Credit Information Quality and Corporate Debt Maturity: Theory and Evidence *

Marco Sorge
The World Bank

and

Chendi Zhang
University of Sheffield

* The authors thank Stijn Claessens, Hans Degryse, Mark Flannery, Steven Ongena, Maria Fabiana Penas, Luc Renneboog and Peer Stein for valuable comments and suggestions. We are grateful to the FSDI team of the World Bank, in particular Stijn Claessens and Konstantinos Tzioumis, for kindly providing us with data. This research was partially funded by the Research Grants program of the Finance, Private Sector and Infrastructure Department, Latin America and the Caribbean Region, World Bank. Corresponding author: Marco Sorge, International Finance Corporation, 2121 Pennsylvania Ave NW, Washington, DC 20433, USA. Phone: +1 202 458 9064. Fax: +1 202 974 4310. Email: msorge@ifc.org

1. Introduction

A common problem faced by many firms around the world is the scarce availability of long-term sources of funds. Exclusive reliance on short-term borrowing may expose companies to illiquidity risks and reduce their overall growth potential. To address these issues, many countries have embarked on policies promoting the development of long-term loan or bond markets with mixed results. However, while the negative implications of excessive short-term borrowing on growth and stability are well known (eg. Chang and Velasco, 2001 and Demirguc-Kunt and Maksimovic, 1998), there is no consensus on its underlying determinants and hence the main priorities for reform.

Under various assumptions, the decision to borrow at short-term maturities has been modelled in the corporate finance literature as a solution to debt-related agency problems (Barnea, Haugen and Senbet, 1980), or justified as a disciplinary tool to limit moral hazard (Rey and Stiglitz, 1993), as the result of coordination failures among banks (Dewatripont and Maskin, 1995), driven by the fear of early project termination by uninformed investors (Von Thadden, 1995), or as the consequence of illiquidity problems and inadequate regulation and institutions (Diamond and Rajan, 2000). In a signalling framework under asymmetric information, firms with favorable insider information may distinguish their quality by issuing short-term debt and roll it over, provided issuing costs are sufficiently high (Flannery, 1986, and Diamond, 1991).

This paper asks the question whether short-term lending is preferred by banks in credit markets where information about borrowers is relatively more opaque and there is a higher dispersion in the credit qualities of obligors. Most models in corporate finance analyze the choice of debt maturity from the perspective of the borrower, which chooses its debt maturity structure and optimizes from a variety of capital sources available in a developed country paradigm. Bearing in mind the credit constraints faced by firms in developing countries, this paper focuses on optimal debt maturity choice from the perspective of the lender. We look into the conditions under which banks would lend short or long term under imperfect information about heterogeneous borrowers. The value of short-term lending as a hedge against uncertainty is analyzed in a dynamic model both under incomplete but symmetric information and with asymmetric information. As a complement to the hidden-action model by Rey and Stiglitz (1993) in "Short-term contracts as a monitoring device", the hidden-

information framework proposed in this paper emphasizes the benefits of short-term contracts as a screening device in high-risk credit markets. Building on Von Thadden (1995), we do not assume that monitoring is perfect and the lender learns the firm's credit quality with certainty. Our paper models information acquisition as a screening process, through repeated short-term lending relationships, which may be more or less effective depending on the level of uncertainty in the micro-, macroeconomic as well as institutional environment.

The results of the model are then tested on empirical data of both developed economies and developing countries around the world. Although most existing empirical studies on corporate debt maturity focus on individual countries (mainly the US), there is a growing literature on how institutional differences across countries influence maturity choices (see, Dermirguc-Kunt and Maksimovic, 1999, Giannetti, 2003, and Fan, Titman and Twite, 2006). All of the above papers mainly focus on legal institutions of countries. A recent study by Djankov, McLiesh, and Shleifer (2006) analyzes the benefits of credit bureaus for the growth of private credit. Our study contributes to this line of research by investigating the impact of institutions aiming at reducing credit information asymmetries on the structure of corporate debt maturity. In particular, we focus on public and private credit bureaus and accounting standards as determinants of debt maturity structure after controlling for the impact of legal institutions, financial development and other macro and micro factors.

The main findings of the paper can be summarized as follows.

From a theoretical standpoint, unlike in Hart and Tirole (1988), we find that it is possible for lenders to separate in equilibrium borrowers of different risk levels, under the assumption that higher-risk borrowers are more myopic, i.e. have higher time discount factors. In this case, repeated short-term contracting becomes an important mechanism for lenders to "learn" about the credit quality of borrowers. Our model shows that a high degree of information asymmetries in credit markets makes short-term lending the choice preferred by banks in equilibrium, although it may not be the socially optimal outcome.

In the empirical part of the paper, we assemble a novel cross-country database to test the main predictions arising from the model. Our main finding is that better credit information (as proxied by the existence and coverage of private and public credit registries as well as by improvements in accounting standards) is associated with a higher share of long-term debt as a proportion of total corporate debt in both developed and developing countries. We also find that countries with more uncertain legal frameworks are characterized by higher short-term

debt. This suggests that short-term lending may be a valuable hedge against uncertainty from the lender's perspective. Furthermore, countries with a lower dispersion of firms' default probabilities are characterized by a higher ratio of short-term to total corporate debt. This is consistent with our theory of short-term lending being used by banks as a screening device when differences in default risks among firms are more opaque. Overall, our findings suggest that promoting institutions and policies to improve the quality of credit information around the world is an important prerequisite for increasing access of firms to long-term finance.

The paper is organized as follows. Section 2 reviews the literature on the determinants of the optimal choice of debt maturity. Section 3 presents a two-period stylized model of a bank choosing loan maturity under incomplete but symmetric information between lender and borrower. Section 4 extends the analysis to a more general dynamic set-up with asymmetric information between lender and borrower, and discusses our main testable hypothesis. Section 5 introduces the data and empirical results, and Section 6 concludes and draws some policy implications.

2. The literature on debt maturity structure

Since Stiglitz (1974) extended Modigliani and Miller's (1958) contribution to formally establish debt maturity irrelevance in perfect markets, the literature in corporate finance on debt maturity choices has identified a variety of imperfections in capital markets that can explain why the choice of maturity in fact matters.[1]

A number of theoretical studies explain why risky firms with long-term projects might borrow on a short-term basis in the presence of asymmetric information. Using a signalling framework, Flannery (1986) shows that firms with favorable insider information may distinguish their quality by issuing short-term debt and roll it over, provided issuing costs are sufficiently high. The model predicts that debt maturity is shorter when there are more information asymmetries and less risk. By incorporating liquidity risk into a framework similar to that in Flannery's model, Diamond (1991) shows that debt maturity is a non-monotonic function of risk ratings: the shortest maturity for both the lowest and highest risk ratings. Rajan (1992) analyzes how information asymmetries and bargaining power affect the

[1] For instance, theories of debt maturity have focused on the role of agency costs (see, Myers, 1977, and Barnea, Haugen and Senbet, 1980), tax (see, Brick and Ravid, 1985, and Lewis, 1990), and coordination failures among banks (Dewatripont and Maskin, 1995). Ravid (1996) provides a comprehensive survey.

choice between short- and long-term debts from arm's length lenders, and Diamond (1993) links the choice of maturity with the choice of seniority of debt contracts under asymmetric information. Using a hidden-action model, Rey and Stiglitz (1993) have further demonstrated the disciplinary role of short-term lending to resolve moral hazard problems. They show that short-term lenders have desirable incentives to exert control and invest in monitoring, and the possibility of not rolling over loans is an effective threat over firms. Furthermore, Von Thadden (1995) argues that monitoring by lenders helps overcome the short-term bias of corporate investment under asymmetric information. [2]

In this paper, the choice of debt maturity is analyzed from the perspective of the lender and not from that of the borrower as common in the literature (see, e.g., Flannery, 1986). This is especially applicable to developing countries where the bargaining power in deciding maturity choice is more likely to be on the side of the banks than the firms which are credit constrained. As a complement to the hidden action model by Rey and Stiglitz (1993), the hidden-information framework proposed in this paper emphasizes the benefits of short-term contracts as a screening device in high-risk credit markets. Building on Von Thadden (1995), we do not assume that monitoring is perfect and the lender learns the firm's credit quality with certainty. Our paper models information acquisition as a screening process, through repeated short-term lending relationships, which may be more or less effective depending on the level of uncertainty in the micro-, macroeconomic as well as institutional environment.

A number of empirical studies have focused on the impact of information asymmetries on the choice of debt maturity by firms within individual countries,[3] or across countries.[4] Using loan-level data for the US, Berger, Espinosa-Vega, Frame and Miller (2005) investigate the importance of information asymmetries and credit risk ratings for loan maturity choices. They find that information asymmetries reduce loan maturities and, consistent with Diamond (1991), the relationship between debt maturity and risk ratings is found to be stronger when

[2] While earlier models have been primarily concerned with financing choices in closed economies, recent financial turmoil in emerging markets has stimulated research into the linkages between debt maturity, the term structure of interest rates and the possibility of self-fulfilling currency and banking crises (see, e.g., Kaminsky and Reinhart, 1999, Demirguc-Kunt and Detrgiache, 1998). Short-term debt has often been criticized as a source of financial instability. On the one hand, a number of theoretical studies show that the accumulation of short-term external debt is important in the generation of self-fulfilling financial crises (see Chang and Velasco, 2001, Rodrik and Velasco, 1999). On the other hand, Diamond and Rajan (2000) argue that the build-up of short-term debt in emerging markets is the consequence of the illiquidity and poor quality of investments in countries lacking adequate regulation and institutions. Detragiache and Spilimbergo (2002) find empirical evidence supporting this theory.

[3] See, Berger, Espinosa-Vega, Frame and Miller (2006) and Ortiz-Molina and Penas (2006), Barclay and Smith (1995), Guedes and Opler (1996) and Stoh and Mauer (1996) for the US studies.

[4] See, Dermirguc-Kunt and Maksimovic (1999), Giannetti (2003), Fan, Titman and Twite (2006), and Schmukler and Vesperoni (2006).

information asymmetries are higher. Recent studies show that institutions aiming at reducing information asymmetries (such as public and private credit registries) foster the development of private credit markets (Jappelli and Pagano, 2002 and Djankov, McLiesh, and Shleifer, 2006), increase access to credit (Barron and Staten, 2003) and firm performance (Kallberg and Udell, 2003) and reduce non-performing loans and the costs of firm financing (Brown, Jappelli and Pagano, 2006). Galindo and Miller (2001) find that, in countries with more developed credit bureaus, firms face less severe financial constraints. This applies to large firms listed on the stock market as well as for small and medium-size companies.

This paper contributes to the empirical literature by investigating the impact of institutions aiming at reducing credit information asymmetries on the structure of corporate debt maturity. In particular, we focus on public and private credit bureaus and accounting standards as determinants of debt maturity structure after controlling for the impact of the legal framework, financial development and other macro and micro factors.

3. Short-term lending as a hedge against uncertainty

In order to understand how uncertainty about borrowers' credit quality may affect optimal debt maturity structure, we begin in this section with a two-period model of a bank choosing loan maturity under incomplete but symmetric information. This stylized framework will then be generalized in Section 4 to a multi-period case with asymmetric information.

The intuition of the model in this section can be briefly summarized as follows. A bank with incomplete information about borrowers' credit quality compares two lending options: (i) committing to a non-renegotiable long-term contract versus (ii) retaining the flexibility of rolling over renegotiable short-term contracts. The latter option carries higher transaction costs but entails the possibility to exit the investment, thus limiting losses, should the borrower default in the first period. Intuitively, the more the uncertainty, the higher will be in equilibrium the bank's preference for renegotiable short-term contracts. From the lender's perspective, short-term lending acts as a hedge against uncertainty.

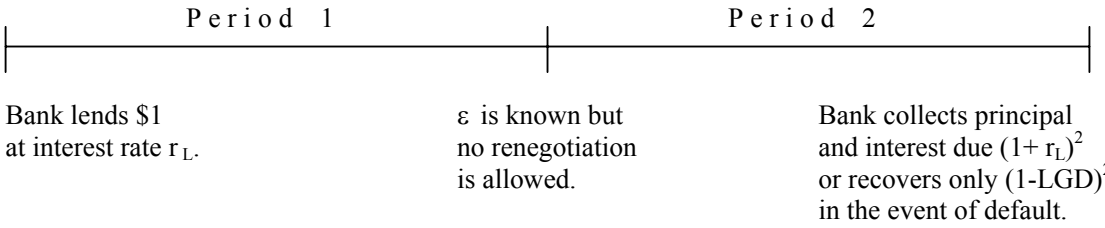
3.1 General set-up and payoff structure

Assume a two-period risk-neutral setting with perfect competition. A bank faces the choice of lending its initial endowment of $1 to either a long-term project or a short-term project as

described below[5]. Alternatively, the bank could simply buy Treasury-bills yielding a risk-free interest rate normalized, without loss of generality, to equal zero.

