Financial Development, Default Rates and Credit Spreads*

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Abstract

This paper documents a diverging trend between rising corporate default rates and constant Baa-Aaa credit spreads in the US economy, from 1950 to 2012. Over the last thirty years, average corporate default rates increased by 467% while credit spreads hardly moved. We present a dynamic equilibrium model where the development of credit markets can be accounted for this empirical evidence. Financial development increases both the default rates of the economy and the expected recovery rates of the firms. These two effects offset each other and translate into constant credit spreads. In the model financial development explains 64% of the rise in default rates and predicts just a 2 basis point increase in the credit spreads. Furthermore, the model quantitatively accounts for a number of trends that characterized public firms over the last decades: the fall in the number of firms distributing dividends, the rise in the degree of dividend smoothing, and the increase in the volatility of public firms.

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1 Introduction

We study the joint dynamics of corporate default and credit spreads over the last 60 years, from 1950 to 2012. We document that, over the last thirty years, defaults rates rose by 467% while credit spreads barely moved. We refer to this evidence as the diverging trend between rising default rates and constant credit spreads.

We provide statistical support of a structural break in the unconditional mean of default rates around 1984. This date splits the series of default rates in two samples with visible different characteristics. On one hand, during the 1950's and 1960's the US economy recorded almost no bankruptcies: the average default rate from 1950 to 1983 equals 0.3%. On the other hand, from the 1980's on we observe a dramatic rise in the number of defaults: the average number of corporate bankruptcies from 1984 to 2012 equals 1.7%. This translates into a 467% increase of default rates throughout the last thirty years. Conversely, the time series of credit spreads does not display any structural shift in its unconditional mean. The average credit spread over the period 1950-1983 records 91 basis points whereas the average spread from 1984 to 2012 amounts to 102 basis points. We run a battery of tests and show that this 11 basis points increase is statistically not significant.

At a first glance, it is hard to reconcile the different behavior of default rates and credit spreads. Anecdotal evidence would suggest the two time series to move together. The credit spread is a market measure of default risk and for this reason it should capture relevant information about default rates[1]. Therefore, such a steep rise in default rates should allegedly be mirrored by credit spreads. However it does not.

To understand this phenomenon, we propose an explanation based on a structural change in the supply side of credit. Although we acknowledge that changes in financial factors, such as shocks to liquidity or to the credit ratings, could account for this diverging trend, we provide a theory that is based just on fundamentals. We conjecture that the widely documented process of deregulation and innovation incurred by the financial sector in the 70s might have produced a reduction in the cost of borrowing which in turn might explain

[1] Longstaff et *al.* (2005) document that 71% of the Baa yield is explained by default risk.

this empirical evidence. Apropos, we construct a dynamic equilibrium model where the development of credit markets and limited enforceability of debt can be accounted for the diverging trend between default rates and credit spreads. We model the development of credit markets in reduced form, as an exogenous reduction of the fixed cost of borrowing. We find that financial development can explain 64% of the observed increase in average default rates and predicts just a 2 basis points increase in the credit spreads. As a robustness check, our explanation quantitatively accounts for a number of trends that have characterized public firms over the last decades: the fall in the number of firms distributing dividends, the rise in the degree of dividend smoothing, and the increase in the idiosyncratic volatility of public firms.

In order to illustrate the model mechanism let us first discuss the implications of the main friction in our economy: limited enforceability of debt contracts. In the model there is a distribution of heterogeneous firms that can default on their debt. In such an event the credit intermediary seizes the assets of the firm. This environment generates endogenous borrowing constraints which depend on the level of capital of the firm, its idiosyncratic efficiency and the demanded amount of debt. In particular, firms with less collateral face tighter constraint because upon default credit intermediaries incur in higher losses. Secondly, less efficient firms face tighter borrowing constraints because they have a higher probability to default in the next period[2]. Finally, larger loans increase the probability of default, by raising the number of scenarios where the firm will not be able to repay its debt. Accordingly, the interest rate which is charged on the loan by the credit intermediary reflects these different determinants of the expected default cost. In conclusion, large or efficient firms can borrow more (or borrow the same quantity at a cheaper price) with respect to ceteris paribus smaller or less efficient ones. In addition to these features, we assume the presence of a fixed borrowing cost that further reduces the financing ability of all firms, hitting disproportionately small firms.

Now, what happens with the development of the credit markets? What happens when

[2]Since the idiosyncratic shock is persistent, their actual status predicts their future productivity. If we assume independent idiosyncratic productivity shocks, the borrowing constraint would not depend on the actual efficiency of the firm.

fixed cost of borrowing are reduced? A reduction in the fixed cost of borrowing has both direct and indirect effects. The *direct effect* is straightforward and two-fold. First of all, there is a reduction in credit rationing. Firms can now benefit from the possibility of accessing small amount of loans, before unfeasible because of the presence of a fixed borrowing cost[3]. Secondly, firms can either raise the same amount of debt at a cheaper price or, equivalently, access at the same price an higher amount of loan (just reallocating the resources before devoted to the payment of the borrowing cost to increase the amount of actual loan). The *indirect effect* is the result of the dynamic response of firms to the new environment. To understand it, we need to look more closely at the optimising behaviour of a firm in presence of endogenous borrowing constraints. In our model firms maximise the expected discounted value of the stream of dividends. Given the presence of endogenously convex loan price schedules, despite being risk neutral the value function of a firm is concave. For this reason, firms seek to smooth dividends against idiosyncratic shocks. Debt is a channel for doing it. Nonetheless the higher is the fixed borrowing cost, the tighter is the borrowing constraint, and, accordingly, the more difficult is for the firm to use efficiently debt for this purpose. In order to partially overcome this obstacle, for a given level of fixed cost of borrowing, firms try to build up physical capital. Physical capital is in fact the collateral against which firms can borrow at a cheaper price. The result is that, for precautionary motive, firms which have been lucky tend to build up more physical capital than what might be motivated by efficiency reasons. Therefore, the higher the level of fixed cost of borrowing, the higher the amount of physical capital devoted for this purpose (the collateral value of capital decreases with the fixed cost of borrowing). Conversely, firms which have not been lucky/small firms, given the high cost of debt, struggle to optimally exploit profitable investment opportunities. As a conclusion in this economy inefficiently large firms coexist with small firms which struggle to grow.

By reducing the fixed cost of borrowing, financial development significantly affects those

[3] For example, suppose that before the credit market development a firm optimal loan (given the interest rate) was 100$ gross of the borrowing cost, and suppose that the cost of the borrowing process was 200$. The cost of the process is higher than the total amount of the loan required, therefore the firm would have not entered that contract. After financial development, there will be less firms constrained in this fashion.

dynamics. Firms can now access more debt and more efficiently. Efficient small firms can finance more investment and grow, while inefficient firms can now reduce their size without being penalized as much as before on their interest rates, due to the lack of collateral. For the same reason, there is a reduction of the size of inefficiently large firms, due to the higher value of collateral. As a consequence, given the higher collateral value of capital, firms can borrow more debt for the same amount of capital, implying an increase in leverage. Together with an higher volatility of debt, this implies an higher volatility of leverage. In this way, it becomes more likely that firms end up in states of the world where they find optimal to default, pushing up the overall default rate of the economy.

Why the rise in default risk does not translate in an increase of the credit spreads? This question requires a quantitative answer, because the change in credit spreads is driven by two counteracting forces which exert their influence through three channels: the fixed cost of borrowing, the quantity of risk and the loss given default for the credit intermediaries.

On the one hand, rising default rates increase the quantity of risk bore by credit intermediaries with the consequence that credit spreads have to rise too. On the other hand, there are two channels through which financial development reduces the credit spreads: the fixed cost of borrowing and the loss given default. First of all, ceteris paribus financial development reduces by construction the fixed cost of borrowing (and therefore the interest rate charged on the loan). The impact on the interest rate is stronger the higher is the expected probability of default of the firm, contributing to the reduction of the credit spread. Secondly, and more importantly from a quantitative point of view, financial development make less stringent the borrowing constraint through the indirect channel we documented above. This translates into larger average size and profits, and turns into larger ex-ante liquidation values in case of default. This channel tempers the loss given default for the credit intermediaries, pushing down credit spreads. In the model, financial development makes default to rise from 0.3% to 1.2%. Yet, credit spreads rise just by 2 basis points because the higher default risk is offset by a 24% upsurge in the median expected recovery rate. The bulk of this increase comes from a boost in the profits of the firm, which go up by 21.73%. The median size of capital rise too, by 9.34%.

The model also predict a number of trend that characterized public firms over the recent decades. First, we show that the reduction of the fixed credit costs changes firms' optimal decisions of dividend payout. After financial development, firms are in fact more able to smooth dividends over time, they can trade off this reduction in volatility with a decrease in the level of dividends. As a result of financial development, the measure of firms distributing dividends shrinks down by 34%. This number accounts for the 73% of the decline documented for the U.S. by Fama and French (2001). Furthermore, in the model the median degree of dividend smoothing increases of a magnitude which is remarkably close to the values estimated by Leary and Michaely (2011). Second, we study the volatility of firms' returns and sales. Indeed, Campbell et *al.* (2001), Comin and Mulani (2006), Comin and Philippon (2006) show the presence of a secular upward trend in the volatilities of firms. We suggest that this empirical evidence can be (at least partially) accounted for by financial development. Indeed, the model is able to reproduce a rise of 72 % in the volatility of sales and 67% for firms' returns.

1.1 Related Literature

This paper adds to the literature on the role of credit markets on firm dynamics. The seminal paper in this field is Cooley and Quadrini (2001), which augments the environment of Hopenhayn (1992) with financial frictions, namely an equity issuance and a bankruptcy deadweight loss. The authors present a model where the dynamics of firms, in terms of growth, job reallocation and exit, is negatively correlated with their initial size and age, as it is in the data. Following Cooley and Quadrini (2001), many papers attempted to understand qualitatively and quantitatively the role of financial frictions on firm characteristics, firm dynamics and the behavior of macroeconomic aggregates. Jermann and Quadrini (2012) show how the limited enforceability of firms' debt might generate endogenous borrowing constraints, which affects not only the dynamics of individual firms, but even the behavior of aggregate financial and real variables. Jermann and Quadrini (2006) use a similar model to show that financial development can be accounted for the rise in volatility of aggregate financial variables and the decline of the volatility of real economic activity. All these models share a common feature: despite firms are allowed to renege on their debt, there is no default in equilibrium. This result stems from the presence of an enforcement constraint, which binds in equilibrium, impeding the firms to default. The existence of enforcement constraints generates in fact arbitrage opportunities which could be exploited by the credit intermediaries. As a consequence, recently, few papers have relaxed this condition allowing for equilibrium default. Arellano et *al.* (2011) build a general equilibrium model which allows for equilibrium default, where financial frictions interact with increases in uncertainty at the firm level to generate a contraction in the economic activity. Khan et *al.* (2012) and Gomes and Schmid (2010a) instead use equilibrium default to show that credit shocks account for a sizable part of the business cycle fluctuations and generate recessions similar to the recent financial crisis of 2007-2009. Finally, Gomes and Schmid (2010b) develop a model with equilibrium default to explain the relationship between firms' leverage, book assets and stock prices.

