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Rollover risk in commercial paper markets and firms' debt maturity choice

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Abstract

By using short-term direct finance firms of the highest credit quality expose themselves to rollover risk in the public debt markets. Firms insure themselves against this risk by securing backup lines of credit from banks that they may use should market liquidity dry up. In a first step, this paper explains why high quality firms introduce a maturity mismatch into their balance sheets and do not simply use long-term direct finance. It also highlights why banks may be willing to roll over a firm's debt while direct investors may not. In a second step, I extend the model to allow for different levels of firm's publicly observable credit quality. Under plausible assumptions about the cost of bank borrowing the model generates a maturity structure choice broadly consistent with observed financing patterns: Low quality firms issue short-term direct debt, medium quality firms issue long-term direct debt, and high quality firms use short-term direct debt in normal times and bank debt in adverse times. The paper suggests that better publicly available information about firm quality and the moderation of the business cycle over the past decade help to explain the decrease in nonfinancial commercial paper outstanding since the beginning of the decade.

Keywords: Rollover risk, Liquidity, Asymmetric Information, Debt maturity
JEL classification: D82, G21, G32

Non-technical summary

A unique feature of the market for nonfinancial commercial paper is that it usually accepts only very high-quality paper that bears virtually no risk of default. Nonetheless, firms are sometimes unable to roll over their commercial paper and have to draw down backup lines of credit which they pre-arranged with banks. This paper lays out a simple model that aims to answer two important questions about the commercial paper market and firms' choice of financing arrangements. First, why are firms of the highest credit quality sometimes denied short-term credit in public markets though their default risk is minuscule? Second, why do they prefer a financing arrangement whereby they use short-term *direct* finance in "good" times and short-term *bank* debt in "bad" times instead of simply issuing long-term direct debt and getting rid of the maturity mismatch? The model proposes that while high-quality firms have no default risk during good times, some of these firms' prospects deteriorate during bad times. Direct investors who do not know which firms' prospects worsen in case of recession are better off denying credit to all firms during bad times. Asymmetric information between investors and the firm hence matters during recessions. However, in good times direct investors refinance all firms and asymmetric information does not play a role.

By contrast, banks by screening borrowers who they committed to lend on a contingent basis are able to differentiate between good and bad firms. However, as screening is costly it is only used when needed (i.e. during recessions). Borrowing short-term and making the choice between direct and intermediated finance dependent on the aggregate state of the economy may in the end be a cheaper option for firms than simply issuing long-term direct debt. In the latter case direct investors need to be compensated for the risk of making a loss as a result of being unable to identify and liquidate bad firms during a recession.

Extending the model to allow for differences in firms' publicly observable risk characteristics (i.e. credit rating) it is possible to derive firms' debt maturity choice

as a function of their ratings. Firms with the highest ratings are able and willing to issue commercial paper and secure a backup line of credit. Firms with slightly lower ratings issue long-term direct debt and firms with still lower ratings are restricted to borrow short-term. These latter firms will always be liquidated during bad times.

Finally, the paper examines the comparative statics with respect to changes in the degree of asymmetric information and the probability of the economy entering a recession. Information between investors and the firm becoming more symmetric (e.g. as a result of the 'IT revolution') and/or recessions becoming less likely ('Great Moderation') lead to an increase in direct lending and fewer firms issuing commercial paper and securing a backup line of credit. These structural reasons may help explain the large decline in nonfinancial commercial paper issuance since the beginning of the decade.

Nicht-technische Zusammenfassung

Kapitalmarktfähige Unternehmen können sich nur dann durch die Ausgabe von kurzfristigen Geldmarktpapieren (Commercial Paper - CP) refinanzieren, wenn sie eine vernachlässigbare Ausfallwahrscheinlichkeit aufweisen. Gleichwohl ist es diesen Firmen bisweilen nicht möglich, eine Anschlussfinanzierung vorzunehmen. In solchen Situationen können CP-Emittenten auf Kreditlinien ausweichen, sofern sie diese zuvor mit Banken vereinbart haben und sich ihre Kreditqualität bei Inanspruchnahme der Kreditlinie nicht verschlechtert hat. In dem vorliegenden Papier werden zunächst zwei Fragenkomplexe näher untersucht. Erstens, warum bekommen Firmen von höchster Kreditqualität zu bestimmten Zeiten keinen Kredit, obwohl ihre tatsächliche Ausfallwahrscheinlichkeit nahe null liegt? Zweitens, warum wählen diese Firmen eine Finanzierungsform, bei der sie sich in guten Zeiten über die Ausgabe von Geldmarktpapieren finanzieren und in schlechten Zeiten einen Bankkredit in Anspruch nehmen? Warum nehmen sie eine Inkongruenz der Laufzeiten zwischen Aktiv- und Passivseite in Kauf, anstatt lang laufende Anleihen zu emittieren und sich somit keinem Refinanzierungsrisiko auszusetzen?

In dem vorgestellten Modell haben sämtliche Firmen im normalen Zustand der Ökonomie zunächst kein Ausfallrisiko. Bei einer Rezession verschlechtern sich die Aussichten eines Teils dieser Firmen allerdings beträchtlich. Direkte Investoren können zwischen solchen Firmen, deren Ausblick unabhängig vom Zustand der Ökonomie ist, und solchen, deren Ausblick sich bei Rezessionen deutlich verschlechtert, nicht unterscheiden und verweigern deshalb im Falle eines wirtschaftlichen Abschwungs *allen* Firmen einen Kredit. Asymmetrische Information zwischen Firmen und direkten Investoren spielt folglich nur in Rezessionsphasen eine Rolle. In guten Zeiten werden hingegen alle Firmen refinanziert. Im Unterschied zu direkten Investoren können Banken private Informationen über potentielle Kreditnehmer gewinnen, vorausgesetzt, sie unterhalten bereits eine Geschäftsbeziehung zu der Firma. Diese Informationen versetzen sie in die Lage, zwischen guten und schlechten

Kreditnehmern zu unterscheiden und in einer Abschwungphase nur gute zu refinanzieren. Da das Screening durch Banken allerdings teuer ist, werden Bankkredite nur dann in Anspruch genommen, wenn eine andere Finanzierungsform nicht verfügbar ist (d.h. in Rezessionen). Die kurzfristige Finanzierung ermöglicht eine flexible Anpassung an veränderte Zustände der Gesamtwirtschaft und kann dabei günstiger sein als die Ausgabe von längerfristigen Bonds. Insbesondere muss eine längerfristige Finanzierung nicht-informierte Investoren für das Risiko kompensieren, in Rezessionen schlechte Firmen nicht erkennen und liquidieren zu können.

Bei einer Erweiterung des Modells um Firmen mit in normalen Zeiten positiven und öffentlich bekannten Ausfallwahrscheinlichkeiten (Ratings), lässt sich die Wahl der Fälligkeit von Verbindlichkeiten in Abhängigkeit des Ratings bestimmen. Firmen mit der höchsten Kreditqualität emittieren CP und sichern ihre Refinanzierung durch eine Kreditlinie bei Banken ab. Firmen mit etwas geringerem Rating emittieren langfristige Anleihen. Firmen, deren Rating gerade noch eine Direktfinanzierung erlaubt, können nur kurzfristige Anleihen emittieren und müssen auf eine Liquiditätsgarantie durch Banken verzichten. Diese theoretischen Ergebnisse sind weitestgehend konsistent mit empirischen Untersuchungen zur Wahl der Laufzeiten von Unternehmensverbindlichkeiten.

In einem letzten Schritt wird der Einfluss einer Änderung des Grades an asymmetrischer Information und der Wahrscheinlichkeit einer Rezession untersucht. Dabei zeigt sich, dass mit zunehmend symmetrischer Information - etwa infolge besserer Verbreitung von Information durch das Internet - und mit abnehmender Rezessionswahrscheinlichkeit ("Great Moderation") sich mehr Firmen direkt am Kapitalmarkt refinanzieren und weniger über die Ausgabe von CP in Verbindung mit einer Kreditlinie. Diese strukturellen Faktoren könnten den deutlichen Rückgang des Volumens an nicht-finanziellen CP in den USA seit Beginn der Dekade miterklären.

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1 Introduction

The subprime crisis of 2007 put an often overlooked segment of the financial markets into the limelight: the market for commercial paper (CP). As uncertainty about credit losses related to the US subprime housing market surged in the summer of 2007, investors began to shun any security for which such losses were deemed possible. In particular, this included asset-backed commercial papers (ABCPs), which are collateralized short-term debt instruments that are continuously rolled over to provide financing to an issuing programme. With major banks providing backup liquidity to ABCP programmes, resulting rollover problems quickly translated into high demands for liquidity from banks. This appears to have taken some CP issuers and banks by surprise during this episode.

By contrast, in the market for *nonfinancial* CP rollover problems and resulting demands for liquidity from banks have been well-known phenomena ever since the Penn Central bankruptcy episode in 1970. In the aftermath of the recession of 1969/1970 and a sharp increase in spreads on commercial paper and bonds, Penn Central Transportation Company failed in June 1970 and defaulted on its USD 82m outstanding CP. As described by Davis (1999) investors, uncertain over credit risk, were driven away from the CP market. Companies in turn proved unable to roll over their CP and without alternative funding sources fears of a wave of corporate bankruptcies spread. Intervention was deemed necessary by the Federal Reserve and took the form of suspension of interest rate ceilings on banks' certificate of deposits

[1]I would like to thank Ben Craig, Klaus Düllmann, Falko Fecht, Thilo Liebig, Reinhard Schmidt, Rainer Schulz, and seminar participants at the Deutsche Bundesbank and the University of Aberdeen for helpful comments. All remaining errors are my own.

and notification that the discount window was available for banks needing reserves to extend loans to companies. No other commercial paper issuer defaulted thereafter. After the Penn Central crisis, companies routinely arranged back-up lines of credit at banks, which they could rely on during times when the commercial paper market turned unreceptive. This greatly enhanced funding stability. For example, during the Russian/LTCM crisis in 1998 and the Enron/Worldcom crisis in 2002 there were again rollover problems in the market for nonfinancial CP. However, during these episodes US non-financial firms were able to switch between markets and backup lines of credit with banks. Moreover, banks experienced larger inflows of funds - possibly from investors fleeing financial markets - just when firms unable to access capital markets drew down backup lines of credit (see Gatev and Strahan (2006)). Thus, banks helped intermediate liquidity back into the system.