The long-term project lasts for two periods. At the beginning of period 1, it is common knowledge that the long-term project requires \$1 bank finance to get started and, if successful, will yield a return equal to $(1+ \alpha +\varepsilon)^2$ only at the end of the second period. At the outset, the bank does not know ε but knows that ε is a random number that will be drawn at the end of period 1 from a zero-mean uniform distribution $\varepsilon \sim U(-\sigma- \alpha, \sigma+ \alpha)$ with $\alpha >0$ and $0<\sigma < 1$. Thus, α is the expected per-period return of the project. At the beginning of period 1, the bank will lend \$1 at the long-term per-period interest rate r_L ($0<r_L<1$). In the event of default (i.e. when the project return is smaller than r_L), the bank recovers only $(1\text{-LGD})^2$ at the end of the two periods (where LGD stands for expected Loss Given Default per period, with $0< \text{LGD}<1$)[6]. In any case, we assume that committing to a long-term loan prevents the bank from being able to re-optimize its lending strategy as new information is revealed over time (once ε is known). Moreover, we will assume for simplicity that it will not be possible to cash out either principal or interest invested in a long-term project until the end of the second period. In summary, the set-up of the long-term project can be illustrated as follows:

TIMELINE OF LONG-TERM PROJECT



The other alternative is for the bank to invest in a sequence of two short-term projects, each one lasting for one period only. At the beginning of period 1, it is common knowledge that short-term projects require \$1 bank finance to get started and, if successful, yield a per-period

[5] For the purpose of contrasting the two options of lending long-term vs. short-term, we will simply assume in this stylised model that banks cannot mix short-term and long-term loans in their portfolio. For a more detailed model explaining optimal combinations of short-term and long-term lending see for example Rey and Stiglitz (1993). Furthermore, we can think of a large number of identical projects that need a total start-up investment of \$1. Given our focus here on the comparison between investing in long-term vs. short-term projects, we only need heterogeneity between and not within the two types of projects.

[6] In the event of the firm defaulting on her loan, the bank expects a non-zero recovery given the protection of collateral or loan covenants. Altman and Suggitt (2000) report estimates of LGDs for bank loans ranging from 13% to 35% depending on seniority and computational assumptions employed.

return equal to (1+ α + ε). For simplicity, we assume that short-term projects yield the same return in each period. The bank does not know ε but knows that ε is a random number that will be drawn at the end of period 1 from a zero-mean uniform distribution ε ~ U (-σ- α, σ+ α) with 0<σ < 1. Thus, α is the expected per-period return of the project. At the beginning of period 1, the bank will lend $1 at the short-term per-period lending rate r_S (0<r_S<1). In the event of default (i.e. when project returns fall below r_S) the bank recovers only 1-LGD per period. By choosing to lend short-term, the bank commits only for one period and will roll over the loan for the second period, only if project returns are above the debt service. In case of default at the end of the first period, the bank will instead cash out its first-period investment and keep its money in Treasury bills for the second period. The set-up of the short-term project can be summarized as follows:

TIMELINE OF SHORT-TERM PROJECTS

Period 1		Period 2
Bank lends $1 at interest rate r_S.	ε is known. If α + ε > r_S the bank will receive full principal and interest (1+ r_S) and reinvest in the project at rate r_S. Otherwise it will recover only 1-LGD, and invest in T-bills for the 2nd period.	Bank collects principal and interest due $(1+ r_S)^2$ or recovers only (1-LGD) in the event of default.

Thus, the bank's expected payoffs from lending either long-term or short-term are:[7]

$$\Pi_L = h(\sigma + r_L)(1 - LGD)^2 + (1 - h(\sigma + r_L))(1 + r_L)^2 \qquad (1)$$

$$\Pi_S = h(\sigma + r_S)(1 - LGD) + (1 - h(\sigma + r_S))(1 + r_S)^2 - c \qquad (2)$$

where $h = \frac{1}{2(\sigma + \alpha)}$ and we have assumed no time discounting. The bank incurs a transaction cost c in the case of repeated short-term lending contracts.

[7] The default probability on the long-term project is: Prob { $(1+ \alpha +\varepsilon)^2 < (1 + r_L)^2$ } = Prob { $\varepsilon < r_L - \alpha$ } = h ($\sigma+r_L$), where h is the probability density function. Similarly, the default probability on the short-term project is h ($\sigma+r_S$).

3.2 The impact of higher volatility on the optimal debt maturity choice

Based on the assumptions and pay-off structures illustrated in the previous subsection, a few preliminary conclusions can be drawn comparing the profits that the bank can expect from lending long-term vs. short-term. On the one hand, short-term lending appears more flexible in adjusting to extreme project outcomes. In case of unexpectedly low revenues from the projects (i.e. very low values of ε), short-term loans are preferable as they allow the bank to exit the investment early and limit the losses. On the other hand, though, in a low-risk environment financing long-term projects can be more productive (in fact it is reasonable to assume that $r_L > r_S$) and will reduce transaction costs.

In order to analyze the impact of return volatility on the bank's expected profits, we differentiate (1) and (2) with respect to σ, obtaining:

$$\frac{\partial \Pi_L}{\partial \sigma} = \frac{(\alpha - r_L)\left[(1 - LGD)^2 - (1 + r_L)^2\right]}{2(\sigma + \alpha)^2} \qquad (3)$$

$$\frac{\partial \Pi_S}{\partial \sigma} = \frac{(\alpha - r_S)\left[(1 - LGD) - (1 + r_S)^2\right]}{2(\sigma + \alpha)^2} \qquad (4)$$

Under the restriction that $r_L < \alpha$ and $r_S < \alpha$ (i.e. debt service is below the expected returns of the projects)[8], it is straightforward to show that both partial derivatives (3) and (4) are negative. For given interest rates[9], a higher volatility (σ) increases projects' default probabilities and consequently reduces lenders' expected profits for both long-term and short-term lending. Furthermore, given that $(1\text{-LGD})^2 < 1\text{-LGD}$, partial derivative (3) will be higher in absolute value compared to (4). This is because the possibility of exiting the investment after a first-period default limits the losses in case of short-term lending.

Summarizing, in a low-risk environment long-term lending can be more productive and associated with lower transaction costs. As σ increases, however, there is a higher probability of very bad states of nature (i.e. a higher probability mass gets shifted to the tails of the distribution of ε). In this case, short-term lending becomes the superior choice as it allows banks to exit the investment early instead of having to continue lending to an unprofitable

[8] This restriction is easily satisfied by most realistic projects whose default probabilities ($h(\sigma+r_L)$ or $h(\sigma+r_S)$) are lower than 50%.

[9] We are concerned here with only the short-term impact of volatility on lenders' profits. In the long run, a higher volatility of project returns will lead to a reallocation of banks' portfolio from long-term to short-term lending until a new equilibrium interest rate is reached.

project. What is driving the bank's preference for short-term lending as volatility increases is the option-like nature of short-term contracting (i.e. capping the downside risk by cashing out 1-LGD at the end of period 1). In this sense, short-term lending can be a valuable hedge against uncertainty.

4. Short-term lending as a screening device

This section extends the previous analysis to a more general dynamic set-up with asymmetric information. When the probability of default is private information of the firms, banks may initially use short-term lending as a screening device until more information is known about the credit quality of the borrowers and it becomes safer to commit to long-term loans. The higher the degree of asymmetric information, the more screening will be necessary through short-term contracting.

4.1 Dynamic contracting with asymmetric information

Consider a multi-period competitive screening game under asymmetric information. Banks are all identical whereas firms can be of two types: high default risk (q_H) and low default risk (q_L) with $q_H > q_L$.[10] At the outset, the bank does not know which type of firm it is facing. However, it has prior beliefs that the firm is high risk with a probability μ^H and is low risk with a probability 1- μ^H. At the beginning of the period, each bank makes a take-it-or-leave-it offer to a firm of lending \$1 at a given per-period interest rate r_t. The firm will decide whether to accept or reject the offer, based on its private information about its own default risk q. In particular, in a discrete-time framework we can simply express ex-ante expected payoff at time t_0 both for the bank (π^B) and the firm (π^F) as:

$$\pi^{B,F} = E_0^Q \left\{ \sum_{t=1}^{T} \delta_t \pi_t^{B,F} \right\} \qquad (5)$$

[10] In an arbitrage-free risk-neutral framework in which all securities are valued based on the risk-free interest rate *i* and the equivalent martingale measure *Q* (see e.g. Harrison and Kreps, 1979), we assume for simplicity that default is an exogenous stochastic event and define default as an unpredictable jump in a Poisson process with intensity q (see Duffie and Singleton, 2003). In other words, this implies that the probability that the firm defaults over an interval of time (t, t+Δ), conditional on the firm not defaulting prior to t, is approximately qΔ (for very small Δ) under the equivalent martingale measure Q. In addition, we assume that the risk-free interest rate i and default risk q are time-invariant (i.e. the firm's "type" remains the same throughout the game; see Besanko and Kanatas, 1996).

where: $\delta_t(q) = e^{-(i+q)t}$ (6)

and E_0^Q denotes the expectation, under the risk-neutral probability measure Q, conditional on the information available at time t=0. Finally, *i* is the risk-free interest rate. It is important to note that the discount factor (δ_t) is a function of q. In other words, it is common knowledge that a high-risk firm will be more myopic, i.e. more impatient about capturing profit opportunities earlier as opposed to later ($\delta_t(q_H) < \delta_t(q_L)$ at each time t>0; see Figure 2).

From a microeconomic perspective, a key reason why a bank could prefer short-term loans as opposed to long-term commitments lies in the possibility of renegotiating the terms of the loan over time as its information set increases (see also Section 3). In other words, the bank will be able in this case to offer at the beginning of each period t (for t = 1,…,T) a different interest rate r_t, based on its beliefs μ_t which it can update given the entire history of the game up to time t.

For these reasons, we will not attempt here to characterize the full set of equilibria that can be enforced with short-term contracts.[11] We will look for separating equilibria, in which the bank, different from the case of "pooling", is able to extract information about the firm's type in the course of the game. Our interest lies in particular in the subset of so-called "Partial Revelation Equilibria" (PBE). As will be seen more precisely below, in this class of equilibria the firm only partially reveals her type in the early stages of the game and the bank fully discovers the risk level of the firm only at a later stage, which we will denote with F (= Full Revelation Stage).[12] As information is revealed sequentially during the game, partial revelation equilibria offer a general set-up to assess the role of short-term contracts as a screening device.[13]

More precisely, we define the full revelation stage as the period F (0<F<T) when by offering r_F the bank is sure that in equilibrium the firm will fully reveal its type. In other words, the

[11] An equilibrium (Perfect Bayesian Equilibrium) will be defined as a set of strategies and beliefs such that: i) strategies are sequentially optimal given beliefs; ii) beliefs are derived from equilibrium strategies and observed actions using Bayes' rule whenever possible.

[12] The full revelation stage F is endogenous depending on the speed of information revelation. We will discuss the determinants of F in Section 4.3.

[13] In particular, we have assumed that there is a simple type of contract between the bank and the firm: a sequence of short-term loans before information is fully revealed and a long-term loan after the full revelation of credit information. Before the full revelation stage F, both parties meet at each time t and the bank retains the discretion of rolling over single-period contracts based on any new information it might learn during the game about the risk level of the firm. After the full revelation stage F, instead, the bank will fully commit to a whole vector of interest rate offers and offer a long-term loan with maturity till the end of the game. The set-up of the dynamic model is summarized in Figure 3.

bank knows that with probability 1 a high-risk firm will accept r_F and a low-risk firm will reject it. This can be written as $\xi_H(r_F) = 1$ and $\xi_L(r_F) = 0$, where $\xi_q(r_t)$ is the posterior probability at time t that a firm of risk level q (which equals either q_H or q_L) will accept a given interest rate r_t.

In the event that a loan gets signed (x=1, otherwise x=0), the firm will be able to finance its projects and will earn each period a net return R(q). Firms with a higher (lower) q will undertake projects with higher (lower) risk and return[14]. In no case will a firm accept a loan at an interest rate above the net return made on the project each period. [15] We also assume that banks incur a cost (K) for providing funds to the firm, and the cost of funding for the bank is higher for lending to high-risk firms than that for lending to the low-risk firms, i.e. $K(q_H) > K(q_L)$.[16] Putting all the pieces together, the pay-off of the firm (who knows her "type" q) can be written as:

$$\pi^F = \sum_{t=1}^{T} \delta_t x_t [R_t - r_t] \qquad (7)$$

The bank's expected pay-off is:

$$\pi^B = E_0^Q \{ \sum_{t=1}^{T} x_t r_t \Gamma_t - K_t d_t - \sum_{t=1}^{F} x_t c d_t \} \qquad (8)$$

where $\Gamma_t \equiv [$ (1-LGD) d_t + LGD δ_t], the risk-free discount factor $d_t = e^{-it}$, and δ, R, Γ and K are all functions of q. We assume that short-term contracting implies a transaction cost (c) incurred in every period $t \leq F$. Given that the bank in case of default will be able to recover only a portion (1-LGD) of the principal and interests, its risk is partially reduced. This intuitively explains why it will discount interest payments from the firm at a rate Γ_t, which is a weighted average between the riskless (d_t) and the risky discount factors (δ_t) (see Duffie and Singleton, 2003). The costs of funding of each loan offer at time t (K_t) and transaction costs (c) incurred during the short-term lending phase ($t \leq F$) are discounted using the risk-free discount factor (d_t) since they are the same in both default and no-default states.