Despite the different panorama of questions involved, these papers share the same idea on the role of equilibrium default. In all of them, equilibrium default is just a financial friction, valued in the extent in which is able to produce dynamics which are relevant for investigating phenomena other than default. In other words, it is the instrumental nature rather than the default phenomenon *per se* to be appraised. This paper reverse this logic. In particular it contributes on the literature investigating the phenomenon of corporate default *per se*. In so doing, we restrict our attention on the relationship between the magnitude of default in the economy (default rate) and the price of risk which is associated to it (credit spreads). From a modeling point of view, this paper builds on Arellano et *al.* (2012), despite the emphasis of the two paper is on completely different questions. In particular, Arellano et *al.* (2012) focus on the role of financial development on firm dynamics, showing how financial development reduces the differences in leverage and growth rates among large and small firms.

In conclusion, despite this paper is the first documenting the diverging trend between the rise in corporate default rates and constant credit spreads, the increase in default rate is not a new stylized fact. Among others, Campbell et *al.* (2008) show that corporate bankruptcies have increased by 150% or 300%, depending on how default is measured. A similar upward trend is instead found by Livshits et *al.* (2010) in the consumer bankruptcies in the United States. They show that, from 1970 to 2002, personal bankruptcies in the United States have increased by around 500%, which is analogous to the number we report on corporate bankruptcies.

2 Data

In this section we document the diverging trend between rising corporate default rates and constant credit spreads from the period 1950-2012. This empirical evidence builds upon the contribution of Giesecke et al. (2011) in the measurement of the average default rates and credit spreads of the economy.

2.1 Corporate Default Rates

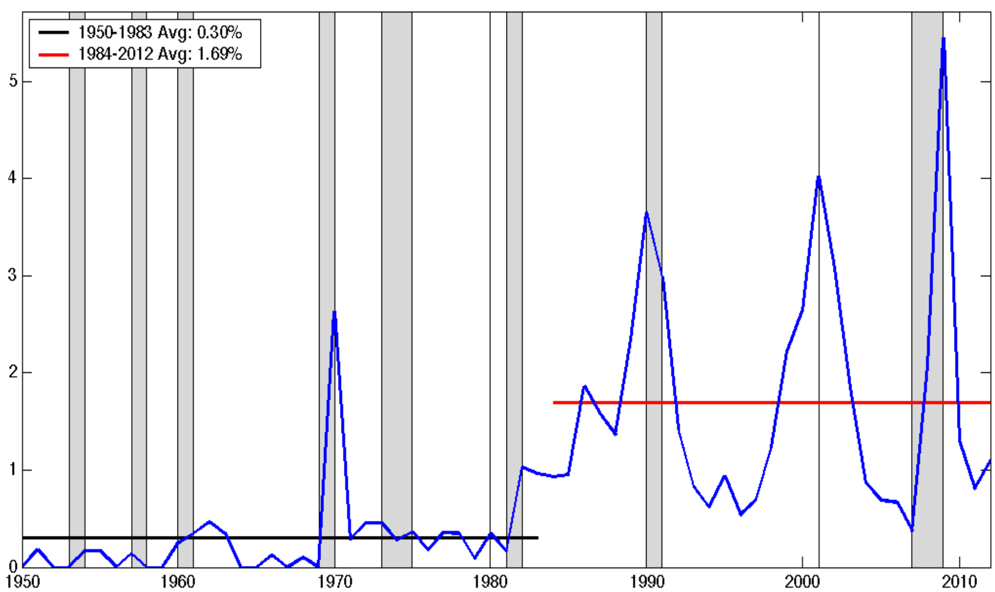
We take the data on US public firms corporate default rates from the Moody's Analytics Default and Recovery Database. The data set covers the credit experiences of over 18,000 corporate issuers that sold long-term public debt at some time between 1920 and 2012[4]. An appealing feature of the Moody's data is given by its rather broad definition of default: it does not include just Chapter 7 and Chapter 11 bankruptcies, but also missed payments and changes in the payment terms of a credit agreement. We think this is the most relevant definition of default for our analysis, which focuses on economic consequences of default[5]. Figure 1 displays the annual default rates for U.S. public corporate firms from 1950 to 2012. Visual inspection of the picture foregrounds a dramatic upsurge in default rates starting from the 1980's on, following a period of almost no default in the 1950's and 1960's. To test for the presence of a break in the data generating process behind the times series of

[4] As of January 1, 2012 approximately 5,000 corporate issuers held a Moody's long-term bond, loan, or corporate family rating.

[5] Indeed, financial intermediaries care about the ultimate economic consequence of a delinquent loan, and not about the form of legal bankruptcy or informal default that the debt obligation might have turned into.

corporate default rates we apply the Bai and Perron (1998)'s SupLR test statistics. This procedure checks the presence of multiple structural changes, occurring at random dates. The test statistic is obtained by running an OLS regression. We test for the existence of at most three break dates. Following Carvalho and Gabaix (2013), we assume that every date T lies in a range $[T_1, T_2]$, with $T_1 = 0.2n$ and $T_2 = 0.8n$, where n denotes the sample size. The choice of a 20% trimming parameter avoids size distortions due to the serial correlation in the data. As a data generator process for the default rates, we consider

Figure 1: Corporate Default Rate



a first order auto-regressive model plus a constant. We run two different test to check for a break in the constant and a joint break in the constant and in the auto-regressive coefficient. Table 2 shows that we reject the null hypothesis of no break for both cases at a 5% significance level. Either case, the SupLR test statistic indicates the existence of a single break, which is estimated at 1983 and 1984. We find statistical evidence of these breaks even after controlling for lagged GDP growth rates. These tests tell us that default rates *did* change their dynamics in the early 1980's. Hereafter, we follow the vast literature on the Great Moderation[6] that indicates the existence of a break in the volatility of US GDP growth around 1984. We will then compare two intervals of time, one going from 1950 to 1983 and the second from 1984 to 2012[7]. In Table 2 we report the mean values of the corporate default rates over the two intervals of time. Default rates rose from an average value of 0.3% during the period 1950-1983 up to 1.7% over the last thirty years. This corresponds to a 467% increase in average default rates. Surprisingly, this number almost equals the 500% increase in consumer bankruptcy documented over the same time period by Livshits et *al.* (2010).

Break Test for Default Rates		
	$Default_t = a + \rho Default_{t-1} + \epsilon_t$	
	H_0: No break in a	H_0: No break in a and ρ
SupLR stat	8.70	18.14
5% Critical values	8.22	10.98
Null of no break	Reject	Reject
Est. break date	1983	1984

Table 1: Break Test for Default Rates

Average Default Rates		
1950-1983	1984-2012	Δ 1984-2012/1950-1983
0.3%	1.7%	+467%

Table 2: Mean Values of Default Rates

[6] See for example Stock and Watson (2002) and Carvalho and Gabaix (2013).
[7] The results of the paper do not change when considering 1983 as the break date.

2.2 Credit Spreads

We measure the intensity of corporate default risk using the default rates of the public firms in the economy. Accordingly, we would need an analogous measure of the average price of bond risk. Unfortunately, such a series does not exist. As in Giesecke et al. (2011), we choose the series of spread of a hypothetical average bond, which is considered to be within the Aaa and the Baa credit rating. Therefore, we compute the spreads as the difference between Moody's Baa and Aaa Seasoned corporate all firms bond yields, and available at the FRED database[8]. Our implicit assumption is that the Baa bond proxies for the risky asset in the economy and the Aaa bond is the risk-free asset.

We argue that this credit spread is the relevant measure for this analysis. First of all, Baa and Aaa rated corporate bonds belong to the investment-grade class. This class is the most representative form of corporate bond in terms of bond issuance[9] (supply side) and have peculiar liquidity properties[10]. The fact that both the risky asset and safe asset belonging to the same class, allows us to control (in the data) for common shift in the supply of liquidity for investment-grade bonds (demand side).

The reason why we preferred the Aaa corporate bond to the Treasury-Bill yield as a proxy of the risk-free rate is manifold. First of all, we study the relation between the dynamics of corporate default and the risk-based-differential in the firms cost of financing. Accordingly, an homogeneity argument would support the choice of a *firm* safe corporate bond yield as a proxy of the risk free rate. Moreover, our explanation of the joint dynamics is based on a structural break in the *firms* cost of financing. While we can empirically support that financial development has affected the *firms* cost of debt financing, we cannot claim the same for the government cost of debt financing. Therefore we would unsoundly model the impact on a leg of the credit spread, missing the fact that financial development affect both the cost of risky firm and *safe* firms. Secondly, we can safely affirm that Aaa corporate

[8] For more information about the series, see Appendix B.3.

[9] Investment grade bonds account for 2/3 for issuance volume in 1996, and more than 90% in 2006, Bessembinder Maxwell (2008) p. 28.

[10] "For regulated financial service firms, such as banks and life insurance companies, required reserves are greater for noninvestment grade bonds. Further, many financial institutions, including pension and mutual funds, face restrictions on amount of non-investment grade debt they can hold". Bessem- binder Maxwell (2008) p. 5.

bonds and Treasury Bills are different securities. Apart from sharing the same rating class, they do not have much in common: they display different market microstructure, taxation, and they are exposed to different sources of risk[11]. All these aspects translate in an average credit spread between Aaa bonds and Treasury Bills amounts to 84 basis points (bp) over the period 1950-2012, which cannot be explained by a simple default risk story we are proposing here[12] .

Figure 2 plots our series of credit spreads, measured in basis points. We can observe how credit spreads were low in the 1950's and 1960's, before peaking up to 232 bp in the 1982. From the 1980's on, credit spreads have been declining to values comparable to the one of 1950's and 1960's. Concomitant with the last financial crisis, credit spreads hike up to 199 bp in the 2009.

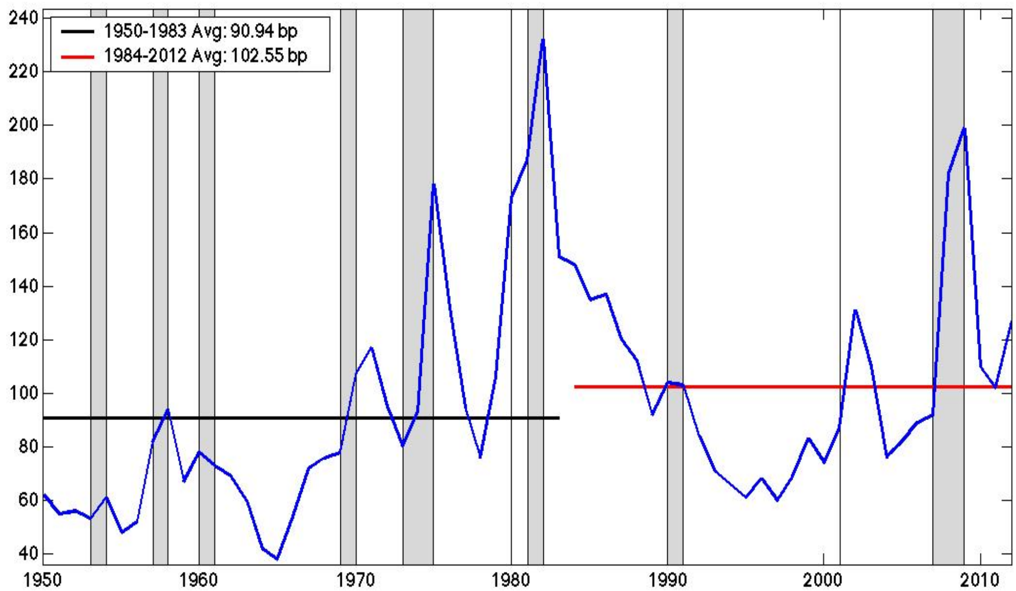
As above, we apply the Bai and Perron (1998)'s test to check for structural changes in the credit spreads. Again, to comply with the assumption of the Bai-perron test, we proxy the credit spreads process as a first-order auto-regressive model plus a constant, and - in conclusion - we test whether there is a break either just in the constant or both in the constant and the auto-regressive parameter. Table 3 shows that we cannot reject the null of no break in either cases. Controlling for lagged GDP growth rates, testing for breaks using quarterly data and using the Chow test with 1983 or 1984 as pre-determined break date does not alter our finding[13]. Table 4 reports the mean values of the credit spreads over the two periods of interest, 1950-1983 and 1984-2012. From the 1950's to the 1970's, the

