On the Coexistence of Bank and Bond Financing

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Abstract

This paper studies why most bond issuing firms also obtain funding from bank loans and credit lines. An entrepreneur has access to a risky investment opportunity, which is profitable ex-ante but might become unprofitable at an intermediate stage. The entrepreneur has incentives to continue an unprofitable project, which he can do if initial public borrowing has raised enough funds to also finance the project continuation. Only the bank is permanently present in the market and can provide and cancel funding on short notice. The dependence on a bank credit line constrains the entrepreneur's continuation decision, thereby increasing ex-ante and ex-post efficiency. Bank loans act as a complement to public debt, rather than as a substitute. A contraction in bank loan supply limits access to bond financing. I conclude that public debt markets cannot always mitigate banking crises.

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1 Introduction

The dramatic decline in economic activity during the Great Recession of 2007-2009 has been attributed to a contraction in the supply of bank loans. A growing body of theoretic literature supports this hypothesis, suggesting various mechanisms of how financial intermediation may propagate or even cause economic shocks. Most of these theories focus on a single source of debt without considering the choice among different debt instruments.

In theories of corporate finance, it is usually assumed that bank loans and bond issuance are substitutes, if not perfect ones.[1] Under this assumption, direct market lending can mitigate contractions in bank loan supply for companies with access to bond issuance. It could then be argued that policy makers should strengthen the corporate debt market and facilitate the credit rating process for smaller companies in order to increase financial stability.

This paper argues that bank debt may, in some cases, complement rather than substitute public debt. It shows that bank loans can solve a conflict of interest between bondholders and shareholders and thereby increase investment levels and efficiency. A reduction in bank loan supply may then decrease the access to direct market borrowing for some companies, which would further amplify the original credit contraction. Moreover, those companies which are substituting bank loans with bond issuance will make less efficient investment choices, worsening the economic outcome.

The three period model presented in the next section features an entrepreneur with access to an investment opportunity but with insufficient funds to undertake the project on his own. He therefore has to raise money, which he can do by issuing a long-term bond and by taking out short-term bank loans. In the second period, the entrepreneur (and everyone else) receives new information on the expected outcome of the project which can render the continuation unprofitable. The entrepreneur then has the option to stop the project and recover a scrapping value. With long-term debt and limited liability, the entrepreneur may have incentives to continue the project inefficiently. The dependence on short-term bank loans can then constrain his continuation decision, thereby increasing ex-ante and ex-post efficiency.

The model derives the determinants of the optimal financial structure of the investment project. In particular it characterizes bond issuance, bank borrowing, credit line agreements and cash holdings of the entrepreneur. I find that more profitable firms are likely to only issue bonds, while less profitable and information sensitive firms require the additional dependence on bank loans and credit lines. More profitable firms are also shown to optimally hoard cash or a similarly liquid asset.

A project with relatively high continuation cost but small scrapping value can be financed through a combination of bonds and a credit line, and will also feature cash holdings. Projects that have

[1] See, for example, (Becker and Ivashina, 2011, p. 5).

a relatively large resale value, even if stopped prematurely, require initial financing through short term debt, which complements any bond issuance. These companies will then avoid cash holdings. I show that a firm's vulnerability to a contraction in bank loan supply depends on its optimal capital structure.

The contribution of this paper is twofold: First, the joint determination of bank loans, credit lines, bond issuance and cash holdings provides new insights on a firm's capital structure choice. Second, this paper highlights that the substitution from bank financing to bond issuance in times of financial distress is less perfect than previously thought, even for large, credit rated companies. In fact, I show that some companies may even reduce their market borrowing in response to a contraction in bank loan supply.

Since bond issuance cannot replicate the benefits of bank loans, policy makers interested in reducing the impact of a banking crisis should focus their efforts on strengthening the banking system itself rather than on easing firms' access to public debt markets.

The next section presents the setup of the model. I will then discuss the assumptions in Section 3, before deriving the financing choices in Section 4. The predictions of the model are analyzed in Section 5, followed by a presentation of the related literature in Section 6. Section 7 discusses the results in light of the recent Great Recession, before Section 8 concludes.

