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 financial structure, i.e. the composition of the corporate sector's external finance, as an important dimension through which credit market imperfections affect the macroeconomy. In the presence of agency costs, the 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 effects of information asymmetries. Hence, the choice of entrepreneurs among alternative instruments of external finance might have important implications for the macroeconomic effects of credit market frictions.

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

Evidence on the financial structure across countries suggest that these questions are relevant. For instance, the traditional distinction between bank-based and market-based countries applies to the euro area and the US. Investment of the corporate sector appears to rely 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 in the euro area, and to 28.9 and 137.1 percent in the US.[1] Other, although less striking, differences in the financial structure of the US and of the euro area occur in the debt to equity ratio of the corporate sector, and in the average risk premium and default rate on bank loans.

Existing DSGE models with agency costs do not allow to explain observed differences in financial structures, as these models do not distinguish between alternative instruments of external finance. In this paper, we introduce two types of financial intermediaries - commercial banks and capital mutual funds - into a DSGE model with agency costs. Each type of financial

[1]Source: Ehrmann et al (2003), Table 14.1.

intermediary offers a different intra-period contractual arrangement to 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 instrument 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 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 the initial net worth (except for a fee to be paid to banks as compensation for the costs of information acquisition). The fact that banks spend resources to obtain 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 show that firms heterogeneity can easily be embedded in a DSGE model 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 with no ex-ante heterogeneity. Second, we calibrate the model in steady state to replicate key differences in the financial structure among 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 the observed differences in financial structures, we compare the ratios of per-capita GDP in the US and in the euro area generated by models with and without endogenous financial structure to the ratio observed in the data.

Recent business cycle research has emphasized the relevance of agency costs for economic fluctuations (see for instance Kiyotaki and Moore (1997), Carlstrom and Fuerst (1997, 1998, 2000), Bernanke, Gertler and Gilchrist (1999), Christiano, Motto and Rostagno (2004) and Faia (2002)). In these models, firms raise external finance from a single type of intermediaries that collect funds from dispersed investors. The presence of agency costs affects the macroeconomy through its effect on net worth. A shock that reduces the level of investment and production today also leads to a reduction in the amount of net worth that can be used to finance firms' production in the following period. This gives rise to an increase in the desired amount of external finance and to a worsening of the agency costs, thus enhancing the propagation of the shock.

Our model builds upon the "output model" presented in Carlstrom and Fuerst (2000), here onwards CF. The main difference is that in their economy, at the time of stipulating the financial contract, firms are identical in the risk of default at the end of the period.[2] Moreover, they have access to one type of financial intermediaries 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. CF address the effect of agency costs on the transmission of aggregate shocks (amplification and persistence). Since the focus of our paper is on the determinants of financial market structures, we restrict our attention to the steady state of the economy.

Our paper also relates to 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 SDGE 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 at all. 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 sequence of events and outline the environment. 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

[2] In CF (2000), 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. As firms are identical in equilibrium, they can be assumed identical ex-ante. In what follows, we will use the term "firms' ex-ante heterogeneity " as implying firms' heterogeneity at the time of stipulating the contract in the risk of defaulting at the end of the period. Contrary to the one considered in CF (2000), this type of heterogeneity does not disappear in equilibrium.

need to charge over marginal costs. We proceed to derive the optimal contract between firms and financial intermediaries, 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 and carry out a sensitivity analysis. In section 5, we look at the implication for allocations of structural differences in financial markets. We do so by fitting the model to the US and the euro area. First, we review the existing evidence on differences in the intermediation activities and in the financial structure of the corporate sector in the two blocks. Then, we present a calibration of the model that replicates in steady state the outlined key differences. In section 6, we conclude and outline our future research on this topic.

2 The Model

We cast the different role of corporate bonds and bank loans into an otherwise standard DSGE model with credit frictions and agency costs, where we maintain the assumption of one-period maturity of the debt. The environment builds upon the "output model" presented in CF.

2.1 The sequence of events

The domestic economy is inhabited by a continuum of identical infinitely-lived households, a continuum of firms owned by infinitely lived risk-neutral entrepreneurs facing idiosyncratic risk in production, and two types of zero-profit financial intermediaries.

At the beginning of each period, households decide optimally how much to work, to consume, to invest and to lend. Lending is carried out through banks and CMFs. By funding a large number of entrepreneurs, these financial intermediaries eliminate the risk of idiosyncratic entrepreneurial uncertainty and guarantee a sure return to the households.

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 market value of the initial capital stock is not sufficient to finance the input bill. Hence, producing firms need to raise external finance.

Each firm i is hit by a sequence of three idiosyncratic productivity shocks, $\varepsilon_{1,it}$, $\varepsilon_{2,it}$ and $\varepsilon_{3,it}$. The first shock, $\varepsilon_{1,it}$, is publicly observed and it realizes before firms take their financing decisions (whether to use CMF or bank finance). The second shock, $\varepsilon_{2,it}$ is a signal that occurs after firms take financing decisions but before borrowing occurs. This signal is not observed by anyone (not even the entrepreneur). Information on the realization of this shock can be acquired by the financial intermediaries at a cost that is proportional to the firm's initial net worth. The third shock, $\varepsilon_{3,it}$, realizes after borrowing and is observable to the entrepreneur only. It can be monitored by financial intermediaries at the end of the period, at a cost that is proportional to the size of the firm's project. We define the difference between banks and CMFs to be that only banks spend resources to acquire information about the signal, $\varepsilon_{2,it}$. This allows them to minimize the inefficient liquidation of firms and to build a reputation for financial flexibility.

Conditional on the realization of the first firm-specific shock $\varepsilon_{1,it}$, the entrepreneur chooses whether or not to produce and what financing instrument to use. Entrepreneurs facing high risk of default at the end of the period (a low $\varepsilon_{1,it}$) either choose not to produce or to produce and borrow through the bank, because this minimizes the risk of costly liquidation. The flexibility provided by bank loans entails a cost through high repayments in good states. Hence, entrepreneurs facing low risk (a high $\varepsilon_{1,it}$) prefer financing through CMFs.

Loans 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 the financial intermediaries. Since credit arrangements are all settled at the end of the period, the competitive financial intermediaries break exactly even on average.

Firms that decide to finance through CMFs obtain a certain amount of trade credit at the beginning of the period against the promise to repay the agreed-upon amount after production has occurred. If the realization of the firm's overall productivity factor is not sufficient to guarantee repayment, the firm's default triggers costly monitoring by the CMF. The observed firm's output is then fully seized and the initial net worth of the firm is completely lost.

Firms that finance through bank loans face a different problem. At the beginning of the period, the firm pays up-front to the bank an evaluation cost to gather information about the second firm-specific productivity shock, $\varepsilon_{2,it}$, which is costly to observe for everyone. Conditional on the realization of this shock, the firm has the option to obtain trade credit and produce or to "drop out" of production. If the realization of $\varepsilon_{2,it}$ is low, the firm decides not to produce and keeps the fraction of the initial net worth remaining after the payment of the fee. If the realization exceeds a certain threshold, the firm decides to produce. Firms that produce obtain a certain amount of trade credit against the promise to repay an agreed-upon amount at the end of the period, as in the case of CMF finance. The difference is that, when the bank sets the terms of the loan, the firm faces lower uncertainty on its overall productivity factor.

After the realization of the last shock, $\varepsilon_{3,it}$, production takes place. Entrepreneurs keep part of their output for own consumption and investment, and use the rest to settle trade credit accounts. If they default on loans, production is verified at a cost by the financial intermediary and all resources in the hands of the entrepreneurs are sized. The timing of firms' financial decisions is summarized in Figure 1.

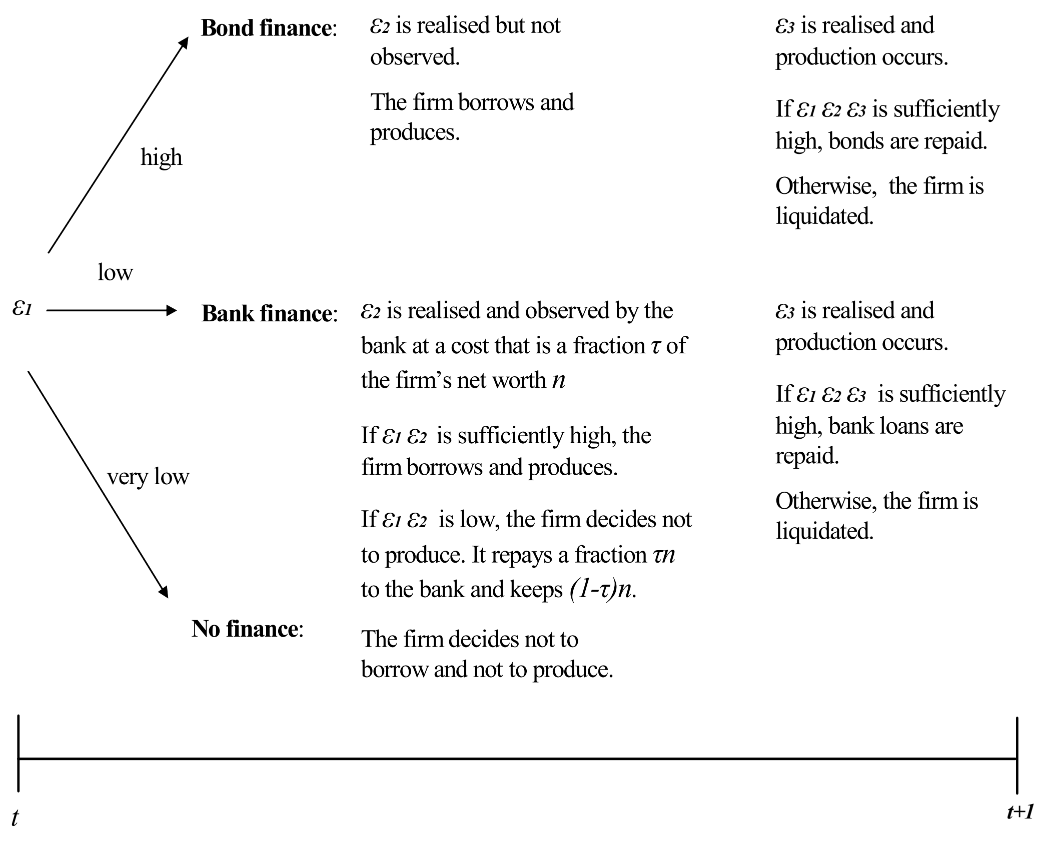

Figure 1: The timing of firms' financing decisions

2.2 The environment

2.2.1 Households

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

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

where β is the households' discount rate, c_t is consumption, l_t denotes working hours and η is a preference parameter.