[11]First, Corporate bonds are (an order of measure) less liquid than Treasury bill. The Treasury bill Average Daily Trading Volume in the U.S. Bond Markets in 2001 amount to 297.9$ billions compared to only 17.9$ billions for the whole corporate bond sector. In 2006 the volumes of T-bill almost doubled (524.7$), while the volumes of corporate bonds raises only to 22.7$, see Bessembinder and Maxwell (2008, p. 29). Second, Corporate bond yields are subject to state taxation, while U.S. Treasury securities are exent. Longstaff (2011) shows that tax risk is an important determinant in the pricing of assets. Third, other than the common default risk and liquidity risk, sovereign bonds present a sizeable recovery rates risk. Due to the high uncertainty which characterise enforcement of international debt contracts sovereign bonds display a sizeable heterogeneity in the recovery rates. For example, the credit loss of the 1983-1986 debt restructuring in Argentina was 30%, while the one of the 2001-2002 crisis amounted to 72%. The other major sovereign default crisis, which involved Russia in the August of 1998, was characterized by a credit loss of 63%.. On the contrary, recovery rates of Moody's Aa and Baa corporate bonds are stable around 40%, see Moody's (2012, p.26)

[12]Huang and Huang (2002) show that the expected Aaa-Treasury Bill spread should be around 1 bp, given the 0.03% expected 5-year average cumulative credit loss of Aaa corporate bonds.

[13]We apply the Chow test to quarterly data using as a pre-determined data any quarter between 1982:1 and 1984:1, and in all cases we reject the presence of a break at the 5% significance level.

Figure 2: Credit Spreads



average value of the credit spread was 91 bp. This average barely changed over the following three decades, reaching 102 bp. On the ground of the evidence provided by the break tests, we interpret this 11 bp increase as statistically not significant. To check whether these 11 basis points are economically significant, we do the following. First of all, in line Giesecke et *al.* (2011) we use a back-to-the-envelope estimate of the average annual credit losses, assuming 40% recovery rate[14]. We find that a 1.4% increase in default rates should have pushed up credit spreads by 84 bp (compared to 11bp). Secondly, despite the record of default in the recent financial crises (5.45%), the credit spread reached a peak of 199 bp, which was lower than the global maximum over the over-all period in consideration, 232 bp, reached in 1982 (before the break) with a default rate of *only* 1.16%. This over period max-max comparison provides further economical support of our claim that something has structurally changed in the dynamics of default rates and credit spreads.

[14]The back-to-the-envelope estimate multiplies the physical probability of default to the expected loss upon default. We consider a 40% recovery rate, which is the average senior unsecured recovery rates on investment grade bond and loans one year prior to default, 1982-2011. Statistics on speculative grade (37%) and all rated (37.43%) are close, see Moody's (2012, p.26). As a result, a 1% default rate translates into 60 basis points.

As a conclusion, the change in average credit spreads over the two periods is insignificant from both an economic and a statistical point of view.

Break Test for Credit Spreads		
	$Spread_t = a + \rho Spread_{t-1} + \epsilon_t$	
	H_0: No break in a	H_0: No break in a and ρ
SupLR stat	5.68	5.62
5% Critical values	8.22	10.98
Null of no break	Accept	Accept
Est. break date	-	-

Table 3: Break Test for Credit Spreads

Average Credit Spreads		
1950-1983	1984-2012	Δ 1984-2012/1950-1983
91 bp	102 bp	+11 bp

Table 4: Mean Values of Credit Spreads

2.3 Diverging Trend

In summary, starting from the early 1980's default rates rose by 467% while credit spreads kept constant. We refer to this evidence as the diverging trend between default rates and credit spreads. Longstaff et *al.* (2005) find that default risk explains 71% of the Baa bond yields. Therefore, a 467% increase in default rates should come at a neat rise in the credit spreads. In addition, even if actual average default rates in both periods are low in absolute value, such a steep increase in default rates should be mirrored in credit spreads for two reasons. First, Almeida and Philippon (2007) show that the risk-adjusted cost of default is four-five times larger than what the physical bankruptcy rates would suggest. This is because default is more likely to occur in bad times, which makes risk-averse agents to care more about financial distress than is suggested by physical credit losses. Second, though the average default in the last thirty years equals 1.7%, now financial distress has become more likely for the median firm too. In this sense, the rise in default rates cannot be diversified and should, therefore, be translated in the pricing of debt.

2.4 Financial Development

In this paper we quantitatively investigate how financial development can affect average default rates and credit spreads, by influencing the economic decision of all the firms. Following the seminal papers of King and Levine (1993) and Rajan and Zingales (1998), a vast literature attempted to study the interaction between financial development and the real economy, an idea that actually traces back to Schumpeter (1911).

We focus on the process of deregulation and innovation that characterized the financial sector during the 1970s. This decade saw the introduction, among others, of ATMs, phone transfers for savings balances at commercial banks, the International Banking Act, the modification on the Regulation Q on the banking system, the 1979 Bankruptcy Reform Act, the Financial Institutions Regulatory and Interest Control Act, the Electronic Fund Transfer Act, the 1979 Bankruptcy Reform Act, NOW (negotiable order of withdraw) accounts, the securitization of debt collateralization, the introduction of the Securities Protection Act and the introduction of Asset Backed Securities (ABS). ABS are securities whose value and income payments are derived from and collateralized by a specified pool of underlying assets. Recently, this instrument has became the first source of funding for U.S. corporate firms, undertaking corporate bonds.

The deregulation in the financial sector has improved the access to credit for corporate firms, especially the small ones, and decreased the cost of external financing. Nowadays firms can borrow more and cheaper than 30 years ago. This view is supported by the empirical evidence provided by Jayaratne and Strahan (1996) and Demyanyk et *al.* (2007), among others. Accordingly, in our analysis we will model financial development in a reduced form, as an exogenous reduction in the fixed costs of borrowing.

3 The Model

3.1 Environment

In the economy there are two types of agents: firms and credit intermediaries. Firms have decreasing returns to scale production technologies and experience in each period a persistent idiosyncratic productivity shock and an i.i.d stochastic fixed cost of operation. They are run by risk neutral managers which maximize the expected discounted stream of dividends. Firms articulate in two types: incumbents and entrants. At each point of time, there is a distribution of heterogeneous incumbents, which are defined as the producing firms of the economy. Incumbents finance investment and dividends using internal and external funds: retained profits, new equity issuance and one-period non-contingent loans from the credit intermediaries. Incumbents can renege on their obligations and default. The presence of default risk generates endogenous borrowing constraints for the firms and makes loans' interest rates to be firm-specific. Less efficient firms and/or firms with less collateral face tighter borrowing constraints and access to loans at higher interest rates than more efficient firms and/or firms with more collateral.

Every period a mass of firms enters the economy and starts the production with a time-to-build lag. Entrants solve a problem identical to the incumbents with the difference that they resort uniquely to external funds.

There is also a competitive financial sector. Each financial intermediary offers a menu of loan sizes and interest rates to firms wherein each loan makes zero expected profits. When a firm defaults, creditors can seize its assets and profits net of a liquidation loss.

3.2 Firms

In the economy there are two types of firms: incumbents and entrants. Henceforth we denote with the i subscript an incumbent firm, while e stands for an entrant firm. We omit the subscript when the distinction is not necessary.

Firms use capital $k \in \mathbf{K} \subset \mathbb{R}_+$ to produce an homogeneous consumption good $y \in \mathbf{Y} \subset \mathbb{R}_+$ using a decreasing returns to scale technology[15,16]

$$y = xk^\alpha \tag{1}$$

where $\alpha \in (0,1)$ captures the degree of concavity of the production function and x is an uninsurable idiosyncratic shock. The idiosyncratic productivity $x \in \mathbf{X} \subset \mathbb{R}_+$ follows a first-order Markov processes whose transition function is $p_x(x'|x)$. In each period firms incur in a stochastic fixed cost of operation. The operating profits before interest and depreciation are defined as:

$$\pi = xk^\alpha - \chi \tag{2}$$

where $\chi \in \chi \subset \mathbb{R}_+$ is the i.i.d. fixed cost of operation drawn from the cumulative distribution $H(\chi)$. This shock is intended to create a link between negative cash flows and the firms' decision of going bankrupt. Without this feature, firms would always have non-negative profits. However, in the data defaulting firms experience negative profits. Physical capital depreciates at a rate $\delta \in (0,1)$ and accumulates with the law of motion

$$k' = (1-\delta)k + i \tag{3}$$

where k and k' denotes, respectively, the actual and next period stock of physical capital and i is the capital investment.

Entrants finance dividends and investment with one-period non-contingent loans and

[15] Diminishing returns to scale at the firm-level may be explained with the span of control models of Rosen (1982) and Lucas (1978).

[16] Decreasing returns to scale technologies and perfect competition prevent the most productive firms from taking over the market completely and allow for the existence of heterogeneity in equilibrium. Since firms can be replicated, returns to scale are constant at the aggregate level.

new equity issuance. Incumbents can resort, in addition, to retained profits. Because of limited enforceability, firms can renege on their debt. Then, loan contracts depend on those firms' characteristics that are informative about the default probability and the loss given default. When an incumbent firm defaults, it partially meets its obligations with the creditors. In such a case, the firm is liquidated and the creditors seize both its profits and undepreciated capital

$$L(k,x) = \max\{(1-\psi)\left(\pi + (1-\delta)k\right), 0\} \tag{4}$$

suffering a liquidation clearance loss $\psi \in (0,1)$. The recovery rate is then $L(k,x)/b$, where b refers to the firm outstanding debt.

Every period, after observing the realization of the shocks, incumbents choose whether to enter into a one-period non-contingent loan contract. A contract formalizes in a 4-tuple (x_i, k'_i, l'_i, r'_i), which delivers a loan l'_i whose repayment value is $b'_i = (1 + r'_i)\, l'_i$, to firms with idiosyncratic efficiency x_i and future stock of physical capital k'_i. Contracts (x_i, k'_i, l'_i, r'_i) belong to a set of debt schedules $\Omega\,(x_i, k'_i, l'_i)$. This specification highlights the dependence of interest rates on three firms' *key characteristics*: 1) the productivity, 2) the size of assets and 3) the size of the loan. If the actual productivity is high, next period productivity is more likely to be high[17]. This decreases the probability of default and the interest rates. Similarly, firms with more capital have a larger collateral and therefore lower interest rates. Finally, larger loans increase the probability of default, implying a higher interest rate. It is worth noticing that the future levels of capital and outstanding debt are chosen at the same time, and they jointly determine the interest rate required by the credit intermediaries. Entrants face the same loan contracts with the difference that their debt schedules and interest rates do not depend on the idiosyncratic shock x_e.