2 The Model

This section presents the setup of the model, assumptions on financial markets and the first best investment choice in this framework. I defer the discussion of the assumptions to the following section.

2.1 Setup

Consider a three period economy that is populated by three agents: an investor, a bank and an entrepreneur. All agents maximize their expected wealth in the last period:

$$U = E_0\left(W_2\right). \tag{1}$$

The entrepreneur has access to an investment project that requires an initial investment of I_0 in period 0 and an additional investment of αI_0 in period 1, where $\alpha < 1$. In period 2, the project can either succeed, yielding a payoff of $Y_2 = 1$, or it can fail, in which case $Y_2 = 0$. Alternatively, the project can be stopped in period 1 and a scrapping value of δI_0 can be recovered.

In period 1, the world can take one of two intermediate states, the good state G and the bad state B. In the good state, the probability of success in period 2 is q, where $q > 0.5$. In the bad state, the probability of success is $1 - q$. In period 0, the ex-ante probability of the good state is p, whereas the probability of the bad state is $1 - p$.

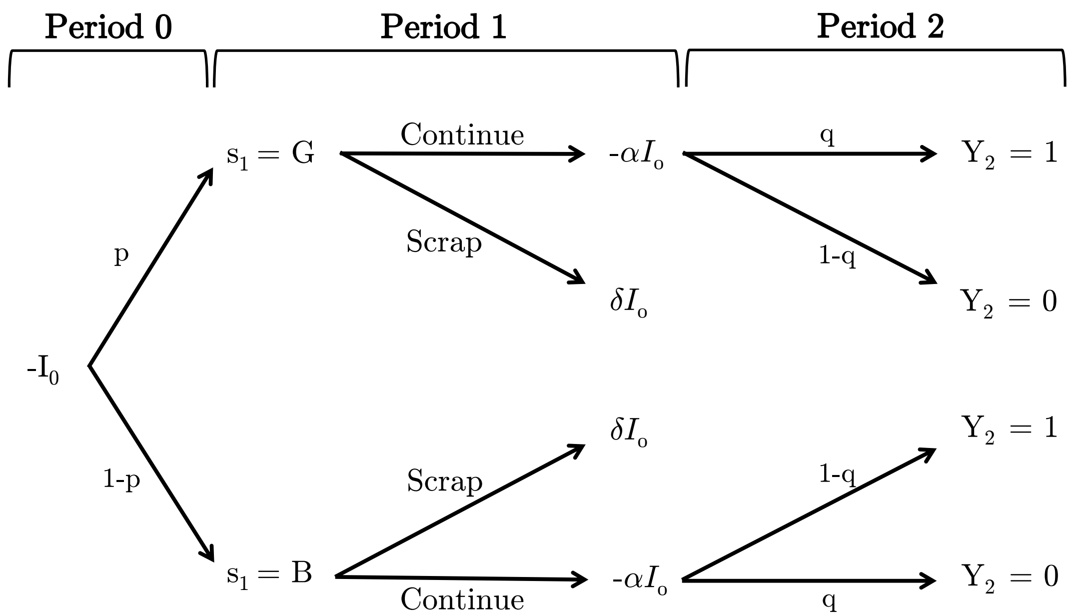

Figure 1: The setup of the investment project.

2.2 Financing

The entrepreneur has no initial endowment and he therefore seeks financing from the bank and the investor.

The investor represents a competitive investment sector with deep pockets that has no bargaining or pricing power. He has an outside investment opportunity that yields him an expected gross return of R_0^{01} between period 0 and 1, and an expected gross return of R_0^{12} between periods 1 and 2. Without loss of generalization, I will assume that $R_0^{01} = R_0^{12} = 1$. In period 0, the entrepreneur can issue two-period bonds to the investor, who is therefore willing to buy any bond that yields an expected return of at least $R_0^{02} = R_0^{01} \cdot R_0^{12} = 1$. There is no bond issuance in period 1 and bond payoffs cannot be conditional on the realization of the intermediate state.