The households are also the owners of the financial intermediaries, to which they lend and from which they borrow on a trade credit account to be settled at the end of each period. Thus, the representative household faces the budget constraints,

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

2.2.2 Entrepreneurs

There is a continuum of perfectly competitive firms indexed by $i \in [0, 1]$, each owned by an infinitely lived risk-neutral entrepreneur. Each firm has a CRS technology described by

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

where K_{it} and H_{it} denote the firm-level capital and labor, respectively. $\varepsilon_{1,it}, \varepsilon_{2,it}$ and $\varepsilon_{3,it}$ are random iid productivity shocks, which occur at different times during the period. All three shocks have mean unity,[3] are mutually independent and have aggregate distribution functions denoted by Φ_1, Φ_2 and Φ_3 respectively. Per independence assumption, these are also the marginal distributions.

Each entrepreneur i starts the period with an amount of capital z_{it}, whose market value provides the firm with an amount of initial net worth, n_{it}. Since the firm's net worth is lower than the amount of finance necessary to undertake production, each entrepreneur needs to raise external funds to finance the input bill x_{it}, where

$$x_{it} = w_t H_{it} + r_t K_{it},$$

[3] An aggregate technology shock can be introduced by assuming that the mean ε_{1t} of the first entrepreneur-specific technology shock is not unitary.

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

Entrepreneurs are infinitely lived, risk-neutral and behave as "Euler equation entrepreneurs" in the language of CF. Their discount factor is given by $\beta\gamma$, where β is the discount factor of households and $0 < \gamma < 1$. The assumption that entrepreneurs are more impatient than regular households, makes them demand a higher internal rate of return to investment and thus opens the room for trade between households and entrepreneurs despite the agency costs of finance. When the internal expected rate of return offsets the entrepreneurs discount factor, entrepreneurs are individually indifferent between consuming and investing.

2.2.3 Agency costs and financial intermediation

Denote as Ω_{at}, Ω_{bt} and Ω_{ct} the subset of firms that at time t choose to abstain from production after seeing $\varepsilon_{1,it}$, approach a bank and (depending on $\varepsilon_{2,it}$) obtain a loan, or raise external finance through CMFs.

Let ω_{it} be the residual uncertain productivity factor at contracting time, i.e. when firms approach financial intermediaries to obtain trade credit, and Φ_ω and φ_ω be respectively its distribution and density function. Then,

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

To produce, each entrepreneur has to request trade credit in the amount $x_{it} - \tilde{n}_{it}$, where $\tilde{n}_{it} = n_{it}$ in case of CMF finance and $\tilde{n}_{it} = (1-\tau)n_{it}$ in case of bank finance. Firms that decide to finance their production through bank loans need to pay in advance of production the up-front fee τn_{it}, which is used by the bank to acquire information about the signal $\varepsilon_{2,it}$. Therefore, they request trade credit $x_{it} - (1-\tau)\,n_{it}$ from the bank for total funds at hand of x_{it}. The cost τn_{it} is not faced by firms that finance through CMFs, as these financial intermediaries do not invest in acquiring information about the firm. Hence, these firms request trade credit $x_{it} - n_{it}$ for total funds at hand of x_{it}.

The financial arrangements between entrepreneurs and financial intermediaries take the form of debt contracts. Each financial intermediary stands ready to finance a project size that is a fixed proportion of the firm's net worth, $x_{it} = \zeta\tilde{n}_{it}$. Each entrepreneur agrees to repay an amount $(1 + r_{it}^j)\,(x_{it} - \tilde{n}_{it})$ at the end of the period, where r_{it}^j for $j = b, c$ is the risk premium charged by banks or CMFs respectively. The fact that only the entrepreneur can costlessly observe the idiosyncratic shock ω_{it}, and thus total production at the end of the period, introduces a moral hazard problem. After the realization of the uncertain productivity factor ω_{it}, the entrepreneur learns the true outcome of production in units of goods, $y_{it} = \varepsilon_{1,it}\omega_{it}H_{it}^{\alpha}K_{it}^{1-\alpha}$. The entrepreneur is able to repay only if ω_{it} exceeds a certain threshold, $\overline{\omega}_{it}^{j}$. However, he or she has an incentive to under-report the realization of the unobserved productivity factor and to declare default, unless costly monitoring is carried out by the financial intermediary. We assume a monitoring technology that uses a fraction μ of the firm's output to monitor production.

Under the assumption that $x_{it} = \zeta\tilde{n}_{it}$, when $\omega_{it} = \varepsilon_{3,it}$ (CMF finance), the optimal contract is a prestate agreement on the circumstances under which monitoring has to occur. It establishes a threshold level $\overline{\omega}_{it}^{j}$ for the uncertain productivity factor above which the entrepreneur repays its debt and keeps any residual profits. Below that threshold, the entrepreneur declares default, the financial intermediary monitors the firm and seizes its entire production. As profits accruing to the entrepreneur in case of bankruptcy are zero, such a contract induces the entrepreneur to tell the truth about its current production and to repay the agreed-upon amount to the intermediary whenever possible.[4]

When $\omega_{it} = \varepsilon_{2,it}\varepsilon_{3,it}$ (bank finance), the terms of the contract depend on whether we allow for the existence of *lotteries*.[5] Since agency costs are a resource loss for the economy and entrepreneurs are risk neutral, the optimal contract (characterized in Appendix B) takes the form of a lottery. It is given by a state-dependent level of the threshold under which monitoring has to occur and of the up-front fee to be paid to the bank. Under such a contract, banks would confiscate the net worth of firms facing low realizations of the first idiosyncratic shock to subsidize production of firms experiencing high realizations of the same shock. If the shock is lower than a certain treshold, the firm would have to surrender its entire net worth to the bank. If the shock is higher than that treshold, the firm would get full funding at the lowest possible cost. Repayments would be minimized and so would be the probability of default and expected

[4]When firms are ex-ante identical, as in CF, the optimal contract is a prestate agreement that fixes the threshold level for the uncertain productivity factor and the firm's project size. Such a contract is efficient because it minimizes expected bankruptcy costs, given incentive compatibility. In our model with ex-ante heterogeneity, firms differ in terms of their credit-worthiness. When the distribution of the idiosyncratic shock ε_{1t} is unbounded, financial intermediaries would finance projects of infinite size for those firms experiencing extremely large values of that shock. The assumption that the project size is a fixed share of the firm's initial net worth ensures that all firms can raise positive and finite amounts of external finance.

[5]On the potential to use lotteries to improve the allocations, see for instance Bernanke and Gertler (1989).

monitoring costs. The contract is optimal because it minimizes agency costs and, since the entrepreneurs are risk-neutral, improve their welfare. 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, the possibility of cross-state subsidization is often assumed away in the literature. We follow this practice in the current context. In the absence of cross-state subsidization, the optimal contract is given by an up-front fee to be paid to the bank and a prestate agreement on the threshold $\overline{\omega}_{it}^{b}$, below which monitoring has to occur.

3 Analysis

We analyze the behavior of the various classes of agents in this economy and we characterize the competitive equilibrium. First, we show that the presence of agency costs in financial intermediation translates into a firm-specific markup that entrepreneurs need to charge over marginal costs. Then, we characterize the contract between firms and financial intermediaries and we derive the endogenous financial structure. We proceed by characterizing consumption and investment decisions of entrepreneurs and households. Finally, we present aggregation results, we impose market clearing and we characterize the competitive equilibrium.

3.1 Factor prices and the markup

Each entrepreneur i starts the period with an amount of capital z_{it}. The entrepreneur's net worth[6], n_{it}, is given by the market value of his capital stock, calculated as the to-be-earned factor payments plus the depreciated capital stock,[7]

$$n_{it} = (1 - \delta + r_t)\, z_{it}. \tag{3}$$

To raise external finance, firms need to sign a contract with the financial intermediaries, which fixes the size of the project x_{it}. Normalizing goods prices, the firm's demand for labor

[6] One possible interpretation is that entrepreneurs sell their capital stock at the beginning of the period against trade credit n_{it}

[7] Entrepreneurs' net worth should include also a fixed income component (e.g. a constant lump-sum subsidy ψ received from the households). This would ensure that, if the entrepreneur defaults in period $t-1$, its net worth in period t is non zero, so that he can obtain external finance and eventually produce. Since introducing a small constant subsidy does not affect aggregate dynamics in the economy, we abstract from it.

and capital is derived by solving the problem

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

subject to the financing constraint

$$x_{it} = w_t H_{it} + r_t K_{it}.$$

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,

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

Denote the Lagrange multiplier on the financing constraint as $s_{it} - 1$. Assuming a binding constraint (as it will be with the optimal financing contract), optimality implies that

$$\begin{aligned} K_{it} &= (1-\alpha)\frac{x_{it}}{r_t} \\ H_{it} &= \alpha\frac{x_{it}}{w_t} \end{aligned}$$

and

$$\mathcal{E}\left[y_{it}\right] = s_{it}x_{it}.$$

Since

$$\mathcal{E}[y_{it}] = \mathcal{E}[\varepsilon_{1,it}\varepsilon_{2,it}\varepsilon_{3,it}]\left(\frac{\alpha}{w_t}\right)^{\alpha}\left(\frac{1-\alpha}{r_t}\right)^{1-\alpha} x_{it},$$

it follows that

$$s_{it} = \begin{cases} \varepsilon_{1,it}q_t & \text{for CMF finance} \\ \varepsilon_{1,it}\varepsilon_{2,it}q_t & \text{for bank finance} \end{cases} \tag{4}$$

where q_t is defined as

$$q_t = \left(\frac{\alpha}{w_t}\right)^{\alpha}\left(\frac{1-\alpha}{r_t}\right)^{1-\alpha}. \tag{5}$$

We can interpret q_t as an aggregate distortion in production arising from the presence of the financing constraint in the economy and s_{it} as a markup, which firms need to charge in order to cover the agency costs of financial intermediation. Note that 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 $s_{it} = q_t$. Aggregating across firms, we obtain

$$\begin{aligned} w_t H_t &= \alpha x_t \\ r_t K_t &= (1-\alpha)\, x_t. \end{aligned}$$

To calculate aggregate output, we need to first learn more about the financial contracts and funds obtained.