Firms issue new equity when their dividends d are negative. The equity issuance comes at an additional proportional cost, $\gamma > 1$. The total cost of distributing dividends $d \in \mathbb{R}$ is

[17] This argument holds as long as firms' idiosyncratic productivity shocks are persistent. In case of i.i.d productivity shocks the interest rate would not depend anymore on the *actual* x, as it happens for the fixed cost shock χ.

then

$$g(d) = d\mathbb{I}_{\{d\geq 0\}} + (\gamma d)\mathbb{I}_{\{d<0\}}$$

where $\mathbb{I}_{\{y\}}$ is an indicator function that takes value 1 when y is true. The implication of the issuance cost is twofold. It prevents firms from distributing dividends and raising equity at the same time and it does not allow firms to issue as much equity as they need to circumvent the financial frictions due to bonds' limited enforceability[18]. Then, the equity issuance cost makes firms to prefer the use of retained profits and debt to equity, in accordance with the pecking order theory.

Firms can also save in the market portfolio of corporate bonds ($l' < 0$). Since the idiosyncratic uncertainty washes out in the aggregate, the gross return on the market portfolio of corporate bonds is the risk-free rate $1 + r_F$. Thus, the repayment value $b \in \mathbf{B} \subset \mathbb{R}$, is

$$b = \Big([1+r]\mathbb{I}_{\{l>0\}} + [1+r_F]\mathbb{I}_{\{l<0\}}\Big)l$$

3.2.1 Incumbents

An incumbent begins with an amount of net-wealth $\omega_i \in \mathbf{W} \equiv \mathbf{X} \times \mathbf{K} \times \chi \times \mathbf{B} \subset \mathbb{R}^3_+ \times \mathbb{R}$, which is a by-product of its holdings of physical capital and outstanding debt, that is

$$\omega_i = \pi_i + (1-\delta)k_i - \Big([1+r_i]\,\mathbb{I}_{\{l_i>0\}} + [1+r_F]\,\mathbb{I}_{\{l_i<0\}}\Big)l_i$$

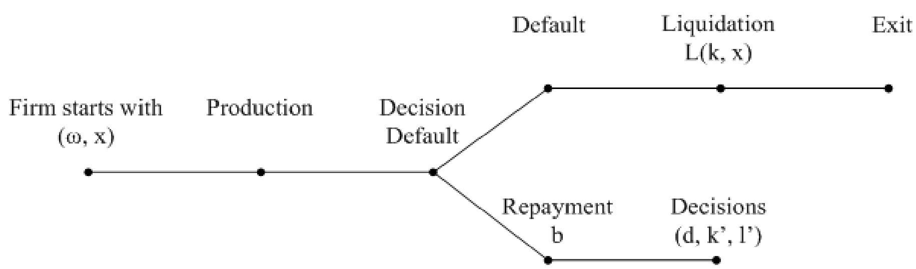
At each point of time, there is a large measure λ of incumbents, which are defined as the set of firms that either were operating or entered in the previous period. λ is the probability measure over (ω_i, x_i), defined on the Borel algebra J generated by the open subset of the product space $\mathbf{J} = \mathbf{W} \times \mathbf{X} \subset \mathbb{R}^4_+ \times \mathbb{R}$.

We assume that an incumbent first observes the realization of the idiosyncratic productivity shock x_i and the stochastic fixed cost of operation χ_i, and then produces. At this point, each firm maximizes the expected present value of future profits in a two stage

[18] The presence of the equity issuance cost and the bankruptcy deadweight loss make the Modigliani and Miller (1958) theorem not to hold in this framework.

decision problem. First, a firm decides whether to default or not. The default implies the exit of the firm and an outside opportunity of not operating equals zero. Therefore, firms default whenever their continuation value is negative. Second, if the firm does not default, it finances the entire value of its outstanding liabilities $(1 + r_i)l_i$, and decides the amount of dividends to distribute d_i, the new level of physical capital k'_i, and the new level of debt l'_i, given the debt schedules $(x_i, k'_i, l'_i, r'_i) \in \Omega(k'_i, l'_i, x_i)$. Figure 3 summarizes the timing of the model.

Figure 3: Timing of the Model



The states of the economy for an incumbent firm are, therefore, (ω_i, x_i). The incumbents' problem can be written as

$$V_i(\omega_i, x_i) = \max_{\phi_{D,i} \in \{0,1\}} (1 - \phi_{D,i}) V_i^c(\omega_i, x_i) \tag{5}$$

where $\phi_{D,i} = \phi_D(\omega_i, x_i)$ is an indicator function that takes value $\phi_{D,i} = 1$ in case of default, and $V_i^c(\omega_i, x_i)$ denotes the continuation value of an incumbent firm which does not default,

$$V_i^c(\omega_i, x_i) = \max_{d_i, k'_i, l'_i} d_i + \beta \mathbb{E}_{H(\chi'_i), x'_i | x_i} \Big[V_i(\omega'_i, x'_i) \Big] \tag{6}$$

$$\text{s.t. } g(d_i) = \omega_i + l'_i - k'_i$$

$$\omega'_i \equiv \omega'_i(k'_i, l'_i, x'_i, \chi'_i) = \pi'_i + (1 - \delta)k'_i - \Big(\left[1 + r'_i\right] \mathbb{I}_{\{l'_i > 0\}} + \left[1 + r_F\right] \mathbb{I}_{\{l'_i < 0\}} \Big) l'_i \tag{7}$$

$$\big(x_i, k'_i, l'_i, r'_i\big) \in \Omega(k'_i, l'_i, x_i) \tag{8}$$

where: 1) β denotes the subjective time discounting rate of the firm's manager; 2) $\mathbb{E}_{H(\chi_i'),x_i'|x_i}$ denotes the expected value over the independent processes of χ_i' and x_i', where the realization of x_i' is conditional on x_i; 3) equation (7) denotes the law of motion of firm's net worth. ω_i' is a random process which inherits the first-order Markov property from the idiosyncratic productivity shock x_i', augmented by the independent i.i.d process of χ_i'. Formally ω_i' follows the transition function $p(x_i'|x_i)H(\mathrm{d}\chi_i')$[19].

Analogously to the analysis of entry and exit in Hopenhayn (1992), we can describe the optimal default policy as a threshold on the idiosyncratic productivity shock. Here the definition of the threshold is complicated by the dependence of the continuation value of the incumbents on both[20] the idiosyncratic productivity shock and the wealth. Using the weakly increasing property of the continuation value on both arguments, Khan et *al.* (2012) prove that for each level of ω_i there exists a schedule $\underline{x}_i = x(\omega_i)$ such that a firm with net-wealth ω_i defaults if and only if its productivity is lower than $\underline{x}_i$. Such a threshold $\underline{x}_i$ is defined as the value of x wherein $V^c(\omega_i, \underline{x}_i) = 0$.

Likewise, it might be shown that when firms default, their net-wealth is negative. Intuitively, when the net-wealth is non-negative, a firm is always able to pay back the debt without resorting to any additional external fund. In turn, this implies that the liquidation value (4) which the creditors seize out of defaulted firms is always less than the due repayment values of the loans. This result guarantees that creditors always incur in a loss when firms default.

Before concluding, it is worth noticing that the negative net-wealth is a necessary but not sufficient condition for the firm to default. Indeed, a firm with negative net-wealth can find optimal not to exit and decide to issue equity and roll over debt to fund its operations.

3.2.2 Entrants

The model features exogenous entry. At each point of time there is a mass Ξ_t of firms which enters in the economy, merely substituting the measure of firms which default. Production

[19] Where we assume that the pdf of $H(\chi_i')$ exists and it is atomless.

[20] In Hopenhayn (1992), the continuation value depends only on the productivity shock.

takes place with a lag, as a time-to-build restriction. The entrants begin the period with an amount of physical capital k_e. They then decide the amount of dividends to distribute d_e, the new level of physical capital k'_e, and debt l'_e (or savings if $l'_e < 0$) with $(k'_e, l'_e, r'_e) \in \Omega(k'_e, l'_e)$ to maximize the expected present value of future profits. The entrants can also decide to raise equity at the proportional cost γ. Once entrants have solved for their optimal choices, they draw next-period idiosyncratic shock x'_e from a cumulative distribution $G(x'_e)$. The state of the economy for an entrant is then k_e. Hence, the entrants' problem can be written as

$$V_e(k_e) = \max_{d_e, k'_e, l'_e} d_e + \beta \mathbb{E}_{H(\chi'_e), G(x'_e)} \Big[V_i(\omega'_e, x'_e) \Big] \tag{9}$$

$$\text{s.t. } g(d_e) = k_e + l'_e - k'_e$$

$$\omega'_e \equiv \omega'_i(k'_e, l'_e, x'_e, \chi'_e) = \pi'_e + (1-\delta)k'_e - \Big(\left[1 + r'_e\right] \mathbb{I}_{\{l'_e > 0\}} + \left[1 + r_F\right] \mathbb{I}_{\{l'_e < 0\}} \Big) l'_e \tag{10}$$

$$\left(k'_e, l'_e, r'_e\right) \in \Omega(k'_e, l'_e) \tag{11}$$

3.3 Credit Intermediaries

In the economy there is a competitive financial sector which lends to firms (or borrows from firms, in case they save). The credit intermediaries offer a menu of loan sizes and interest rates, wherein each loan makes zero profits. For each loan the intermediaries have to pay a *fixed cost* ζ. As suggested by Arellano et *al.* (2012), the fixed credit cost can be interpreted as any financial intermediation cost that creditors incur when issuing a loan, as costs to obtain information about firms' default probability and overhead costs. The higher the value of ζ, the larger the costs firms incur in borrowing from the credit intermediaries, the less developed is the financial sector of the economy. Following Arellano et *al.* (2012), we consider this cost as a proxy for financial development.

The credit intermediaries price firms bonds by defining debt schedules which contingent on firm characteristics. The latter captures the probability of default and the amount of insurance in case of default. Formally, the credit intermediary offers a set of incumbent-specific contracts $(x_i, k'_i, l'_i, r'_i) \in \Omega(k'_i, l'_i, x_i)$ which read: in absence of arbitrage opportunities, the incumbent-specific (x_i, k_i') interest rate r_i' associated to a required amount of loan l_i' is defined by the zero profit (break-even) condition of the intermediaries $\Omega\left(k_i', l_i', x_i\right)$:

$$\left(l_i' + \zeta\right)\left(1 + r_F\right) = \mathbb{E}_{H(\chi_i'), x_i'|x_i}\Big[(1 - \phi_{D,i})(1 + r_i')l_i' + \phi_{D,i}L(k_i', x_i')\Big] \tag{12}$$

where ζ denotes the fixed cost of borrowing and $L(k_i', x_i')$ is the liquidation value of the firm in case of default, as defined in (4). In case of an entrant, the mapping is identical but for the expectation, which is taken unconditionally over the idiosyncratic shock x_e.

The availability and the interest rates of each loan depend on the default risk, on the amount of insurance provided by the expected liquidation value and on the borrowing costs ζ. While the first two channels generate endogenous borrowing constraints which are firm specific, the presence of fixed credit costs limits all firms access to credit. As pointed out above, the fixed cost has a further asymmetric effect: small and less efficient firms suffer disproportionately more from it.