In this paper I focus on the market for nonfinancial commercial paper and on firms' debt maturity choice. Interestingly, despite rollover risk CP (in combination with backstop liquidity facilities) has remained an important funding source for top-rated corporate borrowers. Given the episodes described, two important questions appear to be particularly important. First, given that only firms with virtually no default risk have access to the nonfinancial CP market why are they sometimes denied credit? Second, why are banks willing to supply funding to (at least some) firms when direct investors deny credit? It is important to note that backup lines of credit usually contain 'material adverse change' clauses which allow banks to cancel credit lines if the financial condition of a the would-be borrowing firm significantly changes. This implies that banks do not extend credit in adverse times because they are willing to hold higher credit risk. For backup lines to be of any use to the borrower it must hence be the case that banks at times come to different conclusions about a firms' credit risk than direct investors do. Furthermore, it is important to note that - unlike deposit insurance in the case of banks - backup lines of credit have not prevented the CP market from drying up at times.[2] This may suggest

[2]For simplicity, nonfinancial commercial paper is henceforth referred to only as 'commercial

that rollover crises in the CP market are not the result of a coordination problem (i.e. a 'panic' equilibrium) among dispersed investors but instead are driven by fundamentals.

In contrast to today's observed borrowing arrangements by top quality firms most models that explain the choice of firms between bank loans and publicly traded debt ignore contingent bank lending. Instead, these models claim that firms *either* choose bank loans *or* issue bonds (e.g. Bolton and Freixas (2000), Holmström and Tirole (1997), Chemmanur and Fulghieri (1994)). Though banks are seen to be particularly good at helping borrowers through times of financial difficulties, banking finance is assumed more costly than direct finance. Hence, according to these models firms with a low probability of financial distress prefer to tap the bond markets and refrain from bank borrowing at all times. Why then do we observe contingent bank lending in the form of backup liquidity facilities that nowadays almost always accompany CP programs? The higher costs of using banking finance should be reflected in any fee banks charge for providing backup liquidity facilities and hence should ultimately be borne by firms. Does this not counteract the advantage of using short-term direct finance? Why does the firm not get rid of these costs and the maturity mismatch that gives rise to rollover risk by simply issuing a long-term bond?[3]

This paper presents a model in which asymmetric information between investors and the firm only matters in *some* states of the business cycle. More specifically, I assume that in normal times information about firm quality is broadly symmetric. Having a relationship with a bank is not particularly important for high quality firms in these times as direct lenders will be willing to provide funding. However, during a recession only some firms are hit by a shock that makes their prospects deteriorate. Information about the impact of a shock is however asymmetric. Whereas the firm

paper.'

[3]Indeed, as Calomiris, Himmelberg, and Wachtel (1995) point out, though CP has a short-term maturity, it is not only used to finance short-term needs. Nonfinancial firms indeed often use CP as financing for capital expenditures and roll it over continuously or until alternative financing is found.

knows whether it has been hit, direct investors do not. Direct investors are hence unable to sort out firms whose prospects have deteriorated substantially from those that have not. As a consequence, they are unwilling to renew lending even to high quality firms. By contrast, a bank is assumed to gain private information about borrowers when it commits to lend to the firm on a contingent basis. This enables the bank to sort out high quality firms during times of recession and renew lending to these firms.

However, because of screening costs banking finance is more expensive than direct finance. It thus never makes sense for high quality firms to use intermediated finance during normal times when asymmetric information does not affect outcomes. By setting up a financing arrangement whereby the firm borrows from short-term direct investors during normal times and switches to banking finance in case of recession the firm minimizes intermediation costs while still enjoying the benefit of being refinanced in bad times. Provided there is a sufficient degree of asymmetric information between direct investors and the firm and intermediation costs are not too high the firm may actually prefer this financing arrangement over issuing long-term direct debt. This is so because the firm has to compensate LT direct investors for the potential agency problem at the intermediate stage which might be more costly than using short-term finance together with a backup line of credit. Furthermore, if the cost of using banking finance falls with a higher credit rating it is possible to derive theoretical results about firms' debt maturity choice which are broadly consistent with observed practice. Top quality firms are able and willing to issue commercial paper and secure a backup line of credit. Firms with a slightly lower rating issue long-term direct debt and firms with a still lower rating are restricted to borrow short-term. These latter firms will always be liquidated during bad times.

There is empirical evidence that maturity mismatch and liquidity risk are real concerns for firms and that it affects their choice of debt maturity. In a survey among financial executives Graham and Harvey (2001) report that the two most important factors affecting firms' debt maturity choice were "matching the maturity of debt

with the life of assets" and "the cost of refinancing in bad times" - much in line with the proposed model.

The paper adds to the theoretical literature concerned with the coexistence of bank lending and direct lending, most notably, Bolton and Freixas (2000), Boot and Thakor (1997), Chemmanur and Fulghieri (1994), Holmström and Tirole (1997), and Repullo and Suarez (1998). The main contribution to this literature is to view the choice of top quality firms between direct and intermediated debt as dependent on the aggregate state of the economy rather than a static, one-off choice. Empirically, the fact that banks often experience an increase in asset growth due to a drawdown of credit lines by firms unable to tap CP markets has recently been documented by some authors (e.g. Gatev and Strahan (2006)).

Finally, there are some papers concerned with firms' debt maturity choice. Most notably, in Diamond (1991) firms with a higher credit rating use more short-term debt than firms with lower credit ratings. The reason is that a firm's insiders have information about the firm's default risk that is superior to that of its creditors. This is a problem for a firm that is truly more creditworthy than other firms. Unless it can find some way to signal its private information, it will end up borrowing at too high a rate. Diamond argues that one possible way for the low-risk firm to lower its borrowing costs is to shorten its debt maturity since private information will gradually become more public in the course of time. My model also stresses a firm's concern about being pooled with lower quality borrowers. However, the reason for the firm being concerned is that it fears not being refinanced in case of recession.

The paper is organized as follows: Section II outlines the model. Section III derives the optimal mode of financing for firms without (publicly observable) credit risk. Section IV introduces publicly observable credit risk and derives a firm's debt maturity choice as a function of its rating. Section V discusses comparative static results. Finally, Section VI offers some conclusions.

2 The Model

Consider an economy with three types of risk-neutral agents: firms, banks and direct investors. All agents are protected by limited liability. Firms are run by entrepreneurs who do not have any initial wealth and therefore need to raise outside funds for investment by selling bonds to direct investors or by obtaining bank loans. All contracts are thus restricted to be debt contracts.

2.1 Firms' Projects

There are three dates ($t = 0, 1, 2$) in the economy and a continuum of firms. Each firm (entrepreneur) has the opportunity of undertaking a project that requires an investment of 1 at $t = 0$ and pays off a return at $t = 2$. Firms differ in the way their projects are affected by the state of the economy which is revealed at $t = 1$ after the initial investment has been made, but before any short-term loans are rolled over. With probability λ the economy is in a good state and the return of each project in the economy is Π_H. With probability $1 - \lambda$ a recession occurs which affects *some* firms in the economy in such a way that their projects return only Π_L ($\Pi_L < \Pi_H$) at $t = 2$ subject to continuation. All other projects are unaffected by the recession and still return Π_H.

If instead of being continued a project is liquidated at $t = 1$ it yields a liquidation value of A_H if it is a firm with a high cash flow realization in a recession or A_L if it is a firm with a low cash flow realization in a recession. Firms are labelled according to their return in recessions (alternatively, their liquidation value at $t = 1$): 'Good' firms return Π_H (and have a liquidation value of A_H), whereas 'bad' firms only return Π_L (and have a liquidation value of A_L). Regardless of their project's observable return firms (entrepreneurs) receive a non-transferable private benefit $B > 0$ at date $t = 2$ provided the firm is not liquidated. I assume that $\Pi_H > A_H > 1 > A_L > \Pi_L + B > 0$ which implies - inter alia - that neither from a lender's nor from a social point of view does it make sense to finance a bad firm, i.e. $\lambda(\Pi_H + B) + (1-\lambda)A_L < 1$.

However, the presence of the non-transferable private benefit makes bad firms want to get financing since they are able to gain B in the good state while they cannot lose anything in the bad state (limited liability). This is similar to Holmström and Tirole (1997).

As in Bolton and Freixas (2000) firms differ in the probability p_R of having a high cash flow realization at date $t = 2$ in case of recession (or, if abandoned, a high liquidation value at date $t = 1$). The range of possible values for p_R is simply $\{0, 1\}$. Agents are assumed to have different information about the value of p_R. More specifically, I assume that p_R is information private to the firm at date $t = 0$ and may be revealed to a bank at date $t = 1$ but only if the bank engaged in a relationship with the firm at date $t = 0$. A relationship here involves regular visits with the firm to learn about its business and possibly to get access to private information. A bank and a firm only engage in a relationship at $t = 0$ if the bank either provides outright funding at $t = 0$ or commits to provide funding on a contingent basis at $t = 1$. For direct investors or banks that did not engage in a relationship, p_R is revealed at date $t = 1$ only if the firm is liquidated. By contrast, in case of continuation these investors learn firms' type not before $t = 2$. At date $t = 0$ lenders' prior belief about the value of p_R is $p_R = 1$ with probability θ and $p_R = 0$ with probability $1 - \theta$ so that $E[p_R] = \theta$.

[Figure 1 about here.]

To make matters interesting, I further make the following assumption:

$$\theta\Pi_H + (1-\theta)\Pi_L < 1 \leq \theta A_H + (1-\theta)A_L \tag{1}$$

i.e. the continuation value of a firm of unknown type is less than 1 which in turn is less than the firm's liquidation value. This assumption is equivalent to lenders' prior belief about a given firm's type, θ, lying within the range $(\underline{\theta}, \bar{\theta})$ defined by $\underline{\theta} = \frac{1-A_L}{A_H-A_L}$ and $\bar{\theta} = \frac{1-\Pi_L}{\Pi_H-\Pi_L}$. It implies that given a recession a short-term investor not knowing a firm's type will always liquidate the firm instead of rolling over its

debt and waiting until $t = 2$ for project returns to realize.[4] If the continuation value of the firm was greater or equal to 1, there would always be an investor willing to extend a loan of size 1 at date 1 to a firm of unknown type. Hence maturing short-term debt would always be refinanced. Lending between dates 0 and 1 would then be riskless and the interest rate in this period would equal the direct investor's opportunity cost of capital, which is 1. If the continuation value was greater than its liquidation value the firm's debt would be rolled over in a recession since initial investors in the firm would fare better than if they liquidated the firm. However, the liquidation decision under direct (uninformed) finance is not socially optimal ex post. Instead, it would be optimal to liquidate bad projects (as $\Pi_L + B < A_L$) but to continue good projects (as $\Pi_H + B > A_H$).

