investment of the corporate sector relies much more heavily on bank finance in the euro area than in the US. In 2001, bank loans to the corporate sector amounted to 42.6 percent of GDP in the euro area, and to 18.8 percent in the US. Conversely, outstanding debt securities of non-financial corporations and stock market capitalization amounted respectively to 6.5 and 71.7 percent in the euro area, and to 28.9 and 137.1 percent in the US.<sup>1</sup> Other, although less striking, differences in the financial structure of the US and of the euro area occur in the corporate sector's debt to equity ratio, and in the average risk premium and default rate on bank loans.

In this paper, we introduce heterogeneous firms and alternative instruments of external finance in a standard DSGE model with agency costs. We characterize the optimal choice of firms among alternative instruments and derive the endogenous financial structure. The model can be used as a laboratory to answer questions such as: What generates differences in financial structures among countries? What are the implications of these differences for allocations?

Existing DSGE models with agency costs (e.g. Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997, 1998, 2001), Bernanke, Gertler and Gilchrist (1999), Christiano, Motto and Rostagno (2004) and Faia (2002)) do not allow to explain observed differences in financial structures, as they do not distinguish between alternative instruments of external finance. We introduce two types of financial intermediaries - commercial banks and capital mutual funds - into a DSGE model with credit frictions and information asymmetries. Each type of financial intermediaries (here onwards FI) offers a different intra-period contractual arrangement to

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<sup>1</sup>Source: Ehrmann et al (2003), Table 14.1.

provide external finance to firms. Firms experience a sequence of idiosyncratic productivity shocks, the first being realized before firms take financing decisions. Therefore, when choosing the source of external finance firms are heterogeneous in the risk they face of defaulting at the end of the period. Banks and capital mutual funds (CMFs) differ because banks are willing to spend resources to acquire information about firms in financial distress, while CMFs are not. Conditional on the information obtained, banks give firms the option to obtain loans and produce or to abstain from production and keep their initial net worth (except for an information acquisition fee to be paid to banks). The fact that banks spend resources to acquire information implies that bonds are less costly than bank loans. Nonetheless, financing through bonds is a risky choice for firms, because a situation of financial distress can only be resolved with liquidation and with the complete loss of the firm's initial net worth.

The contribution of the paper is twofold. First, we present a DSGE model where the financial structure of the economy can be endogenously derived from the firms' optimal choice of the financing instrument. Our model can easily embed firms' heterogeneity in the risk of default without giving up tractability. The dynamics of the economy can be described by a system of aggregate equilibrium conditions similar to those arising in models without such heterogeneity. Second, we calibrate the model in steady state to replicate key differences in the financial structure of the US and the euro area. We find that a higher share of bank finance in the euro area relative to the US is due to lower availability of public information about firms' credit worthiness and to higher efficiency of banks in acquiring this information. To assess the quantitative importance of differences in financial structures, we compare the observed ratios of per-capita GDP in the US and in the euro area to those generated by the model with and without an endogenous financial structure.

The most closely related paper to ours is Carlstrom and Fuerst (2001), here onwards CF. The main difference is that in CF, at the time of stipulating the financial contract, firms are ex-ante identical.<sup>2</sup> Moreover, they have access to one financing instrument only. Hence, in their framework it is not possible to address the importance of the composition of firms' external finance for the macroeconomy. Another difference arises in the focus of the analysis.

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<sup>2</sup>In CF (2001), at the time of the contract firms can differ in terms of size. However, due to the specific characteristic of the contract solution, this type of heterogeneity is not relevant in equilibrium and firms can be assumed identical ex-ante. In what follows, we will use the term "ex-ante heterogeneity" as implying heterogeneity at the time of stipulating the contract in the risk of defaulting at the end of the period. This type of heterogeneity is also relevant in equilibrium.

CF address the effect of agency costs on the transmission of aggregate shocks. As the focus of this paper is on the determinants of financial market structures, we restrict the attention to a steady state analysis.

Our paper also relates to some recent theories of financial intermediation (e.g. Chemmanur and Fulghieri (1994) and Holstrom and Tirole (1997), among several others). We share with Chemmanur and Fulghieri (1994) the idea that banks treat differently borrowing firms in situations of financial distress because they are long-term players in the debt market while bondholders are not. Hence, banks have an incentive to acquire a larger amount of information about firms. By minimizing the probability of their inefficient liquidation, banks build a reputation for financial flexibility and attract firms that are likely to face temporary situations of distress. The steady state distribution of firms arising in our DSGE model closely resembles that obtained by Holstrom and Tirole (1997) in a two-period model where firms and intermediaries are capital constrained. The authors find that poorly capitalized firms do not invest. Well capitalized firms finance their investment directly on the market, relying on cheaper, less-information intensive finance. Firms with intermediate levels of capitalization can invest, but only with the help of information-intensive external finance.

The paper proceeds as follows. In section 2, we describe the environment and outline the sequence of events. In section 3, we present the analysis. We start by showing that in our economy the presence of agency costs translates into a firm-specific markup that entrepreneurs need to charge over marginal costs. We proceed to derive the optimal contract between firms and FIs, and we characterize the endogenous financial structure of the economy. We show that in each period, conditional on the realization of the first idiosyncratic shock, entrepreneurs split into three sets: entrepreneurs that decide to abstain from production, entrepreneurs that approach a bank and possibly obtain a loan, and entrepreneurs that raise external finance through CMFs. Finally, we describe the consumption and investment decisions of entrepreneurs and households, present aggregation results and characterize the competitive equilibrium. In section 4, we illustrate the main properties of the model in steady state. In section 5, we review the evidence on differences in the intermediation activities and in the financial structure of the corporate sector in the US and the euro area. Then, we present a calibration of the model that replicates in steady state the outlined key differences. Finally, we explore possible reasons for such differences and we look at the implications for allocations. In section 6, we conclude and outline our future research.

## 2 The Model

We cast the different role of corporate bonds and bank loans into a DSGE model with credit frictions, where we maintain the assumption of one-period maturity of the debt.

The domestic economy is inhabited by a continuum of identical infinitely-lived households, a continuum of heterogeneous firms owned by infinitely lived risk-neutral entrepreneurs, and two types of zero-profit FIs. Each firm, indexed by  $i \in [0, 1]$ , starts the period with an endowment of physical capital and with a constant returns to scale production technology that uses labor and capital as inputs. The value of the initial capital stock is not sufficient to finance the input bill. Hence, producing firms need to raise external finance.

Each firm is hit by a sequence of three idiosyncratic productivity shocks. The first shock,  $\varepsilon_{1,it}$ , is publicly observed and realizes before firms take financial and production decisions. The second shock,  $\varepsilon_{2,it}$ , is not observed by anyone (not even the entrepreneur). Information on the realization of this shock can be acquired by the FIs at a cost that is proportional to the value of the firm. The third shock,  $\varepsilon_{3,it}$ , realizes after borrowing occurs and is observable to the entrepreneur only. It can be monitored by FIs at the end of the period, at a cost that is a fraction of the firm's production.

Banks and CMFs differ in that only banks are willing to spend resources to acquire information about the signal,  $\varepsilon_{2,it}$ . They disclose it to entrepreneurs in exchange of an information acquisition fee.

Loans extended by both types of FIs take the form of intra-period trade credit calculated in units of the output good, as in CF. Firms obtain labor and capital inputs from the households against the promise to deliver the factor payments at the end of the period. This requires a contractual arrangement, which is supplied by a FI.

### 2.1 The environment

#### 2.1.1 Households

Households maximize the expected value of the discounted stream of future utilities,

$$E_0 \sum_{t=0}^{\infty} \beta^t [\ln c_t + \eta (1 - l_t)], \quad 0 < \beta < 1, \quad (1)$$

where  $\beta$  is the households' discount rate,  $c_t$  is consumption,  $l_t$  denotes working hours and  $\eta$  is a preference parameter. The households are also the owners of the FIs, to which they lend on

a trade credit account to be settled at the end of each period. The representative household faces the budget constraints,

$$c_t + k_{t+1} - (1 - \delta)k_t \leq w_t l_t + r_t k_t, \quad (2)$$

where  $w_t$  denotes the real wage and  $r_t$  the rental rate on capital.

### 2.1.2 Entrepreneurs

Each entrepreneur  $i$  enters the period holding capital  $z_{it}$ . The firm operates a CRS technology described by

$$y_{it} = \varepsilon_{1,it} \varepsilon_{2,it} \varepsilon_{3,it} H_{it}^\alpha K_{it}^{1-\alpha}, \quad (3)$$

where  $K_{it}$  and  $H_{it}$  denote the firm-level capital and labor, respectively. The productivity shocks  $\varepsilon_{1,it}$ ,  $\varepsilon_{2,it}$  and  $\varepsilon_{3,it}$  are random iid disturbances, which occur at different times during the period. They have mean unity,<sup>3</sup> are mutually independent and have aggregate distribution functions denoted by  $\Phi_1$ ,  $\Phi_2$  and  $\Phi_3$  respectively. Per independence assumption, these are also the marginal distributions. The entrepreneur faces the constraint that the available funds,  $x_{it}$ , need to equal the costs of renting the factors of production,

$$x_{it} = w_t H_{it} + r_t K_{it}. \quad (4)$$

Entrepreneurs are infinitely lived, risk-neutral and more impatient than households. They discount the future at a rate  $\beta\gamma$ , where  $\beta$  is the discount factor of households and  $0 < \gamma < 1$ . Entrepreneurial utility is linear in consumption and in effort. Running a risky project requires an entrepreneurial effort proportional to the size of the project,  $x_{it}$ . Define  $D_{it}$  as a dummy variable that takes the value of 1 if firm  $i$  produces in period  $t$  and of 0 if it does not. The problem is to maximize the expected value of the discounted stream of future utilities,

$$E_0 \sum_{t=0}^{\infty} (\beta\gamma)^t (e_{it} - \chi x_{it} D_{it}), \quad 0 < \gamma < 1, \quad (5)$$

subject to the budget constraint

$$e_{it} + z_{it+1} = y_{it}^e, \quad (6)$$

Here  $e_{it}$  denotes entrepreneurial consumption,  $z_{it+1}$  is investment in physical capital to be used in period  $t + 1$ , and  $y_{it}^e$  is the share of the firm's production accruing to the entrepreneur after

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<sup>3</sup>An aggregate technology shock can be introduced by assuming that the mean  $\varepsilon_{1t}$  of the first entrepreneur-specific technology shock is not unitary.

repayment of the loans. The parameter  $\chi$  measures the disutility of exerting effort in running the project. Notice that, because entrepreneurs are more impatient than households, they demand a higher internal rate of return to investment. This opens the room for trade between households and entrepreneurs despite the agency costs of external finance.

### 2.1.3 Agency costs and financial intermediation

Entrepreneurs obtain labor and capital inputs from the households against the promise to deliver the factor payments at the end of the period. Given the possibility of default by firms, this promise needs to be backed up by a contractual arrangement with a FI (a bank or a CMF). The competitive FIs are able to diversify the risk among the continuum of firms facing idiosyncratic risk. Hence, they ensure repayment of the factors of production to the households despite the possibility of default by firms. Since credit arrangements are settled at the end of the same period, the intermediaries break exactly even on average.

Let  $\omega_{it}$  be the uncertain productivity factor at contracting time, when firms approach FIs,

$$\omega_{it} = \begin{cases} \varepsilon_{2,it}\varepsilon_{3,it} & \text{for CMF finance} \\ \varepsilon_{3,it} & \text{for bank finance} \end{cases}$$

Firms that decide to raise finance from banks pay an up-front fee that covers the bank's cost of information acquisition about the signal  $\varepsilon_{2,it}$ . The fee is a fixed proportion  $\tau$  of the firm's value  $n_{it}$ . This cost is not faced by firms that sign a contract with CMFs, as these FIs do not acquire information about the unobserved shock. Hence, the disposable net worth of a firm at the time of the contract is given by  $\tilde{n}_{it}$ , where

$$\tilde{n}_{it} = \begin{cases} n_{it} & \text{for CMF finance} \\ (1 - \tau)n_{it} & \text{for bank finance} \end{cases}$$

Conditional on  $\varepsilon_{1,it}$  and possibly  $\varepsilon_{2,it}$  as described in section 2.2 below, each entrepreneur chooses to invest an amount  $0 \leq \hat{n}_{it} \leq \tilde{n}_{it}$  of internal finance in the risky project and requests an amount  $x_{it} - \hat{n}_{it}$  of external finance to back up his promise of repayment, for total funds at hand of  $x_{it}$ . We assume that the financial intermediary is willing to finance a project whose size is a fixed proportion of the internal funds invested,

$$x_{it} = \xi \hat{n}_{it}, \quad \xi \geq 1. \tag{7}$$

This assumption captures the idea that entrepreneurs differ in their ability to run projects. In effect, we assume that the maximal size of a project which an entrepreneur is capable of running is proportional to his net worth.