4 Characterization of the Equilibrium

4.1 Definition of Equilibrium

A recursive equilibrium in this economy is given by the optimal choices of the incumbents $(\phi_{D,i}, k_i', l_i', d_i)$, optimal choices for the entrants (k_e', l_e', d_e), an exogenous risk-free rate r_F and the firm-specific contracts $(x_i, k_i', l_i',\ r_i')$, $(k_e', l_e',\ r_e')$, such that:

1. given the exogenous risk-free rate r_F, the firm-specific contracts $(x_i, k_i', l_i',\ r_i')$, $(k_e', l_e',\ r_e')$ satisfy the zero ex-ante profit condition of the credit intermediary (12)[21], for any choice of (k_i', l_i') and (k_e', l_e');

2. given the exogenous risk-free rate r_F and the firm-specific contracts $(x_i, k_i', l_i',\ r_i')$, the incumbent firms choose $(\phi_{D,i}, k_i', l_i', d_i)$ to maximize their problem described in (5);

[21] Recall the variant of the zero ex-ante profit condition of the credit intermediary (12) for the entrant requires to use in the expectation the unconditional distribution $G(x_e')$ to determine the next period idiosyncratic shock.

3. given the exogenous risk-free rate r_F and the firm-specific contracts (k'_e, l'_e, r'_e), the entrant firms choose (k'_e, l'_e, d_e) to maximize their problem described in (9);

4. given the exogenous risk-free rate r_F, the firm-specific contracts (x_i, k'_i, l'_i, r'_i), (k'_e, l'_e, r'_e), the optimal choices of the incumbents $(\phi_{D,i}, k'_i, l'_i, d_i)$ and the optimal choices for the entrants (k'_e, l'_e, d_e), the law of motion of the distribution of firms is given by

$$
\begin{aligned}
\lambda(\omega'_i, x'_i) = & \int (1 - \phi_{D,i})\, Q\left((\omega'_i, x'_i), (\omega_i, x_i)\right) H(\chi') p_x\left(x'_i | x_i\right) \lambda(\mathrm{d}\omega_i, \mathrm{d}x_i) \\
& + \int \phi_{D,i} Q_e\left(\omega'_e, x'_e\right) H(\chi'_e) G\left(x'_e\right) \lambda(\mathrm{d}\omega_i, \mathrm{d}x_i)
\end{aligned}
$$

where $Q\left((\omega'_i, x'_i), (\omega_i, x_i)\right)$ denotes a transition functions such that

$$
Q\left((\omega'_i, x'_i), (\omega_i, x_i)\right) = \begin{cases} 1, & \text{if } \omega'_i(\omega_i, x_i) = \omega'_i, \;\; x'_i(x_i) = x'_i \\ 0, & \text{if } \; \text{otherwise} \end{cases}
$$

The same applies to $Q_e(\omega'_e, x'_e)$.

4.2 The Role of Financial Development

In this section we investigate analytically the effect of changes in the borrowing cost ζ. The idea is to isolate in the simplest framework the effects of financial development on the borrowing constraints, and the leverage in the economy. We consider a simple economy without uncertainty, where there is a continuum of firms which are born with different idiosyncratic productivity $\bar{x}_i$, henceforth constant. Incumbents do not suffer stochastic fixed cost of operation. Entrants are endowed with no capital and debt. Output is produced using capital, which fully depreciate each period. Firms cannot save or issue equity. The following Propositions follow the results in Arellano et *al.* (2012). The interested reader can refer to Appendix A for the detailed proofs.

Proposition 1. *In this economy there is a unique equilibrium which is characterized as* *follows. In equilibrium:*

1. *The policy functions of the firms are constant,* ($\phi^*_{D,i}$, k'^*_i, l'^*_i, d^*_i)
2. *Firms do not default.* $\phi^*_{D,i} = 0$
3. *Firms can borrow at the risk free rate, corrected for the fixed cost of borrowing. In formula:*

$$(1 + r^*_i)l^*_i = (1 + r^*)l^*_i + (1 + r^*_i)\zeta \tag{13}$$

4. *Firms demand capital up to equalize their marginal product to the risk-free interest rate. Let me name this level of capital as the first-best level of capital,* $k_{fb,i}$*:*

$$k_{fb,i} = \left(\frac{\alpha \bar{x}_i}{1 + r_i}\right)^{\frac{1}{1-\alpha}} \tag{14}$$

   Notice there is a one-onto-one increasing relationship between $k_{fb,i}$ *and* $\bar{x}_i$*.*

5. *Firms are subject to endogenous borrowing constraints.*

The endogenous borrowing constraints arise from the necessity of making *incentive compatible* for the firms not to default. In particular:

Proposition 2. *A no defaulting equilibrium strategy for a firm i is sustained for level of debt* $l^*_i \in [0, l_{D,i}]$*, where* $l_{D,i}$ *represent the equilibrium firm-specific debt limit and it is defined as:*

$$l_{D,i} = \frac{1 + r_i - \alpha}{r_i \alpha} k_{fb,i} - \frac{(1 + r_i)}{r_i}\zeta \tag{15}$$

We name this level of debt, firm specific debt-limit, and it is defined as the level of debt for which it is incentive compatible for the firm not to default.

The endogenous nature of the debt-limit rationalizes the label endogenous borrowing constraint. Proposition 3 investigates the sensitivity of $l_{D,i}$ to financial development and (through the optimal choice of capital), to the level of idiosyncratic productivity of the firms.

Proposition 3. *In equilibrium:*

- $\frac{\partial l_{D,i}}{\partial \zeta} = -\frac{1+r_i}{r_i} < 0$*: the debt-limit is increasing in the level of financial development. The lower the level of financial development (the higher is* ζ*), the lower is the level of debt for which the firm is indifferent whether to default or not.*

- $\frac{\partial l_{D,i}}{\partial k_{fb,i}(\bar{x})} = \frac{1+r_i-\alpha}{r_i\alpha} > 0$*: the debt-limit is increasing in the optimal choice of capital, which depends uniquely on the original idiosyncratic efficiency. Then, the higher is the idiosyncratic productivity, the higher is the debt limit.*

In equilibrium the leverage evaluated at the debt-limit can be expressed as:

$$lev_i = \frac{l_{D,i}}{k_{fb,i}} = \frac{1+r_i-\alpha}{r_i\alpha} - \frac{(1+r_i)}{r_i}\frac{\zeta}{k_{fb,i}} \tag{16}$$

Similarly to what we have just done, Proposition 4 explores the sensitivity of the leverage, lev_i, to financial development.

Proposition 4. *In equilibrium:*

- $\frac{\partial lev_i}{\partial \zeta} = -\frac{1+r_i}{r_i}\frac{1}{k_{fb,i}} < 0$*: the leverage is strictly increasing in the level of financial development. The more developed is the credit intermediation (the lower is the* ζ*), the higher is the equilibrium leverage of the firms.*

- $\frac{\partial lev_i}{\partial k_i^{fb}(\bar{x})} = \frac{1+r_i}{r_i}\frac{\zeta}{(k_{fb,i})^2} > 0$*: the leverage is strictly increasing in the amount of capital. The higher is the productivity of a firm, the higher is the optimal level of capital, the higher is the equilibrium leverage.*

5 Quantitative Analysis

In this section we study the quantitative implications of financial development on the joint behavior of default rates and credit spreads and on other relevant dynamics of the US economy. To that end, we compute two equilibria whose parameters differ only for the value of the fixed borrowing costs. The first equilibrium is calibrated to proxy the behaviour of some relevant facts of the US economy over the period 1950-1983. The second equilibrium approximates the US economy over the period 1984-2012; it takes as given the estimated and calibrated parameters from the first period *but* for the fixed costs of borrowing, which are lowered. In line with the calibration strategy adopted by Buera and Shin (2013)[22], to discipline this cut we match the higher leverage of the firms over the period 1984-2012. As mentioned above, the decline in the fixed cost of borrowing is a reduced form way of modelling financial development[23]. This modelling strategy allows to isolate and study the implications of financial development, and to test whether it might have been a relevant structural explanation of the diverging trend puzzle observe in the data.

5.1 Calibration

We calibrate the model over the period 1950-1983. In the model, one period corresponds to one year.

5.1.1 Uncertainty in the Economy

In order to proceed we need to impose more structure on the stochastic properties of the uncertainty in the economy: the idiosyncratic productivity shock and the stochastic fixed cost of operation. The idiosyncratic productivity shock of the incumbents follows an AR(1) process, such that

$$x_t = \rho_x x_{t-1} + e_t, \quad e_t \sim N(0, \sigma_e^2) \tag{17}$$

In the context of the calibration, we transform (17) into a discrete-state Markov chain, with 9 points in the support, using the standard Tauchen (1986) algorithm. Then, we assume the distribution $G(x)$ from which the entrants draw their first realization of the idiosyncratic shock is a Pareto distribution with exponent c. The choice of such a distribution is in accordance with the empirical evidence that the firms' size distribution is very heavy tailed, see Gabaix (2011) among others. Finally, we assume that the stochastic costs of operation follows an i.i.d. process, where $H(\chi)$ is modeled as a Bernoulli random variable which takes

[22] Buera and Shin (2013) studies the role of financial frictions on the so-called miracle economies. In their calibration, the authors pin down the exogenous size of financial development by matching the evolution of external finance to GDP ratios in the data.

[23] Other examples of models where financial development is modeled as an exogenous reduction of the economy's financial frictions are Buera et *al.* (2011) and Arellano et *al.* (2012).

the value χ with probability p_χ and the value 0 with probability $1 - p_\chi$.

5.1.2 Estimated Parameters

Table 5 reports the values of the estimated parameters, and the source whence are taken. We set the parameters governing the decreasing returns to scale of the firms' production function to $\alpha = 0.65$, following Gomes and Schmid (2010b) and Arellano et *al.* (2012); this value is on the lower bound of reasonable parameters for the Cobb-Douglas production function. The depreciation rate of capital is set to 10%, following most of the literature on the real business cycles. Instead, the bankruptcy deadweight loss is set to $\psi = 30\%$, as in Gomes and Schmid (2010a). This is in line with the findings of Warner (1977), who estimates that the direct and indirect costs associated to corporate bankruptcy equal 30% of the book value of the firm. The risk-free interest rate is set to $r_F = 0.4$ according to the actual value of the annual real interest rate in the United States from 1950 to 1983. As in Arellano et *al.* (2012), we set the subjective discount rate parameter $\beta = 0.9605$. This value is slightly lower than its frictionless equilibrium value of $\frac{1}{1+r_F}$, as a proxy of the impatience of the risk neutral manager. Since there is notax deducibility for interest rate payments, this feature is necessary to give firms an incentive to borrow. The value of the autoregressive parameter is $\rho_x = 0.80$. This value is taken from Foster et *al.* (2008), who estimate the production function and the Solow residual at the firm level. The value of the equity issuance costs $\gamma = 0.35$ is taken from Cooley and Quadrini (2001). Instead, we choose a Pareto exponent of 2 in line with the evidence of Axtell (2001) and Gabaix (2011) that the distribution of firm size is very heavy tailed, with an estimated exponent close to 1. Finally, we follow Armenter and Hnatkosvka (2012) and set the probability of the operational cost to be 6%, which matches the transition rate from positive to negative cash flows observed in the data.