[14] Firms with a higher probability of default tend to "gamble for resurrection" (Ed Kane). This assumption is in line with much of the literature that has applied the option pricing framework to characterize the risk-shifting incentives deriving from limited liability in a volatile financial environment.

[15] In the symmetric information model presented in Section 3, we had considered a representative long-term project and a sequence of short-term projects, whose risk and returns were driven by a random variable ε and therefore unknown both to the bank and the firms running the projects. Here instead the risk/return profiles of the two types of firms, (q_H, R_H) and (q_L, R_L), are common knowledge. However, a firm's type, i.e. which firm belongs to which risk/return pair, is not observable by the bank as it constitutes private information of the firm.

[16] For instance, an important source of funding costs is capital requirements for banks: lending to a higher risk firm is more costly for a bank as it consumes more capital.

Given the setup and payoff structure illustrated above, consider now the following strategies:

$r_t = \frac{d_t}{\Gamma_t^H}(K_H + c)$ for all t = 1, 2, …., F-1 before the firm's type is revealed (9a)

$r_t = \frac{d_t}{\Gamma_t^H}(K_H)$ for all t = F+1, F+2, …., T if the firm has revealed to be high risk (9b)

$r_t = \frac{d_t}{\Gamma_t^L}(K_L)$ for all t = F+1, F+2, …., T if the firm has revealed to be low risk (9c)

This means that interest rate offers in equilibrium will satisfy a zero profit condition under perfect competition (i.e. banks' profits in equation (8) equal zero for any $t \neq F$, if interest rate r_t follows strategies in Equations (9a), (9b) and (9c)). Similarly, perfect competition among firms will equalize the returns of high and low risk projects with their respective costs of funding (i.e. Equation (7) equals zero in equilibrium for any $t \neq F$):

$R_{H,t} = \frac{d_t}{\Gamma_t^H}(K_H + c) > R_{L,t}$ for all t = 1, 2, …., F-1 (10a)

$R_{H,t} = \frac{d_t}{\Gamma_t^H}(K_H) > R_{L,t} = \frac{d_t}{\Gamma_t^L}(K_L)$ for all t = F+1, …., T (10b)

For all periods t<F, given that the interest rate offered by the bank (r_t) is higher than R_L (see Equation (10a)), low-risk firms always reject the loan offer ($\xi_L(r_t)=0$, whereas high-risk firms accept the offer with probability $\xi_H(r_t)$.

What will be the interest rate the bank will charge to induce separation at time F in equilibrium? We show in the Appendix that, given our assumptions about the higher degree of "impatience" of high-risk firms (see Equation (6)), separation can be achieved in equilibrium, if the bank charges r_F such that:

$$R_{L,F} < r_F \equiv \left(R_{H,F} - \sum_{t=1}^{T-F} \delta_t^H (R_{H,t} - R_{L,t}) \right) < R_{H,F} \quad (11)$$

In the repeated rental model, Hart and Tirole (1988) argue that if the discount factor is high enough and T is large, then it is not possible to satisfy both incentive constraints and only pooling equilibria can be sustained. They also note, however, that this problem does not arise in case we allow for an intermediate form of commitment (long-term renegotiable contracts) which would make a "take the money and run" strategy no longer feasible.

Our model allows for separating equilibria even relying on short-term contracts alone. [17] This is because discount factors here not only account for the time value of money, but also for the likelihood of default. As shown in Figure 2, high-risk firms are assumed to be more myopic (see the lower discount curve). Intuitively, they might be closer to default and hence care less about the future: a small profit ($R_{H,F}$ - r_F) is more valuable to high-risk firms at time F than prospective rents they might earn in the following periods by pooling with low-risk firms, i.e. $\sum_{t=1}^{T-F} \delta_t^H \left(R_{H,t} - R_{L,t}\right)$ in Equation (11). For the banks, giving a 'carrot' interest rate at time F represents an investment to obtain information about the borrower and then switch to more efficient long-term contracts. The cost to the bank of charging $r_F < R_{H,F}$ is more than compensated - after having separated firms - by the benefits of (1) increasing lending volumes (x=1 for all t>F) and (2) being able to discriminate interest rate offers by risk type.

4.2 Main implications of the model and testable hypotheses

In the above analysis, the contract between the bank and the firm has two components: an initial short-term screening component under asymmetric information and a long-term lending component under perfect information. In this subsection, we will examine how the timing of information revelation (early revelation vs. late revelation) affects the relative length of these two components. In addition, we will use the results obtained so far to analyze how the bank's optimal choice between long-term and short-term lending might differ from the social optimum depending on the timing of information revelation. Finally, we will discuss which factors influence the timing of information revelation (F) and thus debt maturity structure. This will allow us to draw a number of key implications from the model and outline our main testable hypotheses which will be analyzed in Section 5.

As seen in Section 4.1, the later new information is revealed to the bank about the type of the firm it is facing (i.e. the larger is F), the longer the relative length of the period in which banks roll over short-term loans to screen borrowers. In contrast, the earlier new information is revealed to the bank about the firm's type (i.e. the smaller is F), the longer the relative length of the period under perfect information, and more long-term lending should be observed (Figure 3).

[17] Admati and Perry (1987) use a similar concept of separating equilibrium, where the degree of impatience of firms determines in equilibrium the time delays in accepting offers by different types of firms.

Table 1 summarizes the main results of the models in sections 3 and 4 for various parameter assumptions and indicates whether banks' optimal debt maturity choices correspond also to the social optimum or not. Long-term lending is socially optimal as it maximizes total surplus ex-ante ($E_0^O \{\pi^B + \pi^F\}$) by both reducing the socially wasteful transaction costs of rolling over short-term loans and maximizing total availability of finance (i.e. $\sum_{t=1}^{T} x_t$). In contrast, rolling over short- term lending is not socially optimal as it increases transaction costs of the economy and leads to the possibility of credit rationing.[18]

Thus, a key implication of our model is that short-term lending acts as a screening device and will be chosen in equilibrium by banks- although socially suboptimal - in case that credit information about the borrower is poor and hence the revelation process takes longer. Even though the asymmetric information model presented in this section has different setup from the symmetric information model introduced in Section 3, both models convey a similar message: uncertainty or the lack of information about borrowers' credit quality leads banks to prefer short-term lending in equilibrium, although it may not be the socially optimal outcome. We now consider a particular set of partial revelation equilibria in order to illustrate the determinants of the speed of the information revelation process (i.e. the determinants of F). We analyze the case in which the firm *rejects* the short-term loan offer each period ($r_t = R_{H,t}$ for t<F; see Equation (9a) and (10a)). From Bayes' rule, the posterior probability that the firm is of high or low risk will be:

$$\mu_t^H = \frac{\left(1-\xi_H^{t-1}\right)\mu^H{}_{t-1}}{\left(1-\xi_H^{t-1}\right)\mu^H{}_{t-1} + \left(1-\xi_L^{t-1}\right)\left(1-\mu^H{}_{t-1}\right)} \tag{12}$$

$$\mu^L{}_t = 1 - \mu^H{}_t \tag{13}$$

where ξ_H is the posterior probability that a firm of risk level H will accept a given interest rate R_H (ξ_H = Prob. (Accept R_H | High Risk)), ξ_L is the posterior probability that a firm of risk level L will accept a given interest rate R_H (ξ_L = Prob. (Accept R_H | Low Risk))[19], μ_t^H is the posterior probability at time t that a firm is of risk level H, and μ_t^L is the posterior probability at time t that a firm is of risk level L.

[18] Unlike in Stiglitz and Weiss (1981), it is the low-risk firms that are credit rationed in our model during the screening phase.

[19] As discussed in Section 4.1, we assume that low-risk firms always reject the loan offer ($\xi_L(r_t)=0$ for all t < F) due to the rationality constraint. Our results are robust if there is a non-zero probability that low risk firms make mistakes by accepting the interest rate offer (R_H). Simulation results are available upon request.

We simulate the set of partial revelation equilibria and the results are shown in Figure 4. We find that high quality of information (eg. ξ_H increasing from 30% to 70% - see Figure 4, panel A) increases the slope of the learning curve and the speed of the information revelation process. As a result, information about the risk of the firm is revealed earlier to the bank (eg. F decreases from over 11 to 5 – see Figure 4, panel A), and consequently the bank will prefer to lend less short-term and more long-term. Furthermore, we find that the length of the credit screening phase (F) is a positive function of the prior probability of the firms being high risk (μ^H).[20] This implies that one should observe more short-term debt in countries with higher credit risk environments, consistent with the model discussed in Section 3.

In line with the literature, we have described a stylized setup where the interest rate is used as a screening device to induce firms to self-reveal their types. However, based on the revelation principle, our results can be applied in practice to a number of alternative mechanisms for information revelation, including for example credit registries, credit ratings or relationship banking. [21] The theoretical analysis discussed so far leads us to formulate the following empirical hypothesis:

For a given level of risk (μ^H), we expect better quality of credit information (higher ξ_H) to be associated with a higher ratio of long-term to total corporate debt. [22]

In order to test this hypothesis with empirical data, we will use the existence and coverage of private/public credit bureaus and an index of accounting standards to proxy for the quality of credit information across countries and over time. As it is also important to control for the impact of the risk of a country's economy (μ^H) on debt maturity, we will use variables on legal institutions, financial development, macroeconomic environment and firm characteristics (including dispersion of firm default probabilities) as additional determinants of the debt maturity structure.

---

[20] F increases from 8 to 10 as μ^H goes from 30% to 70% (see Figure 4 Panel B).

[21] Consistent with our model, several studies have found that loan contract terms generally improve for the borrower over the life of banking relationships, especially in the US: interest rates and collateral requirements fall (see, e.g. Berger and Udell, 1995, and Berger, Rosen and Udell, 2002) and the availability of credit increases (see, e.g. Petersen and Rajan, 1994). This is consistent with the view that relationship banking facilitates value-enhancing exchange of credit information (although methodological issues have been raised recently by Brick, Kane and Palia, 2004). See also Lummer and McConnell (1989) for empirical evidence on information acquisition in bank lending. Some other studies, in the European context, have found that loan rates may increase with the duration of banking relationship due to the hold-up problem (see, e.g. Degryse and Van Cayseele, 2000). See Boot (2000) and Degryse and Ongena (2006) for reviews of the related literature. In addition to credit registries and relationship banking, credit ratings by agencies such as S&P or Moody's help to reveal firms' credit information. However, except for a few well-developed markets such as US, UK and Japan, in most other countries only a very small share of firms has a credit rating (Estrella, 2000).

[22] This is consistent with the prediction of the signalling story developed by Flannery (1986) and Diamond (1991), who show that debt maturity is longer when there are less information asymmetries.

5. Empirical evidence

5.1. Data

In order to examine the determinants of the debt maturity structure of firms in countries at different levels of development, we construct a novel database including a number of institutional, macro and micro variables, as briefly illustrated below.

We measure the debt maturity structure of a firm by the ratio of short-term debt (i.e. debt obligations with maturity less than one year) to total debt in the firm's balance sheet. We calculate averages of this ratio across firms for each country, including all countries for which we have data for at least 20 firms, and these firms represent more than 20 percent of the stock market capitalization in that country (source: WorldScope). Our sample covers a total of 14,178 publicly listed firms in 27 industrial economies and 18 developing economies over the period 1994-2004.[23]

As postulated in Section 4.2, improvements in credit information quality are likely to increase the maturity horizon at which financial institutions feel safe to lend. We employ three measures of credit information quality: (i) the existence of a public registry or a private bureau, (ii) the extent of coverage of individuals and companies by public registries or private bureaus and (iii) the quality of accounting standards reported in La Porta, Lopez-de-Silanes, Shleifer and Vishny (1998) (hereafter LLSV).[24] The main sources for these data are the

[23] The industrial economies in our sample are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong (China), Ireland, Israel, Italy, Japan, the Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, Taiwan (China), United Kingdom, and United States. The developing countries are Argentina, Brazil, Chile, China, Czech Republic, Hungary, India, Indonesia, Malaysia, Mexico, Pakistan, Peru, Philippines, Poland, Russian Federation, South Africa, Taiwan, China, Thailand, and Turkey.

[24] The credit bureau coverage variables have more cross-country and time-series variation, but may be predominantly driven by the coverage of retail borrowers rather than corporate loans. This problem is less pronounced for Public Credit Registries, as most of them have loan cut-off minimum amounts, usually excluding retail or small business loans. The indicator variables for the existence of private or public credit bureaus are more likely to reflect the availability of credit information on both individuals and firms, but show less variation than coverage variables as they are binary dummies. The indicator and coverage variables of private credit bureaus are highly correlated with the "Credit Information Index" reported in the World Bank/IFC "Doing Business" database, which measures the extent of credit information available on individuals and firms through either public or private credit registries (correlation coefficients are 0.79 and 0.42 respectively and statistically significant). Additionally, we find that countries with higher coverage of private credit bureaus also have higher percentage of firms rated by either S&P or Moody's (the correlation coefficient is 0.38 and statistically significant). We also use a measure of the quality of accounting standards across countries, which captures more directly the availability of credit information about firms. However, this variable shows little time-series variation. As each of these proxies for the quality of credit information have their own advantages and disadvantages, we will employ several of them in alternative specifications of our baseline regression. It is interesting to note that our main results remain unchanged whichever proxy is chosen.