After the realization of the uncertain productivity factor,  $\omega_{it}$ , the entrepreneur observes the actual production in units of goods,  $y_{it}$ , and announces it to the FI. The realization of  $\omega_{it}$  is only known to the firm, unless there is monitoring. Monitoring is costly in that it requires destroying a fraction  $\mu$  of the firm's output. After the announcement of the entrepreneur, the FI decides whether or not to monitor.

The informational structure at contracting time corresponds to the costly state verification (CSV) framework of Townsend (1979) and Gale and Hellwig (1985).<sup>4</sup> A standard result of this framework is that the optimal contract between each firm and FI is risky debt. The contract specifies how to divide the firm's financing requirement into internal and external finance. It also specifies, for each announced output and prior information ( $\varepsilon_{1,it}$  under CMF finance and  $\varepsilon_{1,it}\varepsilon_{2,it}$  under bank finance), a threshold for the uncertain productivity factor,  $\omega_{it}$ . The firm defaults and the FI commits to monitor if the entrepreneur's announcement of  $\omega_{it}$  is below this threshold. If there is monitoring,  $\omega_{it}$  is made known to the FI and the firm's production is completely seized. The contract also sets a fixed repayment for firms that do not default.

## 2.2 The timing of events

The following list provides an overview of the timing of events in period  $t$ .

Entrepreneurs and households enter the period holding respectively capital  $z_{it}$  and  $k_{ht}$ . Households plan, how much labor to supply, and how much consumption and investment goods to purchase. They also supply labor and rent out their capital stock. Entrepreneurs calculate the end-of-period value  $n_{it}$  of their capital holdings  $z_{it}$ , which is publicly observable.

Financial decisions unfold over three stages.

- I. The first entrepreneur-specific shock  $\varepsilon_{1,it}$  is realized and publicly observed. Conditional on its realization, entrepreneurs decide whether to:

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<sup>4</sup>Restriction (7) is usually not imposed in the costly state verification literature. Its consequences are discussed in greater detail in section 3.2.1.



a. *Abstain from production.* Entrepreneurs facing a low  $\varepsilon_{1,it}$ , or a high risk of default, decide not to borrow and not to produce, i.e. they choose  $\hat{n}_{it} = 0$ . They rent out capital on the market, thus retaining their initial net worth,  $n_{it}$ , until the end of the period.

b. *Possibly borrow from banks and produce.* Entrepreneurs facing an intermediate realization of  $\varepsilon_{1,it}$  decide to approach a bank and to postpone their production decision after the realization of the second productivity shock  $\varepsilon_{2,it}$ .<sup>5</sup>

c. *Borrow from CMFs and produce.* Entrepreneurs facing a high realization of  $\varepsilon_{1,it}$  decide to raise external finance from CMFs and not to acquire information on  $\varepsilon_{2,it}$ .

II.  $\varepsilon_{2,it}$  is realized and not observed by anyone. Information on its realization is acquired by banks at a cost  $\tau n_{it}$  and communicated to entrepreneurs. Conditional on  $\varepsilon_{2,it}$ , entrepreneurs choose their investment level  $0 \leq \hat{n}_{it} \leq \tilde{n}_{it} = (1 - \tau)n_{it}$ , i.e. whether to:

d. *Abstain from production*, in which case  $\hat{n}_{it} = 0$ . These entrepreneurs rent out capital, retaining their remaining net worth,  $(1 - \tau)n_{it}$ , until the end of the period.

e. *Borrow from banks and produce.*

III. Entrepreneurs that have chosen to produce hire labor  $H_{it}$  and rent capital  $K_{it}$  from the households against the promise to deliver the factor payments at the end of the period. This promise is backed up by the value of their own capital holdings plus the value of the additional trade credit obtained from the FI (either a bank or a CMF).

The third shock  $\varepsilon_{3,it}$  is realized and observed by the entrepreneur only. Production takes place,  $y_{it} = \varepsilon_{1,it}\varepsilon_{2,it}\varepsilon_{3,it}H_{it}^\alpha K_{it}^{1-\alpha}$ . The entrepreneurs keep part of output,  $y_{it}^e$ , for own consumption and investment, and sell the rest to households to settle trade credit. Entrepreneurs announce the outcome of production and repay loans or default on loans, if they cannot repay the agreed-upon amount. Conditional on the announcement, the financial intermediaries decide whether or not to monitor.

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<sup>5</sup>At this point, one could introduce the possibilities for entrepreneurs to enter actuarially fair gambles. It turns out that entrepreneurs would enter these gambles, and transfer their entire net worth to those entrepreneurs which draw the highest values of  $\varepsilon_2$ . Equivalently, one could assume that banks are allowed to cross-subsidize projects. They would take resources from low- $\varepsilon_2$  entrepreneurs and give them to high- $\varepsilon_2$  entrepreneurs. Here we effectively outlaw gambling and cross-subsidization, as common in the literature. An assumption which can rule out the benefits of such gambles is sufficient risk aversion for the entrepreneurs. This, however, would substantially increase the complexity of the model.

Entrepreneurs consume  $e_{it}$  and accumulate capital  $z_{i,t+1}$ . Households use the goods purchased for consumption  $c_t$  and investment in capital  $k_{h,t+1}$ .

### 3 Analysis

First, we show that the presence of agency costs translates into a firm-specific markup that entrepreneurs need to charge over marginal costs. Then, we characterize the contract between each firm and FI, and we derive the endogenous financial structure. We proceed by characterizing consumption and investment decisions of entrepreneurs and households. Finally, we present aggregation results and characterize the competitive equilibrium.

#### 3.1 Factor prices and the markup

Each entrepreneur's net worth,  $n_{it}$ , is given by the market value of his accumulated capital stock,  $z_{it}$ , calculated as the to-be-earned factor payments plus the depreciated capital stock,<sup>6</sup>

$$n_{it} = (1 - \delta + r_t) z_{it}, \quad (8)$$

Firms that produce need to sign a contract with the FIs to raise external finance for total funds at hand  $x_{it}$ . Normalizing goods prices, the firm's demand for labor and capital is derived by solving the problem

$$\max \mathcal{E} [\varepsilon_{1,it} \varepsilon_{2,it} \varepsilon_{3,it} H_{it}^\alpha K_{it}^{1-\alpha} - w_t H_{it} - r_t K_{it}]$$

subject to the financing constraint (4). Here the expectation  $\mathcal{E}[\cdot]$  is taken with respect to the productivity variables yet unknown at the time of the factor hiring decision. More precisely,

$$\mathcal{E}[\varepsilon_{1,it} \varepsilon_{2,it} \varepsilon_{3,it}] = \begin{cases} \varepsilon_{1,it} & \text{for CMF financed firms} \\ \varepsilon_{1,it} \varepsilon_{2,it} & \text{for bank financed firms} \end{cases}$$

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<sup>6</sup>One possible interpretation is that entrepreneurs sell their capital stock at the beginning of the period against trade credit  $n_{it}$ . Notice that entrepreneurs' net worth should include also a fixed income component (e.g. a constant lump-sum subsidy  $\psi$ ). This would ensure that, if the entrepreneur defaults in period  $t - 1$ , he can obtain external finance and eventually produce. Since introducing a small constant subsidy does not affect the analysis, we abstract from it.

Denote the Lagrange multiplier on the financing constraint as  $s_{it} - 1$ . Optimality implies that

$$\begin{aligned} K_{it} &= (1 - \alpha) \frac{x_{it}}{r_t} \\ H_{it} &= \alpha \frac{x_{it}}{w_t} \\ \mathcal{E}[y_{it}] &= s_{it} x_{it}. \end{aligned}$$

where

$$s_{it} = \begin{cases} \varepsilon_{1,it} q_t & \text{for CMF finance} \\ \varepsilon_{1,it} \varepsilon_{2,it} q_t & \text{for bank finance} \end{cases} \quad (9)$$

$$q_t = \left( \frac{\alpha}{w_t} \right)^\alpha \left( \frac{1 - \alpha}{r_t} \right)^{1 - \alpha}. \quad (10)$$

We can interpret  $q_t$  as an aggregate distortion in production arising from the presence of agency costs in the economy. Notice that  $s_{it}$  acts as a markup, which firms need to charge in order to cover the agency costs of financial intermediation. Moreover,  $s_{it}$  is firm-specific: depending on what is already known about final firm productivity, i.e. depending on  $\varepsilon_{1,it}$  and (for bank-financed firms)  $\varepsilon_{2,it}$ , the financing constraint may be more or less severe. In CF, as in most of the literature, nothing is known before firms produce, i.e.,  $\mathcal{E}[\varepsilon_{1,it} \varepsilon_{2,it} \varepsilon_{3,it}] = 1$  and  $s_{it} = q_t$ .

### 3.2 Financial structure

In our model, the financial contract is intra-period but the game between firms and FIs unfolds over three stages (described in section 2.2). To derive the endogenous financial structure, we solve the model using backward induction.

First, we derive the optimal choice of agents in stage III. Conditional on the available prior information ( $\varepsilon_{1,it}$  under bank finance and  $\varepsilon_{1,it} \varepsilon_{2,it}$  under bank finance), firms and FIs stipulate a contract that is the optimal solution to a costly state verification (CSV) problem.

Then, we characterize the optimal choice of agents in stage II. Firms that have signed contracts with banks acquire at a cost information about  $\varepsilon_{2,it}$ , on the basis of which they decide whether or not to abstain from production. The decision is taken conditional on the solution of the game in stage III (the financial contract) and on the available prior information ( $\varepsilon_{1,it} \varepsilon_{2,it}$ ). We characterize thresholds for the realization of the observed firm-specific markup  $s_{it}$  that determine the firm's decision of whether or not to borrow and to produce.

Finally, we characterize the optimal decision in stage I. Conditional on the solution of stage II and III (which provides expected pay-off from producing when raising external finance

through banks or CMFs), firms decide whether or not to produce and, if they do, which instrument of external finance to use. We derive thresholds for the realization of the observed firm-specific markup  $s_{it}$  that determine the firm's decision. We show that these thresholds depend only on the distributional assumptions on the three idiosyncratic productivity shocks.

### 3.2.1 The costly state verification contract

The solution to our CSV problem is a standard debt contract (see e.g. Gale and Hellwig (1985)), which is characterized by three properties. First, the repayment to the FI is constant in states when monitoring does not occur. Second, the firm is declared bankrupt if and only if the fixed repayment cannot be honoured. Third, in case of bankruptcy, the FI commits to monitor and completely seizes the output in the hands of the firm. The first and third properties ensure that the contract is incentive compatible. The second property ensures that monitoring is done in as few circumstances as possible to avoid the deadweight loss.

Let  $\Phi_\omega$  and  $\varphi_\omega$  be respectively the distribution and density function of  $\omega_{it}$  and recall that the presence of agency costs implies that  $y_{it} = s_{it}\omega_{it}x_{it}$ . Define

$$f(\bar{\omega}^j) = \int_{\bar{\omega}^j}^{\infty} (\omega - \bar{\omega}^j) \Phi_\omega(d\omega) \quad (11)$$

$$g(\bar{\omega}^j) = \int_0^{\bar{\omega}^j} \omega \Phi_\omega(d\omega) - \mu \Phi_\omega(\bar{\omega}^j) + \bar{\omega}^j [1 - \Phi_\omega(\bar{\omega}^j)] \quad (12)$$

as the expected shares of final output accruing respectively to an entrepreneur and to a lender, after stipulating a contract that sets the fixed repayment at  $s_{it}\bar{\omega}_{it}^j x_{it}$  units of output, for  $j = b, c$ . The index  $j$  denotes the type of FI, where  $b$  indicates banks and  $c$  indicates CMFs. The optimal contract solves the following CSV problem:

$$\max \left[ s_{it}f(\bar{\omega}_{it}^j) - \chi \right] x_{it} \quad (13)$$

subject to constraint (7) and

$$s_{it}g(\bar{\omega}_{it})x_{it} \geq x_{it} - \hat{n}_{it} \quad (14)$$

$$f(\bar{\omega}^j) + g(\bar{\omega}^j) \leq 1 - \mu \Phi_\omega(\bar{\omega}^j) \quad (15)$$

$$\hat{n}_{it} \geq 0, \quad \left[ s_{it}f(\bar{\omega}_{it}^j) - \chi \right] x_{it} \geq \hat{n}_{it} \quad (16)$$

The optimal contract maximizes the entrepreneur's expected utility subject to the restriction on the project size, (7), the lender being willing to lend out funds, (14), the feasibility condition,

(15), and the entrepreneur being willing to sign the contract, (16). Since loans are intra-period, the opportunity cost of lending for the intermediary equals the amount of loans itself,  $x_{it} - \hat{n}_{it}$ .