The bank represents a competitive banking sector that offers one-period saving and lending services and makes zero profit. It pays the competitive rates R_0^{01} and R_0^{12} on one-period deposits in order to attract funds from the investor. The bank faces a cost on its operations that is proportional to its lending. This cost has to be covered by its lending rates, such that the expected return on its loans needs to be at least

$$\tilde{R}_0^{01} = R_0^{01} + \psi = 1 + \psi \tag{2}$$

and

$$\tilde{R}_0^{12} = R_0^{12} + \psi = 1 + \psi, \tag{3}$$

where ψ is the marginal operation cost per unit lent.

I denote with Z_0^{02}, $\tilde{Z}_0^{01}$ and $\tilde{Z}_1^{12}$ the respective contracted interest rates on the bond issued in period 0 and bank loans taken out in period 0 and 1. In case the entrepreneur is unable to repay his debt, he defaults and his creditors receive the remaining funds.

Denoting by F_1 and F_2 the entrepreneur's available funds in periods 1 and 2, the financial setup can be summarized by three participation constraints, namely the two participation constraints of the bank,

$$L_0\tilde{R}_0^{01} = E_0\left[\min\left(L_0\tilde{Z}_0^{01},\ F_1\right)\right], \tag{4}$$

$$L_1\tilde{R}_1^{12} = E_1\left[\min\left(L_1\tilde{Z}_1^{12},\ F_2\right)\right], \tag{5}$$

and the participation constraint of the investor,

$$B_0R_0^{02} = E_0\left[\min\left(B_0Z_0^{02},\ \max\left(F_2 - L_1\tilde{Z}_1^{12},\ 0\right)\right)\right]. \tag{6}$$

Notice that this notation assumes that bank debt is senior to public debt, meaning that bankruptcy assets are first used to repay the bank and that only after bond holders can claim their share. This and the other assumptions made above are discussed in Section 3.

2.3 First Best Investment

Before discussing the above setup, this subsection derives the first best investment choice. In order to do so, it is assumed that the entrepreneur has sufficient funds himself and does therefore not need any financing. He has the choice between three different investment strategies which are to either not invest at all, to invest I_0 but to only continue the project in the good state, or to invest I_0 and to then continue the project regardless of the state. I denote the expected payoff of these three strategies by $\bar{\pi}_0^{00}$, $\bar{\pi}_0^{G0}$ and $\bar{\pi}_0^{GB}$.

They can be calculated as

$$\bar{\pi}_0^{00} = 0, \tag{7}$$
$$\bar{\pi}_0^{G0} = p\,(q - \alpha I_0) + (1-p)\,\delta I_0 - I_0, \tag{8}$$
$$\bar{\pi}_0^{GB} = pq + (1-p)\,(1-q) - I_0 - \alpha I_0. \tag{9}$$

Proposition 1. *The optimal investment decision depending on I_0 can be summarized by three different thresholds, $\bar{I}_0^1$, $\bar{I}_0^2$ and $\bar{I}_0^3$, which satisfy*

$$\forall I_0 > \bar{I}_0^1 : \ \bar{\pi}_0^{G0}(I_0) > \bar{\pi}_0^{GB}(I_0),$$

$$\forall I_0 > \bar{I}_0^2 : \ \bar{\pi}_0^{00}(I_0) > \bar{\pi}_0^{GB}(I_0),$$

$$\forall I_0 > \bar{I}_0^3 : \ \bar{\pi}_0^{00}(I_0) > \bar{\pi}_0^{G0}(I_0).$$

In particular,

$$\bar{I}_0^1 = \frac{(1-q)}{(\delta+\alpha)}, \ \bar{I}_0^2 = \frac{pq + (1-p)\,(1-q)}{1+\alpha}, \ \textit{and}\ \bar{I}_0^3 = \frac{pq}{1 + p\alpha - (1-p)\,\delta}.$$

Proof. See Appendix. □

Assumption 1. *The parameters p, q, δ and α are chosen such that*

$$\bar{I}_0^1 < \bar{I}_0^2 < \bar{I}_0^3.$$

Assumption 1 ensures that there is a range of I_0 for which it is optimal to start the project in period 0 but to scrap it in the bad state in period 1. This range is given by $I_0 \in \left[\bar{I}_0^1, \bar{I}_0^3\right)$.[2]

For all $I_0 < \bar{I}_0^1$ it is optimal to continue the project in both intermediate states. Notice that the trade-off between scrapping in the bad state and continuation in both states is given by the comparison of the sum of opportunity costs and additional investment needs with the expected outcome in the bad state:

$$(\delta + \alpha)\, I_0 \gtrless 1 - q. \tag{10}$$

[2]Here and in the following, I solve the indifference at the thresholds in favor of the least investment-intensive strategy, implicitly assuming an ϵ cost of investment and continuation to the entrepreneur.