3.2 Financial structure

We start by solving the optimal contract between firms and financial intermediaries. We then proceed to characterize thresholds for the realization of the firm-specific markup s_{it} that determine the firm's decision of whether or not to borrow and of what financing instrument to use. We also characterize how the aggregate variable that reflects the importance of the financing distortions in the economy, q_t, affects the distribution of firms among alternative financing instruments.

3.2.1 The costly state verification contract

The contract is a prestate agreement on a threshold for the uncertain productivity factor $\overline{\omega}_{it}^{j}$, below which the entrepreneur defaults and gets monitored. Recall that the presence of agency costs implies that output is valued at a markup s_{it} over marginal costs,

$$y_{it} = s_{it}\omega_{it}x_{it}$$

Each entrepreneur agrees to borrow the amount $x_{it} - \tilde{n}_{it}$ and to repay the amount $(1 + r_{it}^{j})\,(x_{it} - \tilde{n}_{it}) = s_{it}\overline{\omega}_{it}^{j}x_{it}$ at the end of the period. He or she repays if $\omega_{it} \geq \overline{\omega}_{it}^{j}$, and defaults, if not. Define

$$f\left(\overline{\omega}^{j}\right) = \int_{\overline{\omega}}^{\infty} \left(\omega - \overline{\omega}^{j}\right) \Phi_{\omega}\left(d\omega\right) \tag{6}$$

$$g(\overline{\omega}^{j}) = 1 - f(\overline{\omega}^{j}) - \mu\Phi_{\omega}(\overline{\omega}^{j}) \tag{7}$$

as the expected shares of final output accruing respectively to an entrepreneur and to a lender, after stipulating a contract that fixes the threshold at $\overline{\omega}_{it}^{j} = \overline{\omega}^{j}$. The optimal contract solves the problem

$$\max_{\overline{\omega}_{it}} s_{it} f(\overline{\omega}_{it}^{j}) x_{it} \tag{8}$$

subject to

$$
\begin{aligned}
s_{it} g(\overline{\omega}_{it}) x_{it} &\geq x_{it} - \tilde{n}_{it} && (9)\\
x_{it} &= \xi \tilde{n}_{it}, && (10)
\end{aligned}
$$

where $\xi \geq 1$. The contract maximizes the entrepreneur's expected return subject to the lender being indifferent between lending out funds or retaining them, as ensured by (9), and to (10). Since the entrepreneur's expected profits are zero in case of default, he or she has an incentive to reveal the truth and to repay whenever possible. Notice that, since loans are intra-period, the opportunity cost of lending for the intermediary equals the amount of loans itself, $x_{it} - \tilde{n}_{it}$.

Lemma 1 *The expected share of final output accruing to the entrepreneur is monotonically decreasing in the threshold $\overline{\omega}_{it}^{j}$, i.e. $f'(\overline{\omega}_{it}^{j}) < 0$. The expected share accruing to the lender is monotonically increasing in $\overline{\omega}_{it}^{j}$, i.e. $g'(\overline{\omega}_{it}^{j}) > 0$.*

Proof: First, notice that $f'(\overline{\omega}_{it}^{j}) = -\left[1 - \Phi_{\omega}\left(\overline{\omega}_{it}^{j}\right)\right] < 0$. Second, we show that $g'\left(\overline{\omega}_{it}^{j}\right) \geq 0$ by contradiction. Suppose $g'\left(\overline{\omega}_{it}^{j}\right) < 0$. Then, it would be possible to increase expected profits of the firm, $s_{it} f(\overline{\omega}_{it}^{j}) \xi \tilde{n}_{it}$, by reducing $\overline{\omega}_{it}^{j}$ while increasing expected profits of the financial intermediary, $s_{it} g(\overline{\omega}_{it}^{j}) \xi \tilde{n}_{it}$. Hence, $\overline{\omega}_{it}^{j}$ could not be a solution to the contract. ■

Proposition 2 *The unique solution to the CSV problem when $x_{it} = \xi \tilde{n}_{it}$, is a threshold $\overline{\omega}_{it}^{j}$ that satisfies*

$$
s_{it} g(\overline{\omega}_{it}^{j}) = \frac{\xi - 1}{\xi}. \tag{11}
$$

Proof: Notice that $f(0) = \int_0^{\infty} \omega \Phi_{\omega}(d\omega) = 1$ and $g(0) = 0$. Then, Lemma 1 implies that the unique interior solution to problem (8) is given by (11). ■

The terms of the contract can be written as

$$
\overline{\omega}_{it}^{j} = \overline{\omega}^{j}(s_{it}), \tag{12}
$$

where s_{it} satisfies (4).

Lemma 3 *The threshold $\overline{\omega}_{it}^{j}$ is a decreasing function of the firm-specific mark-up s_{it}.*

Proof: From (9) taken as an equality, it follows that $\frac{\partial \overline{\omega}_{it}^{j}}{\partial s_{it}} = -\frac{g(\overline{\omega}_{it}^{j})}{s_{it} g'(\overline{\omega}_{it}^{j})} < 0$. ■

Lemma 3 states that, the higher the firm-specific mark-up s_{it}, the lower the threshold for the idiosyncratic productivity shock, $\overline{\omega}_{it}^{j}$, below which the entrepreneur defaults and is monitored. One implication of Lemma 3 is that also $\frac{\partial \overline{\omega}_{it}^{j}}{\partial q_t} < 0$. For a given realization of the firm-specific shock, a higher q_t reduces the threshold that triggers default and monitoring.

3.2.2 Bank loan continuation

Consider the situation of bank finance, where $\varepsilon_{1,it}$ and $\varepsilon_{2,it}$ are known. The entrepreneur will proceed with the bank loan only if his expected payoff exceeds the opportunity costs of renting his capital to others, i.e. if $s_{it} f(\overline{\omega}^b(s_{it}))\xi \geq 1$, where $s_{it} = \varepsilon_{1,it}\varepsilon_{2,it}q_t$.

Proposition 4 *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 $\underline{s}_d$ that solves the condition*

$$s_{it} f(\overline{\omega}^b(s_{it}))\xi = 1. \tag{13}$$

Proof: Notice that expected profits from proceeding with the bank, $s_{it} f(\overline{\omega}^b(s_{it}))\xi$, are zero for $s_{it} = 0$ and strictly increasing in s_{it}, since $f'\left(\overline{\omega}^b_{it}\right) < 0$ and $\frac{\partial \overline{\omega}^b_{it}}{\partial s_{it}} < 0$. Hence, a solution to condition (13), taken with equality, exists and is unique. Moreover, the solution is constant across firms and time. ■

3.2.3 The choice of the financing instrument

At the beginning of the period, after the random variable $\varepsilon_{1,it}$ realizes, the entrepreneur chooses whether or not to borrow and how to finance production. For simplicity, since we characterize the decision of entrepreneur i at time t, we drop the subscripts.

The expected payoff of an entrepreneur, who proceeds with bank finance conditional on the realization of ε_1, is $F^b(s)n$, where $s = \varepsilon_1 q$ and

$$F^b(s) = (1-\tau)\left(\int_{\frac{\underline{s}_d}{s}} s\varepsilon_2 f(\overline{\omega}^b(s\varepsilon_2))\xi\Phi_2(d\varepsilon_2) + \Phi_2(\frac{\underline{s}_d}{s})\right)$$

The possibility for the entrepreneur to await the further news ε_2 before deciding whether or not to proceed with the bank loan provides option value.

The expected payoff of an entrepreneur, who proceeds with CMF finance conditional on the realization of ε_1, is $F^c(s)n$, , where $s = \varepsilon_1 q$ and

$$F^c(s) = sf(\overline{\omega}^c(s))\xi$$

Finally, the expected payoff for 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

$$F(s) = \max\{1; F^b(s); F^c(s)\}. \tag{14}$$

Conditional on s, entrepreneurs split into three sets: Ω_{at}, the set of entrepreneurs that abstains from raising external finance in period t; Ω_{bt}, the set of entrepreneurs that sign a contract with banks, and Ω_{ct}, the set of CMF-financed entrepreneurs. We show that these three sets are, in fact, intervals in terms of the idiosyncratic first productivity shock ε_1 and we characterize how q moves the bounds of these intervals.

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

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

$(A2)$ $F^{b\prime}(s) < F^{c\prime}(s)$, for all s.

Assumptions $(A1)$ and $(A2)$ impose mild restrictions on the parameters of the model. $(A1)$ requires that

$$\left[\underline{s}_d f(\overline{\omega}^b(\underline{s}_d))\xi - \varphi_{\varepsilon_2}(\frac{\underline{s}_d}{s})\right] \frac{\underline{s}_d}{s^2} + \int_{\frac{\underline{s}_d}{s}} \varepsilon_2 \xi \left[f(\overline{\omega}^b(s\varepsilon_2)) + s\varepsilon_2 f'(\overline{\omega}^b(s\varepsilon_2)) \frac{\partial \overline{\omega}^b}{\partial(\varepsilon_2 s)}\right] \Phi_2(d\varepsilon_2) > 0. \quad (15)$$

A sufficient condition for (15) to be satisfied is that $\varphi_{\varepsilon_2}(\frac{\underline{s}_d}{s}) < 1$, since the expected return evaluated at the threshold $\underline{s}_d$, $\underline{s}_d f(\overline{\omega}^b(\underline{s}_d))\xi$, is one, and $f'(\overline{\omega}^b)\frac{\partial \overline{\omega}^b}{\partial s\varepsilon_2} > 0$.