Notice that constraint (7) usually does not appear in the standard CSV setup. For instance in CF, where firms are identical in terms of default risk, the contract determines optimally the size of the project. This latter turns out to be linear in net worth, as in our model. However, in CF the ratio of the project size to net worth depends on the threshold for the idiosyncratic shock and on the aggregate variable  $q_t$ , while it is constant in our model. This implies that leverage is fixed in our environment. The reason is that, with heterogeneity in the risk of default, firms differ in terms of credit-worthiness. When the distribution of the idiosyncratic shock  $\varepsilon_{1t}$  is unbounded, the optimal project size for firms experiencing extremely large values of that shock would be unbounded. To avoid corner solutions in the allocation of funds from FIs, we set the project size to a fixed share of the firm's initial net worth. This assumption ensures that all firms raise finite amounts of external finance.

**Proposition 1** *Under the optimal contract, the entrepreneur either invests nothing,  $\hat{n}_{it} = 0$ , or invest his entire net worth,  $\hat{n}_{it} = \tilde{n}_{it}$ , requiring an amount  $(\xi - 1)\tilde{n}_{it}$  of external finance. The optimal contract is characterized by a threshold  $\bar{\omega}_{it}^j$ ,  $j = b, c$ , such that, if the entrepreneur announces a realization of the uncertain productivity factor  $\omega \geq \bar{\omega}^j$ , no monitoring occurs. If  $\omega < \bar{\omega}^j$ , the FI monitors at a cost and completely seizes the resources in the hands of the entrepreneur. The threshold is given by the solution to*

$$s_{it}g(\bar{\omega}_{it}^j) = \frac{\xi - 1}{\xi}. \quad (17)$$

**Proof:** Condition (7) and (16) imply that the expected utility of entrepreneurs willing to produce is not lower than the utility from disposing of the net worth initially invested. Notice that the problem is linear in  $\hat{n}_{it}$ . Thus, the solution is "bang-bang", i.e. the entrepreneur either invest nothing and does not produce,  $\hat{n}_{it} = 0$ , or invest everything and produce,  $\hat{n}_{it} = \tilde{n}_{it}$ . Entrepreneurs that produce only raise costly external finance to cover what is needed in excess of the internal funds,  $x_{it} - \tilde{n}_{it} = (\xi - 1)\tilde{n}_{it}$ . Expression (17) for the threshold  $\bar{\omega}_{it}^j$  can be derived by observing that  $f(0) = \int_0^\infty \omega \Phi_\omega(d\omega) = 1$ ,  $g(0) = 0$ ,  $f'(\bar{\omega}_{it}^j) = -\left[1 - \Phi_\omega\left(\bar{\omega}_{it}^j\right)\right] < 0$ , and  $g'(\bar{\omega}_{it}^j) > 0$ . This latter property can be shown by contradiction. Suppose  $g'(\bar{\omega}_{it}^j) < 0$ . Then, it would be possible to increase expected utility of the firm,  $\left[s_{it}f(\bar{\omega}_{it}^j) - \chi\right]\xi\tilde{n}_{it}$ , by reducing  $\bar{\omega}_{it}^j$  while increasing expected profits of the FI,  $s_{it}g(\bar{\omega}_{it}^j)\xi\tilde{n}_{it}$ . Hence,  $\bar{\omega}_{it}^j$  could not be a solution to the contract. It follows that the unique interior solution to the problem is given by (17). ■

The terms of the contract can be written as

$$\bar{\omega}_{it}^j = \bar{\omega}^j(s_{it}), \quad j = b, c \quad (18)$$

where  $s_{it}$  satisfies (9). Notice that  $\frac{\partial \bar{\omega}_{it}^j}{\partial s_{it}} = -\frac{g(\bar{\omega}_{it}^j)}{s_{it}g'(\bar{\omega}_{it}^j)} < 0$  and hence  $\frac{\partial \bar{\omega}_{it}^j}{\partial q_t} < 0$ . The higher the firm-specific mark-up  $s_{it}$  or  $q_t$ , the lower the threshold,  $\bar{\omega}_{it}^j$ , below which the entrepreneur defaults and is monitored. Given the solution to the contract, we can define the risk premium  $r_{it}^j$  as the interest rate charged for the use of external finance. It is implicitly given by the condition  $(1 + r_{it}^j)(x_{it} - \tilde{n}_{it}) = s_{it}\bar{\omega}_{it}^j x_{it}$ .

### 3.2.2 Bank loan continuation

At the beginning of stage II, the second productivity shock,  $\varepsilon_{2,it}$ , is realized and not observed by anyone. Information on this shock is acquired by banks and communicated to the entrepreneur. Conditional on the realization of  $\varepsilon_{2,it}$ , the entrepreneur chooses whether to abstain from production or to obtain trade credit and produce.

**Proposition 2** *A threshold for  $s_{it} = \varepsilon_{1,it}\varepsilon_{2,it}q_t$ , below which the entrepreneur does not proceed with the bank loan, exists and is unique. It is given by a constant  $s_d$  that satisfies*

$$\left[ s_{it}f(\bar{\omega}^b(s_{it})) - \chi \right] \xi = 1. \quad (19)$$

**Proof:** Consider the situation of a firm that, upon payment of the information acquisition fee,  $\tau n_{it}$ , observes  $\varepsilon_{1,it}$  and  $\varepsilon_{2,it}$ . The entrepreneur proceeds with the bank loan if and only if his expected utility exceeds the opportunity costs of renting his capital to others, i.e. if  $\left[ s_{it}f(\bar{\omega}^b(s_{it})) - \chi \right] \xi \geq 1$ , where  $s_{it} = \varepsilon_{1,it}\varepsilon_{2,it}q_t$ . Notice that expected utility from proceeding with the bank is negative for  $s_{it} = 0$  and strictly increasing in  $s_{it}$ , since  $f'(\bar{\omega}_{it}^b) < 0$  and  $\frac{\partial \bar{\omega}_{it}^b}{\partial s_{it}} < 0$ . Hence, a solution to condition (19), taken with equality, exists and is unique. Moreover, it is constant across firms and time. ■

In an environment where banks would be allowed to cross-subsidize firms, each firm would have to decide at the beginning of stage II whether or not to exchange its net worth for an actuarially fair gamble. The gamble would set an up-front fee and a repayment to the bank, which would depend on the prior available information,  $\varepsilon_{1,it}$ , and the unobserved shock,  $\varepsilon_{2,it}$ . In appendix A, we show that the optimal financial arrangement would be one where banks cross-subsidize firms. With  $\varepsilon_{2,it}$  below a certain threshold, the firm would not produce but the

bank would seize completely its net worth. With  $\varepsilon_{2,it}$  above that threshold, the firm would get full funding at the lowest possible cost. Repayments of producing firms would be minimized and so would be the probability of default and expected monitoring costs. The contract with cross-state subsidization would be optimal because it minimizes agency costs, increasing the aggregate resources available for entrepreneurial consumption and hence improving welfare of the risk-neutral entrepreneurs. It might be of interest to investigate the resulting general equilibrium effects in such an environment. However, a frequent objection to contracts that allow for cross-state subsidization is that lotteries are not observed in financial markets. One possible explanation is that investors are risk-averse, an element that is neglected in standard models with agency costs. For this reason, we do not allow firms to gamble.

### 3.2.3 The choice of the financing instrument

In stage I, after  $\varepsilon_{1,it}$  realizes, the entrepreneur chooses whether or not to produce and, if he does, how to finance production. For notational simplicity, we drop the subscripts.

The expected utility of an entrepreneur, who proceeds with bank finance conditional on the realization of  $\varepsilon_1$ , is  $F^b(s)n$ , where  $s = \varepsilon_1 q$  and

$$F^b(s) = (1 - \tau) \left( \int_{\frac{s_d}{s}}^{s\varepsilon_2} s\varepsilon_2 f(\bar{\omega}^b(s\varepsilon_2)) \xi \Phi_2(d\varepsilon_2) - \chi \xi \left[ 1 - \Phi_2\left(\frac{s_d}{s}\right) \right] + \Phi_2\left(\frac{s_d}{s}\right) \right) \quad (20)$$

The possibility for the entrepreneur to await the further news  $\varepsilon_2$  before deciding whether or not to proceed with the bank loan provides option value.

The expected utility of an entrepreneur, who proceeds with CMF finance conditional on the realization of  $\varepsilon_1$ , is  $F^c(s)n$ , where  $s = \varepsilon_1 q$  and

$$F^c(s) = [sf(\bar{\omega}^c(s)) - \chi] \xi. \quad (21)$$

Finally, the expected utility of an entrepreneur, who abstains from production, is simply  $n$ . Note in particular, that all payoff functions are linear in net worth  $n$ .

Knowing its own mark-up  $s = \varepsilon_1 q$ , each entrepreneur chooses his or her best option, leading to the overall payoff  $F(s)n$ , where

$$F(s) = \max\{1; F^b(s); F^c(s)\}. \quad (22)$$

Conditional on  $s$ , entrepreneurs split into three sets:  $\Omega_{at}$ , the set of entrepreneurs that abstains from raising external finance in period  $t$ ;  $\Omega_{bt}$ , the set of entrepreneurs that sign a

contract with banks, and  $\Omega_{ct}$ , the set of CMF-financed entrepreneurs. We show that these three sets are intervals in terms of the first idiosyncratic productivity shock  $\varepsilon_1$ .

In the analysis below, we assume that conditions (A1) and (A2) are satisfied.

$$(A1) \quad F^{b'}(s) \geq 0;$$

$$(A2) \quad F^{b'}(s) < F^{c'}(s), \text{ for all } s = \varepsilon_1 q.$$

Assumptions (A1) and (A2) impose mild restrictions on the parameters of the model. A sufficient condition for (A1) to be satisfied is that  $\varphi_{\varepsilon_2}(\frac{s_d}{s}) < 1$ , since  $s_d f(\bar{\omega}^b(s_d))\xi = 1 + \chi\xi$  and  $f'(\bar{\omega}^b) \frac{\partial \bar{\omega}^b}{\partial (\varepsilon_2 s)} > 0$ . The condition imposed by (A2) is also mild. Intuitively, firms with a low realization of the productivity shock  $\varepsilon_1$  (a low  $s$ ) have expectations of low returns from undertaking production after signing a contract with the bank, as represented by the first two terms in brackets, in the expression for  $F^b(s)$ . For those firms, the gain from minimizing the possibility of liquidation,  $(1 - \tau) \Phi_2(\frac{s_d}{s})$ , is relatively more important. If  $s$  increases, the expected return from production increases both for bank- and for CMF-financed firms. However, the increase is higher under CMF finance because intermediation costs are lower. Hence, there will be a threshold above which expected profits from production for CMF-financed firms exceed those for bank-financed firms. (A1) and (A2) ensure uniqueness of the thresholds  $s_b$  and  $s_c$ .

**Proposition 3** *Under (A1), a threshold for  $s = \varepsilon_1 q$ , below which the entrepreneur decides not to raise external finance, exists and is unique. It is given by a constant  $s_b$  that satisfies*

$$F^b(s) = 1. \tag{23}$$

**Proof:** Notice that  $F^b(0) = 1 - \tau$ . Under (A1), there is a unique cutoff point  $s_b$ , which satisfies the condition  $F^b(s) = 1$ . This point is constant across firms and time. ■

**Proposition 4** *Under (A1) and (A2), a threshold for  $s = \varepsilon_1 q$  above which entrepreneurs sign a contract with the CMF, exists and is unique. It is given by a constant  $s_c$  that satisfies*

$$F^b(s) = F^c(s). \tag{24}$$

**Proof:** Notice that,  $F^b(0) = 1 - \tau > F^c(0)$ . A sufficient condition for existence and uniqueness of a threshold is provided by (A1) and (A2). The threshold  $s_c$  is constant across firms and time. ■



Conditional on  $q_t$ , entrepreneurs split into three sets that are intervals in terms of the first idiosyncratic productivity shock  $\varepsilon_{1,it}$ ,

$$\begin{aligned}\Omega_{at} &= \{\varepsilon_{1,it} \mid \varepsilon_{1,it} < s_b/q_t\} \\ \Omega_{bt} &= \{\varepsilon_{1,it} \mid s_b/q_t \leq \varepsilon_{1,it} \leq s_c/q_t\} \\ \Omega_{ct} &= \{\varepsilon_{1,it} \mid \varepsilon_{1,it} > s_c/q_t\}\end{aligned}$$

for some constants  $s_b, s_c$ . Notice that an increase in  $q_t$  raises expected profits from producing, conditional on the realization of  $\varepsilon_{1,it}$ , and reduces the thresholds  $s_b/q_t$  and  $s_c/q_t$ . Hence, it decreases the share of firms that decide to abstain from production and increases the share of firms that sign a contract with FIs. Notice also that condition (19) determines a threshold  $s_d$  for the firm-specific markup, below which firms that have signed a contract with banks decide to abstain. A corresponding threshold for the second firm-specific shock  $\varepsilon_{2,it}$  can be computed as  $s_d/(q_t\varepsilon_{1,it})$ . Conditional on the realization of  $\varepsilon_{1,it}$ , an increase in  $q_t$  reduces this threshold and the share of firms that decide to abstain conditional on having signed a contract with a bank. The firm's decision on whether or not to produce can be characterized by

$$D_{it} = \begin{cases} 1 & \text{if } \varepsilon_{1,it} > s_c/q_t \text{ or if } s_b/q_t \leq \varepsilon_{1,it} \leq s_c/q_t \text{ and } \varepsilon_{2,it} > s_d/\varepsilon_{1,it}q_t \\ 0 & \text{else} \end{cases}$$