3 Key Assumptions

The model above restricts the available financial instruments to two-period bonds and one-period bank loans. This strong assumption captures the empirical fact that bonds usually have a longer maturity of public debt compared to bank loans, as for example shown by Denis and Mihov (2003). Although I'm not deriving this restricted set of debt instruments from first principles, there are two plausible interpretations of this assumption: First, one can think of it as a reduced-form modeling of the high cost of public debt issuance that makes the re-issuance of bonds in period 1 prohibitively expensive and allows the entrepreneur to issue bonds only once. Second, one can think of period 1 as a stochastic point in time that occurs at some point between 0 and 2. At $t = 0$, the entrepreneur knows that he will face reinvestment costs and receive additional information at some point but does not know when exactly $t = 1$ will occur. Assuming that a bond issuance needs preparation time, only the bank has the immediacy to react instantaneously to the new situation.

While both interpretations seem relevant, I want to stress the importance of the second one. Liquidity provision has long been recognized as a crucial role of financial intermediation, especially since Diamond and Dybvig (1983). This service not only requires maturity transformation, but also the bank's permanent presence in the market, or what I will henceforth call the immediacy of banking.

The issue of credit lines helps to clarify in what way my focus on immediacy differs from usual considerations. Credit lines are often assumed to be unconditional promises of credit provision over a certain period of time, as for example in Holmström and Tirole (2013).[3] Holmström and Tirole argue that evidence of credit line drawdowns suggests that banks are honoring this unconditional promise, even when new information renders the credit line unprofitable to the bank. This assumption stands in contrast to an empirical analysis by Sufi (2009), who finds that credit lines are usually subject to strict cash flow covenants. He states that the contingent credit lines offered by banks are very different from the committed lines of credit that are assumed in the theoretical literature.[4]

Both views can be unified when noting that the evidence cited by Holmström and Tirole concerns credit line drawdowns during financial crises, in particular during the recent subprime crisis and the crisis following the collapse of LTCM. As such, these drawdowns may be less related to firm-specific shocks than to shocks to the financial system, which are usually not covered by credit line covenants. Firms might therefore drawdown their credit lines when they are worried that limited bank loan supply will prevent the bank from renewing credit agreements in the future. However, cash flow covenants might prevent drawdowns in response to firm-specific shocks.

[3]See Section 6 for a more detailed discussion of their model.

[4](Sufi, 2009, p.1060).

While I do not cover credit lines explicitly in the above setup, the bank loan in period 1 should be interpreted as a credit line. This credit line is not uncontingent, but is subject to covenants which adjust the terms of credit depending on the realization of the intermediate state. The credit conditions in those two states are known ex-ante, such that credit terms can be pre-contracted in order to save time when period 1 occurs. According to this interpretation, credit lines do not serve as a liquidity insurance, but instead increase the immediacy of banks.

The bank's immediacy also offers a simple explanation on the assumed seniority of bank debt: banks have direct control over cash flows, and so it seems only natural that they also are the first to take out their share. The seniority of bank loans is an empirically well-established fact, see for example Welch (1997), but is not derived endogenously in the present framework,

The immediacy of banks is costly, because they have to maintain a permanent presence in the market and sustain high enough liquidity to serve sudden funding needs of their customers. This cost is captured by ψ, the marginal cost of banking. I assume ψ to be borne by borrowers and not by savers. This goes back to Fama (1985) who analyzes the price of certificates of deposits that banks use for their financing. Certificates of deposits are subject to a reserve requirement but trade at the same price as similar securities, such as commercial paper and bankers' acceptances, although the latter are not subject to the "reserve tax". Fama concludes that bank borrowers, not savers, bear the cost of reserve requirements.

While it is certainly possible to think of ψ as a "reserve tax", I suggest a wider interpretation in which ψ represents the general cost of banking, in particular the costs of risk and maturity transformation as well as permanent presence in the market. Following this interpretation, a larger ψ represents times of financial distress in the banking sector.