It is important to note that the presence of (non-discriminable) good firms enables bad firms to receive funding at all. A bad firm therefore never wants to signal its type to an investor and always wants to mimic a good firm, for otherwise it would not be able to carry out its project and receive the private benefit B.

2.2 Financing Options

Firms have the possibility of financing a project either by using direct finance or by using intermediated (banking) finance or a combination of the two. These financing options differ in the costs/benefits they offer to firms.

Under direct finance firms simply have to offer the opportunity cost of capital (in expected value terms), i.e. the gross market rate of return, which is normalized to 1. Direct investors never screen firms because they do not have the expertise to generate valuable information. By contrast, banks, engage in costly screening activity whenever they extend a loan which enables them to determine a given

[4]Note that the above assumption is somewhat stronger than necessary to guarantee liquidation during a recession. In fact, for short-term debt not to be rolled it is sufficient that $\theta\Pi_H + (1-\theta)\Pi_L < 1$ and $\theta\Pi_H + (1-\theta)\Pi_L < \theta A_H + (1-\theta)A_L$. However, to facilitate the ongoing analysis I will stick to the stronger assumption.

firm's type. Banks may actually determine the firm's type *before* extending the loan.[5] However, to be able to do so they need to have some prior relationship with the firm. For simplicity, the bank's one-off screening cost $c \geq 0$ is taken to be exogenous. Extending a bank loan of amount 1 at date $t = i$ thus leads to a minimum repayment of $1 + c$ at date $t = i + 1$.

2.3 State-Contingent Contracts

As in Bolton and Freixas (2000) I first consider, as a benchmark, the financing choice of a firm that is able to offer state-contingent returns to investors, i.e. returns that depend on the aggregate state of the economy and the firm's type. I will just consider the contracting problem of a good firm that knows that every contract it offers will be mimicked by a bad firm. Any deviation by the bad firm would reveal its type and would make borrowing impossible. There is hence no possibility in the model for the good firm to escape this pooling equilibrium.

Direct lending. The contracting problem of a good firm that is able to obtain financing from uninformed investors only is to offer state-contingent returns $\{R_2^N, R_{1H}^R, R_{1L}^R, R_{2H}^R, R_{2L}^R\}$ so as to maximize its total surplus, where R_2^N is the date 2 return in normal times and R_{1H}^R, R_{1L}^R and R_{2H}^R, R_{2L}^R are the date 1 and 2 returns in a recession dependent on the firm being good or bad, respectively. Quite crucially, the firm also has to decide whether it wants its project to be liquidated in case of recession or not. Let $x \, \varepsilon \, \{0, 1\}$ be the firm's decision variable which is equal to 1 if it wants to continue its project during a recession and 0 otherwise. The good firm then sets state-contingent returns and x to solve

$$\textbf{max} \;\; \lambda \left[\Pi_H + B - R_2^N\right] + (1 - \lambda) \left[x(\Pi_H + B - R_{2H}^R) + (1 - x)(A_H - R_{1H}^R)\right] \quad (2)$$

subject to

$$\lambda R_2^N + (1 - \lambda) \left[(1 - x)(\theta R_{1H}^R + (1 - \theta) R_{1L}^R) + x(\theta R_{2H}^R + (1 - \theta) R_{2L}^R)\right] \geq 1 \quad (3)$$

[5] In other words, screening without lending is possible but lending without screening is not.

and $R_2^N \leq \Pi_H$, $R_{1H}^R \leq A_H$, $R_{1L}^R \leq A_L$, $R_{2H}^R \leq \Pi_H$, $R_{2L}^R \leq \Pi_L$. It is quite obvious that the good firm will set $R_{1L}^R = A_L$, $R_{2L}^R = \Pi_L$, and $R_2^N = \Pi_H$. The good firm will pledge the highest amounts possible in case of being revealed a bad firm during a recession, as it will never have to pay these amounts anyway. Moreover, the firm prefers repayment in normal times as it has to compensate investors for asymmetric information only during recessionary episodes. Hence, it will set R_2^N equal to the maximum amount possible, Π_H.[6] The good firm's repayment in a recession now depends on its decision whether or not to continue its project. In each case it will set the amount, R_{1H}^R or R_{2H}^R, equal to the lowest value satisfying the constraint (equation 3). Therefore, for $x = 1$ the good firm's repayment in case of recession is given by

$$R_{2H}^R = \frac{1 - \lambda\Pi_H - (1-\lambda)(1-\theta)\Pi_L}{\theta(1-\lambda)}. \tag{4}$$

By contrast, if the firm chooses not to continue its project during a recession (i.e. $x = 0$) its repayment is given by

$$R_{1H}^R = \frac{1 - \lambda\Pi_H - (1-\lambda)(1-\theta)A_L}{\theta(1-\lambda)}. \tag{5}$$

As $A_L > \Pi_L$ the amount the firm has to pay in a recession is lower if the project is liquidated. However, in this case the firm loses its private benefit B. Quite clearly, whether or not the firm wants its project to be completed in bad times, i.e. whether $x = 1$ or $x = 0$, depends on the magnitude of B. If B is 'small' the firm may actually prefer liquidation in bad times.[7]

Assume that B is sufficiently high so that continuation in a recession is actually preferred. It is then possible to determine the extra cost the firm has to pay in a

[6] Note that pledging 1 unit less in the good state while pledging $\lambda/(1-\lambda)$ more in the bad state does not matter to the *firm*. However, pledging 1 unit less in the good state while pledging $\lambda/[\theta(1-\lambda)]$ in the bad state with $0 < \theta < 1$, which would not matter to the *investor*, is clearly less favorable to the firm. Hence, the firm will choose maximum repayment in normal times.

[7] More specifically, for liquidation to be preferred B must be such that $\lambda B + (1-\lambda)\left[\Pi_H - \frac{1-\lambda\Pi_H-(1-\lambda)(1-\theta)\Pi_L}{\theta(1-\lambda)} + B\right] < \lambda B + (1-\lambda)\left[A_H - \frac{1-\lambda\Pi_H-(1-\lambda)(1-\theta)A_L}{\theta(1-\lambda)}\right]$ or $\Pi_H + B - A_H < \frac{1-\theta}{\theta}[A_L - \Pi_L]$. Hence for liquidation to be preferred by a good firm it must be the case that information is asymmetric, i.e. $\theta < 1$.

recession which is due to direct investors not being able to distinguish between good and bad firms (henceforth denoted 'asymmetric information cost'). Let $R^R_{2H}\big|_{\theta=1}$ be the return the good firm has to pledge in the full information case. Then the asymmetric information cost under direct lending is given by

$$R^R_{2H} - R^R_{2H}\big|_{\theta=1} = \frac{1-\theta}{\theta}\left[\frac{1-\lambda\Pi_H}{1-\lambda} - \Pi_L\right] \quad (6)$$

$$= \frac{1-\theta}{\theta}\left[\frac{1}{1-\lambda}(1-(\lambda\Pi_H + (1-\lambda)\Pi_L))\right]. \quad (7)$$

Note that $\lambda\Pi_H + (1-\lambda)\Pi_L$ is the return that each firm (independent of its type and the state of the economy) is able to pay with certainty, i.e. this is the portion of the cash flow on which there is no asymmetric information. For a firm to finance its project, however, it must raise additional capital of $1-(\lambda\Pi_H + (1-\lambda)\Pi_L) > 0$ at date $t = 0$. In the full information case the good firm would simply promise to repay $\frac{1}{1-\lambda}[1-(\lambda\Pi_H + (1-\lambda)\Pi_L)]$ in the recessionary state to ensure financing. By contrast, under asymmetric information the good firm has to incur an additional cost of $\frac{1-\theta}{\theta}$ per unit pledged in the recessionary state.[8]

Banking finance. In contrast to direct investors, a bank that extends a loan at date $t = 0$ and thereby engages in screening activity is able to distinguish between good and bad firms at date $t = 1$. Of course, screening is only valuable if a recession occurs with some positive probability. Given the assumptions about screening costs the maximization problem the firm faces when it only relies on bank lending is to offer 1) state-contingent returns $\{R^N_2,\, R^R_{2H},\, R^R_{1H},\, R^R_{1L}\}$ and 2) a continuation decision at date $t = 1$ in case of recession that is given by $x\ \varepsilon\ \{0,1\}$ to solve

$$\textbf{max}\ \ \lambda(\Pi_H + B - R^N_2) + (1-\lambda)x(\Pi_H + B - R^R_{2H}) + (1-\lambda)(1-x)(A_H - R^R_{1H}) \quad (8)$$

subject to

$$\lambda R^N_2 + (1-\lambda)[\theta x R^R_{2H} + \theta(1-x)R^R_{1H} + (1-\theta)R^R_{1L}] \geq 1 + c \quad (9)$$

[8] It can easily be checked that the asymmetric information cost that the firm incurs should it prefer to be liquidated during a recession is equal to $\frac{1-\theta}{\theta}\left[\frac{1}{1-\lambda}(1-(\lambda\Pi_H + (1-\lambda)A_L))\right]$.

and $R_{1L}^R \leq A_L$, $R_{1H}^R \leq A_H$, $R_{2H}^R \leq \Pi_H$, and $R_2^N \leq \Pi_H$.