### 3.3 Consumption and investment decisions

Consumption and investment decisions of the households are described by the solution to the maximization problem (1) subject to (2), which is given by

$$\eta c_t = w_t \tag{25}$$

$$\frac{1}{c_t} = \beta E_t \left\{ \frac{1}{c_{t+1}} (1 - \delta + r_{t+1}) \right\}. \tag{26}$$

The entrepreneurial decision on consumption and on investment in capital, which will be used as net worth in the following period, derives from the maximization of (5) subject to (6), where  $y_{it}^e = \tilde{n}_{it}$  if firm  $i$  abstains,  $y_{it}^e = s_{it} \left( \omega_{it} - \bar{\omega}_{it}^j \right) \xi \tilde{n}_{it}$  if firm  $i$  borrows and repays, and  $y_{it}^e = 0$  if firm  $i$  borrows and default. The optimality condition is then given by the intertemporal Euler equation

$$1 = \beta \gamma E_t \left\{ (1 - \delta + r_{t+1}) F(\varepsilon_{1,it+1} q_{t+1}) \right\}. \tag{27}$$

Observe that  $q_{t+1}$  depends on  $w_{t+1}$  and  $r_{t+1}$  through (10). This equation ties down a relationship between these two factor prices. It also pins down the evolution of net worth of the entrepreneurs, since they will elastically save and supply capital, so that factor prices satisfy this equation exactly period by period.

### 3.4 Aggregation

We are now ready to calculate aggregate variables. Given  $q_t$  and total entrepreneurial net worth  $n_t$ , we can compute total demand for funds,  $x_t$ , total output including agency costs,  $y_t$ , and total output lost to agency costs,  $y_t^a$ , by integrating across firms. The conditions are:

$$x_t = \psi^x(q_t; s_b, s_c, s_d) \xi n_t \quad (28)$$

$$y_t = \psi^y(q_t; s_b, s_c, s_d) q_t \xi n_t \quad (29)$$

$$y_t^a = \psi^a(q_t; s_b, s_c, s_d) \mu q_t \xi n_t, \quad (30)$$

where the functions  $\psi^x(\cdot)$ ,  $\psi^y(\cdot)$  and  $\psi^a(\cdot)$  are defined in Appendix C.

Aggregate entrepreneurial consumption and investment have to satisfy the constraint

$$e_t + z_{t+1} = \vartheta(q_t; s_b, s_c, s_d) n_t, \quad (31)$$

where the function  $\vartheta(\cdot)$  is also defined in Appendix C.

Finally, aggregate factor demands are given by

$$w_t H_t = \alpha x_t \quad (32)$$

$$r_t K_t = (1 - \alpha) x_t. \quad (33)$$

### 3.5 Market clearing

Market clearing for capital, labor and output requires that

$$K_t = k_t + z_t, \quad (34)$$

$$H_t = l_t, \quad (35)$$

$$y_t = c_t + e_t + y_t^a + K_{t+1} - (1 - \delta)K_t. \quad (36)$$

Market clearing for loans is ensured by condition (4), which equates the total funds available (i.e. the sum of internal and external finance) to the demand of funds.

### 3.6 Competitive equilibrium

Given the process of the idiosyncratic shocks,  $\{\varepsilon_{1,it}, \varepsilon_{2,it}, \varepsilon_{3,it}\}$ , and the initial conditions  $(k_0, z_0)$ , a competitive equilibrium consists of sequences of firm-specific mark-ups,  $\{s_{it}\}_{t=0}^{\infty}$ , threshold levels for the uncertain productivity factor  $\{\bar{\omega}^b(s_{it}), \bar{\omega}^c(s_{it})\}_{t=0}^{\infty}$ , constant thresholds for the firm's mark-up  $\{s_b, s_c, s_d\}_{t=0}^{\infty}$ , production decisions  $\{D_{it}\}_{t=0}^{\infty}$ , demand functions for labor and capital  $\{H_{it}, K_{it}\}_{t=0}^{\infty}$ , and consumption and investment decisions  $\{e_{it}, z_{i,t+1}\}_{t=0}^{\infty}$ , for  $i \in (0, 1)$ . It also consists of aggregate factors  $\{q_t\}_{t=0}^{\infty}$ , allocations  $\{c_t, l_t, H_t, K_t, e_t, x_t, y_t, y_t^e, y_t^a\}_{t=0}^{\infty}$ , laws of motion for the capital stocks  $\{k_{t+1}, z_{t+1}\}_{t=0}^{\infty}$ , and prices  $\{w_t, r_t\}$  such that:

- Households maximize expected utility by choosing  $c_t, h_t$  and  $k_{t+1}$ , subject to the budget constraint, taking prices as given.
- Entrepreneurs decide whether or not to produce. If they do, they choose  $H_{it}$  and  $K_{it}$ , to maximize profits, subject to the production technology and the financing constraint, taking prices as given. Firm  $i$ ,  $i \in \Omega_{ct}$  takes as given also the realization of the first idiosyncratic productivity shock,  $\varepsilon_{1,it}$ . Firm  $i$ ,  $i \in \Omega_{bt}$  takes as given the realization of  $\varepsilon_{1,it}$  and  $\varepsilon_{2,it}$ . Entrepreneurs also choose consumption,  $e_{i,t}$ , and investment,  $z_{i,t+1}$ , to maximize their linear utility, subject to their budget constraint.
- FIs and firms solve a CSV problem. The solution determines the amount of external finance to be used and a threshold level for the uncertain productivity factor  $\bar{\omega}_{it}^j$ ,  $j = b, c$ . When this factor is lower than the threshold, the firm is monitored.
- The market clearing conditions for goods, labor, capital and loans hold.

A competitive equilibrium is characterized by equations (8)-(12), (17) and (19)-(36).

## 4 Steady state properties: a numerical analysis

We parameterize the model at the stochastic steady state, which is characterized in Appendix B. The Appendix also describes the numerical procedure used to compute it. We assume that the iid productivity shocks  $v = \varepsilon_1, \varepsilon_2, \varepsilon_3$  are lognormally distributed, i.e.  $\log(v)$  is normally distributed with variance  $\sigma_v^2$  and mean  $-\sigma_v^2/2$ . We set a discount factor  $\beta = .98$  and a

depreciation rate  $\delta = .025$ ,<sup>7</sup> leading to a real interest rate  $r = 4\%$ . We choose  $\alpha = .64$  in the production function and a coefficient in preferences so that labor equal .3 in steady state,  $\eta = 2.6$ . We set monitoring costs to be 15% of the firm's output,  $\mu = .15$ , in line with the values found in the empirical literature cited below. We are then left with 7 parameters to set  $(\xi, \chi, \tau, \gamma, \sigma_{\varepsilon_1}, \sigma_{\varepsilon_2}, \sigma_{\varepsilon_3})$ . In this section we fix them arbitrarily to show the qualitative properties of the model in steady state, i.e. we set  $\xi = 1.6$ ,  $\chi = 0$ ,  $\tau = .11$ ,  $\sigma_{\varepsilon_1} = .26$ ,  $\sigma_{\varepsilon_2} = .46$ ,  $\sigma_{\varepsilon_3} = .13$ , and  $\gamma = .704$ . In section 5 below, we calibrate the model and choose the parameters to match stylized facts on the financial structure of the corporate sector in the US and in the euro area.

In Figure 1, we show expected profits for entrepreneurs. Panel (a) plots respectively expected profits from abstaining, from signing a contract with a bank and from signing a contract with a CMF, as a function of the firm's mark-up,  $s = \varepsilon_1 q$ . The intersection points of the three curves provide the cutoff points,  $s_b$  and  $s_c$ . The panel also shows the mean of the firm-specific mark-up  $s$ , plus/minus two standard deviations. After the realization of  $\varepsilon_1$ , 95% of the firms' markups lie within this region. Panel (b) shows how expected profits from bank finance move with the information acquisition fee  $\tau$ . When  $\tau = 0$ , expected profits from bank finance always exceed those from abstaining or from CMF finance. All firms raise external finance through banks. When  $\tau$  is large, the option value of acquiring more information is not large enough to offset the cost. All firms either abstain or use CMF finance. Only for intermediate values of  $\tau$ , firms that decide to produce differentiate in terms of their financing choice. They split into bank finance and CMF finance according to the realization of their markup  $s$ .

Figure 2 illustrates the financial decisions of firms. Panel (a) plots how firms allocate among financial instruments. Conditional on the value of the aggregate variable  $q$ , firms experiencing a productivity shock  $\varepsilon_1 \leq s_b/q$  decide to abstain from production. Firms with  $s_b/q \leq \varepsilon_1 \leq s_c/q$  sign a contract with banks. Firms with  $\varepsilon_1 \geq s_c/q$  sign a contract with CMFs. Among firms that sign a contract with banks, those experiencing a productivity shock  $\varepsilon_2 \leq s_d/\varepsilon_1 q$  decide not to proceed to the production stage. Panel (b) plots the threshold  $s_d/\varepsilon_1 q$ , over the range of mark-ups  $(s_b/q, s_c/q)$ , as a function of  $\varepsilon_1$ . Panel (c) shows the probability that  $\varepsilon_2 \geq s_d/\varepsilon_1 q$ , as a function of  $\varepsilon_1$ . The larger  $\varepsilon_1$ , the lower the threshold level for  $\varepsilon_2$  and the higher the probability that the firm will produce, conditional on having signed a contract with a bank.

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<sup>7</sup>The annual depreciation rate is set to equal the US ratio of investment to capital over the period 1964-2001, as reported by Christiano et al (2004).

Figure 3 plots the steady state distribution of firms among production activities. Firms that do not produce are those that decide not to raise external finance because  $\varepsilon_1 \leq s_b/q$ , and those that sign a contract with the bank but, after the realization of  $\varepsilon_2$ , decide to drop out of production. For these firms,  $s_b/q \leq \varepsilon_1 \leq s_c/q$  and  $\varepsilon_2 \leq s_d/q\varepsilon_1$ .

Figures 4 and 5 plot the results from a sensitivity analysis, which is carried out by modifying one parameter at a time. The first experiment is to look at the effect of different entrepreneurial discount factors by changing the value of  $q$ . Notice from the steady state version of equation (27) that, for a given level of entrepreneurial effort  $\chi$ , increasing  $q$  is equivalent to increasing the value of  $\gamma$ . This raises the share of firms that sign a contract with intermediaries and reduces the share of firms that abstain. It also reduces the share of firms that sign a contract with banks relative to CMFs. Intuitively, a higher  $q$  increases the firm's expected profits from raising external finance through banks as well as CMFs. However, the higher is  $q$ , the lower is the option value of waiting that banks provide. Figure 4 illustrates these mechanisms by plotting the shares in steady state as a function of  $q$ . Panel (a)-(c) reports respectively the share of firms that abstain from production, sign a contract with the bank and sign a contract with the CMF. Panel (d) plots the overall fraction of firms that default and are monitored at the end of the period. For a given  $\varepsilon_1$ , the increase in profits reduces the risk of the firm to default. However, it also induces firms with high risk to undertake productive activities. The overall effect is to increase the realized share of default in the economy for low levels of  $q$  and to decrease it afterwards. Finally, panels (e)-(f) plot respectively the share of firms that, after having signed a contract with a bank, abstain or default.

The second experiment, reported in Figure 5, is to change the value of some key parameters, such as  $\tau$ ,  $\sigma_{\varepsilon_1}$  and  $\sigma_{\varepsilon_2}$ . In panel (a), we increase the costs of information acquisition,  $\tau$ , from the .11 to .16, and show with thick lines the new threshold levels,  $s_b/q$  and  $s_c/q$ . The share of firms that sign a contract with banks decreases and a larger fraction of firms decides to abstain. Panel (b) reports the results from increasing  $\sigma_{\varepsilon_1}$  from .26 to .46. Firms experience with higher probability low realizations of the productivity shock  $\varepsilon_1$  before taking their financing decisions. Therefore a larger share of firms decides to abstain. Finally, panel (c) plots the distribution of firms and new thresholds as thick lines, when  $\sigma_{\varepsilon_2}$  is increased from .46 to .56. With a larger variance of the signal  $\sigma_{\varepsilon_2}$ , firms give a higher value to the possibility to acquire more information through banks. The share of firms that raise bank finance increases.