The conflict of interest in this model arises from the fact that with limited liability, the inside equity holder has incentives to make globally inefficient choices. One might argue that this is an unrealistic assumption, as managers are not directly maximizing the equity value of their firm, but the mechanism at hand would also work by introducing a manager with empire building preferences, as assumed, for example, in Zwiebel (1996).

Finally, there are technological assumptions that are necessary for deriving the results presented here. I consider a project with initial investment costs and later follow-up costs to keep the project going. Furthermore, during the course of the project, information about expected profitability is revealed which may make the continuation of the project inefficient. These assumptions are crucial but not unrealistic, as many projects face similar financing needs. One can, for example, think of a pharmaceutical company that develops a new drug which requires further exploration after some initial research. A slightly adjusted framework could capture the liquidity needs of a company which considers the take-over of a competitor in the near future.

4 The Complementarity of Bank and Bond Debt

In this section, I describe the optimal investment choice of the entrepreneur given the participation constraints of the bank and the investor. I will first assume that there is no bank and that the entrepreneur only has access to bond financing. I consider two different setups, one in which the entrepreneur is able to commit to a given investment strategy and the other in which he is unable to do so. The first case will attain the first best investment decision, while inefficiencies might arise in the second case. I will then show how the introduction of bank loans can increase efficiency when there is no commitment.

4.1 Bond Issuance with Full Commitment

As above, the entrepreneur has access to three different investment strategies, namely to not invest, to invest and to continue only in the good state, or to invest and to then always continue regardless of the realized state. It is assumed that the entrepreneur has no initial endowment and he therefore needs to finance the entire project through bond issuance. Since there is no access to the bond market in period 1, he needs to not only raise the initial I_0, but also the possibly needed continuation investment αI_0, which he stores as cash or as a similar risk-free and liquid asset. Notice that in the case of scrapping, the entrepreneur will not receive anything because $\delta I_0 < (I_0 + \alpha I_0) Z_0^{02}$ and $Z_0^{02} \geq 1$.

Denoting the expected profits of the three strategies as $\hat{\pi}_0^{00}$, $\hat{\pi}_0^{G0}$ and $\hat{\pi}_0^{GB}$, it follows that $\hat{\pi}_0^{00} = 0$ and

$$\begin{aligned}
\hat{\pi}_0^{G0} &= pq \max\left(1 - B_0 Z_0^{02},\ 0\right), \\
\text{with} \quad B_0 &= (1+\alpha) I_0, \\
\text{s.t.} \quad B_0 &= pq \min\left(B_0 Z_0^{02},\ 1\right) + (1-p)\left((1-\delta) I_0 + \alpha I_0\right),
\end{aligned} \tag{11}$$

$$\begin{aligned}
\hat{\pi}_0^{GB} &= (pq + (1-p)(1-q)) \max\left(1 - B_0 Z_0^{02},\ 0\right), \\
\text{with} \quad B_0 &= (1+\alpha) I_0, \\
\text{s.t.} \quad B_0 &= (pq + (1-p)(1-q)) \min\left(B_0 Z_0^{02},\ 1\right).
\end{aligned} \tag{12}$$

Notice that $\hat{\pi}_0^{G0}$ and $\hat{\pi}_0^{GB}$ will of course not be defined for all I_0, as the strategies might not be feasible given the constraints.

Lemma 1. *With bond issuance and full commitment, the continuation strategy is feasible for all I_0 that satisfy $I_0 \leq \bar{I}_0^2$. The scrapping strategy is feasible for all $I_0 \leq \bar{I}_0^3$.*

Proof. See Appendix. □

Lemma 2. *Given Assumption 1, both strategies are feasible in the neighborhood of $\bar{I}_0^1$. Furthermore,*

$$\begin{aligned} \hat{\pi}_0^{GB} > \hat{\pi}_0^{G0} > 0 \qquad & \forall I_0 < \bar{I}_0^1, \\ \hat{\pi}_0^{G0} \geq \hat{\pi}_0^{GB} > 0 \qquad & \forall I_0 \in \left[\bar{I}_0^1,\ \bar{I}_0^2\right), \\ \hat{\pi}_0^{G0} \geq 0 \qquad & \forall I_0 \in \left[\bar{I}_0^2,\ \bar{I}_0^3\right). \end{aligned}$$

Proof. See Appendix. □

Lemmata 1 and 2 imply that, with full commitment, the entrepreneur can finance the first best investment strategies by issuing bonds. In particular, he will invest and always continue if $I_0 < \bar{I}_0^1$ and invest and scrap in the bad state if $I_0 \in \left[\bar{I}_0^1,\ \bar{I}_0^3\right)$.