The condition imposed by $(A2)$ is also mild. Intuitively, firms with a low realization of the productivity shock ε_1 (a low s) have expectations of low returns from undertaking production after signing a contract with the bank, as represented by the term $(1-\tau)\int_{\frac{\underline{s}_d}{s}} s\varepsilon_2 f(\overline{\omega}^b(s\varepsilon_2))\xi\Phi_2(d\varepsilon_2)$. For those firms, the gain from minimizing the possibility of liquidation, $(1-\tau)\,\Phi_2(\frac{\underline{s}_d}{s})$, 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 in the case of bond 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 $\underline{s}_b$ and $\underline{s}_c$.

Proposition 5 *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 $\underline{s}_b$ that solves the condition*

$$F^b(s) = 1. \quad (16)$$

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

Proposition 6 *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 $\underline{s}_c$ that solves the* *condition*

$$F^b(s) = F^c(s). \tag{17}$$

Proof: Notice that, $F^b(0) = 1 - \tau > F^c(0) = 0$. Under $(A1)$, $F^{b\prime}(s) > 0$, while $F^{c\prime}(s) = \xi\left[f(\overline{\omega}^c(s)) + sf'(\overline{\omega}^c(s))\frac{\partial\overline{\omega}}{\partial s}\right] > 0$. A sufficient condition for existence and uniqueness of a threshold is provided by $(A2)$. The threshold $\underline{s}_c$ 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 $\varepsilon_{1,it}$,

$$\begin{aligned}
\Omega_{at} &= \{\varepsilon_{1,it} \mid \varepsilon_{1,it} < \underline{s}_b/q_t\} \\
\Omega_{bt} &= \{\varepsilon_{1,it} \mid \underline{s}_b/q_t \leq \varepsilon_{1,it} \leq \underline{s}_c/q_t\} \\
\Omega_{ct} &= \{\varepsilon_{1,it} \mid \varepsilon_{1,it} > \underline{s}_c/q_t\}
\end{aligned}$$

for some constants $\underline{s}_b$, $\underline{s}_c$.

Notice that an increase in q_t raises expected profits from producing, conditional on the realization of the first firm-specific shock, and reduces the thresholds for $\varepsilon_{1,it}$, $\underline{s}_b/q_t$ and $\underline{s}_c/q_t$. Hence, an increase in q_t decreases the share of firms that decide to abstain from production and correspondingly increases the share of firms that raise external finance.

Notice also that condition (13) determines a threshold $\underline{s}_d$ for the firm-specific markup, below which firms that have signed a contract with banks decide to abstain. Recall that $s_{it} = \varepsilon_{1,it}\varepsilon_{2,it}q_t$ for such firms. Then, a corresponding threshold for the second firm-specific shock $\varepsilon_{2,it}$ can be computed as $\underline{s}_d/(q_t\varepsilon_{1,it})$. Conditional on the realization of $\varepsilon_{1,it}$, an increase in q_t reduces the threshold for $\varepsilon_{2,it}$ and the share of firms that decide to abstain after having signed a contract with a bank.

3.3 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,

$$x_t = \left(\int_{\frac{\underline{s}_b}{q_t}}^{\frac{\underline{s}_c}{q_t}} \int_{\frac{\underline{s}_d}{\varepsilon_1 q_t}} (1-\tau)\Phi_2(d\varepsilon_2)\Phi_1(d\varepsilon_1) + \int_{\frac{\underline{s}_c}{q_t}} \Phi_1(d\varepsilon_1)\right)\xi n_t \tag{18}$$

total output including agency costs,

$$y_t = \left(\int_{\frac{\underline{s}_b}{q_t}}^{\frac{\underline{s}_c}{q_t}} \int_{\frac{\underline{s}_d}{\varepsilon_1 q_t}} (1-\tau)\varepsilon_1\varepsilon_2\Phi_2(d\varepsilon_2)\Phi_1(d\varepsilon_1) + \int_{\frac{\underline{s}_c}{q_t}} \varepsilon_1\Phi_1(d\varepsilon_1)\right) q_t\xi n_t \tag{19}$$

and output lost to agency costs,

$$y_t^a = \left(\int_{\frac{s_b}{q_t}}^{\frac{s_c}{q_t}} \int_{\frac{s_d}{\varepsilon_1 q_t}} (1-\tau)\varepsilon_1\varepsilon_2\Phi_3\left(\overline{\omega}^b(\varepsilon_1\varepsilon_2 q_t)\right)\Phi_2(d\varepsilon_2)\Phi_1(d\varepsilon_1) + \int_{\frac{s_c}{q_t}} \Phi_{2*3}\left(\overline{\omega}^c(\varepsilon_1 q_t)\right)\varepsilon_1\Phi_1(d\varepsilon_1) \right) \mu q_t \xi n_t, \tag{20}$$

where Φ_{2*3} is the distribution function for the product $\omega = \varepsilon_2\varepsilon_3$.

3.4 Consumption and investment decisions

Consumption and investment decisions of the households are described by the solution to their problem, which is given by

$$\eta c_t = w_t \tag{21}$$

$$\frac{1}{c_t} = \beta E_t \left\{ \frac{1}{c_{t+1}} (1 - \delta + r_{t+1}) \right\}. \tag{22}$$

The entrepreneurial decision on consumption and on investment in capital, which will be used as net worth in the following period, is described by the entrepreneurs' intertemporal Euler equation,

$$1 = E_t[\beta\gamma(1 - \delta + r_{t+1})F(\varepsilon_{1,it+1}q_{t+1})]. \tag{23}$$

Observe that q_{t+1} is a function of w_{t+1} and r_{t+1}. This equation then ties down a relationship between these two factor prices. The equation 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.

Aggregate entrepreneurial consumption and investment need not exceed the end-of-period real wealth of entrepreneurs,

$$e_t + z_{t+1} = n_t \int F(\varepsilon_1 q_t)\Phi_1(d\varepsilon_1). \tag{24}$$

3.5 Market clearing

Market clearing for capital, labor and output requires that

$$K_t = k_t + z_t, \tag{25}$$

$$H_t = l_t, \tag{26}$$

$$y_t = c_t + e_t + y_t^a + K_{t+1} - (1-\delta)K_t. \tag{27}$$

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 $\left\{\overline{\omega}^b(s_{it}), \overline{\omega}^c(s_{it})\right\}_{t=0}^{\infty}$, constant thresholds for the firm's mark-up $\{\underline{s}_b, \underline{s}_c, \underline{s}_d\}_{t=0}^{\infty}$, 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 $\{c_t, l_t, H_t, K_t, e_t, x_t, y_t, y_t^a\}_{t=0}^{\infty}$, 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 choose H_{it} and K_{it}, for $i \in (0,1)$, to maximize profits, subject to the CRS 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 the first two idiosyncratic productivity shocks, $\varepsilon_{1,it}$ and $\varepsilon_{2,it}$. Entrepreneurs also choose consumption, $e_{i,t}$, and investment, $z_{i,t+1}$, to maximize their linear utility, subject to the budget constraint.

- Financial intermediaries and firms solve a costly state verification problem. The solution to this problem is a threshold level for the uncertain productivity factor $\overline{\omega}_{it}^j$, $j = b, c$. When the productivity factor is lower than the threshold, the firm is monitored.

- The market clearing conditions for goods, loans, labor and capital hold.

The conditions for a competitive equilibrium can be summarized by the system of equations (3), (4), (5), (12), (13), (16), (17), (18), (19), (20), (21), (22), (23), (24), (27), and

$$w_t l_t = \alpha x_t \tag{28}$$

$$r_t (k_t + z_t) = (1 - \alpha) x_t. \tag{29}$$

4 Steady state properties: a numerical analysis

We parameterize the model at the stochastic steady state, which is characterized in Appendix A. 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 σ_v^2 and mean $-\sigma_v^2/2$. As a result, $\varepsilon_2\varepsilon_3$ will also be lognormally distributed, with the variance of log equal to $\sigma_{\varepsilon_2}^2 + \sigma_{\varepsilon_3}^2$.

We set a discount factor $\beta = .98$ and a depreciation rate $\delta = .02$, leading to a real interest rate $r = 4\%$. We choose $\alpha = .64$ in the Cobb-Douglas production function and a coefficient in preferences so that labor equal .3 in steady state, $\eta = 2.6$. We set monitoring costs to be approximately 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 6 parameters to set $(\xi, \tau, \gamma, \sigma_{\varepsilon_1}, \sigma_{\varepsilon_2}, \sigma_{\varepsilon_3})$. In this section we set them arbitrarily at values that are convenient to show the qualitative properties of the model in steady state, i.e. $\tau = .11$, $\xi = 1.6$, $\sigma_{\varepsilon_1} = .26, \sigma_{\varepsilon_2} = .46, \sigma_{\varepsilon_3} = .13, \gamma = .704$. 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 2, we show expected profits for entrepreneurs. Panel (a) plots expected profits from abstaining from production, from signing a contract with the bank and from signing a contract with the 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, $\underline{s}_b$ and $\underline{s}_c$, which determine the financial market structure in steady state. The panel also shows the region corresponding to the mean of the firm-specific mark-up s, plus/minus two standard deviations. After the realization of ε_1, 95% of the existing firms' markups lie within this region. Panel (b) shows how expected profits from bank finance move with the up-front fee τ. 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 τ is extremely large (.3 in the figure), the option value of acquiring more information is not large enough to offset the cost of paying the fee. All firms either abstain or use CMF finance. Only for some intermediate range of τ, 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 3 illustrates the financial decisions of firms. Panel (a) plots how firms allocate among financial instruments. Conditional on the steady state value of the aggregate variable q, firms experiencing a productivity shock $\varepsilon_1 \leq \underline{s}_b/q$ decide to abstain from raising external finance. Firms with $\underline{s}_b/q \leq \varepsilon_1 \leq \underline{s}_c/q$ sign a contract with banks and firms with $\varepsilon_1 \geq \underline{s}_c/q$ sign a contract with CMFs. Among firms that raise bank finance, those experiencing a productivity shock below a certain threshold, $\varepsilon_2 \leq \underline{s}_d/\varepsilon_1 q$, decide to repay the bank an amount τn and not to proceed to the production stage. Panel (b) plots the threshold $\underline{s}_d/\varepsilon_1 q$, over the range of mark-ups $(\underline{s}_b/q, \underline{s}_c/q)$ that give raise to bank finance, as a function of ε_1. Panel (c) shows the probability that $\varepsilon_2 \geq \underline{s}_d/\varepsilon_1 q$, as a function of ε_1. The larger ε_1, the lower the threshold level for ε_2 and the higher the probability that the firm will produce, conditional on having signed a contract with a bank. Under the chosen parameterization, the share of firms that abstain, conditional on having signed a contract with a bank, is .57.