As in the direct lending case it is quite obvious that the good firm will set $R_2^N = \Pi_H$ and $R_{1L}^R = A_L$. Furthermore, the firm will always choose to continue (i.e. $x = 1$) in case of recession since it is always able to pay at least the amount as under liquidation while still being better off. Again, the good firm sets R_{2H}^R equal to the lowest value satisfying the bank's participation constraint (equation 9) or

$$R_{2H}^R = \frac{1}{\theta}\left[\frac{1 + c - \lambda\Pi_H}{1 - \lambda} - (1 - \theta)A_L\right]. \tag{10}$$

The asymmetric information cost that the firm has to incur when using banking finance becomes

$$R_{2H}^R - R_{2H}^R|_{\theta=1} = \frac{1 - \theta}{\theta}\left[\frac{1}{1 - \lambda}(1 + c - (\lambda\Pi_H + (1 - \lambda)A_L))\right]. \tag{11}$$

Note that the asymmetric information cost under bank lending may actually be lower than under direct lending provided the extra cost of banking finance is lower than its expected benefit, i.e. $c < (1 - \lambda)[A_L - \Pi_L]$.

However, if the firm's private benefit B is low and the firm actually prefers being liquidated in a recession under direct finance, the asymmetric information cost under bank lending will be indisputably higher as $c > 0$. Nonetheless, as the good firm's project has a higher continuation than liquidation value (i.e. $\Pi_H + B > A_H$) the firm may still decide to use banking finance. More specifically, the firm will borrow from banks whenever[9]

$$\frac{1}{\theta}c < (1 - \lambda)(\Pi_H + B - A_H). \tag{12}$$

The right-hand side of the inequality is the expected benefit of using banking finance. Quite intuitively, this is the difference between the continuation value and the liquidation value of the good project (in expected value terms). The left-hand side is the expected extra cost of bank lending. Note that this is more than the bank's screening cost as $\theta < 1$. More specifically, it also encompasses the difference in expected

[9] From (2) and (8) with values inserted.

asymmetric information costs between bank lending and direct lending[10], i.e.

$$\frac{1}{\theta}c = \underbrace{\frac{1-\theta}{\theta}c}_{\text{Difference in expected AI costs}} + \underbrace{c}_{\text{Screening cost}} \tag{13}$$

In practice, the state-contingent contracts discussed do not exist. One reason might be that the recessionary state of the economy is difficult to verify by judges. In fact, standard debt contracts do not make repayments dependent on the aggregate state of the economy nor let they firms generate observable profits only during recessions. Nonetheless, note that the theoretical results developed here are somewhat in line with responses to the survey by Graham and Harvey (2001). In particular, in the survey financial executives cited the 'cost of refinancing in bad times' as the second most important factor affecting their debt maturity choice. Refinancing in bad times should be more expensive (or even not possible) because a good firm would have to compensate investors for being unable to distinguish it from bad firms. Similarly, in the previous discussion good firms wanted to avoid *repayment* in bad times as they would have to compensate investors for information being asymmetric.

3 Firms' Choice among Standard Debt Instruments

In this section I focus on standard debt instruments where the firm's repayment does not depend on the state of the economy. More specifically, the firm can now choose between issuing long-term bonds or short-term bonds, using banking finance or issuing commercial paper together with securing a backup line of credit.

Long-term bonds. For the firm to issue long-term bonds it has to ensure that direct investors' expected return is at least equal to their opportunity cost of providing finance, i.e.

$$\lambda R^{LT} + (1-\lambda)[\theta R_H^{LT} + (1-\theta)\Pi_L] = 1 \tag{14}$$

[10] This is $(1-\lambda)\left[\frac{1-\theta}{\theta}\frac{1}{1-\lambda}c\right]$.

or

$$R^{LT} = \frac{1-(1-\lambda)(1-\theta)\Pi_L}{\lambda+(1-\lambda)\theta} \tag{15}$$

where R^{LT} is the long-term (gross) interest rate. Note that $R^{LT} > 1$ as long as $\theta < 1$, i.e. as long as there is asymmetric information present (otherwise, very intuitively, $R^{LT} = 1$). In addition, for $R^{LT} > 1$ there must be a positive probability of a recession occurring for otherwise the return of all firms would be Π_H with certainty.

Short-term bonds. With short-term bonds investors are given the opportunity to rethink their investment decision at $t = 1$ upon the arrival of new information, i.e. they are effectively given an option to liquidate the firm at this date. Due to the underlying assumptions[11] short-term debt will never be rolled over at $t = 1$ since in the presence of asymmetric information the investor is always better off liquidating the firm. In order to determine the short-term interest rates first note that the interest rate between dates 1 and 2 in the *good* state, R_2^{ST}, must be 1 as there is no credit risk in this period. Hence the interest rate between dates 0 and 1, R_1^{ST}, is given by

$$\lambda R_1^{ST} \cdot R_2^{ST} + (1-\lambda)[\theta R_1^{ST} + (1-\theta)A_L] = 1 \tag{16}$$

or

$$R_1^{ST} = \frac{1-(1-\lambda)(1-\theta)A_L}{\lambda+(1-\lambda)\theta} \tag{17}$$

for $R_1^{ST} \leq A_L$.[12] As $A_L > \Pi_L$ borrowing short-term is cheaper than borrowing long-term, i.e. $R^{ST} \equiv R_1^{ST} \cdot R_2^{ST} = R_1^{ST} < R^{LT}$, provided there is asymmetric information ($\theta < 1$). There is thus a very simple explanation for the long-term interest rate being higher than the short-term interest rate. The long-term investor has to be compensated for a lower profit outcome at date $t = 2$ in case of continuation during a recession. Note that the difference between the long-term and the short-term interest rate increases with θ falling (i.e. $\partial(R^{LT} - R^{ST})/\partial\theta < 0$). This means

[11] In particular, $\theta\Pi_H + (1-\theta)\Pi_L < 1 < \theta A_H + (1-\theta)A_L$.

[12] For $R_1^{ST} > A_L$ the firm just pays back its liquidation value in case of recession.

that the higher the degree of asymmetric information, the wider the interest rate spread.

For ST finance to be actually preferred by a good firm it is necessary that the cost of using LT debt outweighs its benefit, i.e. $R^{LT} - R^{ST} > (1-\lambda)[\Pi_H + B - A_H]$. Plugging the derived values for R^{ST}, R^{LT} into this inequality we get[13]

$$\theta < \theta^* = \frac{A_L - \Pi_L - \lambda(\Pi_H + B - A_H)}{A_L - \Pi_L + (1-\lambda)(\Pi_H + B - A_H)} < 1. \tag{18}$$

Banking. A bank that extended a loan at $t = 0$ and engaged in screening activity is assumed to know a given firm's type at date $t = 1$. A bank is therefore able to make the right continuation versus liquidation decision, i.e. it liquidates bad firms and continues good firms. The interest rate on bank lending is therefore given by

$$R^B = \frac{1 + c - (1-\lambda)(1-\theta)A_L}{\lambda + (1-\lambda)\theta} \tag{19}$$

For pure banking finance to have a potential role, it must be that $R^B < R^{LT}$. Otherwise the good firm would always be able to complete its project at lower cost. This is equivalent to

$$c < (1-\lambda)(1-\theta)(A_L - \Pi_L) \tag{20}$$

which means that the extra cost of bank lending (i.e. the screening cost) has to be lower than the extra benefit of using it.

However, given that direct investors are always willing to extent credit between dates 0 and 1, bank borrowing (and screening) is actually not needed during this period. Banking finance may be needed at $t = 1$ in case of recession when direct investors are unwilling to roll over short-term loans. As a prerequisite for lending at this stage, however, the bank needs to verify in a timely manner that the firm is of good type. As has been pointed out, this is only possible if the bank engaged in

[13] For the following critical θ^* to be greater than 0 we further require $\lambda < (A_L - \Pi_L)/(\Pi_H - A_H)$.

a relationship at $t = 0$ with the firm, such as a commitment to lend on a contingent basis in return for a fee. For firms, lending on a contingent basis may be an attractive option as they only need to compensate banks for screening in the recessionary state and not for screening in the good state when it is actually not needed.

Mixed finance: Commercial Paper and Backup Line of Credit. If banking is not too costly and the firm is given the option it might use direct finance in normal, i.e. non-recessionary, states of the economy and banking finance in recessionary states. However, for banking finance to actually play a superior role in recessionary states banks in the model have to commit to lend on a contingent basis, thereby engaging in a relationship with the firm at $t = 0$.

In practice, most commercial paper issuers maintain backup liquidity through bank lines of credit. These are often being structured as multi-year revolver agreements in which a bank commits to loan funds to a firm on demand at a floating base rate that is tied to the prime rate, LIBOR rate, or certificate of deposit rate. As compensation, the bank receives various fees from the firm. In particular, banks often receive a commitment fee that is a percentage of the unused credit line.[14] In what follows I will look at this financing arrangement in the context of the stated model. For simplicity, I assume that the firm either uses the total amount of the funds committed by the bank or nothing at all. Furthermore, the (gross) rate charged in case of recession is assumed to equal the rate charged under direct finance (which was normalized to 1).

The commitment fee F that the bank requires the firm to pay is then given by

$$\lambda F + (1 - \lambda)[\theta + (1 - \theta)A_L - (1 + c)] = 0 \tag{21}$$

or

$$F = \frac{(1 - \lambda)[1 + c - (1 - \theta)A_L - \theta]}{\lambda}. \tag{22}$$

[14] Alternatively, the firm pays a facility fee that is a percentage of the credit line and is paid whether or not the line is activated.

The expected total cost for the firm to finance its project now becomes $(1-\lambda)[1+c-(1-\theta)A_L-\theta]+1$. Note that the good firm's project will now be refinanced at $t=1$ with certainty.

Proposition 1: Faced with different financing options, a good firm that wants to continue its project in case of recession will prefer using mixed finance to issuing long-term bonds whenever the degree of asymmetric information is sufficiently high.
Proof: See the appendix.

Note that if there was no asymmetric information in the economy, the good firm would always prefer to issue long-term debt as long as using banking finance is more costly, i.e. as long as $c>0$. Interestingly, the good firm's payment in normal times, i.e. $1+F$, is higher than its payment in bad times which simply equals 1. With this form of financing the firm therefore comes closer to the optimal financing arrangement in the state contingent contract case.

4 Publicly observable Credit Risk

The preceding section focused on firms with projects that are riskless in normal times. In this section I broaden the analysis to include firms that differ in the observable riskiness of their projects.[15] More specifically, projects now generate a verifiable return Π_H at $t=2$ with probability p (and Π_L with probability $1-p$) subject to continuation at $t=1$.[16] The success probability p is publicly observable and can be thought of as a credit rating. Projects again generate a private benefit $B>0$, which entrepreneurs obtain at $t=2$ if the firm is not liquidated.