Proposition 2. *With full commitment, bond issuance is sufficient to attain the first best investment choice.*

Proof. Follows directly from Lemmata 1 and 2. □

4.2 Bond Issuance without Commitment

When the entrepreneur cannot commit to an investment strategy ex-ante, one has to think more specifically about his continuation decision in period 1. Having issued a bond in period 0, he receives nothing when scrapping the project but he will profit from continuation when the project goes well. The entrepreneur is therefore continuing the project as long as

$$(1-q)\max\left(1 - B_0 Z_0^{02},\ 0\right) > 0, \tag{13}$$

which is true for all $I_0 < \bar{I}_0^3$. Unable to commit to scrapping, he can only raise funds for the strategy in which he continues in both states.

Proposition 3. *Given Assumption 1 and without the ability to commit to a strategy, the entrepreneur will invest in the project as long as $I_0 < \bar{I}_0^2$. The project will then always be continued in period 1. For all $I_0 > \bar{I}_0^2$, the entrepreneur is unable to raise funds and he will therefore not undertake the project.*

Proof. As shown by Equation 13, the entrepreneur will continue the project for all $I_0 < \bar{I}_0^3$. The bondholder's participation constraint can then only be satisfied if $I_0 \leq \bar{I}_0^2$. The indifference at $\bar{I}_0^2$ is as above resolved in favor of not investing. □

Notice that the inefficiency is twofold. First, there is an ex-ante inefficiency because the entrepreneur who has access to a project with $I_0 \in \left[\bar{I}_0^2, \bar{I}_0^3\right)$ is unable to raise funds, although these projects are in the range of efficient investments. Second, there is an ex-post inefficiency because projects with $I_0 \in \left[\bar{I}_0^1, \bar{I}_0^2\right)$ are always continued although they would optimally be scrapped in the bad state. An entrepreneur with $I_0 \in \left(\bar{I}_0^1, \bar{I}_0^3\right)$ therefore receives less profit if he is unable to commit to a strategy.

4.3 Introducing Bank Loans

Short-term debt can naturally solve the conflict of interest that arises between the entrepreneur and the bond holder. Notice though that bank loans require a higher expected return than bonds, namely $1 + \psi$. The ability of banks to reduce inefficiencies will therefore depend on ψ.

When $\psi > 0$, a bank loan is only useful if it helps to constrain the continuation decision of the entrepreneur in the bad state. This is the case when the entrepreneur's funding needs for continuation are larger than the maximum loan the bank is willing to provide in the bad state in period 1.

Since bank debt is assumed to be senior, the maximum loan in the bad state, $L_{1|B}^{\max}$, is given by

$$L_{1|B}^{\max} = \frac{1-q}{1+\psi}. \tag{14}$$

There is similarly a maximum loan in the good state, given by

$$L_{1|G}^{\max} = \frac{q}{1+\psi}. \tag{15}$$

The funding needed to continue the project in period 1 is given by the continuation investment plus eventual repayments of period 0 bank loans minus any cash balances that were saved in period 0:

$$L_1^{\text{cont}} = \alpha I_0 + \tilde{Z}_0^{01} L_0 - \left(B_0 + L_0 - I_0\right). \tag{16}$$

It is furthermore required that

$$I_0 \leq B_0 + L_0. \tag{17}$$

In order to induce scrapping in the bad state but allow for continuation in the good state, it is sufficient that

$$L_{1|B}^{\max} \leq L_1^{\text{cont}} < L_{1|G}^{\max}. \tag{18}$$

Bank loans are expensive and the entrepreneur will try to keep both L_0 and L_1 as small as possible. L_1 is increasing in L_0 and decreasing in B_0 such that it is optimal to keep L_0 as small as possible subject to the constraints stated in Equations 17 and 18.