World Bank/IFC "Doing Business" database as well as the World Bank Public and Private Credit Registries Surveys. In addition, we obtain the credit registries establishment dates from Miller (2003), Love and Mylenko (2003), and Djankov, McLiesh and Shleifer (2006).

The differences in corporate debt maturity structures across countries may reflect varying quality of legal institutions and contracting environments (see Demirguc-Kunt and Maksimovic, 1998). In particular, we control for the impact of the legal framework by including variables on countries' legal origins, shareholder rights and creditor rights (see LLSV, 1998)[25], as well as the corruption perception indices provided by Transparency International.

In order to control for the degree of domestic financial development, we use the ratio of total deposits in the financial system to GDP, the ratio of the private bond market capitalization to GDP, and the ratio of overhead costs to bank assets (as a measure of banking sector efficiency) obtained from Beck, Demirguc-Kunt and Levine (2000). In addition, we control for whether or not a country is one of the world's major financial centers, i.e. US, UK, Switzerland and Japan, and whether or not the country has had a systemic banking crisis as defined in Caprio and Klingebiel (2003).

Macroeconomic variables may also influence firms' choices of debt maturity. In particular, GDP growth rate is a proxy for the investment opportunity set faced by firms (Smith and Watts, 1992), and the inflation rate provides evidence for firms and banks on whether the local currency is a stable measure of value to be used in long-term contracting. Hence we include among our controls the growth rate of GDP per capita as well as indices of consumer price inflation. A dummy variable is also added to control for any structural differences between developed and developing economies not already captured by other explanatory variables.

[25] The LLSV shareholder rights variable measures the costs faced by minority investors who want to influence decision-making within the firm. It is obtained by adding a score of one for each of the following elements: (i) shareholders are allowed to vote by mail, (ii) shareholders are not required to deposit their shares with a trustee prior to voting, (iii) the law allows cumulative voting for directors, (iv) the law gives minority shareholders special protection, (v) the minimum percentage of share capital that entitles a shareholder to call for an extraordinary general meeting is less than or equal to 10%, and (vi) shareholders have pre-emptive rights that can only be waived by a shareholder vote. The LLSV creditor rights variable is obtained by adding a score of one for each of the following provisions of creditor protections: (i) the bankruptcy laws prohibit an automatic stay on assets, (ii) secured creditors are permitted to repossess their collateral in bankruptcy, (iii) the bankruptcy law prohibits borrowers from unilaterally obtaining court protection from creditor demands, and (iv) creditors can dismiss managers and replace them with administrators when a firm becomes bankrupt. We use the creditor rights variable reported in Djankov, McLiesh and Shleifer (2006), who introduce time-variations in the index due to reforms of bankruptcy laws.

Finally, we use a set of micro-level variables to control for the differences in firm characteristics across countries. First, larger firms may face reduced information asymmetries and less financial constraints. Therefore we control for firm size by using the natural logarithm of firms' total assets. Second, we use the return on assets to capture profitability and liquidity of firms. Third, the ratio of fixed assets to total assets is included to reflect the maturity structure of firms' assets. Firms with more fixed assets have higher collateral value but lower asset liquidity (Grudes and Opler, 1996) and tend to raise more long-term debt in order to match the maturity of their assets and liabilities (Stohs and Mauer, 1996). Fourth, we include the standard deviation of firms' default probabilities in each country, based on Altman's (1968) Z-score, to control for the higher dispersion in the credit quality of firms in certain markets and hence the banks' increased need for screening their clients (as implied by our model in Section 4).

5.2. Econometric results

We start with a brief review of bivariate correlations among the key variables that will enter our analysis. Figure 5 displays the average ratios of short-term debt to total debt for firms in our sample of 45 countries over the 1994-2004 period. China has the highest short-term debt ratio, whereas the United States have the lowest, at about one-third of China's. There is a clustering of developing countries at the top of the range, such as Malaysia, Turkey and Hungary, indicating that firms in low-income countries use more short-term debt as a proportion of total debt. Additionally, we find the short-term debt ratio to be positively correlated with countries' corruption levels, inflation rates, firms' default probabilities and domestic banks' non-performing loans (see Figures A1 and A2 in the Appendix). Figure 7 shows the key scatter-plots, which will be the focus of our empirical analysis. They suggest a negative correlation between short-term debt ratios and variables capturing the quality of credit information, namely the coverage of private credit bureaus and the quality of accounting standards. [26]

[26] In Appendix Table A1, we report the average short-term debt ratio, the average private and public credit registries coverage, the average annual GDP growth and consumer price inflation rate for each country in our sample over the 1994-2004 period. We find that credit bureaus in countries with the lowest short-term debt ratios, namely US, Norway, New Zealand and Canada, have a higher than 80% coverage of the population, whereas the coverage in China is zero.

Figure 6 shows on the world map which countries currently have public credit registries, private credit bureaus or both. Many countries started their public or private credit bureaus during our sample period, which allows us to evaluate the impact of institutional reforms in credit reporting systems on corporate debt maturities. For instance, Peru, Portugal and Thailand established their first private bureaus in 1995, 1996 and 1999, respectively. After these dates, the average short-term to total debt ratios for firms in these countries dropped by 8%, 8% and 9%, respectively, compared to the years prior to the establishment of credit bureaus. In addition, according to the Loanware/Bondware Capital Markets database, the average maturity of loans and bonds for borrowers domiciled in these countries appears significantly longer after the establishment of credit bureaus than before (the increases in average maturities of loans and bonds for borrowers domiciled in each of these countries were 130%, 70% and 40%, respectively, comparing the period before and after the establishment of credit bureaus). This anecdotal evidence seems to confirm the above documented correlations between credit information quality and debt maturity.

In order to control for other concomitant factors which may also be affecting corporate debt maturity, we attempt to disentangle the impact of better credit information by estimating the following panel regression:

STD/TD = f *(Credit Information Quality, Macroeconomic Environment, Firm Characteristics, Country Fixed Effects, Year Fixed Effects)*

where the dependent variable *STD/TD* is the average short-term debt to total debt ratio of all available listed companies for each country in each year. Our estimation sample contains country-year observations for 45 countries over 11 years. Panel A of Table 2 presents summary statistics for the variables used in our regression analysis and Panel B provides more details on variable definitions and data sources.

We proxy for *Credit Information Quality* using indicator variables capturing the existence of private and public credit registries. Furthermore, GDP Growth and Inflation are included to control for the *Macroeconomic Environment.* We also include four variables to account for specific *Firm Characteristics*: Log of Total Assets, Return on Assets, the Fixed Assets to Total Assets ratio, and the Dispersion of Default Risks. We introduce both *Country Fixed Effects* and *Year Fixed Effects* to control for unobserved heterogeneity across countries and over time.

Panel A of Table 3 presents the results. We find that the establishment of private credit bureaus in a country reduces its average short-term to total debt ratio in the corporate sector by about 3% ceteris paribus, which is statistically significant at the 1% level. This result is consistent with our hypothesis that better credit information reduces the need for banks to use short-term debt as a screening device (see Section 4). Our findings also support the prediction by Flannery (1986) and Diamond (1991) that debt maturity is shorter when there are more information asymmetries.

As for macroeconomic fundamentals, lower GDP growth rate and/or higher inflation are associated with a shortening of debt maturity (consistent with the literature). Furthermore, firm characteristics appear important in explaining within country variation in corporate debt maturities over time: adding these variables in the regressions improves the R-squared (within group) by 17%. In line with our expectations, larger and/or more profitable firms obtain easier access to long-term finance. Although we only have data for publicly listed firms, which tend to be relatively large firms, we expect that the effect of better credit information in lengthening debt maturities would be even stronger for smaller unlisted firms, which generally have no credit ratings and present higher informational asymmetries.

In order to further examine the institutional determinants of corporate debt maturity structure around the world, we next turn to estimate the following panel regression:

STD/TD = f *(Credit Information Quality, Legal Institutions, Financial Development, Macroeconomic Environment, Firm Characteristics, Year Fixed Effects)*

where we have replaced country fixed effects with several institutional variables capturing different degrees of development in the legal framework and the financial sector across countries. We include a Common Law Origin indicator, Shareholder Rights, Creditor Rights, and a Corruption index as measures of the quality of *Legal Institutions*. Furthermore, we use five variables to capture the degree of domestic *Financial Development*, namely the Deposit to GDP ratio, the Private Bond to GDP ratio, the Bank Costs to Assets ratio, a Financial Center indicator and a Banking Crisis indicator.

As a robustness check on the regression in Panel A, we employ alternative proxies for *Credit Information Quality*, namely the coverage of public and private credit registries as well as a measure of the quality of accounting standards.

Results are shown in Panel B of Table 3. We find that firms in countries with better credit information have a lower ratio of short-term to total debt on average. This suggests that

improvements in the coverage of public and especially private credit registries, as well as in the quality of accounting standards, may increase firms' access to long-term finance. These findings confirm our previous results reported in Panel A of Table 3.

Additionally, the quality of the legal framework appears an important determinant of corporate debt maturity. Consistent with Fan, Titman and Twite (2006), we find a higher share of long-term corporate debt in less corrupted countries and in countries with common law origins. As pointed out by LLSV (1998), countries with a common-law tradition provide better protections for shareholder and creditor rights. After controlling for countries' legal origins, we find a higher share of long-term corporate debt in countries where creditor rights protection is relatively poor, a result similar to that of Demirguc-Kunt and Maksimovic (1999). This is consistent with the view that poor protection of creditor rights may cause lenders to liquidate short-term loans at maturity even for good borrowers. Thus, borrowers have an incentive to lock in long-term loans in order to avoid the liquidation risk (see Diamond, 1991).

We also find that corporate debt maturity is influenced by the development of domestic financial markets. In general, countries with a large banking sector, compared to the size of their economy, are characterized by a higher share of short-term corporate debt, similar to the finding by Fan, Titman and Twite (2006). We also observe a significant shortening of the maturity structure of corporate debt during banking crises (consistent with the literature).

Furthermore, a number of firm characteristics, in addition to firm size and profitability, appear relevant in explaining corporate debt maturity structures across countries. By taking into account both cross-country and time-series variations in firm characteristics, we find that firms with more fixed assets tend to borrow long term, consistent with the hypothesis that firms try to match the maturity of their assets and liabilities (see, Stohs and Mauer, 1996). Finally, countries with higher dispersion of firms' credit qualities are characterized by more long-term debt. This is consistent with our theoretical predictions in Section 4: when the pool of obligors is more heterogeneous, screening high-risk from low-risk firms is relatively easier. By contrast, when differences in default risks among firms are more opaque, screening may take longer and banks need to resort to more short-term lending. This is also consistent with Flannery's (1986) prediction that debt maturity is an upward-sloping function of risk.

The overall conclusion of our empirical analysis is that – controlling for other macro and micro characteristics – the quality of credit information and the legal framework are crucial

determinants of firms' debt maturity choices around the world. Comparing the R-squared of the regressions across the three columns of Panel B of Table 3, we find that our proxies for *Credit Information Quality* and *Legal Institutions* explain together 44% of the variation in the maturity structure of corporate debt, whereas adding financial development, macro and micro variables only increases the R-squared by an additional 19%.[27]

5.3. Robustness checks

We have performed a number of robustness checks for our results (available on request). First, different measures of the debt maturity structure were used. For instance, following Demirguc-Kunt and Maksimovic (1999), we used the ratio of short-term debt to total assets. We also used the medians (instead of the means) of the short-term debt ratios and our results are unchanged.

Second, alternative specifications of explanatory variables were employed. For instance, we used interchangeably indicator variables for the establishment of credit registries, credit bureau coverage variables and an overall index of the quality of credit information. We replaced the corruption index by the Rule of Law variable obtained from International Country Risk Guide and also included alternative macro and micro characteristics variables such as bank concentration, non-performing loans and market-to-book ratios of firms. These variables were not included in the final specification either because of correlations with other variables or because of limits on data availability. Our main results are robust to alternative specifications of the model.

Third, we investigated potential endogeneity bias in our regressions. In particular, the development of domestic financial sectors as well as firms' profitability and default risk may be influenced by firms' financial decisions including debt maturity choices.[28] To address this

[27] This result appears even stronger when we analyze the sub-samples of developed and developing economies, separately. For developed economies, we find that credit information and the legal framework are the driving factors of debt maturity choices, explaining 74% of the variations in the debt maturity structure. In contrast, including macro and micro variables only marginally improves the R-squared by 12%.

[28] In their analysis to explain debt maturity structure, Demirguc-Kunt and Maksimovic (1999) use bank assets divided by GDP to proxy for the size of banking sector, which might be endogenous as the size is affected by the aggregate decisions of all firms (The authors use two-stage regressions to control for this dependence). Our proxy for financial development, deposits of total financial system to GDP, may be less affected by a potential endogeneity problem because the amount of short-term funds (i.e. deposits) that are available to the domestic financial system can be regarded as exogenous with respect to firms' financial decisions measures (see Fan,

issue, we use one-year lagged values of financial development variables (except the financial center and banking crisis indicators) and firm characteristics variables as instruments. This instrumental variable approach assumes that past values of these variables are correlated with their current values but not with the current error terms. The instrumental variable regression confirms our main results reported in Table 3.