	Firms	
$\alpha = 0.65$	Production Function Returns to Scale	Arellano et *al.* (2012)
$\delta = 0.10$	Capital Depreciation	Arellano et *al.* (2012)
$\psi = 0.30$	Bankruptcy Deadweight Loss	Gomes and Schmid (2010a)
$r_F = 0.04$	Real Risk-Free Interest Rate	Data (see Appendix B.4)
$\beta = 0.96$	Time Discounting Parameter	Arellano et *al.* (2012)
$\rho_x = 0.80$	Idiosyncratic Shock Persistence	Foster et *al.* (2008)
$\gamma = 0.35$	Equity Issuance Cost	Cooley and Quadrini (2001)
	Incumbents	
$p_\chi = 0.06$	Probability Operational Cost	Armenter and Hnatkosvka (2012)
	Entrants	
$c = 2$	Pareto Exponent	Axtell (2001)

Table 5: Estimated Parameters

5.1.3 Calibrated Parameters

The remaining parameters are calibrated in order to match targets which are computed over the horizon 1950-1983, consistently with the timing of the structural break in the model. There are four parameters to be calibrated: σ_e, the standard deviation of the idiosyncratic productivity shock, χ, the value of the stochastic costs of operation, ζ, the borrowing fixed cost and k_e, which is the endowment of capital for an entrant. Therefore, we need four targets. In principle, these targets should be statistics able to capture relevant information about the process driving the phenomenon of default in the US economy. In this spirit, we choose: 1) the average ratio of debt over asset, b_i/a_i, where the assets in the model are given by $a_i = x_i k_i^{\alpha} + k_i$, 2) the cross-sectional standard deviation of the average ratio of debt over asset, 3) the average default rate from 1950 to 1983 and 4) the growth rate of entrants. The value of the last target is taken from Arellano et *al.* (2012). All the other targets are computed using Compustat data, as described in Appendix B.

Results of the calibration. Table 6 shows the value of the calibrated parameters while Table 7 compares the targets in the data with the one provided by the moments of the model. The stochastic operational cost is calibrated to $\chi = 9$. In relative terms, it represents 9% of the assets of the median firm. As far as the targets are concerned, on one hand, the average debt to asset ratio in the model is slightly overestimated at 0.29, compared to the actual value in the data of 0.24. In the model, firms borrow a little too much. On the other hand, the cross-sectional standard deviation of the ratio is much closer to the actual one, with a value of 0.17 compared with the 0.16 in data. The average default rate is perfectly matched: in the model the 0.3% of the firms defaults, as it is in the data. This is a successful matching since it is well known that models with equilibrium default struggle in providing quantitatively reasonable amount of default in the economy. (As instance, in Arellano et *al.* (2012), the average default rate implied by the model is zero). Conversely, this model does not suffer the same weakness. The reason of this relevant difference rests on the introduction of the stochastic fixed cost of operation. Finally, we perfectly match the growth rate of the entrants.

Parameter	Description
$\sigma_e = 0.65$	Standard Deviation Idiosyncratic Shock
$\chi = 9$	Stochastic Operational Cost
$\zeta = 0.60$	Borrowing Fixed Costs
$k_e = 145$	Capital Entrants

Table 6: Calibrated Parameters

Target	Data	Model
Average Debt to Asset Ratio	0.24	0.29
Standard Deviation of Debt to Asset Ratio	0.16	0.17
Average Default Rate	0.3%	0.3%
Growth Rate Entrants	0.95%	0.95%

Table 7: Targets

5.2 Results: Financial Development and the Diverging Trend

We study the quantitative implications of financial development on the dynamics of default rates and credit spreads. To that end, we exogenously cut from 0.6 to 0.4 the fixed borrowing costs calibrated in the first equilibrium. We discipline this reduction by matching the higher ratio of total debt to asset observed over the period 1984-2012. This structural change leads a median firm leverage ratio of 0.36 in the second equilibrium, close to the 0.33 measured in the data. To confirm the plausibility of the magnitude of these values, note that the ratio of the fixed borrowing costs over the loan value for the median firm is 0.5% in the first equilibrium and 0.13% in the second equilibrium. Those figures are in line with the results in Altinkilic and Hansen (2000), which study a panel of 628 industrial firms from 1990 until 1997 and find that the fixed cost of debt issuance for public debt equals on average around 0.1% of the debt principal. As a byproduct, this result provides a robustness check of the consistency of our calibration.

Hereafter, we refer to the (first) equilibrium with borrowing fixed costs of $\zeta_1 = 0.6$ as the *pre*-1984 steady-state, and the (second) equilibrium with borrowing fixed costs of $\zeta_2 = 0.4$ as the *post*-1984 steady-state.

Table 8 reports the quantitative predictions of the model and the effects of financial development on default rates and credit spreads. The model successfully explains the dramatic rise in default rates. The *post*-1984 steady-state is characterized by an average default rate of 1.2%, implying a 300% increase between the two periods. Therefore, financial development accounts for the 64% of the total increase of default rates observed since the early 1980's. This result uniquely stems from the *interplay* between financial development and the stochastic fixed cost of operation. On the one hand, the reduction in the fixed cost of borrowing tempers the non-linearities of the value function of the firms[24], making the debt a cheaper source of financing. As a result, efficient firms can finance through debt investment and build a more efficient size; conversely, inefficient firms can disinvest part of their capital, without being penalized as much as before due to the lack of collateral. Then,

[24] In particular, it decreases the marginal utility cost of increasing debt, where utility is measured in terms of expected discounted feature profits.

Moment	***pre*-1984**	***post*-1984**	**Δ *post*-1984/*pre*-1984**
Fixed Borrowing Cost			
Model	0.6	0.4	-33%
Data	-	-	-
Median Debt to Asset Ratio			
Model	0.29	0.36	24%
Data	0.24	0.33	37%
Aggregate Default Rate			
Model	0.3%	1.2%	300%
Data	0.3%	1.7%	467%
Aggregate Credit Spread			
Model	75bp	77bp	2bp
Data	91bp	102bp	11bp
Median Expected Recovery Rate			
Model	37%	46%	24%
Data	–	–	–

Table 8: Predictions of the Model

the reduction of the fixed cost of borrowing increases the average firm's indebtedness and volatility. On the other hand, given the higher collateral value of capital, firms can borrow more debt against the same amount of capital, implying an increase in leverage. Together with an higher volatility of debt, this implies an higher volatility of leverage. Indeed, the median firm leverage goes up from 0.29 to 0.36, while its volatility rises from 0.17 to 0.20. Thence, it becomes more likely that firms end up in states of the world where they find optimal to default, pushing up the overall default rate of the economy.

Yet, the idiosyncratic productivity shock alone is not sufficient to imply the default of the firms. This is a consequence of the persistency property of the idiosyncratic productivity shock process and the forward-looking nature of the borrowing constraint. In particular, the persistent nature of the shock makes it highly predictable. A fortiori since the shock is highly persistent, the intermediary anticipates that a low-efficient firm will keep being inefficient in the next period, and, therefore, curtails the amount of loans for which the firm might find tempting to default. Intuitively, this is the reason at the base of the failure experienced by equilibrium default models in providing default in equilibrium. On the other hand, the rare event (small probability) and unpredictable (i.i.d) nature of the stochastic operational cost provides a modeling expedient for introducing a significant amount of unpredictable uncertainty in the economy, which eventually produces defaults in equilibrium.

On the other side of the picture, Table 8 reports a 2 bp increase in the credit spread, in line with the empirical evidence. From the point of view of the magnitude, average credit spreads in both equilibria are around 20 bp *lower* than the real ones, which are around 90 bp. This result is not a surprise. Traditionally, macro-models have been having hard time in provide quantitatively reasonable credit spreads. Indeed, Chen et *al.* (2009) stress how models which are not able to provide sizable equity premium would never be able to predict the right amount of credit spreads, linking the equity premium puzzle to what they call the credit spread puzzle. In order to overcome these difficulties and match the level of credit spreads, we should add aggregate uncertainty in the model, as in Chen (2010). This would add countercyclical default, countercyclical price of risk and procyclical liquidation values, which, in turn, would deliver sizable credit spreads.

Table 8 shows that the model *does* predict the dramatic rise in default rates and the constancy of credit spreads. What is the rationale for this result? The answer to this question is purely quantitative, and stems from the magnitude of three counteracting effects that financial development has on credit spreads. To clarify this point, let us restate Equation (12) as

$$l_i'(1+r_F) + \underbrace{\zeta(1+r_F)}_{\text{Fixed Cost Channel}} = \mathrm{E}_{H(\chi_i'),x_i'|x_i}\Big[\underbrace{(1-\phi_{D,i})(1+r_i')l_i' + \phi_{D,i}}_{\text{Default Risk Channel}} \underbrace{L(k_i',x_i')}_{\text{Insurance Channel}}\Big]$$

When pricing a debt, the credit intermediaries evaluate the fixed cost of issuing a loan (*fixed cost channel*), the probability of default of the firm (*default risk channel*) and the amount of insurance provided by the liquidation value in case of default (*insurance channel*).

As seen before, financial development increases (on average) the probability of endogenous default. Therefore, in absence of any form of insurance in case of default, credit spreads would have to increase, tracking monotonically the rise in default rates observed in the data. Nonetheless, there are two channels through which financial development reduces the credit spreads: the fixed cost of borrowing and the loss given default. First of all, financial development reduces by construction the fixed cost of borrowing (and therefore the interest rate charged on the loan). The impact on the interest rate is stronger the higher is the expected probability of default of the firm, contributing to the reduction of the credit spread. Secondly, financial development increases (on average) the liquidation value. Because of the reduction in the financial frictions in the economy, firms behave more optimally (literally, firms are less constrained in their optimization decisions) and increases their size of operation. As a consequence, firms (on average) produce higher profits and have a larger size. To attach some numbers on these dynamics, in the model firms' median profit and median size increase, respectively, by 21.73% and 9.34% when passing from the *pre*-1984 to the *post*-1984 equilibrium. Both these two components enter the definition of the liquidation value $L(k_i', x_i')$, and increase the insurance component of the credit spread. Indeed, the expected recovery rate hikes up by 24%, from a value of 37% in the first equilibrium to a value of 46% in the second one. Ergo, financial development produces (on average) a dramatic increase in the liquidation value which offsets the increase in the probability of default, producing just a 2 bp increase in the credit spreads in the second equilibrium.

5.3 Further Results

In the model, financial development is able to account for a number of trends - other than the rise in default rates - which characterized public firms over the last decades. Namely, the model gives relevant predictions on the number of firms distributing dividends, the way firms decide to smooth these dividends over time, and the level of firms' volatility.

5.3.1 Dividend Payout.

First of all, the way firms pay dividends has substantially changed over time. As reported by Fama and French (2001), the number of firms distributing dividends was 66.5% in the 1978. Instead, in 1999 only the 20% of firms does it. Second, Leary and Michaely (2011) show that firms have constantly increased the way they smooth dividends over time.

We use the model to check whether financial development can account for these changes in the dynamics of dividends.