Lemma 3. *For all I_0 and α such that*

$$I_0 \in \left(\frac{1-q}{\alpha\,(1+\psi)},\ \frac{p\left((2q-1)+\frac{1-q}{1+\psi}\right)}{(1-(1-p)\,\delta+p\alpha)} \right),$$

and

$$\alpha \geq \bar{\alpha}^1 = \frac{(1-q)\,(1-(1-p)\,\delta)}{p\,(2q-1)\,(1+\psi)},$$

an optimal financing of the scrapping strategy is given by

$$B_0 = (1+\alpha)I_0 - \frac{1-q}{1+\psi} \ \textit{and} \ L_0 = 0,$$

as well as

$$L_{1|G} = \frac{1-q}{1+\psi} \ \textit{and} \ L_{1|B} = 0.$$

The contracted rates on the bank loan L_1 and the bond are then given by

$$\tilde{Z}_{1|G}^{12} = \frac{1+\psi}{q} \ \textit{and} \ \ Z_0^{02} = \frac{1}{pq} - \frac{1-p}{pq}\frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right)}.$$

The above lemma states that if α is large enough and I_0 falls in the specified interval, the scrapping strategy is optimally induced by only issuing bonds in period 0, while depending on a credit line in period 1. This credit line will be canceled if the bad state occurs. Under these circumstances the firm will have cash holdings of

$$C_0 = B_0 - I_0 = \alpha I_0 - \frac{1-q}{1+\psi}. \tag{19}$$

For low I_0 or low α, it is necessary to increase the funding needs in period 1 by taking out a bank loan in period 0.

Lemma 4. *For all I_0 such that*

$$I_0 \in \begin{cases} \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi},\ \frac{1-q}{\alpha(1+\psi)}\right) & if\ \alpha \geq \bar{\alpha}^1 \\ \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi},\ \frac{p(2q-1)+\frac{1-q}{1+\psi}\left(\frac{1}{1+\psi}-(1-p)\right)}{\left(1+\frac{1}{1+\psi}\alpha-(1-p)(\delta+\alpha)\right)}\right) & otherwise \end{cases}$$

a optimal financing of the scrapping strategy is given by

$$B_0 = I_0 - \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right),\ and\ L_0 = \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right),$$

as well as

$$L_{1|G} = \frac{1-q}{1+\psi}\ and\ L_{1|B} = 0.$$

The contracted rates on the bank loans L_0 and $L_{1|G}$ and the bond are then given by

$$\tilde{Z}_0^{01} = 1+\psi,\ \tilde{Z}_{1|G}^{12} = \frac{1+\psi}{q}\ and\ Z_0^{02} = \frac{1}{pq} - \frac{1-p}{pq}\frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right)}.$$

Under the conditions specified in Lemma 4 the entrepreneur will not have any cash holdings but will take out a short-term loan in period 0. This loan could possibly also be replicated through the issuance of commercial paper.

Notice that the efficient continuation choice only depends on $\delta + \alpha$, as stated in Equation 10, but, as the two lemmata above show, the financing choice with bank loans is affected by the relative sizes of δ and α.

Finally, one can show that if I_0 is too large, the scrapping strategy is neither profitable nor feasible.

Lemma 5. *There is a threshold $\tilde{I}_0^3$ such that for all $I_0 > \tilde{I}_0^3$ the scrapping strategy is not feasible. In particular,*

$$\tilde{I}_0^3 = \begin{cases} \frac{p\left((2q-1)+\frac{1-q}{1+\psi}\right)}{(1-(1-p)\delta+p\alpha)} & if\ \alpha \geq \bar{\alpha}^1, \\ \frac{1-q}{\alpha(1+\psi)} & if\ \alpha < \bar{\alpha}^1. \end{cases}$$

Proof. Follows from the proofs of Lemmata 3 and 4 in the Appendix. □

The results above imply that the scrapping strategy can only be induced in the interval $I_0 \in \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi},\ \tilde{I}_0^3\right)$, such that projects with $I_0 \in \left(\tilde{I}_0^3,\ \bar{I}_0^3\right)$ are inefficiently not undertaken. The size of this interval is growing in ψ, which highlights the complementarity of bank loans and bonds in that range.