Fourth, alternative estimation methodologies were employed. In addition to our baseline fixed-effects and pooled OLS regressions, we estimated the model with random-effects estimators and cross-sectional estimators. We also used clustered standard errors to take into account autocorrelation of observations within a country. In all of these tests, our main results remain unchanged.

6. Conclusion and policy implications

A common problem faced by many firms around the world is the scarce availability of long-term sources of funds. Exclusive reliance on short-term borrowing may expose companies to illiquidity risks and reduce their overall growth potential. To address these issues, many countries have embarked on policies promoting the development of long-term loan or bond markets with mixed results. However, while the negative implications of excessive short-term borrowing on growth and stability are well known (eg. Chang and Velasco, 2001 and Demirguc-Kunt and Maksimovic, 1998), there is no consensus on its underlying determinants and hence the main priorities for reform.

This paper provides new theoretical and empirical evidence suggesting that the quality of credit information may be a key element to explain the maturity structure of corporate debt. From the perspective of the lender, the optimal choice of corporate debt maturity is analyzed in a dynamic model both under incomplete but symmetric information and with asymmetric information. In markets with poor credit information and hence a high degree of uncertainty about borrower quality, we find suboptimal equilibria in which short-term contracts are preferred either as a hedge against uncertainty to limit losses in bad states (in the symmetric information case) or as a screening device to learn about borrower credit quality in the course of a repeated lending relationship (in the asymmetric information case).

Titman, and Twite, 2006). In addition, our results are unchanged if we use the stock market turnover ratio (which are exogenous with respect to firms' debt maturity choices) as an instrument to the size of debt markets.

The implications of the model are supported by panel data from both developed and developing countries. Our main finding is that better credit information (as proxied by the existence and coverage of private and public credit registries as well as by improvements in accounting standards) is associated with a higher share of long-term debt as a proportion of total corporate debt. This does not imply that, in and of itself, better credit information is a sufficient condition for developing long-term corporate debt markets. Our results do suggest, however, that improving credit reporting systems and accounting standards around the world may increase the maturity horizon at which financial institutions feel safe to lend. This would contribute to lengthening the maturity structure of corporate debt thus placing firms on a more solid footing to avoid illiquidity risks and exploit their full growth potential.

References:

Admati, A. and M. Perry, 1987, Strategic delay in bargaining, *Review of Economic Studies* 54 (3), 345-364

Allen, F., 2001, Financial structure and financial crises, *International Review of Finance* 2, 1-19

Altman, E., 1968, Financial ratios, discriminant analysis and the prediction of corporate bankruptcy, *Journal of Finance* 23, 589-609

Altman, E. and H. Suggitt, 2000, Default rates in the syndicated bank loan market: 1991–1997, *Journal of Banking and Finance* 24, 229-253

Barclay, M. and C. Smith, 1995, The maturity of corporate debt, *Journal of Finance* 50, 609-631

Barnea, A., R. Haugen and L. Senbet, 1980, A rationale for debt maturity structure and call provisions in the agency theoretic framework, *Journal of Finance* 35, 1223-1234

Barron, J.M. and Staten, M., 'The Value of Comprehensive Credit Reports: Lessons from the US Experience' in M. Miller (2003), *Credit Reporting Systems and the International Economy*, Cambridge, Massachusetts: MIT Press.

Beck, T., A. Demirguc-Kunt and R. Levine, 2000, A new database on financial development and structure, *World Bank Economic Review* 14, 597-605

Berger, A., M. Espinosa-Vega, W. Frame and N. Miller, 2005, Debt maturity, risk, and asymmetric information, *Journal of Finance* 60(6), 2895-2923

Berger, A., R. Rosen and G. Udell, 2002, The effect of market size structure on competition: The case of small business lending, *Board of Governors of the Federal Reserve System Working Paper*

Berger, A. and G. Udell, 1995, Relationship lending and lines of credit in small firm finance, *Journal of Business* 68, 351-381

Besanko, G. and D. Kanatas, 1996, The regulation of bank capital: do capital standards promote bank safety?, *Journal of Financial Intermediation* 5, 160-183

Boot, A., 2000, Relationship banking: what do we know? *Journal of Financial Intermediation* 9, 3-25

Brick, I., E. Kane and D. Palia, 2004, Evidence of jointness in the terms of relationship lending, *Rutgers University Working Paper*

Brick, I. and S. Ravid, 1985, The relevance of debt maturity structure, *Journal of Finance* 40, 1423-1437

Brown, M., T. Jappelli and M. Pagano, 2006, Information sharing and credit market performance: firm-level evidence from transition countries, *CEPR Working Paper*

Calvo, G., A. Izquierdo, and L. Meijia, 2004, On the empirics of sudden stops: the relevance of balance sheet effects, *NBER Working Paper* 10520

Caprio, G. and D. Klingebiel, 2003, Episodes of systemic and borderline financial crises, *World Bank Working Paper*

Chang, R. and A. Velasco, 2001, A model of financial crises in emerging markets, *Quarterly Journal of Economics* 116 (2), 489-517

Degryse, H. and S. Ongena, 2006, Competition and regulation in the banking sector: a review of the empirical evidence on the sources of bank rents, *Tilburg University Working Paper*

Degryse, H. and P. Van Cayseele, 2000, Relationship lending within a bank-based system: Evidence from European small business data, *Journal of Financial Intermediation* 9, 90-109

Demirguc-kunt, A. and E. Detragiache, 1998, The determinants of banking crises: Evidence from developing and developed countries, *IMF Staff Papers* 45

Demirguc-Kunt, A. and V. Maksimovic, 1998, Law, finance and firm growth, *Journal of Finance* 53 (6), 2107-2137

Dermirguc-Kunt, A. and V. Maksimovic, 1999, Institutions, financial markets, and firm debt maturity, *Journal of Financial Economics* 54, 295-336

Detragiache, E. and A. Spilimbergo, 2002, Empirical models of short-term debt and crises: Do they test the creditor run hypothesis?, *IMF Working Paper 01/2*

Dewatripont, M. and E. Maskin, 1995, Credit and efficiency in centralized and decentralized economies, *Review of Economic Studies* 62, 541-555

Diamond, D., 1991, Debt maturity structure and liquidity risk, *Quarterly Journal of Economics* 106, 709-738

Diamond, D., 1993, Seniority and maturity of debt contracts*, Journal of Financial Economics* 33, 348-368

Diamond, D. and R. Rajan, 2000, Banks, short term debt and financial crises: theory, policy implications and applications, *NBER Working Paper* 7764

Djankov, S., C. McLiesh, and A. Shleifer, 2006, Private credit in 129 countries, *Journal of Financial Economics*, forthcoming

Duffie, D. and K. Singleton, 2003, Credit risks*,* Princeton University Press

Eichengreen, B., R. Hausmann and U. Panizza, 2003, Currency mismatches, debt intolerance and original sin, *NBER Working Paper 10036*

Estrella, A., 2000, Credit ratings and complementary sources of credit quality information, *Basel Committee on Banking Supervision Working Paper*, 3

Fan, J., S. Titman and G. Twite, 2006, An international comparison of capital structure and debt maturity, *HKUST Working Paper*

Flannery, M., 1986, Asymmetric information and risky debt maturity choice, *Journal of Finance* 41, 19-37

Galindo, A. and M. Miller, Can Credit Registries Reduce Credit Constraints? Empirical Evidence on the Role of Credit Registries in Firm Investment Decisions, Working Paper, Inter-American Development Bank

Giannetti, M., 2003, Do better institutions mitigate agency problems? Evidence from corporate finance choices, *Journal of Financial and Quantitative Analysis* 38, 185-212

Guedes, J. and T. Opler, 1996, The determinants of the maturity of corporate debt issues, *Journal of Finance* 51, 1809-1833

Harrison, M. and D. Kreps, 1979, Martingales and arbitrage in multiperiod security markets, *Journal of Economic Theory* 20, 381-408

Hart, O. and J. Tirole, 1988, Contract renegotiations and Coasian dynamics, *Review of Economic Studies* 55, 509-540

Jappelli, T. and M. Pagano, 2002, Information sharing, lending, and defaults: Cross-country evidence, *Journal of Banking and Finance* 26, 2017-2045

Jarl Kallberg and Gregory Udell, 2003, "The Value of Private Sector Business Credit Information Sharing: The U.S. Case," Journal of Banking and Finance 27(3), 449-469

Kaminsky, G. and C. Reinhart, 1999, The twin crises: The causes of banking and balance-of-payments problems, *American Economic Review* 89, 473-500

Kaminsky, G. and S. Schmukler, 2003, Short-run pain, long-run gain: The effects of financial liberalization, *NBER Working Paper* 9787

Krugman, P., 1999, Balance sheets, the transfer problem, and financial crises, in P. Isard, A. Razin and A. Rose, eds., *International Finance and Financial Crises*, Kluwer Academic Publishers: Boston

La Porta, R., F. Lopez-de-Silanes, A. Shleifer and R. Vishny, 1998, Law and finance, *Journal of Political Economy* 106, 1113-1155

Levine, R., 2004, Finance and growth: theory and evidence, *NBER Working Paper* 10766

Lewis, C., 1990, A multi-period theory of corporate financial policy under taxation, *Journal of Financial and Quantitative Analysis* 25, 25-43

Love, I. and N. Mylenko, 2003, Credit reporting and financial constraints, *World Bank Working Paper*

Lummer, S. and J. McConnell, 1989, Further evidence on the bank lending process and the reaction of the capital market to bank loan agreements, *Journal of Financial Economics* 25, 99-122.

Miller, M., 2003, Credit reporting systems around the globe: the state of the art in public and private credit registries, in Miller, ed., *Credit reporting systems and the international economy*

Modigliani, F. and M. Miller, 1958, The cost of capital, corporation finance and the theory of investment, *American Economic Review* 48, 261-297

Myers, S., 1977, Determinants of corporate borrowing, *Journal of Financial Economics* 5, 147-175

Ortiz-Molina, H. and M. Penas, 2006, Lending to small businesses: the role of loan maturity in addressing information problems, *Tilburg University Working Paper*

Petersen, M. and R. Rajan, 1994, The benefits of lending relationships: Evidence from small business data, *Journal of Finance* 49, 3-37

Rajan, R., 1992, Insiders and outsiders: The choice between informed and arm's-length debt, *Journal of Finance* 47(4), 1367-1400

Ravid, S., 1996, Debt maturity: a survey, *Financial Markets, Institutions and Instruments* 5, 1-69

Rey, P. and J. Stiglitz, 1993, Short-term contracts as a monitoring device, *NBER Working Paper* 4514

Rodrik, D. and A. Velasco, 1999, Short-term capital flows, *NBER Working Paper 7364*

Smith, C. and R. Watts, 1992, The investment opportunity set and corporate financing, dividends and compensation policies, *Journal of Financial Economics* 32, 263-292

Stiglitz, J., 1974, On the irrelevance of corporate financial policy, *American Economic Review* 64, 851-66

Stiglitz, J. and A. Weiss, 1981, Credit rationing in markets with imperfect information, *American Economic Review* 71, 393-410

Stoh, M. and D. Mauer, 1996, The determinants of corporate debt maturity structure, *Journal of Business* 69, 279-312

Von Thadden, E., 1995, Long-term contracts, short-term investment and monitoring, *Review of Economic Studies* 62, 557-575.

Table 1: Main implications of the model

This table summarizes the main implications and empirical predictions of the model.

Model	Parameter Assumption	Contracting environment	Information Revelation	Optimal Debt Maturity	Socially Optimal?
Symmetric Information	High σ	High risk environment		Short-Term	No
	Low σ	Low risk environment		Long-Term	Yes
Asymmetric Information	High ξ_H	High information quality	Early revelation	Long-Term	Yes
	Low ξ_H	Low information quality	Late revelation	Short-Term	No
	High μ_H	High risk environment	Late revelation	Short-Term	No

Table 2: Summary statistics and variable definitions

This table presents the summary statistics (Panel A) and variable definitions and sources (Panel B) for our regression data. Variables with a prefix "D" are binary dummies.