## 5 Comparing the US and the euro area: a calibration exercise

In this section, we review the evidence on the financial structure of the corporate sector in the US and the euro area. We calibrate the model to capture in steady state some key differences and we provide model-based answers to the questions: What are the causes of differences in the financial structure? What are the implications for allocations?

### 5.1 Evidence on intermediation and financial structures

We present and summarize in Table 1 the empirical evidence on the costs of financing through bank loans or corporate bonds in the US and in the euro area. Some distinguishing features emerge: the debt to equity ratio and the ratio of bank finance to bond finance are lower in the US than in the euro area, while the converse is true for the interest rate spread on bank loans.

**Spread on bank loans.** In the US, the spread between the prime rate on bank loans to business and the commercial paper rate is 298 bps over the period 1997-2003. In the euro area, over the same period, the spread between the interest rate on loans up to 1 year of maturity to non-financial corporations and the three-month interest rate, is 267 bps.<sup>8</sup> These numbers should be seen as upper estimates of the existing spreads. English and Nelson (1998) report selected results from the August 1998 Survey of Terms of Business Lending in the US. The spread between the average loan rate to domestic firms (weighted by loan volumes) and the commercial paper rate emerging from the survey is 188 bps, while for the same year the spread between the prime rate and the commercial paper rate is 301 bps. The existence of higher spreads in the US relative to Europe is confirmed by existing studies. Carey and Nini (2004) find that the difference in gross spreads of bank syndicated loans over LIBOR in US versus EMU is 29.8 bps. This finding is confirmed by existing calculations of net interest margins in the banking industry by country. Cecchetti (1999) reports interest rate margins for the US in 1996 to be 268 bps. In the same year, the average interest rate margin for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain is 204.

**Spread on corporate bonds.** The average spread of US corporate bonds for the period 1997-2003 is 339 bps. English and Nelson (1998) report similar spreads between bank loans rated 1 (best) and 5 (worst) in the 1998 Survey of Terms of Business Lending, and between

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<sup>8</sup>Source: for the US, Federal Reserve Board, Table H15; for the euro area, European Central Bank, MU12 average based on country reporting to BIS.

yields on AA rated bonds and "junk" bonds covered in the same survey. The spreads reported are around 200 bps.<sup>9</sup> Mahajan and Fraser (1986) find no evidence of differences among bond spreads in the US and the euro area. Using more recent data, Carey and Nini (2004) examine spreads estimated using daily Merrill Lynch bond index yields and swap data for the period 1999-2003 for A- and BBB-rated firms. They find only small mean and median differences between US and euro area, after accounting for duration and currency effects.<sup>10</sup>

**Default rates.** Carlstrom and Fuerst (1997) report annual default rates from the Dun and Bradstreet data set of 3.9%. Bernanke, Gertler and Gilchrist (1999) compute the average annual firms failures in the post World War II period at 3%. Helwege and Kleiman (1996) find an average annual default rate for all high yield bond issuers of 4.5% over the period 1981-1995. Ammer and Packer (2000) examine bonds of 492 issuers present in Moody's database over the period 1983-1988. They find that the average annual default rate by type of issuer is 1.93% for US non-financial corporations but lower for foreign firms (0.54%). However, after controlling for the rating composition of each sectorial pool, they find similar default rates for US and foreign firms. Finally, Moody's Investors Service (2003) documents that among US non-financial corporate issuers that default without going bankrupted, the default rate on loans is approximately 20% lower than the overall default rate on bonds, over the period 1995-2003. For European non-financial corporate issuers, the default rate on loans is approximately 27% lower than the overall default rate on bonds, over the period 1990-2003.

**Bankruptcy costs.** On bankruptcy costs, Warner (1977) estimates small direct costs in a study of 11 railroad bankruptcies, with a maximum of 5.3% of the firm's value. Altman (1984) finds that the direct costs (those explicitly paid by the debtors in the bankruptcy process) plus indirect costs (those related to the loss of customers, suppliers and employees, and the managerial expenses) tend to be higher for industrial firms, between 12.1% and 16.7%. The largest estimate, 36% of the firm's value, is reported by Alderson and Betker (1995).

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<sup>9</sup>The spread is defined as the average of the average yield to maturity on selected long term bonds (rated Aaa and Baa) minus the 3-months Treasury Bill. Source: Federal Reserve Board Table H15.

<sup>10</sup>Our model assumes no fixed cost of issuance of corporate bonds. Santos and Tsatsaronis (2003) use the IFR Platinum database compiled by Thomson Financial Studies, which covers 3,110 bonds issued by the private sector between 1994 and 2001. They find that average gross issuance fees over the period considered are small: 0.82% of the amount raised for bonds issued in US dollars and 0.89% for bonds issued in euros. Given the size of these fees and the similarity among US and euro area, we abstract from them in our analysis.

**Debt to equity.** The debt to equity ratio for the US non-farm, non-financial corporate business sector is 0.41 over the period 1997-2003. For the euro area, the same ratio for non-financial corporations is 0.61 over the period 1997-2002.<sup>11</sup>

**Bank finance to bond finance.** The ratio of bank finance to bond finance in the US is 0.75 over the period 1997-2003. For the euro area, it is 7.3 over the same period.<sup>12</sup>

Table 1. Summary table of financial facts

Variable	US	Period	EA	Period
Risk premium bonds	.019-.034	1997-2003	as in US	1999-2003
Risk premium loans	.019-.030	1997-2003	.016-.027	1997-2003
Default rate bonds	.02-.45	1981-1995	as in US	1989-1991
Default rate loans	rate on bonds -20%	1995-2003	rate on bonds -27%	1990-2003
Bank to bond finance	.75	1997-2003	7.3	1997-2003
Debt to equity	.41	1997-2003	.61	1997-2002

## 5.2 Calibration

We set  $\alpha = .64$ ,  $\delta = .025$ ,  $\beta = .98$  and  $\mu = .15$  on the basis of previous studies. We fix  $\eta = 2.6$ , so that  $l = .3$  in steady state. We choose the remaining free parameters to match selected stylized facts in the US and in the euro area.

Notice that the parameter measuring entrepreneurial effort,  $\chi$ , plays an important role in our calibration exercise. Recall that the endogenous financial structure in the model depends on the expected utility from each financing choice, which in turns depend on the aggregate mark-up  $q$ . Equation (27) shows that, in the absence of entrepreneurial effort, the variable  $q$  would be determined by the distributional assumptions on the idiosyncratic shocks and by

<sup>11</sup>For the US, debt is defined as credit market instruments (sum of commercial paper, municipal securities, corporate bonds, bank loans, other loans and advances, mortgages) over the market value of equities outstanding (including corporate farm equities). Source: Flow of Funds Accounts, Table B.102. Masulis (1988) reports a ratio of debt to equity for US corporations in the range 0.5-0.75 for the period 1937-1984. The ratio exhibited a downward trend over the last decades due to financial innovations. For the euro area, debt includes loans, debt securities issued and pension fund reserves of non-financial corporations. Equity includes quoted and non-quoted equity. Source: Euro area Flow of Funds.

<sup>12</sup>For the US, securities are the sum of commercial paper, municipal securities and corporate bonds. Source: Flow of Funds Accounts, Table L 101. For the euro area, loans are those taken from euro area MFIs and other financial corporations by non-financial corporations. Securities are defined as securities other than shares issued by non-financial corporations. Source: Euro area Flow of Funds.



the parameter  $\gamma$ . Hence, the choice of  $\gamma$  would affect both the investment decisions of the entrepreneurs and the financial structure in the economy. However, marked differences in the financial structure between the US and the euro area are accompanied by rather homogeneous investment behaviour.<sup>13</sup> We set the parameter  $\chi$  to replicate reasonable investment to GDP ratios in the two blocks, while matching the observed differences in the financial structure.

We consider three versions of the model, which capture to various extent differences in the financial structure. We calibrate them to ensure that they replicate aggregate default rates and risk premia and that they generate reasonable investment to GDP ratios. We use these three models to quantify the effects of differences in the financial structure on per-capita GDP.

**Model.** This is the model described in sections 2 and 3 above, calibrated to minimize its prediction errors. We set six parameters (i.e.  $\xi, \tau, \gamma, \sigma_{\varepsilon_1}, \sigma_{\varepsilon_2}, \sigma_{\varepsilon_3}$ ) to minimize the squared log-deviation of the model predictions about financial facts from the data. The facts we aim to replicate are the risk premia on bonds and on bank loans, the default rates on bonds and on bank loans, the ratio of bank finance to bond finance and the ratio of debt to equity. The remaining free parameter,  $\chi$ , is set to minimize the squared log-deviation of the model-based investment to GDP ratio from the data.

**Benchmark I.** This is a benchmark model with no ex-ante heterogeneity and a single type of FI (as in CF). It is obtained by setting  $\sigma_{\varepsilon_1} = \sigma_{\varepsilon_2} = 0$ . The parameter  $\xi$  is set to replicate the firm's debt to equity ratio, while  $\gamma, \sigma_{\varepsilon_3}$  and  $\chi$  are set to replicate the aggregate default rates, average risk premia and investment to GDP ratios predicted by the calibrated model.

**Benchmark II.** This is a benchmark model with ex-ante heterogeneity and a single type of FI. It is built by setting  $\sigma_{\varepsilon_2} = 0$ , in which case no firm chooses to raise bank finance. The parameter  $\xi$  is set to match the firm's debt to equity ratio, while  $\gamma, \sigma_{\varepsilon_3}$  and  $\chi$  are set to replicate the aggregate default rates, average risk premia and investment to GDP ratios predicted by the calibrated model. Finally,  $\sigma_{\varepsilon_1}$  is set to the same value obtained in the calibrated model.

Table 2 evaluates the performance of the calibrated model in terms of the financial facts outlined above. The model closely matches two important differences between the US and the euro area: the firm's average debt to equity ratio and the ratio of bank finance to bond finance. It produces reasonable default rates on bank loans and slightly overestimates default

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<sup>13</sup>Over the period 1999-2004, the ratio of gross fixed capital formation to GDP has been similar in the two blocks, being .192 in the US and .206 in the euro area. Source: European Central Bank.

rates on corporate bonds. Aggregate default rates, as reported in Table 3, are in line with those observed in the data. The model also generate reasonable risk premia on bank loans, although higher in the euro area than in the US. However, the model underestimates the risk premium on bonds in the euro area and overestimates it in the US.

Table 2. Financial facts

Variable	US Model	US Data	EA Model	EA Data
Bank loans to corporate bonds	.89	.75	7.6	7.3
Firm's debt to equity	.41	.41	.61	.61
Default rate on bonds	.061	.020-.045	.054	.02-.045
Default rate on loans	.032	.016-.036	.036	.015-.033
Risk premium on bonds	.046	.019-.034	.006	.019-.034
Risk premium on loans	.016	.019-.030	.023	.016-.027

Table 3 lists other properties of the calibrated model in steady state. The model delivers ratios of aggregate consumption to GDP of .865 for the US and of .874 for the euro area. The ratios of investment to GDP are respectively .117 and .114. Notice that these values should not be compared directly to the ratios observed in the data, given the absence of a public sector in the model. It is important, however, that the model-based investment to GDP ratio is broadly similar in the two blocks. This enables us to analyze the effect of differences in the financial structure for allocations, as these differences cannot be imputed to other features of the economy, such as a different propensity to save and to invest. Table 3 also reports output lost to agency costs, which is slightly above 1% of GDP, the value of  $q$ , and the steady state distribution of firms. Both in the calibrated models of the US and of the euro area all firms decide to approach a FI. However, in the euro area a larger share of firms decide to sign contracts with banks. Notice the lower drop-out rate conditional on bank finance in the model of the euro area. After having signed a contract with a bank and observed the second shock  $\varepsilon_2$ , the remaining residual uncertainty from production is lower in the euro area (see the value of  $\sigma_{\varepsilon_3}$  in the calibrated model reported in Table 4). Hence, a larger share of firms decides to produce.

Table 3: Steady state properties of the calibrated models

Variable	US Model	EA Model
$\frac{c+e}{y}$	.865	.874
$\frac{I}{y}$	.117	.114
$\frac{y^a}{y}$	.018	.012
$q$	1.58	1.71
average default	.041	.037
average risk premium	.027	.020
share abstain	0	0
share bank	.547	.879
share CMF	.453	.121
drop-out if banking	.267	.045

### 5.2.1 Explaining differences in financial structures

Table 4 reports the parameter values selected for each of the three models, for the US and the euro area. It also reports the sum of the variances of the uncertain productivity factors,  $\varepsilon_2$  and  $\varepsilon_3$ . Notice that  $\sigma_{\varepsilon_1}$  provides a measure of the *public information* available in the financial market, i.e. the information known to firms and FIs before signing the contract. A larger  $\sigma_{\varepsilon_1}$  allows FIs to better discriminate firms according to their risk. Credit worthy firms are those that, having experienced a high realization of the first shock, face a relatively low risk of default at the end of the period. On the other hand,  $\sigma_{\varepsilon_2}$  provides a measure of the amount of *private information*, which is costly to acquire and can only be obtained by banks.