Figure 4 plots the steady state distribution of firms among production activities. Firms that do not undertake production are those that decide not to raise external finance because $\varepsilon_1 \leq \underline{s}_b/q$, and those that sign a contract with the bank but, after having observed the second firm-specific shock, decide to drop out of production. For these firms, $\underline{s}_b/q \leq \varepsilon_1 \leq \underline{s}_c/q$ and $\varepsilon_2 \leq \underline{s}_d/q\varepsilon_1$.

Figure 5 and 6 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 that this is equivalent to changing the value of γ. For a given value of r and σ_{ε_1}, the steady state version of equation (23) maps uniquely values of q into values of γ. A higher q leads to higher expected profits from production. This increases the share of firms that sign a contract with intermediaries and reduces the number 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 benefit arising from the possibility to drop out of production that banks provide. Figure 5 illustrates these mechanisms by plotting the shares of firms 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. A higher q increases expected profits, decreasing the share of firms that decide not to raise external finance (panel (a)) and the share of firms that sign a contract with the bank (panel (b)), while increasing the share of CMF financed firms (panel (c)). Panel (d) plots the overall fraction of firms that default and are monitored at the end of the period. For a given ε_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 we carry out is to change the value of some key parameters, such as τ, σ_{ε_1} and σ_{ε_2}, as reported in Figure 6. Panel (a) reports the results from increasing the costs of collecting information by banks. We raise τ from the .11 to .16 and show with thick lines the new threshold levels, $\underline{s}_b/q$ and $\underline{s}_c/q$. Not surprisingly, the share of firms that sign a contract with banks decreases. Moreover, a larger fraction of firms decides to abstain because the costs of financial intermediation (in terms of cost of loans or risk of default) are too large. Panel (b) reports the results from increasing the degree of heterogeneity in the economy. We raise σ_{ε_1} from .26 to .46. Firms experience with higher probability low realizations of the productivity shock ε_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 σ_{ε_2} is increased from .46 to .56. With a larger variance of the signal σ_{ε_2}, firms give a higher value to the possibility to acquire more information through banks. The share of firms that raise bank finance increases.