Panel A: Summary statistics

	Variables	Mean	Median	Std. Dev.
Short-Term Debt	STD/TD	46.13	47.10	11.52
Information Asymmetries	Private Credit Bureau Cov.	33.33	22.70	30.34
	Public Credit Registry Cov.	3.74	0.00	9.74
	Accounting Standards	62.74	64.00	11.24
Legal Institutions	D Common Law	0.30	0.00	0.46
	Shareholder Rights	3.56	4.00	1.06
	Creditor Rights	2.08	2.00	1.31
	Corruption	4.06	4.20	2.45
Financial Development	Deposit /GDP	70.78	57.10	47.11
	Private Bond /GDP	0.22	0.15	0.25
	Bank Costs /Assets	0.04	0.03	0.02
	D Financial Center	0.09	0.00	0.28
	D Banking Crisis	0.18	0.00	0.38
Macroeconomic Environment	GDP Growth	3.19	3.00	3.94
	Inflation	7.94	2.83	24.08
	D Developed Country	0.55	1.00	0.50
Firm Characteristics	Log of Total Assets	13.80	13.78	0.93
	Return on Assets	4.70	4.92	6.97
	Fixed Assets /Total Assets	0.14	0.13	0.09
	Dispersion of Default Risk	15.32	14.03	7.36

Panel B: Variable definitions and sources

	Variables	Descriptions and Data Source
Share of Short-Term Debt	STD/TD	Short-term debt (i.e. less than one year maturity) divided by total debt of a firm. Average across firms in each country. Source: Worldscope and World Bank FSDI
Credit Information Quality	Private Credit Bureau (D- / -Cov.)	Variable with a prefix "D": Dummy =1 if a private credit bureaus exists; Variable with a postfix "Cov.": Private credit bureaus coverage as a % of the adult population. Source: Doing Business (2006), Miller (2003), Love and Mylenko (2003) and Djankov, McLiesh and Shleifer (2006)
	Public Credit Registry (D- / -Cov.)	Variable with a prefix "D": Dummy =1 if a public credit registry exists; Variable with a postfix "Cov.": Public credit registries coverage as a % of the adult population. Source: Doing Business (2006), Miller (2003), Love and Mylenko (2003) and Djankov, McLiesh and Shleifer (2006)
	Credit Information Index	The index ranges from 0 to 6, with a score of 1 assigned for each of the following 6 features of the credit information system: . Both positive and negative credit information is distributed. . Data on both firms and individuals are distributed. . Data from retailers, trade creditors or utilities as well as financial institutions are distributed. . More than 2 years of historical data are distributed. . Data on loans above 1% of income per capita are distributed. . By law, borrowers have the right to access their data.
	Accounting Standards	Accounting standard ratings in 1990 (0 worst-100 best). Source: LLSV (1998)
Legal Institutions	D Common Law	Dummy =1 if legal origin is common law, and =0 if the origin is civil law or socialist. Source: LLSV (1998)
	Shareholder Rights	Shareholder right index (i.e. new anti-director index) (0 least - 6 most rights). Source: LLSV (1998)
	Creditor Rights	Creditor right index (0 least - 4 most rights). Source: LLSV (1998) and Djankov, McLiesh and Shleifer (2006)
	Corruption	Corruption perception index (reversed: 0 least - 10 most corrupted). Source: Transparency International
Financial Development	Deposit /GDP	Demand, time and saving deposits in deposit money banks and other financial institutions as a share of GDP. Source: Beck, Demirguc-Kunt and Levine (2000)
	Private Bond /GDP	Private bond market capitalization divided by GDP. Source: Beck, Demirguc-Kunt and Levine (2000)
	Bank Costs /Assets	Banks' overhead costs divided by bank assets in each country. Source: Beck, Demirguc-Kunt and Levine (2000)
	D Financial Center	Dummy =1 if the country is US, UK, Switzerland, or Japan, and =0 otherwise. This classification follows Eichengreeen, Hausmann and Panizza (2003).
	D Banking Crisis	Dummy =1 if there is a systemic banking crises, and =0 otherwise. Source: Caprio and Klingebiel (2003)
Macro Environment	GDP Growth	Growth rate of GDP per capita. Source: World Development Indicators
	Inflation	Consumer Price Inflation. Source: World Development Indicators
	D Developed Country	Dummy =1 if the country is a developed country, and =0 if it is a developing country. The classification is based on Gross National Income per capita. Source: World Bank
Firm Characteristics	Log of Total Assets	Natural logarithm of average total assets (in thousand US$) across firms in each country. Source: Worldscope and World Bank FSDI
	Return on Assets	Return of assets (net income before interest divided by total assets of a firm). Average across firms in each country. Source: Worldscope and World Bank FSDI
	Fixed Assets /Total Assets	Fixed assets (net property, plant and equipment) divided by total assets of a firm. Average across firms in each country. Source: Worldscope and World Bank FSDI
	Dispersion of Default Risk	Standard deviation of default probabilities (based on Altman's (1968) Z-score) across firms in each country. Source: Worldscope and World Bank FSDI

Table 3 - Determinants of debt maturity structure

The tables below present our estimation results for the determinants of corporate debt maturity structure. The dependent variable is the average ratio of short-term debt to total debt of firms in each of the countries in our sample (STD/TD). The explanatory variables in Panel A are credit information quality for model (1), all of the above plus macroeconomic environment in model (2), and finally all of the above plus firm characteristics in model (3). The explanatory variables in Panel B are credit information quality and legal institutions in model (1), all of the above plus financial development and macroeconomic environment in model (2), and finally all of the above plus firm characteristics in model (3). Panel A includes country and year effects whereas Panel B includes only year effects. The p-values are in parentheses, calculated with White standard errors to correct for potential heteroskedasticity. Bold coefficients indicate a statistical significance level of at least 10%.

Panel A:

Dependent Variable	STD/TD	(1)		(2)		(3)	
	Constant	**48.45**	(0.00)	**48.56**	(0.00)	**111.08**	(0.00)
Credit Information Quality	D Private Credit Bureau	**-3.86**	(0.00)	**-3.58**	(0.00)	**-2.95**	(0.01)
	D Public Credit Registry	-1.21	(0.40)	-0.68	(0.66)	0.03	(0.98)
Macro Environment	GDP Growth			**-0.16**	(0.02)	**-0.14**	(0.01)
	Inflation			**0.01**	(0.06)	**0.04**	(0.00)
Firm Characteristics	Log of Total Assets					**-4.61**	(0.00)
	Return on Assets					**-0.17**	(0.01)
	Fixed Assets /Total Assets					8.13	(0.25)
	Dispersion of Default Risk					0.03	(0.57)
Country Fixed Effects	D Country	Yes		Yes		Yes	
Year Fixed Effects	D Year	Yes		Yes		Yes	
	R-squared (within)	0.12		0.13		0.30	
	R-squared (overall)	0.92		0.93		0.94	
	Observations	461		452		434	

Panel B:

Dependent Variable	STD/TD	(1)		(2)		(3)	
	Constant	**62.39**	(0.00)	**54.66**	(0.00)	**128.54**	(0.00)
Credit Information Quality	Private Credit Bureau Cov.	**-0.08**	(0.00)	**-0.08**	(0.00)	**-0.06**	(0.01)
	Public Credit Registry Cov.	-0.03	(0.54)	**-0.10**	(0.07)	-0.02	(0.67)
	Accounting Standards	-0.09	(0.18)	**-0.14**	(0.07)	**-0.16**	(0.07)
Legal Institutions	D Common Law	**-5.15**	(0.00)	**-5.28**	(0.00)	**-5.83**	(0.00)
	Shareholder Rights	-0.61	(0.27)	0.69	(0.26)	0.20	(0.74)
	Creditor Rights	**3.85**	(0.00)	**2.90**	(0.00)	**2.59**	(0.00)
	Corruption	**2.17**	(0.00)	**1.72**	(0.00)	**2.18**	(0.00)
Financial Development	Deposit /GDP			**0.10**	(0.00)	**0.08**	(0.00)
	Private Bond /GDP			-1.62	(0.44)	2.57	(0.21)
	Bank Costs /Assets			5.41	(0.87)	-3.05	(0.93)
	D Financial Center			**-3.81**	(0.01)	-0.01	(0.99)
	D Banking Crisis			**5.78**	(0.00)	**6.23**	(0.00)
Macro Environment	GDP Growth			-0.11	(0.46)	-0.13	(0.44)
	Inflation			0.01	(0.59)	**0.07**	(0.02)
	D Developed Country			-1.16	(0.53)	**-3.52**	(0.06)
Firm Characteristics	Log of Total Assets					**-3.79**	(0.00)
	Return on Assets					**-0.31**	(0.02)
	Fixed Assets /Total Assets					**-41.88**	(0.00)
	Dispersion of Default Risk					**-0.34**	(0.00)
Year Fixed Effects	D Year	Yes		Yes		Yes	
	R-squared	0.44		0.55		0.63	
	Observations	370		331		319	

Figure 1: Preference for long-term vs. short-term lending (π_L vs. π_S) as a function of the volatility of project returns (σ)

Numerical example assuming α =0.3, $r_L = r_S$ =0.2, LGD =0.5, c =0.1

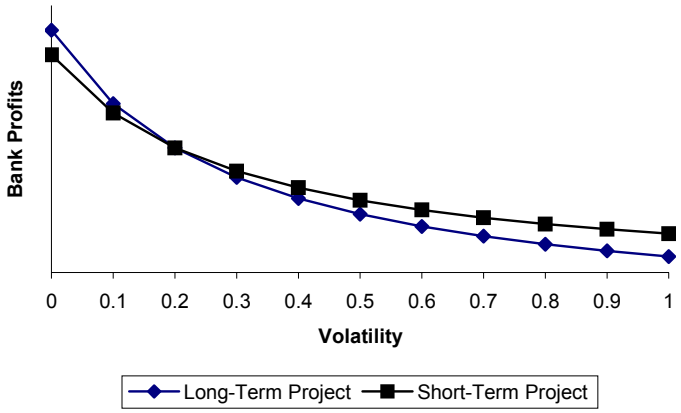


Figure 2: Risk-adjusted discount factors

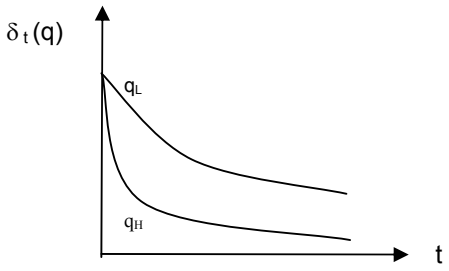


Figure 3: Timeline of the dynamic model

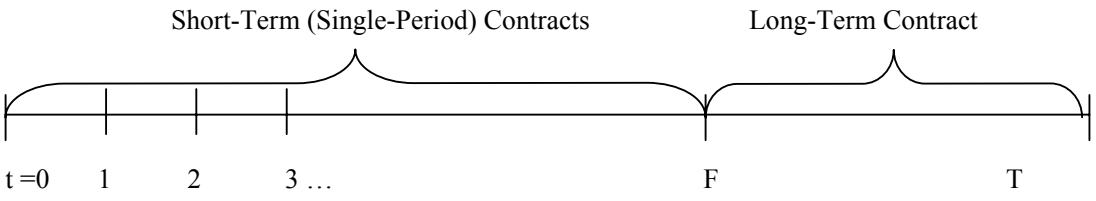
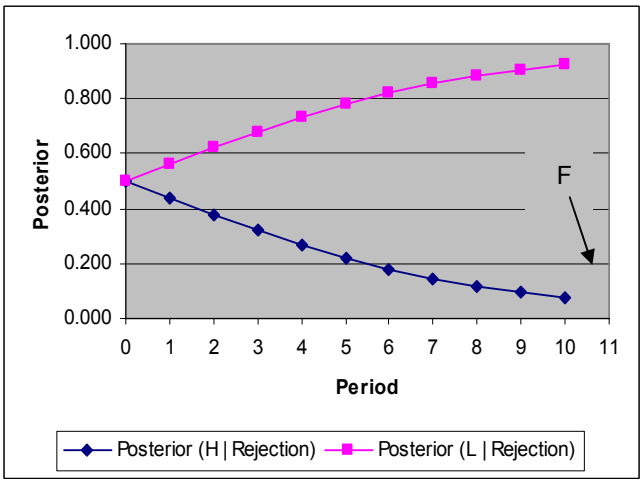


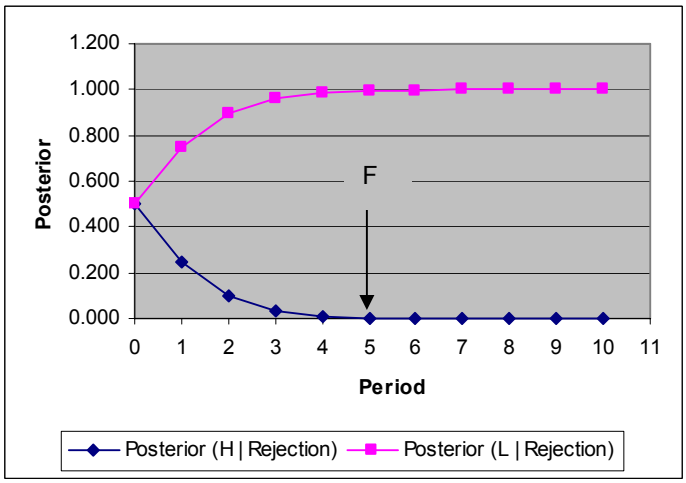
Figure 4: Implications of the model

Panel A: The impact of information quality (ξ_H) on the speed of information revelation

ξ_H = 30% (μ^H = 50%, ξ_L =0)