The table shows the chosen calibration for each of the three models. In the benchmark I and benchmark II models, the value of the parameter  $\tau$  is irrelevant. As  $\sigma_{\varepsilon_2} = 0$ , firms never choose to raise bank finance, for any value  $\tau > 0$ .

In the benchmark I model, the only uncertainty arises from the third idiosyncratic shock,  $\varepsilon_3$ . For the US, a standard deviation of .61 for  $\varepsilon_3$  and a coefficient  $\gamma$  of .983 are able to reproduce the observed average risk premium and aggregate default rate. In the benchmark II model, where the degree of ex-ante heterogeneity is fixed at  $\sigma_{\varepsilon_1} = .194$ , the overall uncertainty at contracting time is still due only to  $\varepsilon_3$ . However, a slightly higher standard deviation  $\sigma_{\varepsilon_3}$  is necessary to produce the same average risk premium and default rate. The reason is that a higher  $\sigma_{\varepsilon_1}$  corresponds to higher disclosure of public information in the financial market, which

allows intermediaries to discriminate firms according to their risk. A larger standard deviation of the unexpected productivity at contracting time ( $\sigma_{\varepsilon_3}$ ) is thus necessary to generate the same aggregate risk premium and default rate.

In the model calibrated to generate the stylized facts observed in the US and the euro area, substantial differences arise in the parameter values. Two points are worth noticing. First, the degree of ex-ante heterogeneity  $\sigma_{\varepsilon_1}$ , i.e. the availability of public information in the financial market, is substantially larger in the US than in the euro area, while the volatility of the signal  $\varepsilon_2$  in the US is only slightly above the one for the euro area. Second, the calibrated model of the euro area suggests lower information acquisition costs, as reflected by the value of the parameter  $\tau$ , relative to the US. This conclusion is strengthened when looking at an alternative measure of the efficiency of banks in providing information to the market, which accounts for the degree of uncertainty about the signal  $\varepsilon_2$ . For a given information acquisition fee  $\tau$ , banks are more efficient if they are able to disclose information about a more volatile signal, i.e. if  $\frac{\tau}{\sigma_{\varepsilon_2}^2}$  is lower. In the calibrated model,  $\frac{\tau}{\sigma_{\varepsilon_2}^2}$  equals .173 for the US and .141 for the euro area.

Overall, the model points to lower availability of public information in the financial market and to relatively higher efficiency of banking services as a major explanation for the larger role of bank finance relative to bond finance in the euro area.

Table 4. Parameters in the alternative models

Parameters	$\tau$	$\chi$	$\gamma$	$\xi$	$\sigma_{\varepsilon_1}$	$\sigma_{\varepsilon_2}$	$\sigma_{\varepsilon_3}$	$\sum_{i=2}^3 \sigma_{\varepsilon_i}^2$
US benchmark I	.013	.42	.983	1.41	0	0	.610	.372
US benchmark II	.013	.38	.807	1.41	.194	0	.630	.397
US model	.013	.056	.575	1.41	.194	.274	.571	.401
EA benchmark I	.008	.48	.984	1.61	0	0	.540	.292
EA benchmark II	.008	.38	.710	1.61	.035	0	.544	.297
EA model	.008	.062	.497	1.61	.035	.238	.533	.341

### 5.2.2 Effects of differences in financial structures on allocations

We compare the model-based gaps in per-capita GDP arising under alternative models to the gap observed in the data. This allows us to provide a measure of the quantitative importance of differences in financial structures.

The ratio of per-capita GDP in the US relative to the euro area is 1.42 over the period 2001-2003.<sup>14</sup> Table 5 reports the model-based ratios. The second row indicates that the ratio is unitary in a model which does not account for differences in the financial structure. The third row reports a value of 1.03 for the benchmark I model, where the only difference arises in the debt to equity ratio (.41 for the US and .61 for the euro area). The lower leverage in the US implies lower costs of external finance and creates a positive GDP gap in the US versus the euro area. The fourth row shows that adding ex-ante heterogeneity ( $\sigma_{\varepsilon_1}$  being .194 for the US and .035 for the euro area) without introducing alternative instruments of external finance, as in the benchmark II model, increases the ratio to 1.16. For a given debt to equity ratio, higher availability of public information in the US reduces the agency costs and increases output relative to the euro area. The fifth row shows, using the calibrated model, that the ratio of per capita GDP in the US versus the euro area falls to 1.11. For a given debt to equity ratio and degree of heterogeneity, the larger role of banks in the euro area is able to mitigate the limited availability of public information. The flexibility provided by banks together with their information role enables to reduce the gap between per capita GDP in the two blocks.

Our analysis confirms the importance of the financial structure for the macroeconomy. Abstracting from other major factors, such as total factor productivity, a model that account only for differences in financial structures can explain a substantial fraction of the difference in per-capita GDP.

Table 5: Financial structure and per-capita GDP

<b>Differences in the financial structure</b>	$\frac{y^{US}}{y^{EU}}$
None	1
Debt to equity	1.03
Debt to equity Heterogeneity	1.16
Debt to equity Heterogeneity Bond vs bank finance	1.11
Data	1.42

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<sup>14</sup>The ratio is built using annual GDP per person employed at current prices in euros. Source: European Central Bank, Statistics Pocket Book.

## 6 Conclusions

We have presented a DSGE model with agency costs, ex-ante firms' heterogeneity and multiple instruments of external finance. In this economy, the choice of entrepreneurs among alternative financing instruments determines the overall cost of information asymmetries and credit market frictions. The calibrated model suggests that a larger share of bank finance in the euro area relative to the US is due to lower availability of public information about firms' credit worthiness and to higher efficiency of banks in acquiring this type of information. We also find that differences in the financial structure affect allocations, leading to sizeable discrepancies in per-capita GDP.

The setup presented in this paper can be extended in various directions. In ongoing research, we develop a monetary DSGE model of the financial structure and ask whether it can replicate the differences in the transmission of monetary policy observed in the US and the euro area (as documented, for instance, by Angeloni et al (2003)). Information on financial structures is typically regarded as important by central banks. Movements in the policy rate influence market interest rates, the price of financial assets, and real activity through changes in the financial decisions of consumers and investors. Features of the financial system such as the relative importance of bank loans versus other instruments of external finance may thus help to explain differences in the transmission of monetary policy.

## Appendix

### A. Cross-state subsidization

We consider a general class of contracts between banks and firms, which specify the threshold level  $\bar{\omega}(s\varepsilon_2)$  and the up-front fee  $c(s\varepsilon_2)$  that, given  $s = \varepsilon_1 q$ , maximize the firm's expected return across realizations of  $\varepsilon_2$ , subject to the project size being a fixed share of the firm's net worth, the feasibility constraint, the bank breaking even in expectations across states, the sum of all repayments across firms covering the information costs faced by the bank, and the up-front fee not exceeding the available initial net worth.

The optimal contract is given by the pair  $[\bar{\omega}^b(s\varepsilon_2), c(s\varepsilon_2)]$  that solves the problem

$$\max_{c(s\varepsilon_2), \bar{\omega}^b(s\varepsilon_2)} \int_{\frac{s_d}{s}}^1 s\varepsilon_2 f(\bar{\omega}^b(s\varepsilon_2)) (1 - c(s\varepsilon_2)) \zeta \Phi_2(d\varepsilon_2) + \int^{\frac{s_d}{s}} (1 - c(s\varepsilon_2)) \Phi_2(d\varepsilon_2)$$

subject to constraint (7), (15) and

$$\begin{aligned} & \int_{\frac{s_d}{s}} s\varepsilon_2 g(\bar{\omega}^b(s\varepsilon_2)) (1 - c(s\varepsilon_2)) \zeta \Phi_2(d\varepsilon_2) + \int_{\frac{s_d}{s}} c(s\varepsilon_2) \Phi_2(d\varepsilon_2) \\ & \geq \int_{\frac{s_d}{s}} (1 - c(s\varepsilon_2)) (\zeta - 1) \Phi_2(d\varepsilon_2) + \tau \end{aligned} \quad (37)$$

$$\int c(s\varepsilon_2) \Phi_2(d\varepsilon_2) \geq \tau \quad (38)$$

$$c(s\varepsilon_2) \leq 1 \text{ for all } \varepsilon_2. \quad (39)$$

Denote as  $\lambda(s)$ ,  $\theta(s)$  and  $\eta(s\varepsilon_2)$  the Lagrangean multipliers on constraints (37), (38) and (39) respectively. The first order condition with respect to  $\bar{\omega}^b(s\varepsilon_2)$  is given by

$$s\varepsilon_2 \left\{ f'(\bar{\omega}^b(s\varepsilon_2)) - \lambda(s) \left[ f'(\bar{\omega}^b(s\varepsilon_2)) + \mu\phi(\bar{\omega}^b(s\varepsilon_2)) \right] \right\} (1 - c(s\varepsilon_2)) \zeta \leq 0, \text{ if } \varepsilon_2 \geq \frac{s_d}{s}. \quad (40)$$

The conditions with respect to  $c(s\varepsilon_2)$  are given by

$$-s\varepsilon_2 f'(\bar{\omega}^b(s\varepsilon_2)) \zeta + \lambda(s) \left\{ -s\varepsilon_2 g(\bar{\omega}^b(s\varepsilon_2)) \zeta + \zeta - 1 \right\} + \theta(s) - \eta(s\varepsilon_2) \leq 0, \text{ if } \varepsilon_2 \geq \frac{s_d}{s} \quad (41)$$

$$-1 + \lambda(s) + \theta(s) - \eta(s\varepsilon_2) \leq 0, \text{ if } \varepsilon_2 < \frac{s_d}{s}.$$

The first two constraints of the FI are binding at the optimum. Therefore,  $\lambda(s)$  and  $\theta(s)$  must be strictly positive. Notice also that condition (40) implies that at the optimum, when monitoring costs are not zero,

$$\lambda(s) = \frac{f'(\bar{\omega}^b(s\varepsilon_2))}{f'(\bar{\omega}^b(s\varepsilon_2)) + \mu\phi(\bar{\omega}^b(s\varepsilon_2))} > 1,$$

since  $f'(\bar{\omega}^b) < 0$  and  $g'(\bar{\omega}^b) > 0$ . It follows that  $\theta(s) + \lambda(s) - 1 \geq 0$ , and optimality requires that  $\eta(s\varepsilon_2) = \bar{\eta}(s) > 0$  or

$$c(s\varepsilon_2) = 1, \text{ if } \varepsilon_2 < \frac{s_d}{s}.$$

Hence, the contract is given by an up-front fee of 100% of the initial net worth, if the firm does not produce, and by a threshold for the unobserved shock  $\bar{\omega}^b(s\varepsilon_2)$  and an up-front fee  $c(s\varepsilon_2)$  that satisfy (40) and (41), if the firm undertakes production. Notice that the threshold  $\bar{\omega}^b$  is contingent on  $s$  and on the realization of the observed shock  $\varepsilon_2$ , but it does not depend on the realization of the unknown productivity shock,  $\varepsilon_3$ . Hence, firms have no incentive to mis-report the realization of the shock that cannot be observed by the bank.

The contract is optimal. The bank now uses the net worth of non-producing firms to provide part of the external finance, at no cost, to producing firms. Repayments are minimized and

so is the aggregate probability of default and expected monitoring costs. This increases the fraction of output accruing to the entrepreneurs and hence their aggregate consumption. Since entrepreneurs are risk-neutral, cross-subsidization enhances their welfare.