In the model, credit frictions affect the optimal dividend payout of the firms. Indeed, although the objective function of the firms is linear, due to the presence of endogenous price schedules their value functions are strictly concave. Therefore, when deciding the value of dividends to distribute, firms trade off level with volatility. In the first equilibrium, credit frictions are tight and firms cannot smooth dividends as they wish. This extra volatility is then compensated by a higher level of dividends. When financial development tempers the credit frictions of the firms, they become better able at insuring dividends from the effects of the persistent idiosyncratic shocks. Hence firms change their payout policy by increasing the smoothing of dividends while reducing their average level. As shown in Table 9, because of financial development the number of firms distributing dividends shrinks down by 34%. This mechanism explains then 73% of the decline in the number of firms paying dividends observed in the data. Meanwhile the degree at which firms smooth dividends rise substantially. For measuring the degree of dividend smoothing, we follow Lintner (1956) by estimating the following regression

$$\Delta d_{i,t} = d_{i,t} - d_{i,t-1} = \alpha + \beta_1 d_{i,t-1} + \beta_2 y_{i,t} + \epsilon_{i,t}$$

where $d_{i,t}$ denotes the dividend of the i-th firm in time t, while $y_{i,t}$ is the value of the firm's sales. We then estimate the speed of adjustment of dividends by $-\hat{\beta}_1$. When this value equals 0, dividends are perfectly smoothed and follow a random walk. As reported in Table 9, in our model financial development makes the estimated speed of adjustments to decline from 0.43 to 0.22, which implies a substantial increase in the degree of firms' dividend smoothing. These values provided by the model are remarkably close the estimates of Leary and Michaely (2011), which find an estimated speed of adjustment of about 0.3 during the 1960's and 1970's and about 0.2 for the most recent years.

5.3.2 Firm Volatility.

Campbell et *al.* (2001) provide evidence on an upward trend in the volatility of firms' return, which has more than doubled from the 1960's untill the late 1990's. Comin and Mulani (2006) and Comin and Philippon (2006) find that the idiosyncratic volatility of firm's sales and employment experienced an analogous increase. All these papers conjecture the origin of such trends and suggest that increased competition, R&D innovations, changes in the corporate governance of the firms and the institutionalization of equity ownership could have spurred the volatility of firms. Here we show that financial development could have been another source of such steep increases of volatility. Actually, in the model the rise in the volatility of firms' sales and returns is the other side of the coin of the evidence reported above on dividends. Indeed, firms achieve a higher degree of dividend smoothing by increasing the volatility of their debt, which in turn spurs the fluctuations in investment, and eventually firms' sales and returns. We compute our measure of volatilities as in Comin and Mulani (2006), as

$$\sigma(x_{i,t}) = \sqrt{\frac{\sum_{\tau=t-4}^{t+5} (x_{i,\tau} - \bar{x}_i)^2}{10}}$$

where $\bar{x}_{i,}$ is the average of the variable $x_{i,t}$ between the periods $t-4$ and $t+5$. In what follows, we compute the volatility of two variables:firms' sales $y_{i,t}$ and firms' cum dividend returns $ret_{i,t} = \frac{V(\omega_{i,t}, x_{i,t}) + d_{i,t}}{V(\omega_{i,t-1}, x_{i,t-1})}$. The bottom of Table 9 shows that, in the model, the median volatility of sales rise from a value of 0.14 to 0.24, and the one of returns from 0.12 to 0.20. Therefore, financial development causes an increase in the volatility of firms' sales and returns which equals 72% and 67%, respectively.

Average Credit Spreads			
	1950-1983	1984-2012	Δ 1984-2012/1950-1983
N. Firm Paying Dividend	58.2%	38.4%	-34%
Degree Speed of Adjustment	0.43	0.22	-49%
Firm Volatility			
	1950-1983	1984-2012	Δ 1984-2012/1950-1983
Median Sales Volatility	0.14	0.24	72%
Median Return Volatility	0.12	0.20	67%

Table 9: Results on Dividend Payout and Firm Volatility

6 Conclusion

In this paper we document a diverging trend between default rates and credit spreads in the US economy over the last 60 years. On one hand, the (average) corporate default rate rose from an average of 0.3%, during the period 1950-1983, to a value of 1.7% over the period 1984-2012. On the other hand, the (average) credit spreads barely moved, recording a 11 basis point increase. We run a battery of tests to show that this movement in credit spreads is statistically insignificant. Therefore, over the last three decades, default rates experienced a 467% increase, while credit spreads kept constant. Hence, nowadays corporate bankruptcies are more and more frequent than thirty years ago, but this came at no effect on the average borrowing cost.

We present a dynamic equilibrium model with heterogeneous firms where the development of credit markets and limited enforceability of debt contracts can be accounted for the diverging trend between rising default rates and constant credit spreads. We model the development of credit markets through an exogenous reduction of fixed costs of borrowing, as a reduced form for the development of the U.S. financial system during the 1970's and 1980's.

The predictions of the model are quantitatively appealing. Financial development accounts for the 64% of the rise in the default rates, which is accompanied by an increase in credit spreads of just 2 basis points. Indeed, the reduction in the fixed borrowing costs make debt cheaper: Firms can access larger loans to invest more in capital and grow up in size. At the same time, firms that become inefficient can disinvest without being as penalized as before in their interest rates, due to the lack of collateral. So, the volatility of investment goes up, just because debt becomes more volatile too. Hence, financial development increases the level of debt, its volatility and makes eventually default more likely. On the other hand, credit spreads barely move because the insurance channel due to the financial development prevails on the default risk channel. Indeed, if on one side the cut in the borrowing fixed costs increases (on average) the endogenous probability of default in the economy, on the other side it reduces (on average) the wedge between the actual firms' optimal choices and the frictionless ones. As a consequence, financial development increases both the median size of capital by 9.34% and median profits by 21.73%. The upsurge in the expected liquidation value of the firms offsets the dramatic rise in default rates, leaving the credit spreads unchanged.

Furthermore, we show that in the model financial development can account for a number of trends - other than the increase in default rates - that characterized public firms in the last thirty years. First, we show that the reduction of the fixed credit costs changes firms' optimal decisions of dividend payout. Since firms are now better able to smooth dividends over time, they can trade off this reduction in volatility with a decrease in the level of dividends. As a result of financial development, the measure of firms distributing dividends shrinks down by 33%. This number accounts for the 73% of the decline documented for the U.S. by Fama and French (2001). Furthermore, in the model the median degree of dividend smoothing increases of a magnitude which is remarkably close to the values estimated by Leary and Michaely (2011). Second, we study the volatility of firms' returns and sales. Indeed, Campbell et *al.* (2001), Comin and Mulani (2006), Comin and Philippon (2006) show the presence of a secular upward trend in the volatilities of firms. We suggest that this empirical evidence can be (at least partially) accounted for by financial development. Indeed, the model is able to reproduce a 72% in the volatility of sales and a 67% for firms' returns.

As a last remark, in this paper all the action and the difference over time in the dynamics of real and financial variables is due to financial development. Yet, we model it as an exogenous reduction in the fixed costs of borrowing. In line with the mechanism described in this paper, in Peri and Rachedi (2013) we show that the way the bankruptcy procedure is legally formalized in a country can endogenously affect in equilibrium its credit costs. We leave further analysis on how the 1970's financial developments spilt over the real economy as a future avenue of research.

7 References

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A The Role of Financial Development

Assumptions 1. *Let us assume the following:*

1. $\delta = 1$*: full depreciation. This assumption implies that capital is not anymore a state.*
2. $\psi = 1$*: full clearance loss which implies no liquidation value.*
3. $x_i = \bar{x}_i$*: each firm initially experiences (is endowed with) a different idiosyncratic shock, henceforth constant. For example, firms are born of a particular type, where the type captures different levels of productivity.*
4. *Firms do not suffer the stochastic fixed cost of operation.*
5. *Firms cannot issue equity.*
6. *Entrants are endowed with no debt and no capital.*
7. *The subjective time discounting parameter* β *equals* $\frac{1}{1+r_F}$.

Under these assumptions, operating profits and the firm net-worth reduces to:

$$\pi_i = x_i k_i^\alpha$$
$$w_i = \pi_i - (1 + r_i)l_i$$

Let us now characterize the equilibrium properties of this economy. Since there is no uncertainty in the model, in equilibrium the firms optimal policies are constant, (ϕ_D^*, k'^*, l'^*, d^*). In principle there are two putative equilibria where firms choose with probability one to default ($\phi_D^* = 1$) or not to default ($\phi_D^* = 0$). On one hand, we can show that the defaulting equilibrium is not an equilibrium for the firm. The proof is trivial and is made by contradiction.

Proof. Let us assume that a firm defaults in equilibrium; this means that it exits without distributing any dividend. This strategy violates the profit maximizing condition. We can find a feasible strategy that delivers an higher payoff. In particular not defaulting, producing at the first best level of capital each period, distributing the rest in dividend (without using debt) is a feasible strategy with constant policies which provides an higher payoff. □

On the other hand we can show that the No-Defaulting equilibrium holds only for a bounded set of loans. Despite the proof is more involved, the intuition is straightforward. An increase in the accorded level of debt increases the incentive for the firm to deviate from the equilibrium policy of not defaulting, distributing a big dividend in the current period and defaulting the period later. In particular in what follows we will show that there exists a threshold value of debt, $l^*_{D,i}$ above which firms will find optimal to deviate from the no default equilibrium strategy. Let us prove it.

Proof. The proof articulates as follows:

1. Proposition 5 states the zero-profit condition of the intermediary under Assumptions 1
2. We plug the result of Proposition 5 in the problem of the incumbents and we find the optimal policy of capital
3. We define the incentive compatibility constraint of the firm given the above policy functions
4. We define from the incentive compatibility constraint of the firm the debt-limit

Proposition 5. *Under Assumptions 1, the equilibrium zero profit condition* $(l^*_i, r^*_i) \in \Omega(l^*_i, \bar{x}_i; \lambda)$ *can be rewritten as:*

$$(1 + r^*_i)l^*_i = (1 + r^*)l^*_i + (1 + r^*)\zeta \tag{18}$$

Proof. The credit intermediary zero profit condition reduces to:

$$\begin{aligned} l_i' + \zeta &= \frac{\mathrm{E}_{x'|x}\Big[(1-\phi_{D,i})(1+r_i)l_i' + \phi_{D,i}L(k')\Big]}{1+r} \\ l_i' + \zeta &= \frac{(1-\phi_{D,i})(1+r_i')l_i' + \phi_{D,i}L(k')}{(1+r)} \\ l_i' + \zeta &= \frac{(1-\phi_{D,i})(1+r_i')l_i'}{(1+r)} \end{aligned}$$

The first step is a result of the absence of idiosyncratic uncertainty while the second one comes from the absence of liquidation value. Since we showed before that the firm does not default in equilibrium, the equilibrium level of debt obeys:

$$l_i^* + \zeta = \frac{(1+r_i^*)l_i^*}{(1+r^*)} \tag{19}$$

which concludes the proof.

□

Hence the firms in equilibrium can borrow at the risk free rate, corrected for the fixed cost of borrowing. This result stems from the fact that firms do not default in equilibrium. However, this result does not imply that firms can borrow as much as they want. This point is made clear following the proof.