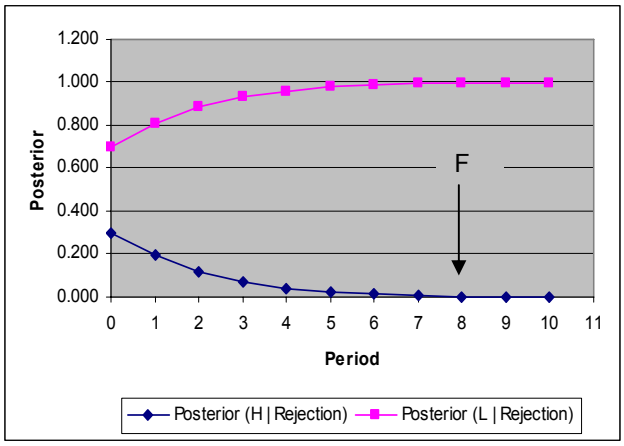


ξ_H = 70% (μ^H = 50%, ξ_L =0)



Panel B: The impact of the risk of environment (μ^H) on the speed of information revelation

μ^H = 30% (ξ_H = 50%, ξ_L =0)



μ^H = 70% (ξ_H = 50%, ξ_L =0)

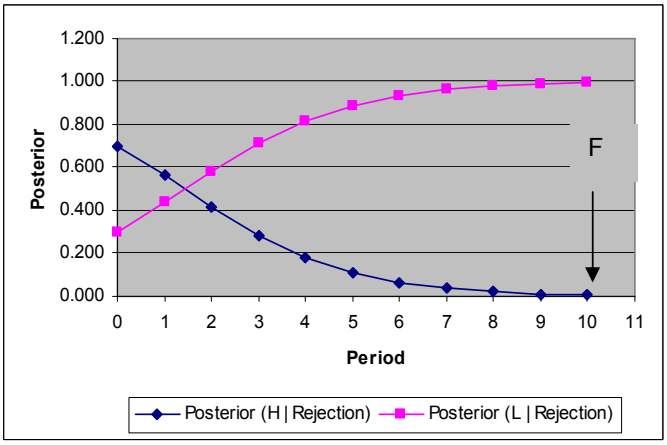


Figure 5: Average short-term debt to total debt ratios

This figure presents the average short-term debt to total debt ratios of firms in each country for the 1994-2004 period. The countries in the figure are ordered with the share of short-term corporate debt increasing from left to right.

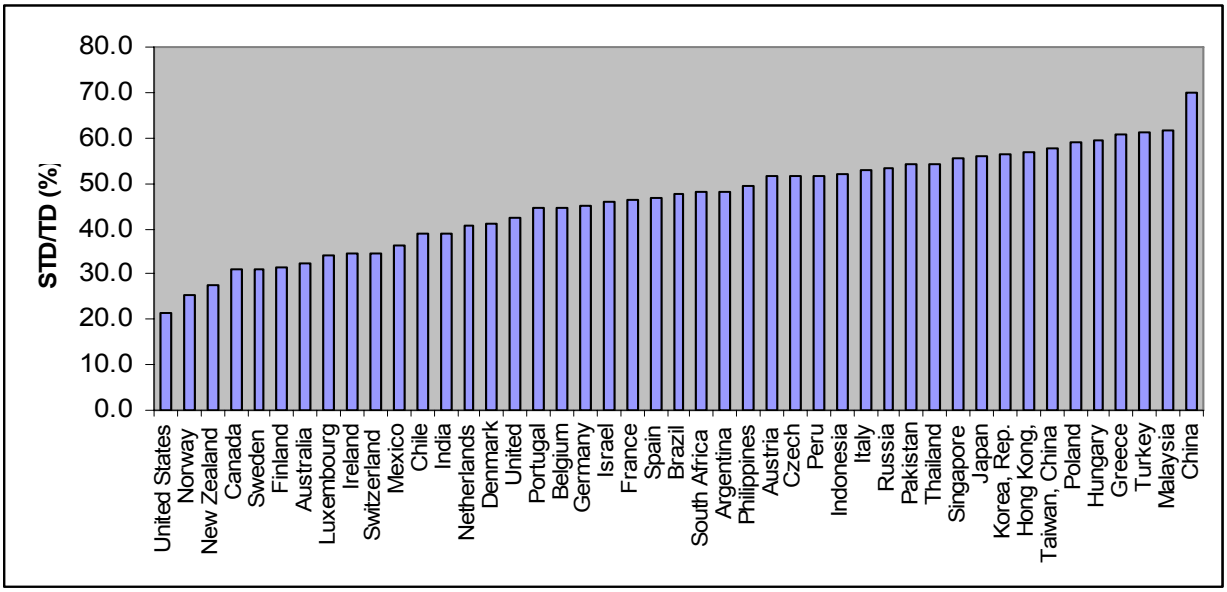


Figure 6: Existence of public or private credit registries around the world

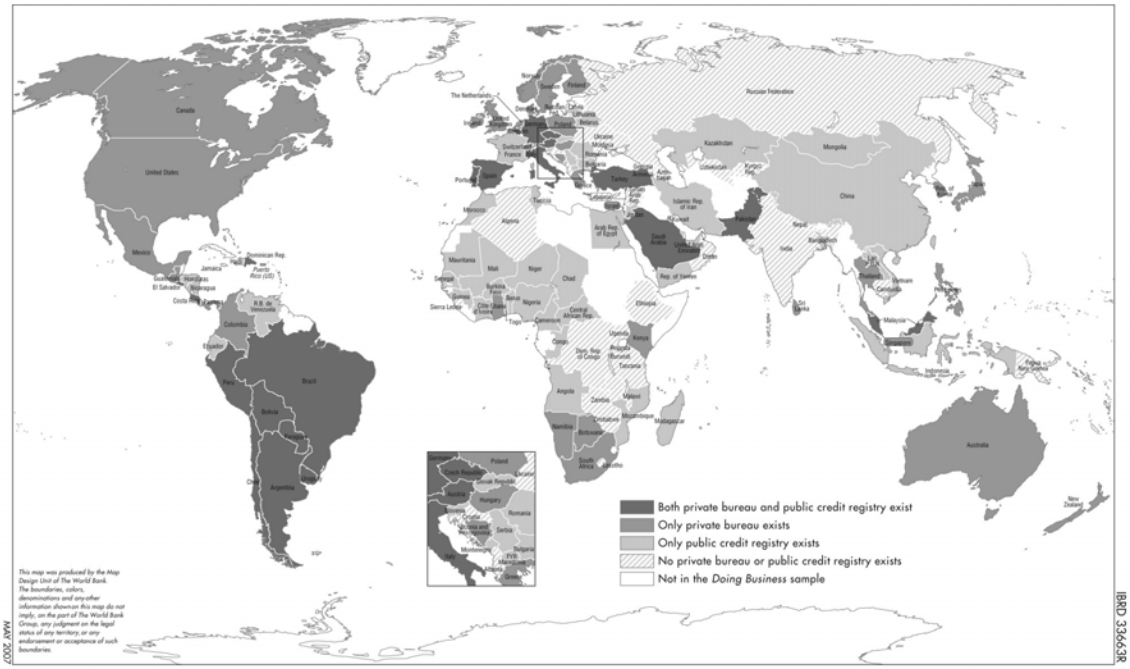
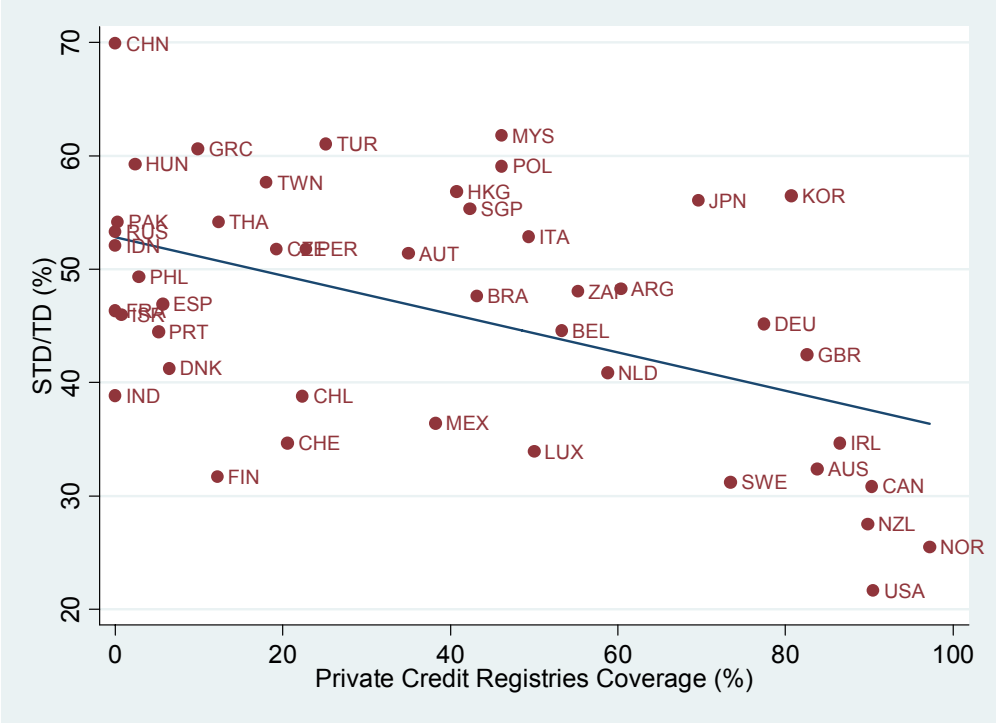
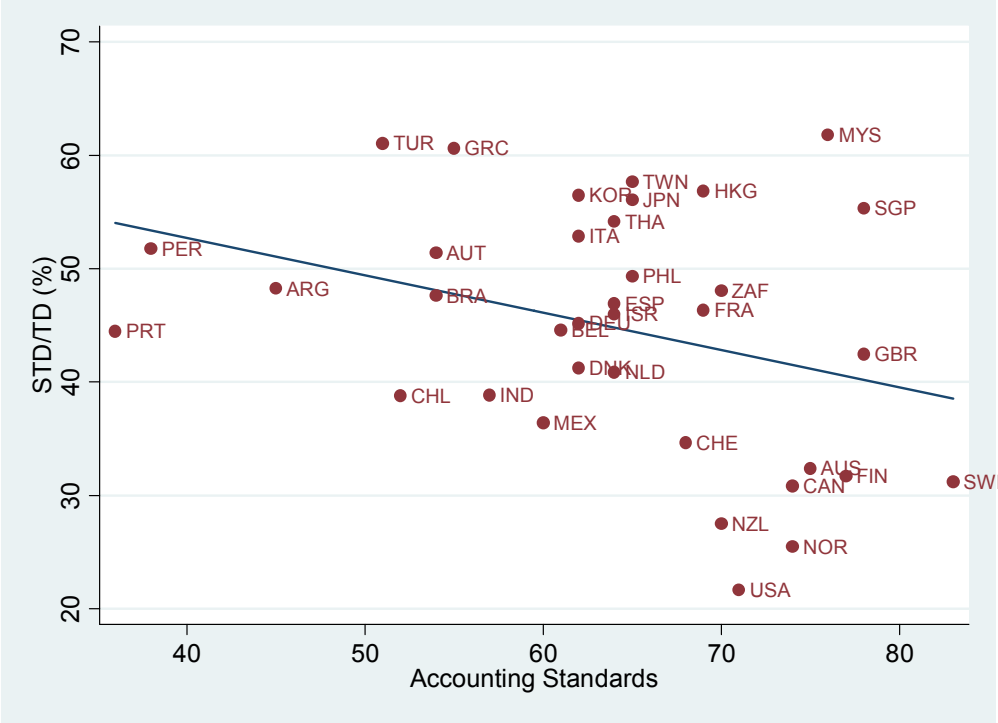


Figure 7: Short-term debt and credit information quality

This figure presents the average short-term debt to total debt ratios (STD/TD) of firms in each country for the 1994-2004 period. The Y-axis is STD/TD. The X-axes are the coverage of private credit registries or the quality of accounting standards.





Appendix

The dynamic model with asymmetric information: derivation of separating equilibria.

We will show below how the strategies outlined in Section 4.1 can be sustained as a Partial Revelation Equilibrium (PBE) in which the bank uses short-term interest rate offers to effectively screen and ultimately separate firm types.

Under perfect competition among banks, interest rates will equalize in equilibrium the cost of funding. As seen in Section 4.1, the cost of funding loans to high-risk firms is assumed to be higher than the cost of funding loans to low-risk firms. Thus, in a static framework, there are in principle two possible values of r for the bank to choose from (R_H or R_L). Under asymmetric information, the bank could either charge an interest rate R_H and lend only to high-risk firms or offer R_L and lend to both types of firms.[29] More formally:

$$\begin{aligned} r(\mu^H) &= R_H && \text{if } \mu^H > \mu^* \\ &= R_L && \text{if } \mu^H < \mu^* \\ &= \text{either } R_H \text{ or } R_L && \text{if } \mu^H = \mu^* \end{aligned} \qquad \text{(A4)}$$

where μ^* is the cut-off prior probability μ^H that makes the bank indifferent ex-ante between lending at R_H only in the event that the firm is high risk and lending at R_L in either case, i.e. whichever the firm's risk level.