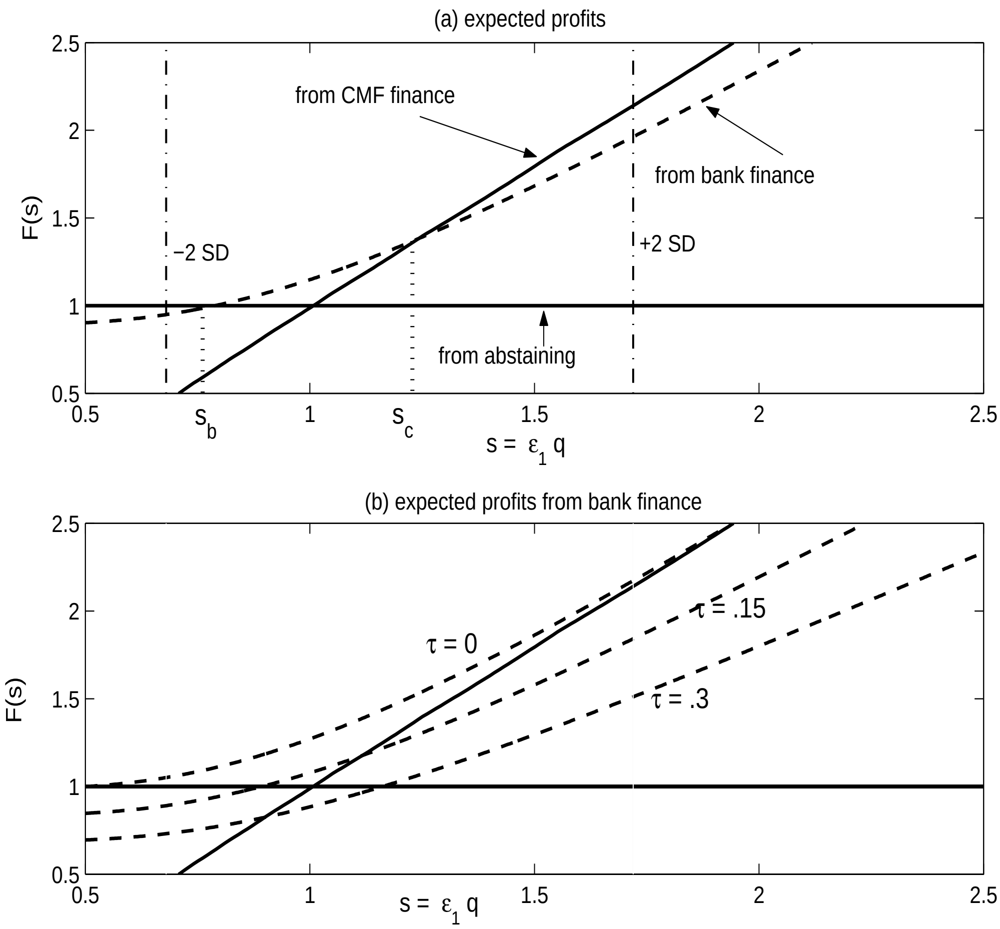

Figure 2: Steady state properties

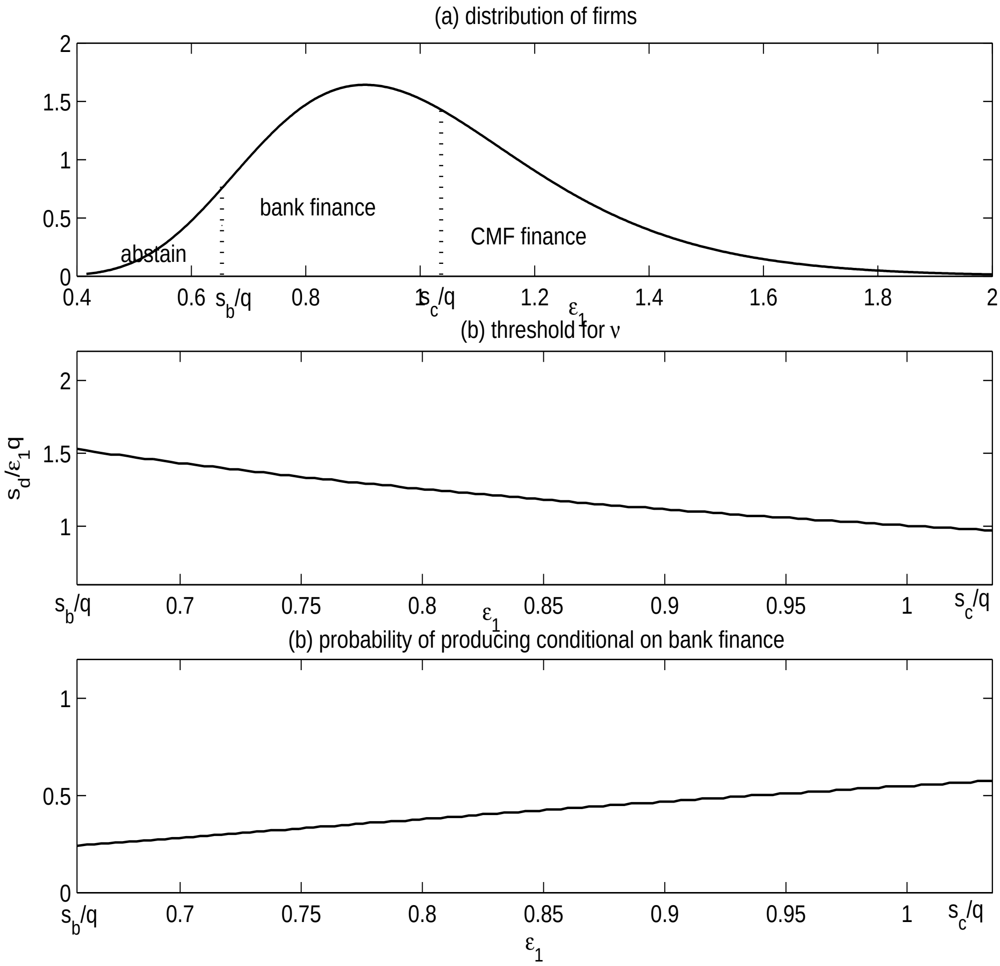

Figure 3: Steady state properties

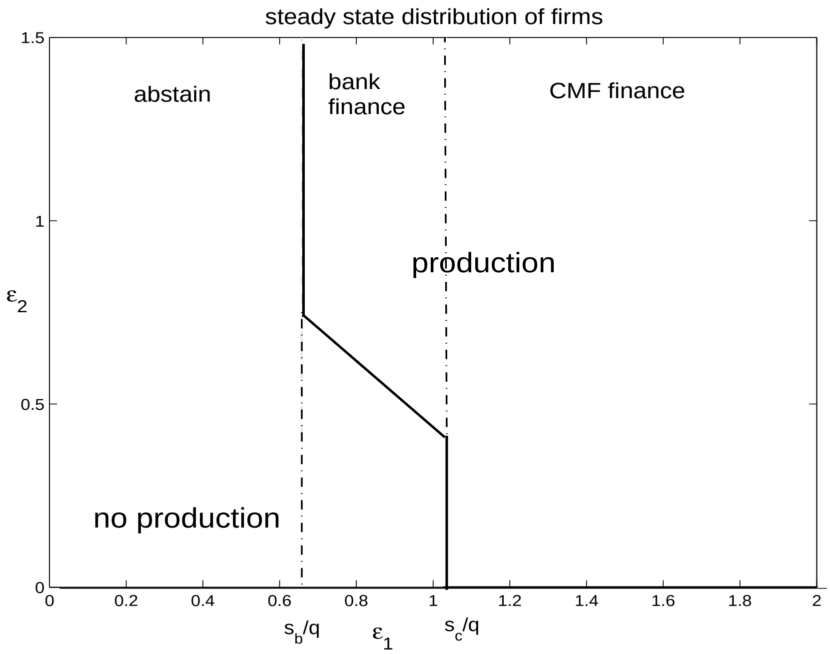

Figure 4: Steady state properties

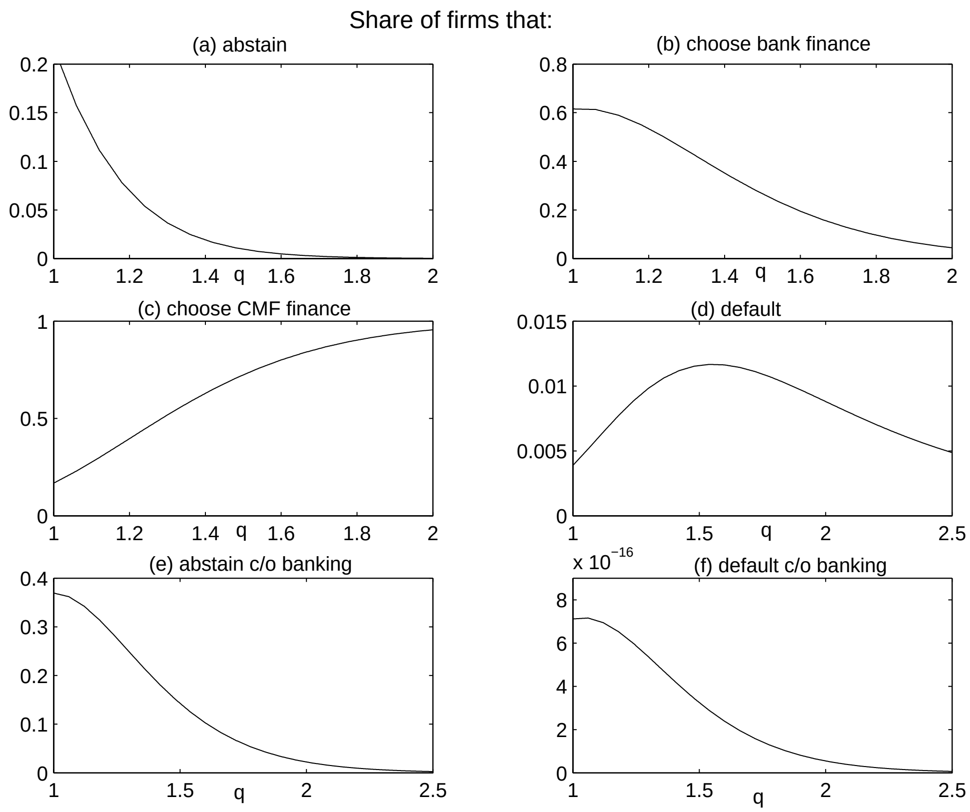

Figure 5: Sensitivity analysis

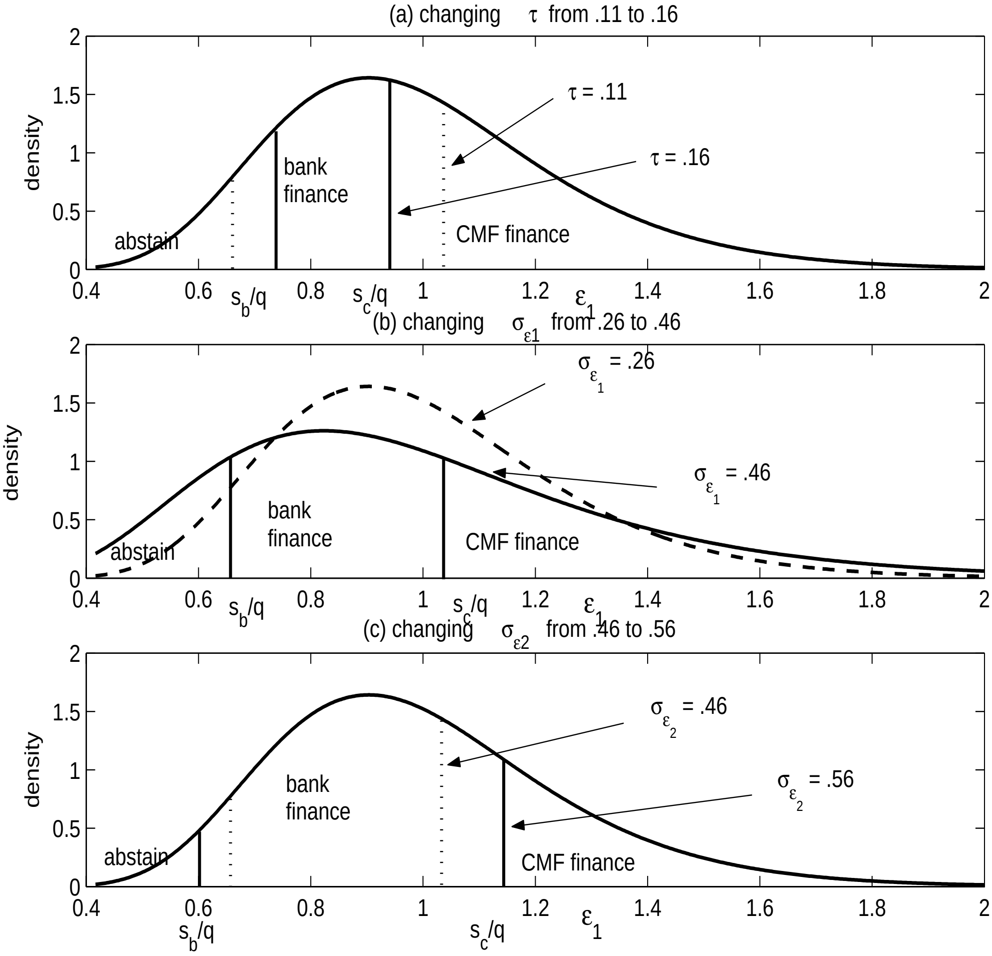

Figure 6: Sensitivity analysis

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

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

5.1 Evidence on intermediation and financial structures

We review 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.

Bank loans

We compute the average gross spread on bank loans to be 298 bps in the US and 267 bps in the euro area over the period 1997-2003.[8] Carey and Nini (2004) confirm the existence of higher mean interest rate spreads on bank syndicated loans in the US relative to Europe. They find that the difference in gross spreads over LIBOR in US versus EMU is 29.8 bps. These findings are also 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 2.68. In the same year, the average interest rate margin for Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain is 2.04.

Corporate bonds

We compute the average spread of US corporate bonds for the period 1997-2003 to be 339 bps.[9] 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, after accounting for duration and currency effects.[10]

[8] The US spread is defined as the prime rate on bank loans to business minus the commercial paper rate. Source: Federal Resrve Board Table H15. The spread for the euro area is defined as the interest rate on loans (up to 1 year of maturity) to non-financial corporations minues the three-month interest rate, MU12 average based on country reporting to BIS. Source: European Central Bank.

[9] 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 Resrve Board Table H15.

[10] 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.

Default rates

Aggregate default rates from the Dun and Bradstreet data set are reported in Carlstrom and Fuerst (1997). They amount to an annual rate 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 aggregate annual default rate for all high yield bond issuers of around 4.5% for the period 1981-1995. Ammer and Packer (2000) examine bonds of 492 issuers present in Moody's database over the period 1983-1988 and compare default rates among US firms and foreign firms. They find that the average annual default rate for US non-financial corporations is 1.93% while the rate is lower for foreign firms (0.54%). The default rate is much larger on US corporate bonds. The average for non-financial firms rated from Aaa to C is 6.2% while the corresponding average for foreign firms is 4.6%. On the basis of probit estimates, the authors argue that, after controlling for the rating composition of each sectorial pool, similar default rates would apply to US and foreign firms in the sample. 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, for 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, for 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% at the bankruptcy filing date. The largest estimate is reported by Alderson and Betker (1995), which quantify bankruptcy costs at 36% of the firm's value.

Financial structure

We compute the ratios of bank finance to bond finance. For the US, the average ratio over the period 1997-2003 is 0.75.[11] For the euro area, the ratio over the same period is 7.3.[12] Over the period 1997-2003, we also compute the debt to equity ratio for the US non-farm, non-financial corporate business sector, which averaged 0.41.[13] For the euro area, the debt to equity ratio for non-financial corporations is 0.61 over the period 1997-2002.[14]

Table 1 summarizes the evidence just described.

Table 1. Summary table of facts

Variable	**US**	**Period**	**EA**	**Period**
Risk premium bonds	0.034	1997-2003	as in US	1999-2003
Risk premium loans	0.030	1997-2003	0.027	1997-2003
Default rate bonds	0.02-0.62	1981-1995	as in US	1989-1991
Default rate loans	rate on bonds minus 20%	1995-2003	rate on bonds minus 27%	1990-2003
Bank to bond finance	0.75	1997-2003	7.3	1997-2003
Debt to equity	0.41	1997-2003	0.61	1997-2002

5.2 Calibration

We set $\alpha = .64, \delta = .02, \beta = .98, \mu = .15$, and $\eta = 2.6$ to obtain $l = .3$. We choose the remaining free parameters to match selected facts about financial markets in the US and in the euro area. We consider three different versions of the model.

[11] Source: Flow of Funds Accounts, Table L 101. Securities are the sum of commercial paper, municipal securities and corporate bonds.

[12] 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.

[13] 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.

[14] 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.

Benchmark-CF. This is a benchmark model with no ex-ante heterogeneity and a single type of financial intermediary (as in CF). It is obtained by setting $\tau = 1$ and $\sigma_{\varepsilon_1} = \sigma_{\varepsilon_2} = 0$. The parameter ξ is then set to match the firm's debt to equity ratio (.41 in the US and .61 in the euro area), while γ and σ_{ε_3} are set to match the evidence on aggregate default rates and risk premia (aggregate default being 4.5% and average risk premia being 3.4% both for the US and the euro area).

Benchmark-DFU . This is a benchmark model with ex-ante heterogeneity and a single type of financial intermediary. We build this benchmark by setting $\tau = 1$ and $\sigma_{\varepsilon_2} = 0$. The parameter ξ is set to match the firm's debt to equity ratio in each of the two blocks, γ and σ_{ε_3} to match the evidence on aggregate default rates and risk premia, and σ_{ε_1} is set to the value used in model-DFU below.