## B. The stochastic steady state

We denote steady state variables by dropping the time subscript. The unique steady state can be obtained as follows. First, compute  $r, q, w$  and  $c$  by solving the system

$$\begin{aligned} 1 &= \beta(1 - \delta + r) \\ 1 &= \beta\gamma\{(1 - \delta + r)F(\varepsilon_1 q)\} \\ q &= \left(\frac{\alpha}{w}\right)^\alpha \left(\frac{1 - \alpha}{r}\right)^{1 - \alpha} \\ \eta c &= w \end{aligned}$$

To compute the overall expected profits  $F(\varepsilon_1 q)$ , given by the steady state version of (27), we use the following procedure. First, under our distributional assumptions on the productivity shocks  $\varepsilon_1, \varepsilon_2$  and  $\varepsilon_3$ , we use some results from the optimal contract literature (see the appendix of Bernanke et al (1999)),

$$\begin{aligned} \varphi_\omega(\bar{\omega}^j) &= \varphi(x) \frac{1}{\bar{\omega}^j \sigma} \\ f(\bar{\omega}^j) &= 1 - \Phi(x - \sigma) - \bar{\omega}^j [1 - \Phi(x)] \\ g(\bar{\omega}^j) &= \Phi(x - \sigma) + \bar{\omega}^j - (\bar{\omega}^j + \mu) \Phi(x), \end{aligned}$$

where  $\varphi$  and  $\Phi$  denote the standard normal,  $x \equiv \frac{\log \bar{\omega}^j + 0.5\sigma^2}{\sigma}$  and  $j = b, c$ . Second, we solve numerically the condition

$$sg(\bar{\omega}^j(s)) = \frac{\xi - 1}{\xi},$$

to obtain the function  $\bar{\omega}^j(s)$ . The function  $\bar{\omega}^b(s)$  for bank-financed firms is derived by defining  $s = \varepsilon_1 \varepsilon_2 q$  and by using the variance  $\sigma_{\varepsilon_3}^2$  of the log-normal distribution. The function  $\bar{\omega}^c(s)$  for CMF-financed firms is derived by defining  $s = \varepsilon_1 q$  and by using the variance  $\sigma_{\varepsilon_2}^2 + \sigma_{\varepsilon_3}^2$ . The cutoff value for proceeding with the bank loan is found by solving numerically the condition

$$\left[ s_d f(\bar{\omega}^b(s_d)) - \chi \right] \xi = 1.$$

Using  $s_d$ , it is then possible to compute the expected utility for the bank-financed entrepreneur,  $F^b(s)$ , where  $s = \varepsilon_1 q$ . The expected utility for the CMF-financed entrepreneur can be



computed as

$$F^c(s) = [sf(\bar{\omega}^c(s)) - \chi] \xi.$$

With this, it is possible to calculate the overall return  $F(s)$  to entrepreneurial investment, the thresholds  $s_b$  and  $s_c$ , and the ratios  $\frac{x}{z}$ ,  $\frac{K}{x}$  and  $\frac{l}{x}$ , as given by

$$\frac{x}{z} = \psi^x(q; s_b, s_c, s_d) \xi (1 - \delta + r)$$

$$\frac{K}{x} = \frac{1 - \alpha}{r}$$

$$\frac{l}{x} = \frac{\alpha}{w},$$

where the function  $\psi^x(\cdot)$  is the steady state version of the function defined in Appendix C.

Now write the budget constraint of the household as

$$\frac{c}{z} = w \frac{l}{z} + (r - \delta) \frac{k}{z},$$

where

$$\frac{l}{z} = \frac{l}{x} \frac{x}{z},$$

and

$$\frac{k}{z} = \frac{K - z}{z} = \frac{K}{x} \frac{x}{z} - 1.$$

Then, compute  $z$  as  $z = \frac{c}{\frac{c}{z}}$  and use it to compute the aggregate variables  $n, x, K, l, k$  and  $c$ . Finally, use the steady state version of equations (29) and (31) to compute  $y$  and  $e$ , and of the resource constraint (36) to compute  $y^a$ .

## C. Aggregation

Define

$$\psi^x(q_t; s_b, s_c, s_d) \equiv \int_{\frac{s_b}{q_t}}^{\frac{s_c}{q_t}} \int_{\frac{s_d}{\varepsilon_1 q_t}} (1 - \tau) \Phi_2(d\varepsilon_2) \Phi_1(d\varepsilon_1) + \int_{\frac{s_c}{q_t}} \Phi_1(d\varepsilon_1)$$

$$\psi^y(q_t; s_b, s_c, s_d) \equiv \int_{\frac{s_b}{q_t}}^{\frac{s_c}{q_t}} \int_{\frac{s_d}{\varepsilon_1 q_t}} (1 - \tau) \varepsilon_1 \varepsilon_2 \Phi_2(d\varepsilon_2) \Phi_1(d\varepsilon_1) + \int_{\frac{s_c}{q_t}} \varepsilon_1 \Phi_1(d\varepsilon_1)$$

$$\psi^a(q_t; s_b, s_c, s_d) \equiv \int_{\frac{s_b}{q_t}}^{\frac{s_c}{q_t}} \int_{\frac{s_d}{\varepsilon_1 q_t}} (1 - \tau) \varepsilon_1 \varepsilon_2 \Phi_3(\bar{\omega}^b(\varepsilon_1 \varepsilon_2 q_t)) \Phi_2(d\varepsilon_2) \Phi_1(d\varepsilon_1) + \int_{\frac{s_c}{q_t}} \Phi_{2*3}(\bar{\omega}^c(\varepsilon_1 q_t)) \varepsilon_1 \Phi_1(d\varepsilon_1),$$

where  $\Phi_{2*3}$  is the distribution function for the product  $\omega = \varepsilon_2 \varepsilon_3$ . Then, total demand for funds,  $x_t$ , total output including agency costs,  $y_t$ , and total output lost to agency costs,  $y_t^a$ , are given by equations (28), (29) and (30) in the text.

Now let  $\vartheta_b(\varepsilon_1, q_t; s_d)$  be the average profits per unit of net worth of the bank-financed entrepreneurs, given the first idiosyncratic shock  $\varepsilon_1$ , aggregate information  $q_t$ , and threshold  $s_d$  :

$$\vartheta_b(\varepsilon_1, q_t; s_d) = (1 - \tau) \left[ \int_{\frac{s_d}{\varepsilon_1 q_t}}^{\infty} \varepsilon_1 \varepsilon_2 q_t f(\bar{\omega}^b(\varepsilon_1 \varepsilon_2 q_t)) \xi \Phi_2(d\varepsilon_2) + \Phi_2\left(\frac{s_d}{\varepsilon_1 q_t}\right) \right].$$

Also, let  $\vartheta_c(\varepsilon_1, q_t)$  be the average profits per unit of net worth of the CMF-financed entrepreneurs, given the first idiosyncratic shock  $\varepsilon_1$ , and aggregate information  $q_t$  :

$$\vartheta_c(\varepsilon_1, q_t) = \varepsilon_1 q_t f(\bar{\omega}^c(\varepsilon_1 q_t)) \xi.$$

Finally, let  $\vartheta(q_t; s_b, s_c, s_d) n_t$  be the aggregate profits of the entrepreneurial sector, where

$$\vartheta(q_t; s_b, s_c, s_d) = \Phi_1\left(\frac{s_b}{q_t}\right) + \int_{\frac{s_b}{q_t}}^{\frac{s_c}{q_t}} \vartheta_b(\varepsilon_1, q_t; s_d) \Phi_1(d\varepsilon_1) + \int_{\frac{s_c}{q_t}}^{\infty} \vartheta_c(\varepsilon_1, q_t) \Phi_1(d\varepsilon_1).$$

The aggregate budget constraint for the entrepreneurs can then be written as equation (31) in the text.