Firms within a given risk class (defined by p) differ in the way their projects are

[15] A numerical example for purposes of illustration is available from the author upon request.

[16] Obviously, the previous section can be considered a special case with $p=1$ in this more general setting.

affected by a recession. Some projects are unaffected and still return $p\Pi_H + (1-p)\Pi_L$ in expected value terms whereas others return only Π_L at $t = 2$ with certainty. The probability $p_R \epsilon \{0, 1\}$ of the firm's project being affected by a recession is again information private to the firm at $t = 0$ and revealed to a bank at $t = 1$ only if the bank set up a relationship with the firm at $t = 0$. Direct investors or banks without a relationship learn about the firm's type at $t = 1$ only if the firm is liquidated. Quite intuitively, the liquidation value of a good firm - like the expected return at date 2 - now depends on the firm's credit rating and is given by $A(p) = pA_H$. By contrast, the liquidation value of a bad firm, A_L, is for simplicity assumed to be independent of the firm's credit rating.[17]

As in the previous section, lenders believe that a given firm is of type $p_R = 1$ with probability θ and $p_R = 0$ with probability $1-\theta$ so that $E[p_R] = \theta$.[18] To simplify the ongoing analysis I will further set $\Pi_L = 0$.

[Figure 2 about here.]

4.1 Financing Options

Long-term direct finance. When buying long-term debt investors have to wait until date 2 to realize returns and hence do not have the opportunity to react to new information being revealed at date 1. Direct investors are therefore willing to provide long-term finance as long as

$$\lambda p R^{LT}(p) + (1 - \lambda)\theta p R^{LT}(p) = 1 \tag{23}$$

[17] $A(p) = pA_H$ also ensures that good firms with a low success probability do not get funding just because they will be liquidated at $t = 1$. Making the liquidation value of *bad* firms also dependent on the credit rating unnecessarily burdens the analysis.

[18] For simplicity I assume that lenders' prior belief about the value of p_R is independent of the firm's credit rating. Firms with a lower credit rating may well have a higher proportion of firms affected by a recession, in which case θ would be a decreasing function of p. However, this unnecessarily burdens the analysis.

or

$$R^{LT}(p) = \frac{1}{p[\lambda + (1-\lambda)\theta]} \tag{24}$$

where $R^{LT}(p) < \Pi_H$ is the long-term interest rate. The required repayment in case of success is thus determined by the firm's credit rating p and, as before, the degree of asymmetric information θ and the probability of the economy being in a good state λ. A higher credit rating, less asymmetric information, and a higher probability of a good state all lead to a lower individual interest rate.

The expected repayment of a good firm (i.e. one whose project return will be unaffected by a recession) is then given by

$$pR^{LT}(p) = \frac{1}{\lambda + (1-\lambda)\theta} \tag{25}$$

which is greater than 1 whenever information is asymmetric ($\theta < 1$) and equal to 1 whenever information is symmetric ($\theta = 1$). Good firms' expected repayment under asymmetric information surpasses investors' investment contribution because they have to cross-subsidize bad firms whose expected repayment is less than 1. Bad firms always imitate good firms because otherwise they would not receive funding and would thus be unable to receive the private benefit B.

Short-term direct finance. By lending short-term the investor is given the opportunity to rethink his investment decision at $t = 1$ upon the arrival of new information, i.e. he is given the option to liquidate a firm's project. Under certain assumptions about the degree of asymmetric information being present the investor will exercise his liquidation option whenever the economy is in a recession and abstain from doing so whenever it is in a good state.

Proposition 2: An uninformed investor who provided short-term funding to a firm at $t = 0$ will always roll over the firm's debt at $t = 1$ when the economy is in a good state. He will not roll over the firm's debt when the economy is in

a recession provided the degree of asymmetric information is sufficiently high, i.e. $\theta \leq \min\left\{\frac{1}{\Pi_H}, \frac{A_L}{\Pi_H - A_H + A_L}\right\} < 1$.

Proof: See the appendix.

In what follows I assume that asymmetric information is sufficiently high so that uninformed short-term investors will not roll over the firm's debt in a recession. In the context of the model the short-term interest rate between dates 1 and 2, $R_2^{ST}(p)$, is then simply $1/p$ as lending in this period only takes place in the good state of the economy and the firm's interest rate is determined by its individual success probability. The short-term interest rate between dates 0 and 1, $R_1^{ST}(p)$, is then implicitly defined by

$$\lambda p R_1^{ST}(p) R_2^{ST}(p) + (1-\lambda)[\theta \min\{R_1^{ST}(p), pA_H\} + (1-\theta)A_L] = 1 \qquad (26)$$

for all $R_1^{ST}(p)/p < \Pi_H$. Note in particular that in a recession a good firm pays back $R_1^{ST}(p)$ as long as this is less or equal to the firm's liquidation value pA_H. For $R_1^{ST}(p) > pA_H$ the firm just pays back its liquidation value. The interest rate therefore displays a kink at the critical probability level p^k defined by $R_1^{ST}(p) = p^k A_H$. More specifically, the short-term interest rate between dates 0 and 1 for different values of the firm's credit rating p is given by

$$R_1^{ST}(p) = \begin{cases} \frac{1-(1-\lambda)(1-\theta)A_L}{\lambda+(1-\lambda)\theta} & \forall p \geq p^k \\ \frac{1}{\lambda}[1-(1-\lambda)(\theta p A_H + (1-\theta)A_L)] & \forall p < p^k \\ \text{No ST funding available} & \forall p < \underline{p}^{ST} \end{cases} \qquad (27)$$

where $p^k = \frac{1-(1-\lambda)(1-\theta)A_L}{A_H[\lambda+(1-\lambda)\theta]}$ is the probability value at which the short-term interest rate displays a kink and $\underline{p}^{ST} = \frac{1-(1-\lambda)(1-\theta)A_L}{\lambda\Pi_H+(1-\lambda)\theta A_H}$ is the critical value below which investors are unwilling to lend short-term.[19] It is obvious that $\underline{p}^{ST} < p^k$ as $\Pi_H > A_H$

[19]The maximum repayment a firm is able to offer over the two periods is Π_H so that the minimum credit rating for which financing is still possible is implicitly defined by $\Pi_H = R_1^{ST}(\underline{p}^{ST}) \cdot R_2^{ST}(\underline{p}^{ST})$. Note that the good firm actually has two short-term interest options to choose from as long as

so that the short-term interest rate will always exhibit a kink for the relevant range of p.

Provided an investor receives a higher return during a recession by liquidating a firm's project, the long-term interest rate lies above the cumulative short-term rate over two periods. Quite intuitively, the firm has to compensate investors for a lower profit outcome in case of continuation in the bad state by pledging a higher return in the good state.

Lemma 1: As long as it is optimal for a short-term investor to liquidate a firm during a recession, the cumulative short-term interest rate over two periods lies below the long-term rate for all firms with credit rating $p > \underline{p}^{LT}$.
Proof: See the appendix.

Note that for the short-term rate to lie below the long-term rate it is crucial that there is a sufficiently high degree of asymmetric information. If information were symmetric (or marginally asymmetric) an investor would always roll over a firm's debt in a recession. Hence, in this case the short-term rate would equal the long-term rate. From the discussion above it should also be clear that there are some firms with credit rating $p < \underline{p}^{LT}$ for which short-term borrowing is the only available financing option. Since at $\underline{p}^{LT}$ the short-term interest rate is strictly less than the maximum pledgeable income in the good state (which is Π_H) by continuity there are some firms with credit rating $p < \underline{p}^{LT}$ (and $p > \underline{p}^{ST}$) that can pledge enough income to secure short-term financing. Quite crucially, these firms are restricted to borrow short-term and cannot borrow long-term. By contrast, firms with success probability $p > \underline{p}^{LT}$ can choose between long-term and short-term borrowing.

$R_1^{ST}(p) < pA_H$: It may pay the same return in the good and the bad state of the economy or it may pledge its full liquidation value in the bad state and pay a lower return in the good state. It is easy to verify that the firm always prefers the first option and pays the same return in the good and the bad state whenever this is possible.

In what follows I assume that all firms that have the option to choose between the two financing modes prefer long-term financing. In effect, this means that the utility of using LT finance outweighs the utility of using ST finance for all firms with credit rating $p > \underline{p}^{LT}$ or

$$p[\Pi_H - R^{LT}(p)] + B > \lambda[p\Pi_H - R_1^{ST}(p) + B] \tag{28}$$

for all p with $\underline{p}^{LT} < p < p^k$ and

$$p[\Pi_H - R^{LT}(p)] + B > \lambda[p(\Pi_H - R^{ST}(p)) + B] + (1-\lambda)[pA_H - R_1^{ST}(p)] \tag{29}$$

for all $p > p^k$.[20] This basically means that the private benefit B that firms receive at $t = 2$ in case of project continuation is large enough to make them choose the long-term financing option whenever this is possible. By inspection, it is obvious that there always exists such a B so that all firms prefer the long-term option.

CP + Backup line of credit. Instead of long-term finance the firm may use short-term direct finance together with a backup line of credit. The important thing to keep in mind is that backup lines of credit are not credit enhancements. If a company goes bankrupt, the bank will not pay off its maturing CP. They are therefore not an insurance against a deterioration in the firm's credit quality but an insurance against a rollover crisis in the CP market. If the CP market dries up, a backup line allows an issuer whose credit quality has not changed to substitute bank borrowing for CP borrowing. For backup lines to play any role it must therefore be that information becomes *symmetric* between banks and firms at $t = 2$ but remains *asymmetric* between direct investors and firms (otherwise direct investors would always refinance good firms). However, note that information between banks and firms cannot already be symmetric at $t = 1$. Otherwise by offering credit only to good firms on slightly more attractive terms than direct investors banks would

[20] Notice that it is not sufficient to just focus on the first equation as the RHS of the second equation is higher than the RHS of the first equation for all $p < p^k$.

capture all good firms while bad firms would turn to direct finance. Under these circumstances, the market for direct debt would break down.