In order to derive further insights on the firms optimal behaviors let's analyze the problem of the incumbents. Under Assumptions 1 it reduces to:

$$\begin{cases} V_i = \max\limits_{\{k_i', l_i'\}} d_i + \dfrac{1}{1+r} V_i(x_i'; \lambda') \\ \text{s.t} \quad d_i = \bar{x}_i k_i^{\alpha} - k_i' + l_i' - (1+r_i) l_i \\ \qquad \big(l_i', r_i'\big) \in \Omega(l_i', \lambda) \end{cases}$$

Substituting the zero profit condition (18):

$$\begin{cases} V = \max_{\{k_i', l_i'\}} d_i + \frac{1}{1+r} V_i(x_i'; \lambda') \\ \text{s.t} \quad d_i = \bar{x}_i k_i^\alpha - k_i' + l_i' - (1+r) l_i - (1+r)\zeta \end{cases}$$

The first order necessary conditions reads:

$$1 = \frac{\alpha \bar{x}_i (k_i')^{\alpha-1}}{1+r} \qquad (k_i)$$
$$1 = \frac{1+r}{1+r} \qquad (b_i)$$

from which we obtain:

$$1 + r = \alpha \bar{x}_i (k_i')^{\alpha-1} \qquad (k_i)$$

Hence in equilibrium firms can equal their marginal product to the risk free rate, choosing the first best level of capital:

$$k^* = k_{fb,i} = \left(\frac{\alpha \bar{x}_i}{1+r} \right)^{\frac{1}{1-\alpha}} \tag{20}$$

Notice that the firms still suffer a dead-weight loss due to the fix-cost of borrowing ζ, but this burden does not affect the optimal choice of capital which is taken at the margin. At this point we can define the firm incentive compatibility constraint as the feasible set of policies strategies for which the firm does not want to default. In equilibrium:

$$\Phi(\omega_i^*, \bar{x}_i; \lambda) = \left\{ (d_i^*, l_i^*, k_i^*) \in \mathbb{R}^2 \times \mathbb{R}_+ : \omega_i^* + d_i^* + l_i^* - k_i^* \geq 0 \right\} \tag{21}$$

Given the monotonicity properties of the firms value function there exists a firm specific debt limit $l_{D,i}$, such that any accorded level of debt higher than this debt limit, will provide an incentive for the firm to deviate and default. This interpretation rationalizes the label endogenous borrowing constraint.

The debt limit is defined as the level of debt for which the optimal policy functions deliver a zero-net worth:

$$\bar{x}_i k_{fb,i}^{\alpha} - k_{fb,i} + l_{D,i} - (1+r) l_{D,i} - (1+r)\zeta = 0$$

which simplifies to:

$$\bar{x}_i k_{fb,i}^{\alpha} - k_{fb,i} - r l_{D,i} - (1+r)\zeta = 0 \tag{22}$$

Proposition 6. *A no defaulting equilibrium strategy for a firm i is sustained for level of debt $l_i^* \in [0, l_{D,i}]$, where $l_{D,i}$ represent the equilibrium firm-specific debt limit and it is defined as:*

$$l_{D,i} = \frac{1+r-\alpha}{r\alpha} k_{fb,i} - \frac{(1+r)}{r}\zeta \tag{23}$$

Proof. Substituting (20)

$$\begin{aligned}
l_{D,i} &= \frac{\bar{x}_i k_{fb,i}^{\alpha} - k_{fb,i} - (1+r)\zeta}{r} \\
&= \frac{\bar{x}_i \left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{\alpha}{\alpha-1}} - \left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{1}{\alpha-1}} - (1+r)\zeta}{r} \\
&= \frac{\bar{x}_i^{-\frac{1}{\alpha-1}} \left(\frac{1+r}{\alpha}\right)^{\frac{1}{\alpha-1}+1} - \left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{1}{\alpha-1}} - (1+r)\zeta}{r} \\
&= \frac{\left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{1}{\alpha-1}} \left[\frac{1+r}{\alpha} - 1\right] - (1+r)\zeta}{r} \\
&= \frac{\left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{1}{\alpha-1}} \left[\frac{1+r-\alpha}{\alpha}\right] - (1+r)\zeta}{r} \\
&= \frac{\left[\frac{1+r-\alpha}{\alpha}\right] \left(\frac{1+r}{\alpha \bar{x}_i}\right)^{\frac{1}{\alpha-1}}}{r} - \frac{(1+r)\zeta}{r} \\
&= \frac{1+r-\alpha}{r\alpha} k_{fb,i} - \frac{1+r}{r}\zeta
\end{aligned}$$

□

Now, we can easily derive the following derivatives:

$$\frac{\partial l_{D,i}}{\partial \zeta} = -\frac{1+r_i}{r_i} < 0$$
$$\frac{\partial l_{D,i}}{\partial k_{fb,i}} = \frac{1+r_i-\alpha}{r\alpha} > 0$$

reported in Proposition 3. First, the debt-limit is increasing in the level of financial development. The lower the level of financial development (the higher is ζ), the lower is the level of debt for which the firm is indifferent whether to default or not. Second, the debt-limit is increasing in the optimal choice of capital, which, in this context, is function uniquely of the original idiosyncratic shock. The higher is the idiosyncratic shock (quality of production), the higher is the debt limit, i.e. the threshold of debt for which a firm is indifferent whether to default or not.

□

Let us now define the leverage at the debt limit as:

$$\frac{l_{D,i}}{k_{fb,i}} = \frac{1+r_i-\alpha}{r_i\alpha} - \frac{1+r_i}{r_i}\frac{\zeta}{k_{fb,i}} \tag{24}$$

From which we can easily derive the following derivatives:

$$\frac{\partial \frac{l_{D,i}}{k_{fb,i}}}{\partial k_i^{fb}} = \frac{1+r_i}{r_i}\frac{\zeta}{(k_{fb,i})^2} > 0$$
$$\frac{\partial \frac{l_{D,i}}{k_{fb,i}}}{\partial \zeta} = -\frac{1+r_i}{r_i}\frac{1}{k_{fb,i}} < 0$$

reported in Proposition 4. First, the leverage is strictly increasing in the amount of capital. The higher is the productivity of a firm, the higher is the optimal level of capital, the higher is the equilibrium leverage. Second, the leverage is strictly increasing in the level of financial development. The more developed is the credit intermediation, the lower is ζ, the higher is the equilibrium leverage of the firms.

B Data

B.1 Firm Characteristics.

Data on firms characteristics are taken from Compustat, fundamental annual data from 1950 to 2006. Compustat includes public firms listed on the three US exchanges, NYSE, AMEX, and Nasdaq, with a non-foreign incorporation code.

Following Covas and DenHaan (2011), we exclude: 1) American Depository Receipts (ADRs) - securities created by U.S. banks to permit a U.S.-based trading of stocks listed on foreign exchanges; 2) financial firms (SIC classification between 6000 and 6999); 3) utilities (SIC classification between 4900 and 4949); 3) firms involved in major mergers (Compustat footnote code AB[25]); 4) firms with missing value for the book value of assets.

Entrants are defined as firms which are showing up on Compustat for the first time. The assets, ($a \equiv k_{it} + xk_{it}^{\alpha}$), in the model, are computed as the book value of assets (Compustat data item 6 - mnemonic AT).

The total debt, (b_{it}) in the model, is computed as long-term debt (item 9 , mnemonic) plus debt in current liabilities (item 34, mnemonic), since there is no distinction among the two in the present model.

B.2 Default Rate.

Data on corporate default rates are taken from Moody's. Moody's definition of default is applicable only to debt or debt-like obligations (e.g., swap agreements). In particular, four events constitute a debt default under Moody's definition:

1. a missed or delayed disbursement of a contractually-obligated interest or principal payment (excluding missed payments cured within a contractually allowed grace period), as defined in credit agreements and indentures (*liquidity default*);

2. a bankruptcy filing or legal receivership by the debt issuer or obligor that will likely

[25] Compustat assigns a footnote AB to total sales if sales increase by more than 50 percent in response to a merger or an asset acquisition.

cause a miss or delay in future contractually-obligated debt service payments (*Chapter 7 Default*);

3. a distressed exchange whereby 1) an obligor offers creditors a new or restructured debt, or a new package of securities, cash or assets that amount to a diminished financial obligation relative to the original obligation and 2) the exchange has the effect of allowing the obligor to avoid a bankruptcy or payment default in the future; (*Chapter 11 Default* - Part A) or

4. a change in the payment terms of a credit agreement or indenture imposed by the sovereign that results in a diminished financial obligation, such as a forced currency re-denomination (imposed by the debtor himself, or his sovereign) or a forced change in some other aspect of the original promise, such as indexation or maturity. (*Chapter 11 Default* - Part B)

Moody's definition of default does not include so-called technical defaults, such as maximum leverage or minimum debt coverage violations, unless the obligor fails to cure the violation and fails to honor the resulting debt acceleration which may be required. Moreover, the current index excludes payments owed on long-term debt obligations which are missed due to purely technical or administrative errors which are 1) not related to the ability or willingness to make the payments and 2) are cured in very short order (typically, 1-2 business days).

B.3 Credit Spreads.

Data on credit spreads are taken from the St Louis FRED. Credit spreads are computed using the monthly seasonally not-adjusted Moody's Seasoned Corporate Bond Yield, from 1950 to 2012. The series follows an investment bond that acts as an index of the performance of all bonds given a specific rating by Moody's Investment Firm. Annual series are constructed by averaging the monthly percent bond yields. The spread is then computed as the difference of the natural logarithm of BAA and AAA bond yields.

B.4 Ex-post Real Risk Free Interest Rate.

The ex-post real risk free interest rates are computed using data on 1) the Treasury Constant Maturity Rate bill, from the St Louis FRED, and 2) the Personal Consumption Expenditures (PCE) Chain-type Price Index, from the Bureau of Economic Analysis.

The ex-post real risk free interest rate is computed as the difference between the three-month Treasury bill rate minus the realized inflation in the subsequent quarter.

We use the three-month Treasury Constant Maturity Rate, at monthly frequency. We then build annual data averaging (equal weights) the monthly rates.

For the inflation, we use the seasonally adjusted quarterly rate of the Personal Consumption Expenditures (PCE) Chain-type Price Index. The annualized growth for PCE deflator is computed by taking 400 times the first differences of the natural logs of the PCE deflator. The series of ex-post real interest rate so constructed goes from 1950 to 1983.

C Computational Algorithm

The computation adopts the discrete choice method. Grids on bond and capital consist of 200 grid points.

The computational algorithm articulates as follows:

1. It starts with the guess of: 1) the continuation value function of the incumbents; 2) the default policy function of the incumbents; 3) the debt schedules of the incumbents. In line with Arellano et *al.* (2012) the initial guess of the debt schedules is the risk free interest rate.

2. It iterates over the continuation value function of the incumbents in the fixed point algorithm till convergence.

3. The implied continuation value function is used for updating, through the optimal default decision rule (5), the default policy function. Clearly the convergence of the value function implies the convergence of the default policy functions, but not *viceversa.*

4. The implied default policy functions are used to update the endogenous probability

of default, which in turns is used for updating the feasible correspondence Ω-set and, therefore, the debt schedules (12).

5. Points 2, 3, 4 are iterated till convergence of the debt schedules.

Technical Details:

- The levels of tolerance for the convergence of the value function and of the debt schedules are set to 1e-6.
- The grids are controlled not to be binding in equilibrium.
- The statistics reported in Table 8 are obtained using the (ergodic) distribution at period T=1000, obtained simulating 15000 firms over 1000 periods, .
- The Tauchen (1986) algorithm truncates the $\pm$ inf values of the support of the normal distribution at $\pm 20\sigma_{log(x)}$.