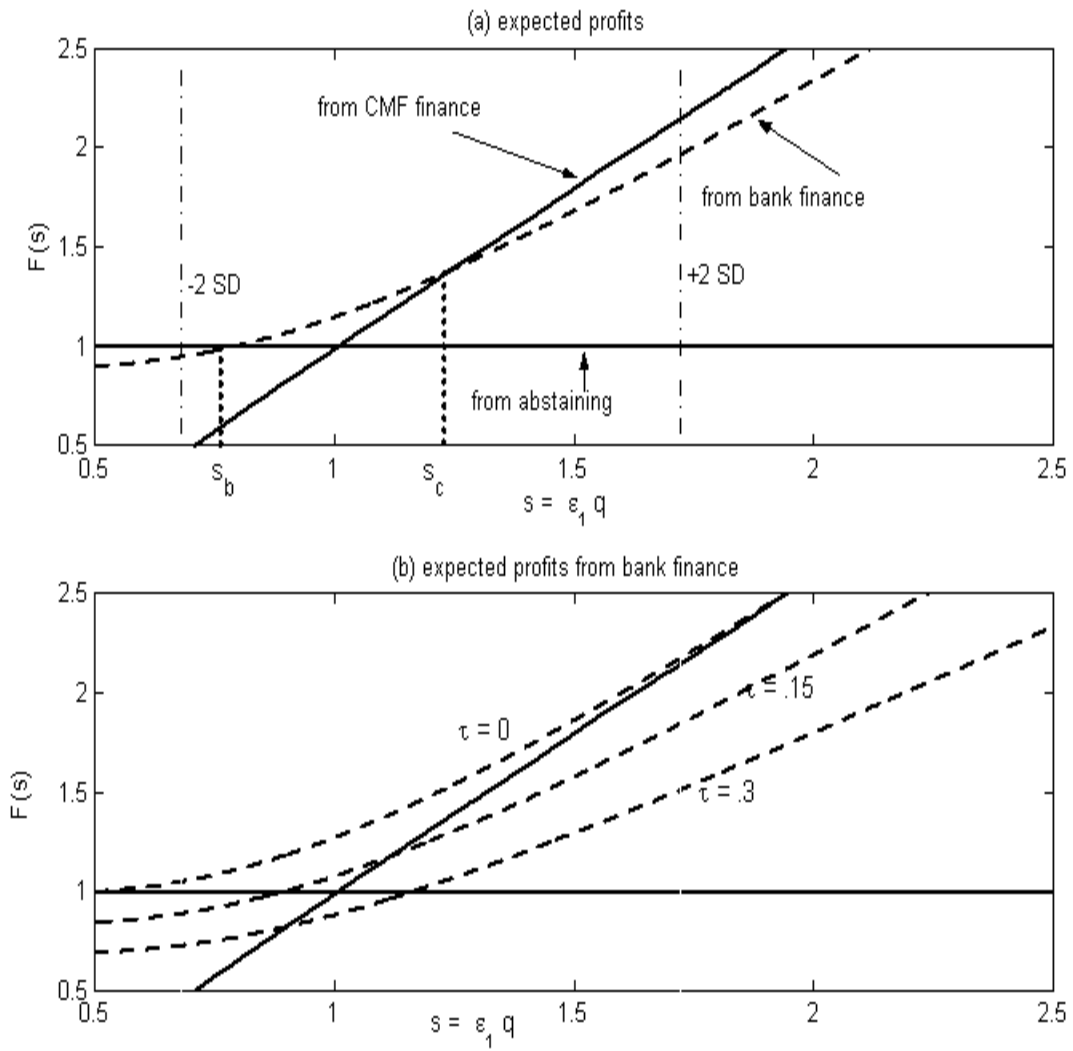


Figure 1: Steady state properties

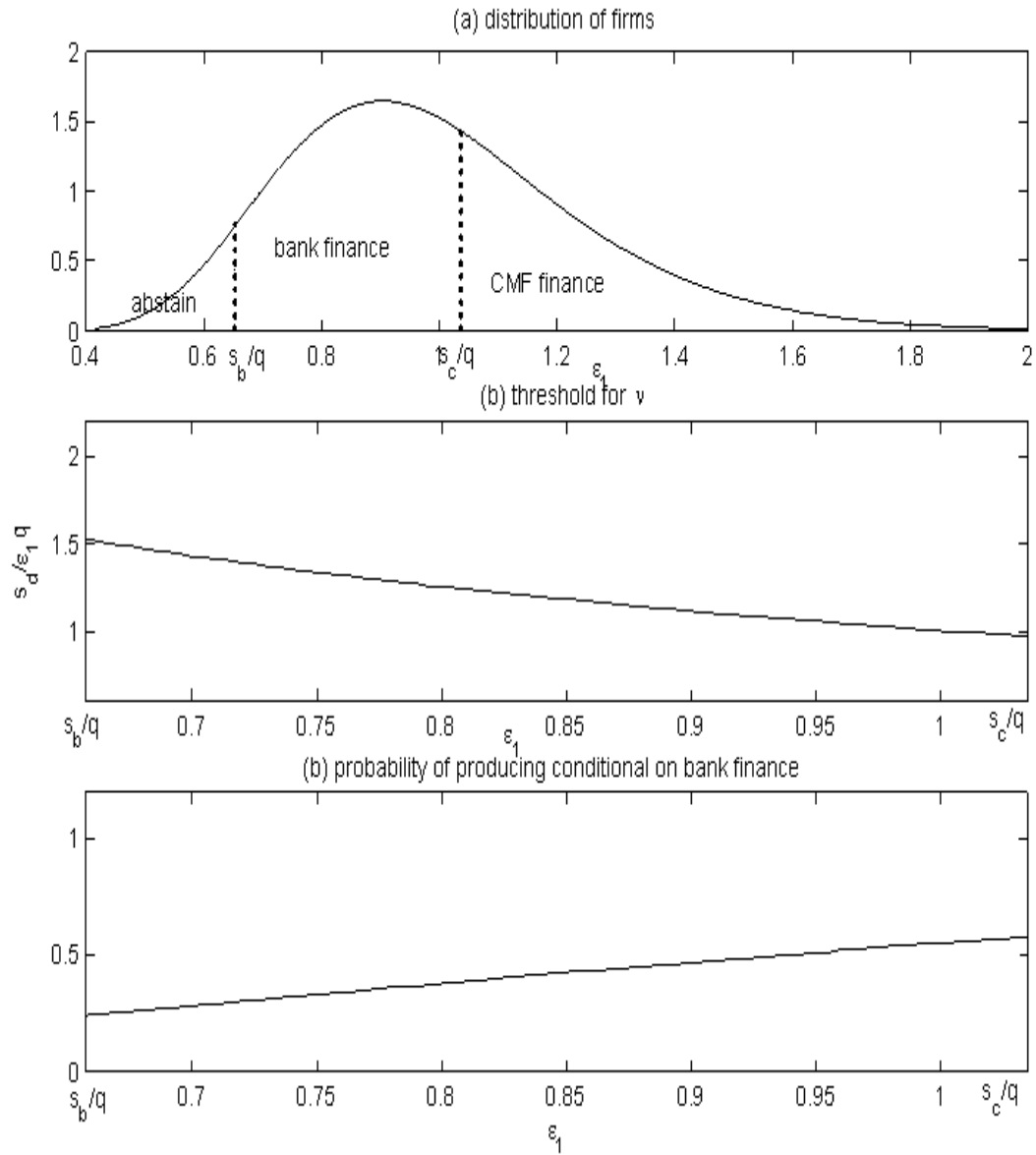


Figure 2: Steady state properties

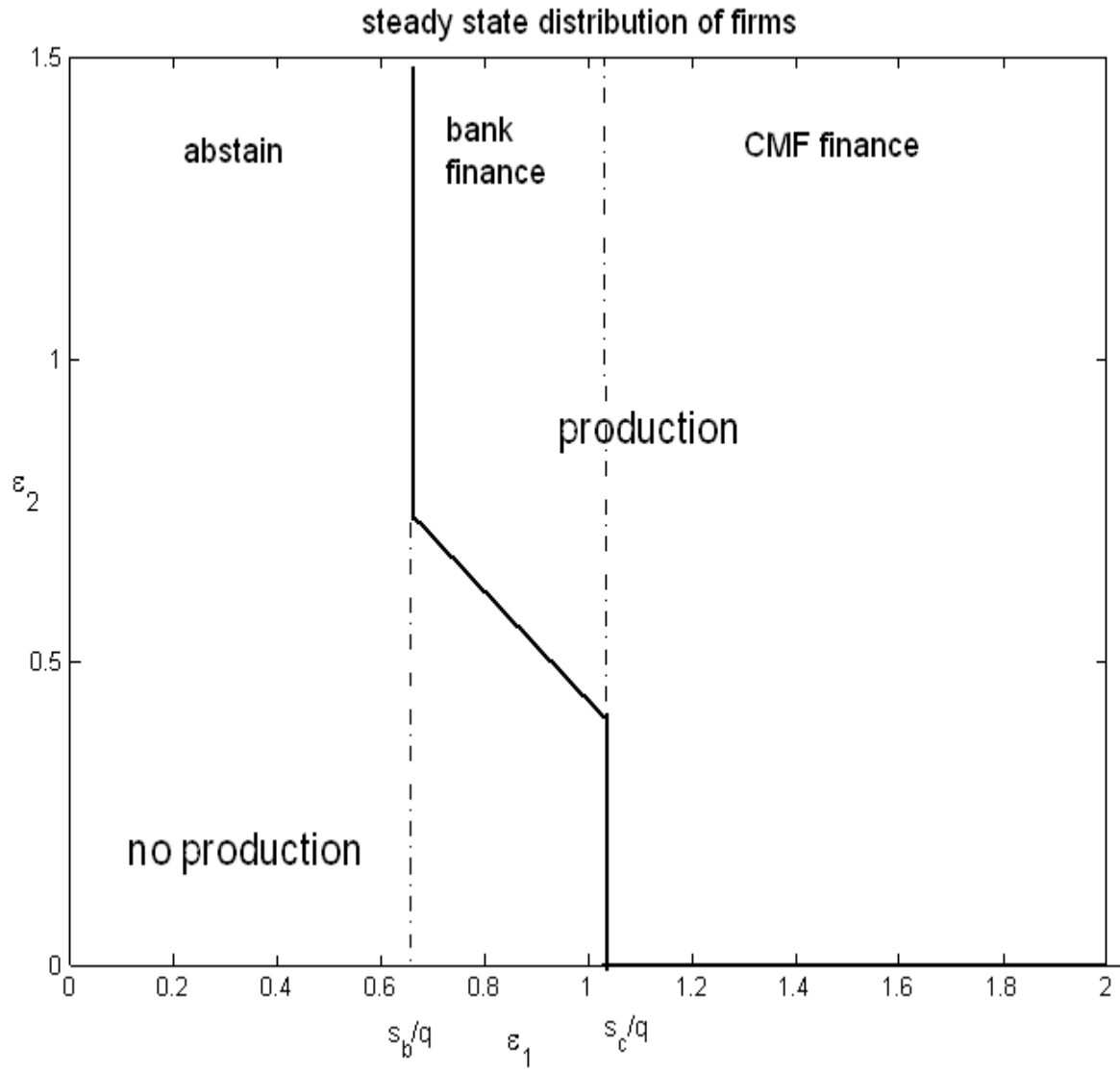


Figure 3: Steady state properties

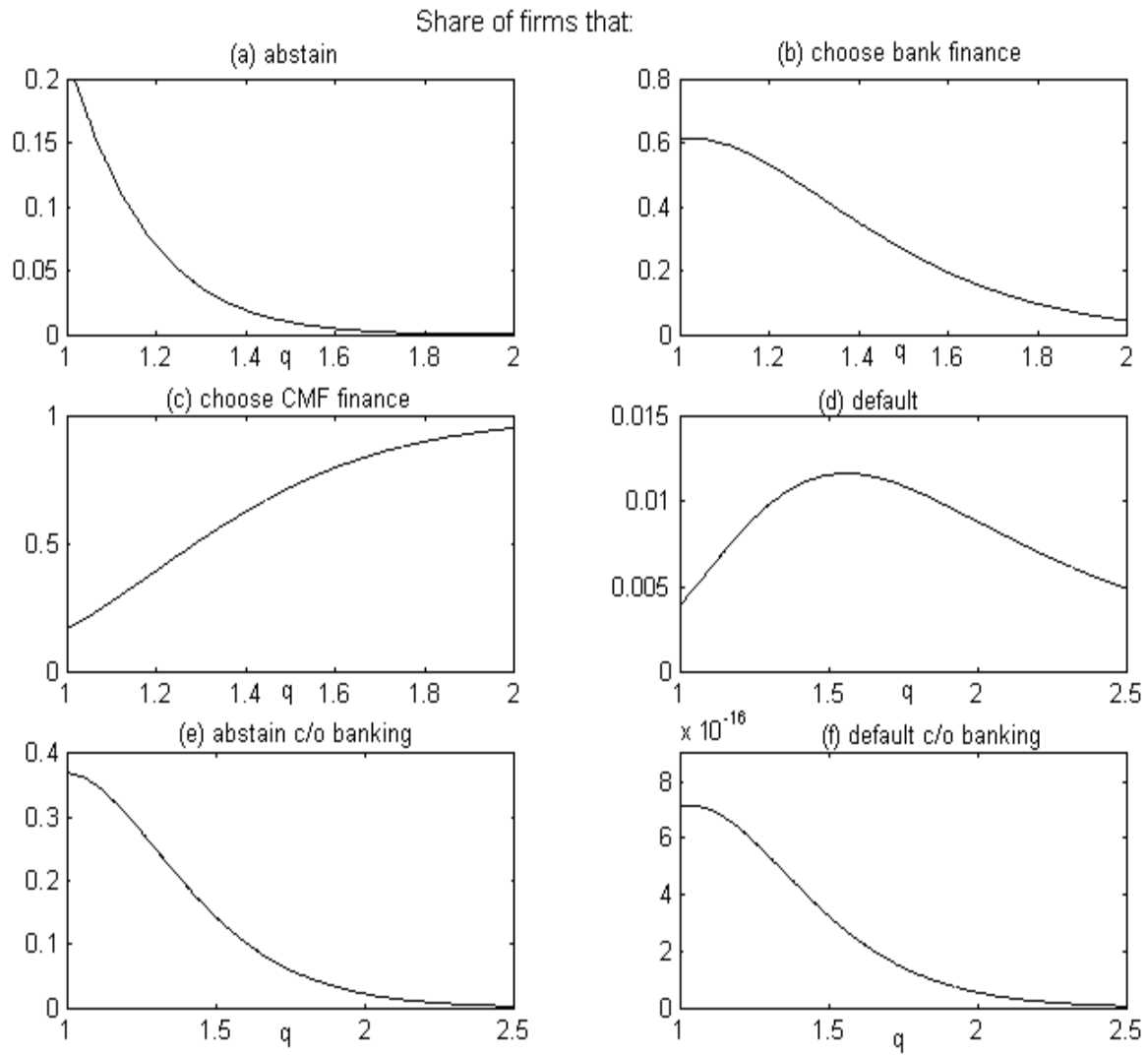


Figure 4: Sensitivity analysis

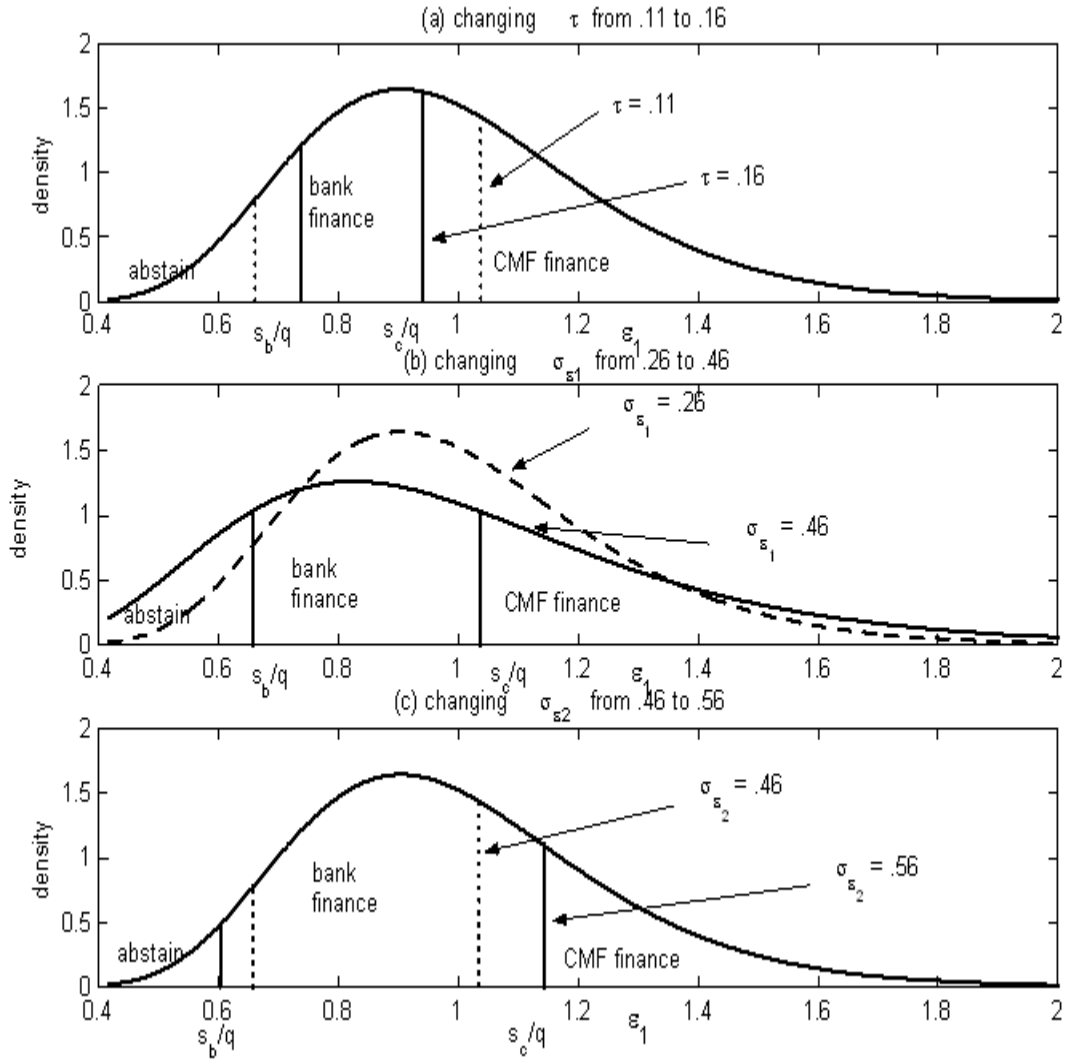


Figure 5: Sensitivity analysis

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