Whenever there is a recession a bank that has committed to a backup line thus pays direct investors the firm's promised short-term rate $R_1^{ST}(p)$ at $t = 1$ if the firm has been identified as good. Whenever the firm is revealed as bad banks invoke the 'material adverse change clause'. The investor is then left with the firm's liquidation value A_L. Implicitly, I assume that enforceability of contracts is not an issue. The bank always refinances a good firm in a recession even if it will make a loss. In the context of the model this is quite plausible as every firm can be perfectly identified after either liquidation or continuation and thus every breach of contract is publicly observable.

The uninformed short-term investor's required return is then given by:

$$\lambda R_1^{ST} + (1-\lambda)[\theta R_1^{ST} + (1-\theta)A_L] = 1 \tag{30}$$

or

$$R_1^{ST} = \frac{1-(1-\lambda)(1-\theta)A_L}{\lambda + (1-\lambda)\theta.} \tag{31}$$

By comparison, this is simply the short-term interest rate between dates 0 and 1 that applies to all firms with credit rating $p > p^k$. However, in the present case this interest rate may even apply to firms with a credit rating below p^k as good firms' projects will always be continued and their maximum repayment in a recession will therefore be higher than their liquidation value pA_H. The maximum interest rate (or lowest credit rating for which short-term finance together with a backup line is still available) is now determined by what the firm can pay in the good state taking into account the fee it has to pay for the backup line of credit. In the context of the model the firm always prefers a commitment fee that is a percentage of the *unused* credit line to a facility fee that is a percentage of the credit line and is paid whether or not the line is activated.[21] This is so because the firm wants to avoid asymmetric information costs that it has to pay during a recession. For simplicity, I assume that

[21] Of course, a firm that is unable to pay the full commitment fee (plus the short-term interest rate

the firm either uses the total amount of the funds committed by the bank or nothing at all.

Quite crucially, banks' screening costs are now assumed to be decreasing in the firm's probability of success p, i.e. $c(p) = c + 1 - p$.[22] Screening costs may actually be lower for higher rated companies as these firms are often active in more mature industries and often have more transparent business models. Banks therefore may find it less costly to determine whether or not these firms' prospects have been severely impacted by an impending recession.

Given that bank borrowing costs are decreasing in p, the commitment fee that the bank charges in the good state is defined by

$$\lambda F(p) + (1 - \lambda) \left[\theta \left(R_1^{ST} - (1 + c(p)) R_1^{ST} \right) \right] = 0 \tag{32}$$

or

$$F(p) = \bar{\lambda} \theta c(p) R_1^{ST} \tag{33}$$

with $\bar{\lambda} \equiv \frac{1-\lambda}{\lambda}$.

In the good state the bank receives the commitment fee $F(p)$ at $t = 1$ from all firms whose projects have been successful, independent of whether the particular firm is good or bad.[23] In a recession the bank receives the cumulative short-term interest rate at $t = 2$ only from good firms with successful projects. In this state of the economy, the bank pays direct investors who invested in a good firm the short-term interest rate at $t = 1$ for which it incurs total costs of $1 + c(p)$ per unit at $t = 2$.

between dates 0 and 1 and both multiplied by $1/p$) may, in principle, prefer paying some fee also in the bad state to issuing long-term direct debt. However, for a sufficiently high cost of using banking finance firms with a credit rating that would permit both sorts of finance nonetheless prefer direct debt. Hence the assumption that firms may only pay a commitment fee is not overly restrictive in the context of the model.

[22] Obviously, for $p = 1$ the screening cost is simply c, as in the previous section when there was no publicly observable credit risk on the part of the firm.

[23] One may think of a firm taking up another short-term loan at $t = 1$ of size $F(p)$ and promising to repay $1/p \cdot F(p)$ at $t = 2$.

Firms are able to issue commercial paper and secure a backup line of credit as long as their required repayment at $t = 2$ is less or equal to the maximum amount they can pledge, i.e. Π_H. The lowest credit rating for which this financing option is available is hence given by

$$\left[R_1^{ST} + F\left(\underline{p}^{CP}\right)\right] / \underline{p}^{CP} = \Pi_H \tag{34}$$

or

$$\underline{p}^{CP} = \frac{R_1^{ST} + \bar{\lambda}\theta(1+c)R_1^{ST}}{\Pi_H + \bar{\lambda}\theta R_1^{ST}}. \tag{35}$$

It is obvious that banking must not be too costly for otherwise no firm would be able to finance itself by issuing CP and securing a backup line of credit.[24] Furthermore, firms that are able to choose this financing form are also able to choose long-term direct finance.

Lemma 2: Provided that Π_H is large enough, firms with a credit rating that allows for CP + CL financing are also able to use long-term direct finance, i.e. $\underline{p}^{CP} > \underline{p}^{LT}$.
Proof: See the appendix.

From this it is obvious that there may be some firms who would actually prefer issuing CP together with securing a backup line but are, in fact, restricted to issue long-term debt. However, it may also be the case that all firms prefer LT debt, even those with virtually no default risk who are able to issue CP.

4.2 Firms' Choice between Long-term Direct Debt and CP with Backup Line of Credit

Obviously, if bank lending did not entail extra costs, i.e. $c(p) = 0$, and information was asymmetric, all firms with $p > \underline{p}^{CP}$ would choose to issue commercial paper

[24] The upper limit for c so that only firms with the highest credit rating (i.e. $p = 1$) will choose CP + CL can be derived by setting $\underline{p}^{CP} = 1$ in (35) and solving for c.

and secure a backup line of credit at $t = 0$ and switch to bank borrowing in case of recession at $t = 1$.[25] Their expected total cost would then be $R_1^{ST}(p)$ which is strictly less than the expected total cost of issuing long-term direct debt, $pR^{LT}(p)$. In fact, there would not even be a role for commercial paper as investors would be equally well off borrowing from banks between dates 0 and 1.

By contrast, if bank borrowing did entail extra costs but information was symmetric, a good firm would never choose to issue CP and secure a backup line of credit as it would be a costlier option without any extra benefit. However, the firm would be indifferent between long-term and short-term direct finance (as short-term finance would always be rolled over). By the same reasoning, if bank borrowing was costless and information was symmetric, firms would be indifferent between all three financing options.

As a consequence, for firms to prefer different long-term financing arrangements information needs to be asymmetric and bank borrowing must entail extra costs. Quite intuitively, when considering the two long-term options firms face a trade-off: By using direct finance they incur asymmetric information costs but not bank borrowing costs. By issuing CP plus a backup line of credit they incur bank borrowing costs but possibly lower asymmetric information costs. As bank borrowing costs are lower when a firm's success probability is higher, there is a critical credit rating above which all firms prefer to issue CP together with securing a backup line of credit. To determine this critical level note that firms prefer issuing CP together with securing a backup line whenever their expected cost is lower than issuing long-term debt or

$$R_1^{ST} + \lambda F(p) \leq pR^{LT} \tag{36}$$

[25] If bank lending does not entail extra costs the commitment fee that the bank charges, $F(p)$, is zero, independent of the firm's credit rating. The lowest credit rating at which this financing option is still possible is then less or equal to the lowest credit rating at which long-term direct finance is possible, i.e. $\underline{p}^{CP} = \frac{1-(1-\lambda)(1-\theta)A_L}{\Pi_H[\lambda+(1-\lambda)\theta]} \leq \frac{1}{\Pi_H[\lambda+(1-\lambda)\theta]} = \underline{p}^{LT}$.

which is equivalent to

$$p \geq 1 + c - \frac{(1-\theta)A_L}{\theta[1-(1-\lambda)(1-\theta)A_L]} \equiv p_*^{CP}. \tag{37}$$

For some firms to actually choose this financing arrangement it is necessary that these firms are both *able* and *willing* to issue CP and secure backup liquidity.

Proposition 3: For some $c \geq 0$ there are some firms with credit rating $p < 1$ that choose to be financed by issuing CP together with securing a backup line of credit.

Proof: See the appendix.

Given Lemma 2 and Proposition 3 the firm's theoretically derived debt maturity choice - which is broadly consistent with observed practice - is illustrated in figure 3.

[Figure 3 about here.]

Firms of the highest credit quality choose to issue CP together with a backup line of credit. Firms of slightly lower credit quality prefer (or are restricted) to issue long-term bonds. Finally, firms of even lower credit quality are restricted to issue short-term bonds.[26] Note that the focus of the analysis has been firms with a credit

[26]One might wonder why bad firms with a high credit rating do not use short-term finance only (without a backup line of credit). They would thereby be able to obtain the same effective financing arrangement, i.e. short term finance in the first period and short term finance in the second period if the economy is in a good state and no finance in the second period if the economy is in a bad state. However, they would not have to pay the commitment fee for the provision of the backup line of credit and would therefore be better off.

This is so because firms have to have a (publicly observable) credit rating to be able to tap public debt markets. If a firm with a high rating wants to issue a short-term bond without securing a backup line of credit it signals that it is a bad firm. But then it does not receive any financing at all. It hence prefers to secure a backup line and to pool with good firms of the same high rating category.

rating high enough to issue direct debt. In the context of the model, banks just have a screening role. To explain bank lending for lower rated companies (below $\underline{p}^{ST}$) banks would also need to improve profitability somehow to make lending worthwhile.

5 Comparative Statics

The total volume of US nonfinancial firms' outstanding CP peaked at USD 351 bn in November 2000 and declined by more than 70 percent until it reached a nadir in December 2003. Since then the market has recovered strongly. However, as of November 2007 outstanding CP remains about 50 percent below its peak in the fall of 2000. Relative to historical patterns, the decline has been unusually pronounced. As documented by Shen (2003) in the previous five episodes of recession-related market shrinkage, the largest reduction in volume outstanding was about 27 percent.

How may the model help to explain these developments? In general, the model predicts that if the economy enters a recession short-term finance will not be rolled over by direct investors. Firms with a low credit rating and *bad* firms with a high credit rating will thus be liquidated during bad times. However, *good* firms with a high rating are able to replace short-term direct finance with short-term bank lending if they secured a backup line of credit ex ante. Overall, we should therefore observe a decrease in short-term direct finance during recessions and an increase in short-term bank lending ceteris paribus. However, besides cyclical factors *structural* factors may also influence the amount of direct finance outstanding and may alter the critical credit ratings at which firms choose different financing options. In what follows I consider an increase in the probability that the economy is in the good state (which for obvious reasons I call 'Great Moderation'). Furthermore, I will look at how an increase in computing power and wider availability of information ('IT Revolution') alters firms' debt maturity choice in the context of the model.