Model-DFU. The model is calibrated to minimize the squared log-deviation of the model predictions from the data, as summarized in Table 3, for each of the two blocks.

Table 2. Parameters in the alternative models

Parameters	τ	γ	ξ	σ_{ε_1}	σ_{ε_2}	σ_{ε_3}	$\sum_{i=1}^{2}\sigma^2_{\varepsilon_i}$	$\sum_{i=1}^{3}\sigma^2_{\varepsilon_i}$
US benchmark-CF	1	.65	1.41	0	0	.561	.315	.315
US benchmark-DFU	1	.68	1.41	.13	0	.564	.318	.335
US model-DFU	.021	.65	1.41	.13	.292	.590	.433	.450
EA benchmark-CF	1	.46	1.61	0	0	.561	.315	.315
EA benchmark-DFU	1	.46	1.61	.09	0	.562	.316	.324
EA model-DFU	.016	.34	1.61	.09	.400	.536	.447	.455

Table 2 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 shocks ε_2 and ε_3, i.e. of the uncertain productivity factors, and the sum of all three variances. Notice that σ_{ε_1} provides a measure of the *public information* available in the financial market, i.e. the information known to firms and financial intermediaries before signing the contract. A larger σ_{ε_1} allows financial intermediaries to 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, σ_{ε_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 that differences arise in the parameters of the three models. In the benchmark-CF model, the only uncertainty arises from the third idiosyncratic shock, ε_3. For the US, a standard deviation of .561 for ε_3 and a coefficient γ of .65 are able to reproduce an average risk premium and an aggregate default rate in line with the data. In the benchmark DFU model, where the degree of ex-ante heterogeneity is fixed at $\sigma_{\varepsilon_1} = .13$, the overall uncertainty at contracting time is still due only to ε_3. However, a slightly higher standard deviation σ_{ε_3} is necessary to produce the same average risk premium and default rate. The reason is that a higher σ_{ε_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 (σ_{ε_3}) is thus necessary to generate the same aggregate risk premium and default rate.

Comparing the models for the US and the euro area, the table shows that the variance of ε_3 is unchanged in the benchmark-CF models of the two blocks. The different ratio of debt to equity only reflects in a different value of the entrepreneurs' discount factor. Intuitively, entrepreneurs in the euro area need a higher amount of costly external finance, $x - n$, to be able to produce the same amount of output. This requires lower investment in the firm's net worth and thus entrepreneurs discounting the future at a higher rate.

The benchmark-DFU model for the US generates a higher overall variability relative to the one for the euro area (as reflected by the sum of all variances). This is mainly due to higher availability of public information (σ_{ε_1}).

When the model is calibrated to generate the stylized facts observed in the US and the euro area, we obtain substantial differences in the parameter values. Three points are worth noticing. First, the degree of ex-ante heterogeneity σ_{ε_1}, i.e. the availability of public information in the financial market, is larger in the US than in the euro area. Conversely, the volatility of the signal ε_2 is larger in the model of the euro area, providing an explanation for the more intensive use of bank finance versus bond finance. The incentive to use banks is enhanced by the lower cost of acquiring information, as reflected in the value of the calibrated up-front fee τ. A more appropriate measure of the efficiency of banks in providing information should take into account the precision of the signal ε_2, as measured by $\frac{1}{\sigma^2_{\varepsilon_2}}$. Therefore, a useful measure is given by $\frac{\tau}{\sigma^2_{\varepsilon_2}}$, which equals .24 for the US and .10 for the euro area. The availability of private versus public information in the financial market and the relative costs of banking services seem a major explanation of the differences in the financial structure of the US and the euro area.

Table 3. Properties of the calibrated model

Variable	Model US	Data US	Model EA	Data EA
Bank loans to corporate bonds	.74	.75	7.1	7.3
Firm's debt to equity	.41	.41	.61	.61
Default rate on loans	.043	.016-.050	.027	.016-.045
Default rate on bonds	.095	.045-.062	.077	.045-.062
Risk premium on loans	.016	.030	.036	.027
Risk premium on bonds	.039	.034	.015	.034

Table 3 evaluates the performance of the model in terms of the key financial facts outlined above. The model closely matches two important features of the financial structure in the US and the euro area: the firm's average debt to equity ratio and the ratio of bank finance to bond finance. However, it fails to reproduce the higher spread on bank loans in the US relative to the euro area. In particular, the model underestimates the risk premium on loans in the US and the risk premium on bonds in the euro area. The model also produces reasonable default rates on bank loans but overestimates default rates on corporate bonds. Nonetheless, aggregate default rates for the corporate sector, reported in Table 4, are close to those observed in the data.

Table 4: Facts in steady state

Variable	US benchmark-DFU	model US	EA benchmark-DFU	model EA
y	.88	.93	.76	.67
$\frac{c+e}{y}$	.86	.86	.89	.91
$\frac{I}{y}$	.13	.12	.10	.07
$\frac{y^a}{y}$	.006	.018	.007	.011
average default rate	.046	.061	.045	.031
average risk premium	.034	.025	.034	.032
share abstain	0	0	0	0
share bank	0	.51	0	.88
share CMF	1	.49	1	.12
dropout if banking	0	.31	0	.07

Table 4 lists other properties of the calibrated models in steady state and compare them to those arising in the benchmark-DFU model. The benchmark-CF model is not reported as it leads to values similar to those arising under the benchmark-DFU model. Notice that the low calibrated value for γ in the model of the euro area implies that entrepreneurs heavily discount the future. Therefore, they require large returns to physical capital to invest. This explains why the model delivers a ratio of investment to GDP that is much lower in the euro area relative to the US. Correspondingly, entrepreneurial consumption is larger, and so is the ratio of total private consumption to GDP. The table also reports output lost to agency costs as a share of GDP. This increases with the average default rate. The reason why output lost to agency costs is higher in the models of the euro area relative to those of the US, despite the lower average default rate, is that firms use a larger share of external finance. Finally, the table reports the steady state distribution of firms. Interestingly, both in the calibrated models of the US and of the euro area all firms decide to produce and to raise external finance. The larger share of bank finance explains the ratio of bank loans to corporate bonds observed in the data. Notice also 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 having observed the second shock ε_2, the remaining residual uncertainty from production is lower in the euro area. Hence, a larger share of firms decides to undertake production.

Table 5: Financial structure and per-capita GDP

Differences in the financial structure	$\frac{y^{US}}{y^{EU}}$
None	1
Debt to equity	1.16
Debt to equity Ex-ante heterogeneity	1.16
Debt to equity Ex-ante heterogeneity Bond vs bank finance	1.39

Differences in financial structures in the calibrated models of the US and the euro area lead to different values of per-capita GDP. In Table 5, 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 1.62 in the data.[15] The

[15] Output is average annual GDP per capita at market prices, for the period 2002-2003. Source: OECD Economic Outlook.

second row of the table 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 1.16 for a model where the only difference is in the debt to equity ratio (.41 for the US and .61 for the euro area). The fourth row shows that adding ex-ante heterogeneity (σ_{ε_1} being .13 for the US and .09 for the euro area) without introducing alternative instruments of external finance does not increase the explanatory power of the model. However, using the model presented in this paper, the ratio increases to 1.39. A model that account for differences in financial structures (abstracting from other factors, such as TFP) can explain 86 percent of the gap observed in the data.

6 Conclusions

We have presented a DSGE model with agency costs, 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 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 discrepancies in aggregate consumption, investment and per-capita GDP.

The model presented in this paper can be extended in various directions. One possibility, which we plan to explore in future research, is to build a monetary extension of this model to analyse whether different financial structures can account for differences in the transmission of monetary policy observed in the US and the euro area. 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. Hence, features of the financial system such as the relative importance of bank loans versus other instruments of external finance may help to explain differences in the transmission of monetary policy.

Appendix

A. 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 equations

$$\begin{aligned} 1 &= \beta(1-\delta+r) \\ 1 &= \beta\gamma(r+1-\delta)\int F(\varepsilon_1 q)\Phi_1(d\varepsilon_1) \\ q &= \left(\frac{\alpha}{w}\right)^{\alpha}\left(\frac{1-\alpha}{r}\right)^{1-\alpha} \\ \eta c &= w. \end{aligned}$$

To compute the overall expected profits $F(\varepsilon_1 q)$, we use the following procedure. First, under our distributional assumptions on the productivity shocks $\varepsilon_1, \varepsilon_2$ and ε_3, we can use the following results from the optimal contract literature (see the appendix of Bernanke et al (1999)),

$$\varphi_\omega\left(\overline{\omega}^j\right) = \varphi(x)\frac{1}{\overline{\omega}^j\sigma}$$

$$f(\overline{\omega}^j) = 1-\Phi(x-\sigma)-\overline{\omega}^j\left[1-\Phi(x)\right]$$

$$g(\overline{\omega}^j) = \Phi(x-\sigma)+\overline{\omega}^j-\left(\overline{\omega}^j+\mu\right)\Phi(x),$$

where φ and Φ denote the standard normal, $x \equiv \frac{\log\overline{\omega}^j+0.5\sigma^2}{\sigma}$ and $j = b, c$. Second, we need to solve for the thresholds $\underline{s}_d, \underline{s}_b$ and $\underline{s}_c$. We start by solving numerically the condition

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

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

$$\underline{s}_d f(\overline{\omega}^b(\underline{s}_d))\xi = 1.$$

Using $\underline{s}_d$, it is then possible to compute the expected payoff to the banking entrepreneur,

$$F^b(s) = (1-\tau)\left(\int_{\frac{\underline{s}_d}{s}}\frac{s}{\sigma_{\varepsilon_2}}f(\overline{\omega}^b(\varepsilon_2 s))\xi\varphi\left(\frac{\log\varepsilon_2+\frac{\sigma^2_{\varepsilon_2}}{2}}{\sigma_{\varepsilon_2}}\right)d\varepsilon_2+\Phi\left(\frac{\log\frac{\underline{s}_d}{s}+\frac{\sigma^2_{\varepsilon_2}}{2}}{\sigma_{\varepsilon_2}}\right)\right),$$

where $s = \varepsilon_1 q$. The payoff for the CMF-financed entrepreneur can be computed as

$$F^c(s) = sf(\overline{\omega}^c(s))\xi$$

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

$$\frac{x}{z} = \left(\int_{\frac{\underline{s}_b}{q}}^{\frac{\underline{s}_c}{q}} \int_{\frac{\underline{s}_d}{\varepsilon_1 q}} (1-\tau)\Phi_2(d\varepsilon_2)\Phi_1(d\varepsilon_1) + \int_{\frac{\underline{s}_c}{q}} \Phi_1(d\varepsilon_1) \right) \xi \left(1 - \delta + r\right)$$

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

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

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 (19) and (24) to compute y and e, and of the resource constraint (27) to compute y^a.