This extends to the dynamic model of section 4.1 as follows. To support the strategies (9), (10) and (11) in section 4.1 as an equilibrium, the beliefs $\mu^H{}_t$ must be such that, at each time t<F, the bank will find it optimal to charge $R_{H,t}$. We know that this will indeed be the case only if, at each time t, the bank still believes that there is a sufficiently high chance that the firm is high-risk (even in case the history of the game is such that the firm has always rejected all previous offers). To parallel the inequality in Equation (A4), we need to require that the bank's time t posterior probability that the firm is high-risk (μ_t) be higher than the threshold μ^*_t :

$$\mu^H{}_t \geq \mu^*_t \qquad \text{for all } t<F \qquad \text{(A5)}$$

Similar to (A4), the threshold value μ^*_t can be inferred as the posterior belief that makes the bank indifferent at time t between lending at R_H only in the event that the firm is high risk and lending at R_L in either case, i.e. whichever the firm's risk level.

[29] The bank knows that, by raising the interest rate charged, it will attract only risky borrowers and low risk firms will be credit-rationed. However, unlike the classic credit-rationing equilibrium in Stiglitz and Weiss (1981), in this model when the proportion of risky firms is sufficiently high ($\mu^H > \mu^*$), the prospect of lending a large dollar amount at a high interest rate R^H more than offsets the bank's concern for taking on a higher risk. By contrast, if the bank were to charge R^L it would still attract also high-risk types, only that the interest rate charged would now be insufficient to ensure an adequate risk-adjusted return to cover the cost of funding high-risk firms.

To illustrate further the above restriction on beliefs, we focus on the case where the bank sees its offer at time t-1 rejected by the firm (i.e. $x_{t-1} = 0$). With what (posterior) probability will it still believe at time t that -despite the rejection- the firm is high risk ? From Bayes' rule:

$$\mu_t^H \quad (x_{t-1} = 0) = \frac{\left(1 - \xi_H^{t-1}\right)\mu^H{}_{t-1}}{\left(1 - \xi_H^{t-1}\right)\mu^H{}_{t-1} + \left(1 - \xi_L^{t-1}\right)\left(1 - \mu^H{}_{t-1}\right)} \qquad \text{(A6)}$$

Substituting (A6) back into (A5), we obtain the following restriction on beliefs:

$$\frac{\left(1 - \xi_H^{t-1}\right)\mu^H{}_{t-1}}{\left(1 - \xi_H^{t-1}\right)\mu^H{}_{t-1} + \left(1 - \xi_L^{t-1}\right)\left(1 - \mu^H{}_{t-1}\right)} \geq \mu_t^* \qquad \text{for all } t<F \qquad \text{(A7)}$$

The bank will want to maximize the probability that at each time t the high-risk firm will reveal her type. In other words, in the bank's preferred equilibrium, the constraint on beliefs (A7) will bind and the sequence of equilibrium beliefs $\{\mu^H{}_t\}$ can be determined by applying the binding constraints (A6) and (A7) recursively starting from prior beliefs $\mu^H{}_t$ and $(1-\mu^H{}_t)$.

What will be the interest rate the bank will charge to induce separation at time F in equilibrium ? It is easy to verify that the bank will not be able to induce full separation by offering $r_F = R_H$. This is because, faced with such an offer at time F, a high-risk firm will be better off "pretending" to be low risk. In fact, if she rejects it, the bank will conclude that she has revealed to be low-risk and the firm will therefore enjoy low interest rate offers at R_L ever after.

More precisely, in order to induce truthful revelation, the following incentive compatibility constraint needs to hold at time F:

$$R_{H,F} - r_F \geq \sum_{t=1}^{T-F} \delta_t^H \left(R_{H,t} - R_{L,t}\right) \qquad \text{(A8)}$$

The right-hand side represents the time-F value of all the rents that a high-risk firm would enjoy for all remaining periods after F, if she "pretends" to be low risk. The left-hand side reflects the 'carrot' that the bank needs to offer in order to induce a high-risk firm to truthfully reveal her type at time F. Solving for r_F , (A8) gives:

$$r_F \leq \left(R_H - \sum_{t=1}^{T-F} \delta_t^H \left(R_H - R_L\right)\right) \equiv R^* < R_H \qquad \text{(A9)}$$

It is easy to verify that $R^* < R_H$. On the other hand, the lower bound on r_F will naturally be R_L. In fact, if the bank charges anything lower than that, then it will not be able to achieve any separation, because in that case a low-risk firm will also accept ("take the money and run"). Optimally the bank will charge in equilibrium the highest r_F such that (A9) holds, i.e. $r_F = R^*$ while at the same time it must be that:

$$R^* > R_L \,. \qquad \text{(A10)}$$

Given the expression for R* in (A9), Equation (A10) requires that:

$$\sum_{t=1}^{T-F} \delta_t^H < 1 \qquad \text{(A11)}$$

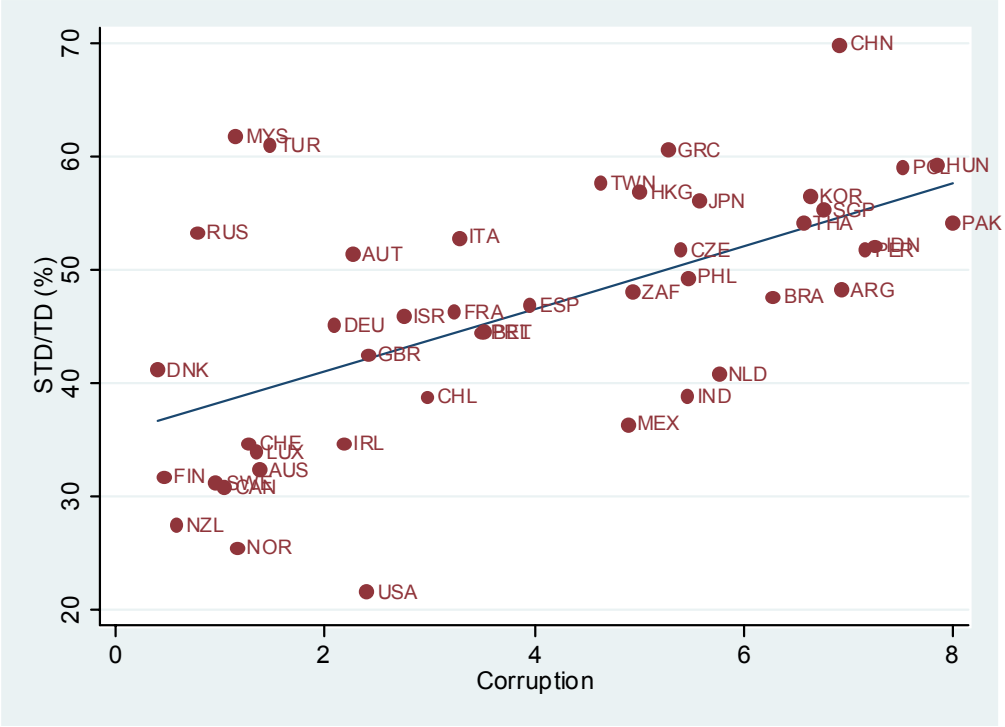
ie. separation is possible provided that discount factors for high-risk firms are sufficiently low (or equivalently their risk level q^H sufficiently high).

Table A1: Sample characteristics (average for the 1994-2004 period)

Country	Number of Years	Short-Term Debt /TD	Private Credit Bureau Cov.	Public Credit Registry Cov.	GDP Growth	Inflation
Argentina	11	48.3	49.8	15.3	2.0	4.7
Australia	11	32.4	74.3	0.0	2.9	2.6
Austria	11	51.4	31.5	0.8	1.9	1.8
Belgium	11	44.6	53.3	11.0	2.2	1.8
Brazil	11	47.7	43.7	3.4	3.1	44.8
Canada	11	30.8	82.4	0.0	3.4	2.0
Chile	11	38.8	22.6	21.5	4.8	4.4
China	11	69.9	0.0	0.1	9.0	3.9
Czech Republic	6	51.7	14.6	0.3	2.6	5.3
Denmark	11	41.2	5.9	0.0	2.0	2.2
Finland	11	31.7	10.1	0.0	3.4	1.4
France	11	46.3	0.0	1.2	2.2	1.6
Germany	11	45.2	70.8	0.4	1.3	1.5
Greece	11	60.6	8.8	0.0	3.0	5.2
Hong Kong, China	11	56.9	23.8	0.0	3.8	1.2
Hungary	7	59.3	1.2	0.0	3.5	12.8
India	11	38.8	0.0	0.0	5.0	6.3
Indonesia	11	52.1	0.0	0.2	3.3	13.6
Ireland	11	34.6	75.5	0.0	6.4	3.0
Israel	11	45.9	0.7	0.0	1.3	5.6
Italy	11	52.9	43.0	5.6	1.7	2.7
Japan	11	56.0	76.2	0.0	1.3	0.0
Korea, Rep.	11	56.5	80.7	0.0	5.6	3.9
Luxembourg	1	33.9	50.0	0.0	3.5	1.9
Malaysia	11	61.8	46.1	12.6	5.6	2.5
Mexico	11	36.4	34.7	0.0	2.9	14.6
Netherlands	11	40.9	54.0	0.0	2.3	2.3
New Zealand	11	27.5	83.3	0.0	2.3	2.1
Norway	11	25.4	94.9	0.0	2.6	2.1
Pakistan	11	54.1	0.3	0.0	1.3	7.1
Peru	7	51.8	14.2	9.6	4.2	5.7
Philippines	11	49.3	0.9	0.0	4.0	6.1
Poland	5	59.1	38.0	0.0	4.3	10.7
Portugal	11	44.5	2.9	50.9	1.9	3.3
Russia	6	53.3	0.0	0.0	2.2	48.9
Singapore	11	55.3	49.6	0.0	5.3	1.1
South Africa	11	48.0	48.4	0.0	3.1	6.4
Spain	11	46.9	5.0	31.3	2.5	3.2
Sweden	11	31.2	53.4	0.0	2.9	1.2
Switzerland	11	34.6	18.3	0.0	1.3	0.8
Taiwan, China	11	57.6	3.5	0.0	4.8	1.3
Thailand	11	54.1	10.2	0.0	3.3	3.4
Turkey	11	61.0	19.3	0.4	4.0	60.8
United Kingdom	11	42.5	68.4	0.0	2.9	2.7
United States	11	21.6	82.7	0.0	3.4	2.5
Average	10.2	46.1	33.3	3.7	3.2	7.9

Figure A1: Short-term debt and country risk

This figure presents the average short-term debt to total debt ratios (STD/TD) of firms in each country for the 1994-2004 period. The Y-axis is STD/TD. On the X-axes are variables capturing country risk.



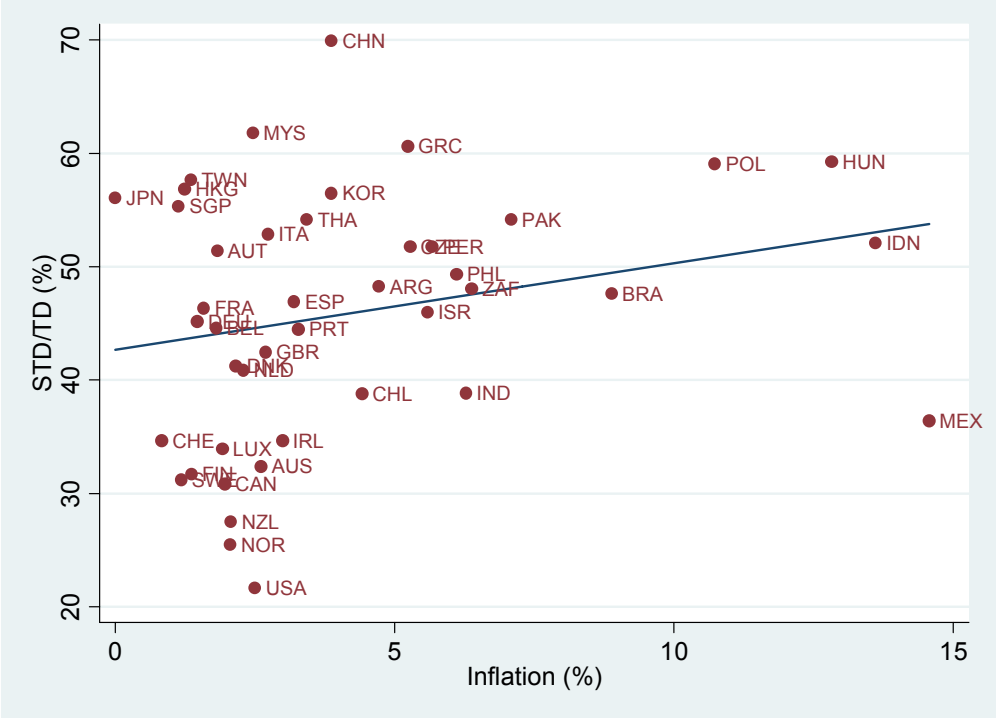


Figure A2: Short-term debt and microeconomic risk

This figure presents the average short-term debt to total debt ratios (STD/TD) of firms in each country for the 1994-2004 period. The Y-axis is STD/TD. On the X-axes are variables capturing microeconomic risk.