An increase in the probability of the economy being in the good state, λ, means that the economy is less likely to enter a recession where some firms generate a

return of zero with certainty. Hence at any given credit rating a firm of unknown type has a higher overall success probability. The interest rate for any given credit rating should therefore be lower. However, it is then obvious that at the lowest credit rating at which short-term direct finance was previously possible, the firm's maximum pledgeable income, Π_H, lies above the total interest the firm is expected to pay over the two periods. Hence, a firm with a slightly lower credit rating will still have enough pledgeable income to be financed via short-term direct debt. As a consequence, a higher λ will lead to an increase in direct lending to higher risk firms (or equivalently to a lower $\underline{p}^{ST}$). What happens to the amount of CP issued together with a backup line of credit? Certainly, the expected cost of this financing arrangement, $R_1^{ST} + \lambda F(p)$, falls when λ rises. But so does the expected cost of long-term direct finance, pR^{LT}. In fact, it turns out that the expected cost of long-term direct finance falls even more strongly so that issuing CP together with a credit line becomes less attractive and p_*^{CP} increases.

Proposition 4: If the economy becomes less likely to experience a recession, interest rates and the bank's commitment fee for any given credit rating decline. More firms are able to use direct finance, i.e. $\underline{p}^{ST}$ decreases, and fewer firms issue CP together with securing a credit line ex ante, i.e. p_*^{CP} increases.
Proof: See the appendix.

I next turn to the impact of information becoming more easily available. This, in particular, may be associated with lower costs of computing power, improved software, and, above all, the better accessibility of information via the Internet. In the context of the model, the 'IT revolution' may have affected two important parameters with different consequences for the total amount of direct finance being issued and firms' choice of financing arrangements.

On the one hand, it may have lowered banks' screening costs, resulting in a lower c, which, in turn, would have led to a lower cost of providing backup lines of

credit, $F(p)$. More firms would then be able and willing to issue CP and secure a backup line of credit. CP issuance should therefore have gone up over the last two decades ceteris paribus. On the other hand, better accessibility of information at lower cost should have made it easier for direct investors to identify bad firms. As a consequence, the share of bad firms obtaining finance should have declined, or, equivalently, information should have become more symmetric, i.e. θ should have increased. Ceteris paribus, an increase in θ leads to more firms being able to obtain direct finance and to more long-term direct finance being issued (partly at the expense of CP being issued together with a backup line of credit).

Proposition 5: If information becomes more symmetric, i.e. θ increases, some firms of lower credit quality that were previously denied credit are now able use direct finance. Furthermore, more long-term direct finance and less CP will be issued.
Proof: See the appendix.

In sum, the model suggests that while there will always be a decrease in CP issuance during bad times, structural factors (e.g. a lower probability of a recession and/or more symmetric information) may lead firms of the highest credit quality to issue fewer CP even in good times. The reason is that the total cost for this long-term financing arrangement (i.e. also taking into account the cost of the backup line of credit) may not decrease as much as the cost of just issuing long-term direct debt. These structural changes may therefore help to explain why the market for nonfinancial CP has remained far below its former peak level despite a strong increase in risk tolerance and a marked upturn in credit quality up until the summer of 2007.

6 Discussion and Conclusion

The simple model developed here generates qualitative predictions about the equilibrium in debt markets that appear broadly consistent with some stylized facts. Firms of the highest credit quality issue commercial paper and secure backup lines of credit ex ante. During periods when public credit markets prove unreceptive, banks often experience an increase in asset growth due to a drawdown of credit lines by firms as documented in Gatev and Strahan (2006). The model stresses that this is part of intended financing arrangement whereby high quality firms use direct finance during 'normal' times when asymmetric information between lenders and the firm does not matter and use intermediated finance when asymmetric information does matter. Short-term finance then provides the necessary flexibility to adjust to changing economic circumstances. In this sense, financial systems naturally become more 'bank-based' during recessionary episodes and more 'market-based' during normal times.[27]

In practice, only firms of the highest credit quality opt for this financing arrangement. Firms of slightly lower quality choose long-term direct finance instead. The model claims that good firms of less than top quality prefer long-term direct debt not because of the longer maturity since by issuing CP (and securing a backup line) they are not at risk of refinancing either. Rather, for these firms contingent bank lending becomes too expensive and therefore unattractive. Finally, firms of still lower credit quality are restricted to borrow short-term since they do not have enough pledgeable income to borrow long-term. Studies of large firms with access to public securities markets support the view that a firm's debt maturity increases as its credit rating falls, at least until its credit rating becomes speculative. They also find that firms without a credit rating typically use more short-term debt.[28]

The model identifies structural factors that may explain why the nonfinancial

[27] This in a way differs from the widely held view that financial systems are either bank- or market based.

[28] see, for example, Barclay and Smith (1995)

commercial paper has shrunk since the start of the decade. In particular, better accessibility of information ('IT revolution') may have led to information between direct investors and the firm having become more symmetric. Furthermore, the probability of recessions may have decreased ('Great Moderation'). Both factors should have contributed to CP being a less attractive financing option today.

It should be noted that the model just focuses on firms on the lower end of the credit risk spectrum, i.e. firms that have a credit rating and are able to tap bond markets. More risky firms, by contrast, typically borrow from banks or from finance companies rather than by selling bonds to the public. Banks may play quite a different role for these borrowers. In particular, they may not just screen firms but may also engage in close monitoring and may thereby lower individual credit risk.

Furthermore, the applicability of the model to other parts of the commercial paper market appears somewhat limited. In particular, the rollover crisis in the market for asset-backed commercial paper in the second half of 2007 appears difficult to reconcile with the notion of an intended financing arrangement. Instead, banks may have been overly optimistic about liquidity in this part of the commercial paper in general. Or they may have used this financing arrangement to extend lending without incurring a capital charge[29] ('regulatory arbitrage') and relying on central bank liquidity if liquidity demands prove too high ('moral hazard'). Further research about this part of the CP market is certainly needed.

[29] Under Basel I banks do not have to hold capital against backup lines of credits.

7 Appendix

Proof of Proposition 1

For a good firm to issue CP along with securing a backup line of credit instead of issuing long-term bonds it must be that the cost of long-term finance is higher than the cost of mixed finance, i.e.

$$\frac{1-(1-\lambda)(1-\theta)\Pi_L}{\lambda+(1-\lambda)\theta} = \Pi_L + \frac{1-\Pi_L}{\lambda+(1-\lambda)\theta} > (1-\lambda)[1+c-(1-\theta)A_L-\theta]+1 \quad (38)$$

Solving for θ we obtain:

$$\theta_1 > \sqrt{\frac{z}{y}+\left(\frac{x}{2y}\right)^2}-\frac{x}{2y} \quad (39)$$

$$\text{or} \quad \theta_2 < -\sqrt{\frac{z}{y}+\left(\frac{x}{2y}\right)^2}-\frac{x}{2y} \quad (40)$$

with $x = 1-\Pi_L+\lambda(A_L-1)+(1-\lambda)(1+c-A_L)$, $y = (1-\lambda)(A_L-1)$, and $z = 1-\Pi_L-\lambda(1+c-A_L)$.

Note that for a solution we also require that either θ_1 or θ_2 lie in the interval between 0 and 1. Since $-x/2y > 1$ the only possible solution to the inequality is θ_2. Define the critical level of asymmetric information by $\theta^c = -\sqrt{\frac{z}{y}+\left(\frac{x}{2y}\right)^2}-\frac{x}{2y}$. Then as long as $\theta < \theta^c$ good firms will prefer to issue CP along with securing a backup line of credit instead of issuing long-term bonds. Q.E.D.

Proof of Proposition 2

The first part follows straight from the firm's liquidation value function. Given that the continuation value of a firm in the good state is $p\Pi_H$, the sufficient condition for an investor to roll over a firm's debt is[30]: $p\Pi_H > \theta p A_H + (1-\theta)A_L$ which is equivalent to

$$p > \frac{(1-\theta)A_L}{\Pi_H - \theta A_H} \quad (41)$$

[30]It is not a *necessary* condition as a firm's project might be continued even if its continuation value is below its liquidation value as long as the continuation value is ≥ 1.

Since the RHS of this inequality is a decreasing function of θ we simply have to prove that for $\theta = 0$ or $p = A_L/\Pi_H$ the firm is unable to get short-term funding. We thereby insure that for all relevant values of p (i.e. those at which financing takes place) the firm's continuation value is higher than its liquidation value. To see this simply note that for $p = A_L/\Pi_H$ the continuation value of a firm in normal times is $\left(\frac{A_L}{\Pi_H}\right)\Pi_H = A_L < 1$ and the liquidation value of an unknown firm is $\theta\left(\frac{A_L}{\Pi_H}\right)A_H + (1-\theta)A_L < 1$. Hence no matter whether he refinances or liquidates the firm at the interim stage the investor is unable to recoup his initial investment. He thus refrains from financing the firm at $t = 0$. Q.E.D.

To prove the second part it is necessary to show that in a recession the continuation value of a firm of unknown type is 1) less than the initial investment required[31], i.e. $\theta p\Pi_H < 1$, and also 2) less than the firm's liquidation value, i.e. $\theta p\Pi_H < \theta pA_H + (1-\theta)A_L$. It is easy to see that as long as $\theta \leq 1/\Pi_H$ condition 1) is fulfilled, regardless of the firm's credit rating p. Furthermore condition 2) is fulfilled as long as

$$p < \frac{(1-\theta)A_L}{\theta(\Pi_H - A_H)}. \tag{42}$$

Hence, whenever $\theta \leq \frac{A_L}{\Pi_H - A_H + A_L} < 1$ the firm's liquidation value is higher than its continuation value, regardless of its credit rating. As a result, in a recession a firm of unknown type will be liquidated whenever $\theta \leq \min\left\{\frac{1}{\Pi_H}, \frac{A_L}{\Pi_H - A_H + A_L}\right\} < 1$. Q.E.D.

Proof of Lemma 1

For firms with credit ratings $p > p^k$ the cumulative short-term rate over two periods lies below the long-term rate whenever

$$R^{ST} = \frac{1-(1-\lambda)(1-\theta)A_L}{p[\lambda+(1-\lambda)\theta]} < \frac{1}{p[\lambda+(1-\lambda)\theta]} = R^{LT} \tag{43}$$

which is obviously true for all p.