B. Cross-state subsidization

We consider a general class of contracts between banks and firms, which specify the threshold level $\overline{\omega}\left(s\varepsilon_2\right)$ and repayment $c\left(s\varepsilon_2\right)$ that, given $s = \varepsilon_1 q$, maximize the firm's expected return across realizations of ε_2, subject to four constraints: 1) the project size being a fixed share of the firm's net worth; 2) the bank breaking even in expectations across states; 3) the sum of all repayments across firms covering the information costs faced by the bank; and 4) the repayment not exceeding the available initial net worth.

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

$$\max_{c(s\varepsilon_2),\overline{\omega}^b(s\varepsilon_2)} \int_{\frac{\underline{s}_d}{s}} s\varepsilon_2 f\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)\left(1 - c\left(s\varepsilon_2\right)\right)\zeta\Phi_2(d\varepsilon_2) + \int^{\frac{\underline{s}_d}{s}} \left(1 - c\left(s\varepsilon_2\right)\right)\Phi_2(d\varepsilon_2)$$

subject to the constraints

$$\int_{\frac{s_d}{s}} s\varepsilon_2 g\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)\left(1-c\left(s\varepsilon_2\right)\right)\zeta\Phi_2(d\varepsilon_2)+\int^{\frac{s_d}{s}} c\left(s\varepsilon_2\right)\Phi_2(d\varepsilon_2) \tag{30}$$
$$\geq \int_{\frac{s_d}{s}}\left(1-c\left(s\varepsilon_2\right)\right)\left(\zeta-1\right)\Phi_2(d\varepsilon_2)+\tau$$

$$\int c\left(s\varepsilon_2\right)\Phi_2(d\varepsilon_2)\geq\tau \tag{31}$$

$$c\left(s\varepsilon_2\right)\leq 1 \text{ for all } \varepsilon_2. \tag{32}$$

The first order condition with respect to $\overline{\omega}^b\left(s\varepsilon_2\right)$ is given by

$$\int_{\frac{s_d}{s}} s\varepsilon_2\left\{f'\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)-\lambda\left(s\right)\left[f'\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)+\mu\phi\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)\right]\right\}\left(1-c\left(s\varepsilon_2\right)\right)\zeta\Phi_2(d\varepsilon_2)\leq 0, \tag{33}$$

if $\varepsilon_2\geq\frac{s_d}{s}$. The condition with respect to $c\left(s\varepsilon_2\right)$ is given by

$$\int_{\frac{s_d}{s}}\left\{-s\varepsilon_2 f\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)\zeta+\lambda\left(s\right)\left\{-s\varepsilon_2 g\left(\overline{\omega}^b\left(s\varepsilon_2\right)\right)\zeta+\zeta-1\right\}+\theta\left(s\right)\right\}\Phi_2(d\varepsilon_2)-\eta\left(s\varepsilon_2\right)\leq 0, \tag{34}$$

if $\varepsilon_2\geq\frac{s_d}{s}$, and by

$$\int^{\frac{s_d}{s}}\left[-1+\lambda\left(s\right)+\theta\left(s\right)\right]\Phi_2(d\varepsilon_2)-\eta\left(s\varepsilon_2\right)\leq 0,$$

if $\varepsilon_2<\frac{s_d}{s}$. Here $\lambda\left(s\right),\theta\left(s\right)$ and $\eta\left(s\varepsilon_2\right)$ are the Lagrangean multipliers on constraints (30), (31) and (32) respectively.

The first two constraints of the financial intermediary are binding at the optimum. Therefore, $\lambda\left(s\right)$ and $\theta\left(s\right)$ must be strictly positive. Notice also that condition (33) implies that at the optimum, when monitoring costs are not zero,

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

since $f'\left(\overline{\omega}^b\right)<0$ and $g'\left(\overline{\omega}^b\right)=-\left[f'\left(\overline{\omega}\right)+\mu\phi\left(\overline{\omega}\right)\right]>0$.

The optimal condition for $c\left(sv\right)$ is given by (34), if $\varepsilon_2\geq\frac{s_d}{s}$, and by

$$\left[\theta\left(s\right)+\lambda\left(s\right)-1\right]\Phi_2\left(\frac{s_d}{s}\right)-\eta\left(s\varepsilon_2\right)\leq 0,\ \text{ if } \varepsilon_2<\frac{s_d}{s}.$$

Since $\theta\left(s\right)+\lambda\left(s\right)-1\geq 0$, optimality requires that $\eta\left(s\varepsilon_2\right)=\overline{\eta}\left(s\right)>0$ or

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

Hence, the optimal 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 $\overline{\omega}^b\left(s\varepsilon_2\right)$ and an up-front fee $c\left(s\varepsilon_2\right)$ that satisfy (33) and (34), if the firm undertakes production.

References

[1] Alderson, Michael J. and Betker, Brian L."Liquidation Costs and Capital Structure." Journal of Financial Economics, 1995, 39(1), pp. 45-69.

[2] Altman, Edward I. "A Further Investigation of the Bankruptcy Cost Question." Journal of Finance, 1984, Vol. 39 (4), pp. 1067-89.

[3] Ammer, John and Packer, Frank. "How consistent are credit ratings: a geographic and sectorial analysis of default risk." Board of Governors of the Federal Reserve System, International Finance Discussion Papers, No. 668, June 2000.

[4] Bernanke, Ben S. and Gertler, Mark. "Agency Costs, Net Worth, and Business Fluctuations." American Economic Review, 1989, LXXIX, pp. 14-31.

[5] Bernanke, Ben S., Gertler, Mark and Gilchrist, Simon. "The Financial Accelerator in a Quantitative Business Cycle Framework." In: Taylor, John B. and Woodford, Michael, eds. Handbook of macroeconomics. Volume 1C. Handbooks in Economics, vol. 15. Amsterdam; New York and Oxford: Elsevier Science, North-Holland, 1999, pp. 1341-93.

[6] Carey, Mark and Nini, Greg. "Is the corporate loan market globally integrated? A pricing puzzle." Mimeo, 2004, Federal Reserve Board, Washington, DC.

[7] Carlstrom, Charles T., and Fuerst, Timothy. "Agency Costs, Net Worth, and Business Cycle Fluctuations: A Computable General Equilibrium Analysis." American Economic Review, 1997, 87(5), pp. 893-910.

[8] Carlstrom, Charles T., and Fuerst, Timothy. "Agency Costs and Business Cycles." Economic Theory, 1998, 12, pp. 583-597.

[9] Carlstrom, Charles T., and Fuerst, Timothy. "Monetary Shocks, Agency Costs and Business Cycles." Carnegie Rochester Conference Series on Public Policy, 2001, 54(0),pp. 1-27.

[10] Cecchetti, Stephen G.: "Legal structure, financial structure and the monetary policy transmission mechanism." NBER Working Paper, No. 7151, June 1999.

[11] Ehrmann, Michael, Giambacorta, Leonardo, Martinez-Pages, Jorge and Andreas Worms." Financial systems and the role of banks in monetary policy transmission in the euro

area." In: Angeloni, Ignazio, Kashyap, Anil and Mojon, Benoit, eds. Monetary Policy Transmission in the Euro Area, 2003, Cambridge University Press.

[12] Chemmanur, Thomas J. and Fulghieri, Paolo. "Reputation, Renegotiation, and the Choice between Bank Loans and Publicly Traded Debt." Review of Financial Studies, 1994, 7(3), pp. 475-506.

[13] Christiano, Lawrence, Motto, Roberto and Rostagno, Massimo. "The Great Depression and the Friedman and Schwartz Hypothesis." ECB Working Paper Series, 2004, n. 326.

[14] Cooley, Thomas F. and Quadrini, Vincenzo." Monetary Policy and the Financial Decisions of Firms." Mimeo, 1999.

[15] Faia, Ester. "Monetary Policy in a World with Different Financial Systems." ECB Working Paper 183, 2002.

[16] Helwege, Jean and Kleiman, Paul. "Understanding Aggregate Deafault Rates of High Yield Bonds." Current Issues in Economics and Finance, 2(6), May 1996. Federal Reserve Bank of New York.

[17] Holstrom, Bengt and Tirole, Jean. "Financial Intermediation, Loanable Funds, and the Real sector." The Quarterly Journal of Economics, 1987, CXII(3), pp. 663-691.

[18] Kiyotaki, Nobuhiro and Moore, John. "Credit cycles." Journal of Political Economy, 1997, 105(2), pp. 211-48.

[19] Mahajan, Arvind, and Fraser, Donald. "Dollar Eurobond pricing and US bond pricing." Journal of International Business Studies, 1986, 17, pp. 21-37.

[20] Masulis, Ronald. W. "The impact of Capital Structure Change on Firm Value: Some Estimates." Journal of Finance, 1983, 38, pp. 107-26.

[21] Moody's Investors Service. "Relative Default Rates on Corporate Loans and Bonds." Special Comment, September 2003.

[22] Santos, João, A.C. and Tsatsaronis, Kostas. "The cost of barriers to entry: evidence from the market for corporate euro bond underwriting." BIS Working Papers, No. 134, September 2003.

[23] Townsend, Robert M. "Optimal Contracts and Competitive Markets with Costly State Verification." Journal of Economic Theory, 1979, 21(2), pp. 265-93.

[24] Warner, Jerald. "Bankruptcy Costs: Some Evidence." Journal of Finance, 1977, 32(2), pp. 337-48.