[31] Otherwise the investor would always be able to recoup his initial investment contribution and thus would never liquidate the project.

For firms with credit rating p, $\underline{p}^{LT} < p < p^k$, the short-term interest rate is given by $R^{ST} = \frac{1-(1-\lambda)(\theta p A_H + (1-\theta)A_L)}{\lambda p}$. Rewrite the investor's participation constraint for providing long-term finance to get

$$R^{LT} = \frac{1-(1-\lambda)\theta p R^{LT}}{\lambda p}. \tag{44}$$

As $\theta p A_H + (1-\theta)A_L > \theta p \Pi_H \geq \theta p R^{LT}$ for all $\theta \leq \min\left\{\frac{1}{\Pi_H}, \frac{A_L}{\Pi_H - A_H + A_L}\right\}$ the short term interest rate lies below the long-term rate for all p with $\underline{p}^{LT} < p < p^k$. Q.E.D.

Proof of Lemma 2

To see that issuing long-term direct finance is always possible for a firm able to issue CP together with securing a backup line of credit provided that Π_H is large enough first note that if $\underline{p}^{CP} > \underline{p}^{LT}$ for $c = 0$ then it also holds for $c > 0$. For $c = 0$ rewrite $\underline{p}^{CP} > \underline{p}^{LT}$ to get

$$\Pi_H - \frac{1}{\lambda + (1-\lambda)\theta} > \frac{\lambda(1-\theta)A_L}{\theta[1-(1-\lambda)(1-\theta)A_L]}. \tag{45}$$

Now, assume that the above statement was not true. Then even for the largest possible value of Π_H the inequality would not hold true. Π_H is bounded above by the 'no rollover' condition, i.e. $\theta\Pi_H < 1$. Setting $\Pi_H = \frac{1}{\theta}$ the above inequality simplifies to $A_L < 1$ which is true by assumption. Hence, for Π_H large enough $\underline{p}^{CP} > \underline{p}^{LT}$. Q.E.D.

Proof of Proposition 3

To prove that under the given assumptions some firms will actually choose to be financed via CP + CL, it is necessary to show that for some $c > 0$ 1) some firms with credit rating $p < 1$ are *able* to use CP + CL and 2) some firms with credit rating $p < 1$ *prefer* using CP + CL to issuing long-term direct debt.

To prove the first part it is necessary to show that $\underline{p}_{CP} < 1$ for some $c > 0$ or

$$\frac{R_1^{ST} + \frac{1-\lambda}{\lambda}\theta(1+c)R_1^{ST}}{\Pi_H + \frac{1-\lambda}{\lambda}\theta R_1^{ST}} < 1. \tag{46}$$

For $c = 0$, it is obvious that this inequality holds true as $R_1^{ST} < \Pi_H$. However, then, by continuity, it must also hold true for c slightly above 0. Q.E.D.

The second part is true as long as $p_{CP}^* < 1$ or

$$1 + c - \frac{(1-\theta)A_L}{\theta[1-(1-\lambda)(1-\theta)A_L]} < 1. \tag{47}$$

Again, for $c = 0$, it is obvious that this inequality holds as long as $A_L > 0$. But then, again, by continuity, it must also hold for c slightly above 0. Q.E.D.

Proof of Proposition 4

It is straightforward to show that $R^{LT}(p)$, $R_1^{ST}(p)$ for $p \geq p^k$, and $F(p)$ all fall in λ. In addition, $R_1^{ST}(p)$ for $\underline{p}^{ST} \leq p < p^k$ also falls in λ as long as $\theta p A_H + (1-\theta)A_L < 1$ which is the case for $p = p^k$ and hence also for all $p < p^k$.

Turning to the critical credit ratings, it is straightforward to show that p_*^{CP} increases in λ. Furthermore, the lowest credit rating at which short-term direct finance is still available, $\underline{p}^{ST}$, falls with λ increasing as long as

$$\theta < \frac{\Pi_H - A_L\Pi_H}{A_H - A_L\Pi_H} \tag{48}$$

It is obvious that the RHS is larger than 1 as $\Pi_H > A_H$ by assumption and the restriction is therefore not binding. Hence, $\underline{p}^{ST}$ also falls in λ. Q.E.D.

Proof of Proposition 5

It is straightforward to show that $\underline{p}^{LT}$ falls and p_*^{CP} rises in θ. In addition, $\underline{p}^{ST}$ falls in θ as long as

$$\lambda < \frac{A_H - A_L A_H}{A_L\Pi_H - A_L A_H} \tag{49}$$

However, we know that bad firms are not worth financing, i.e. $\lambda\Pi_H + (1-\lambda)A_L + B < 1$, which is equivalent to

$$\lambda < \frac{1 - A_L - B}{\Pi_H - A_L}. \tag{50}$$

No matter what value B assumes λ cannot exceed $\frac{1-A_L}{\Pi_H-A_L}$. However, this is less than the restriction required for $\underline{p}^{ST}$ to fall in θ. Hence, $\underline{p}^{ST}$ always falls in θ. Q.E.D.

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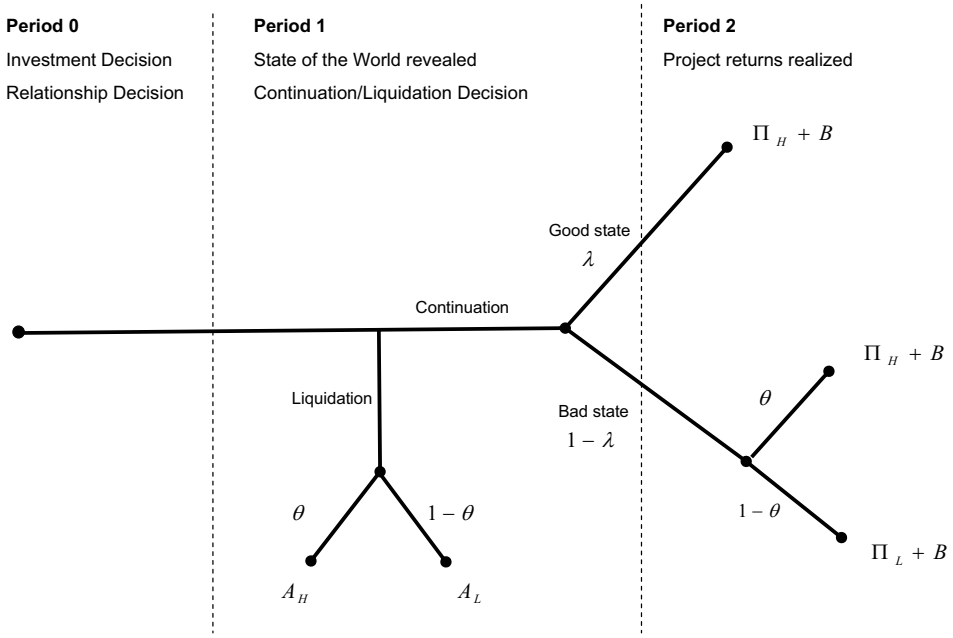

Figure 1: Uncertainty structure and project payoff

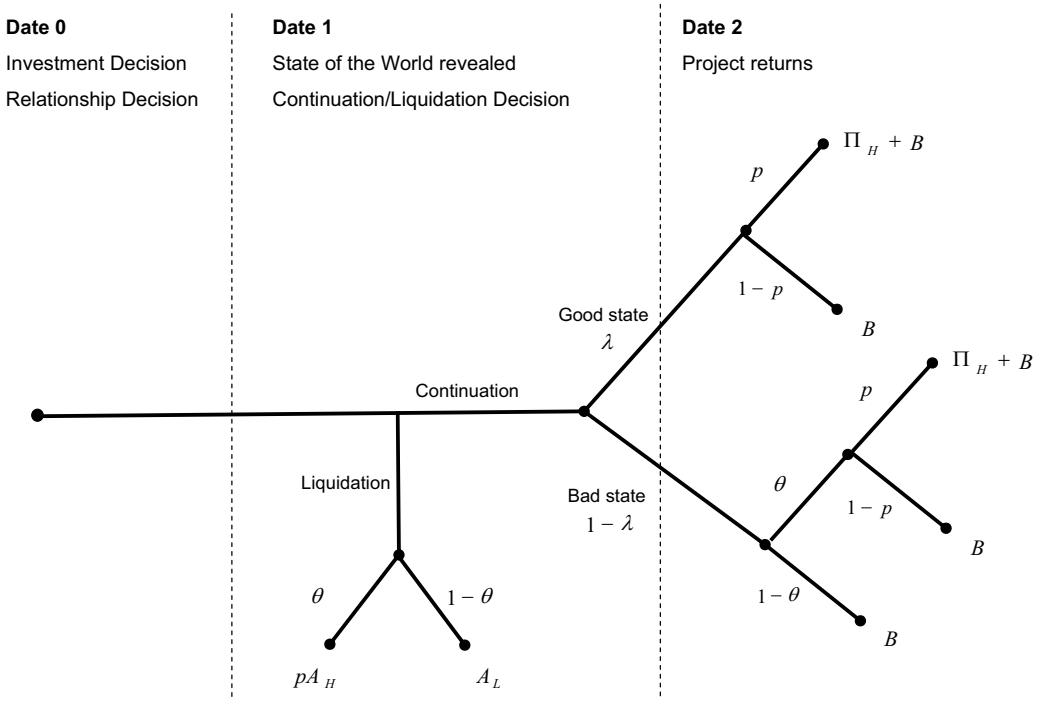

Figure 2: Uncertainty structure and project payoff for a firm with credit rating p

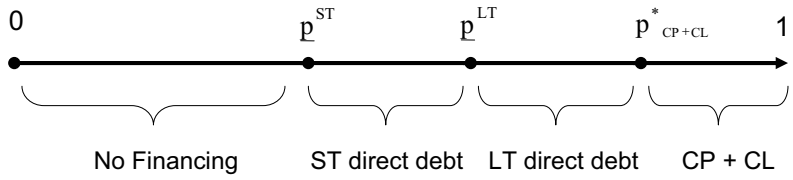

Figure 3: Firms' debt maturity choice

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