Having derived the optimal capital structure which induces scrapping, it is now possible to solve for the optimal investment strategy by comparing the profits of not investing, investing with induced scrapping in the bad state, and investing with uncontingent continuation. The latter is of course optimally financed by issuing only bonds.

The following assumption ensures that there is a range of I_0 for which induced scrapping is optimal and Proposition 4 then characterizes the optimal investment choice.

Assumption 2. *ψ is small enough such that $\tilde{I}_0^3 > \bar{I}_0^2$.*

Proposition 4. *Denote with π^{cont} the profit of always continuing the project, and with π^{scrap} the profit when scrapping is induced by a bank loan. Given Assumptions 1 and 2, there are two threshold values $\widetilde{I}_0^1$ and $\tilde{I}_0^3$ which satisfy*

$$\begin{aligned} \forall I_0 < \widetilde{I}_0^1 : \quad & \pi^\star = \pi^{cont}, \\ \forall I_0 \in \left[\widetilde{I}_0^1, \tilde{I}_0^3\right) \quad & \pi^\star = \pi^{scrap}. \\ \forall I_0 \geq \tilde{I}_0^3 \quad & \pi^\star = 0. \end{aligned}$$

Furthermore,

$$\bar{I}_0^1 < \widetilde{I}_0^1 < \widetilde{I}_0^3 < \bar{I}_0^3.$$

In particular,

$$\widetilde{I}_0^1 = \begin{cases} \frac{(1-q)((1-p)+\psi)}{(1+\psi)(1-p)(\delta+\alpha)} & if \ \alpha > \max\left(\bar{\alpha}^1, \ \bar{\alpha}^2\right), \\ \frac{(1-q)\left((1-p)+\frac{2\psi+\psi^2}{1+\psi}\right)}{(1+\psi)(1-p)(\delta-\alpha)+\psi\alpha} & otherwise, \end{cases}$$

with

$$\bar{\alpha}^2 = \frac{(1-p)\delta}{\psi},$$

and $\tilde{I}_0^3$ as defined in Lemma 5.

5 Comparative Statics and Empirical Evidence

The last section derived the optimal financing decision for the firm in terms of the parameters of the model. In the following, I will discuss how these results translate into real-world firm characteristics.

5.1 Firm Profitability

The results above have been derived in terms of I_0, which is a measure of the cost of the project. The value of assets in place at the end of period 1 is $(1+\alpha)I_0$ for any project that is continued. The return of the project has been fixed to 1, such that $\frac{1}{(1+\alpha)I_0}$ can be seen as a measure of profitability. Firms with high profitability, in particular firms with $I_0 < \widetilde{I}_0^1$, will only use bond financing. Firms with lower profitability need to constrain their investment choice by using bank loans.

Analyzing a sample of 1177 credit-rated firms in the US, Adrian et al. (2012) indeed find that less profitable firms are more likely to issue bank debt.[5]

The model furthermore predicts that for less profitable firms with $I_0 > \widetilde{I}_0^1$, the *share* of bank financing decreases as I_0 increases, since L_1 is constant and L_0 is weakly decreasing in I_0. I have no empirical evidence on this hypothesis.

5.2 Information Content

The larger the value of q, the more information is revealed in period 1. An increase in q widens the interval of projects that require a bank loan, since

$$\frac{\partial \widetilde{I}_0^1}{\partial q} < 0 \text{ and } \frac{\partial \widetilde{I}_0^3}{\partial q} > 0. \tag{20}$$

Ceteris paribus, projects with a larger q will therefore be more likely to require the dependence on a bank loan.

It is not easy to find a corresponding measure of this information sensitivity in real world data, but one could think that growth firms are more dependent on future developments than established firms. Adrian et al. (2012) use *Tobin's q* as a proxy for a firm's growth opportunities and find that firms with larger *Tobin's q* are in fact more likely to take out bank loans.

5.3 The Cost of Banking

The parameter ψ represents the cost of banking in this model. An increase in ψ can be interpreted as a contraction in bank loan supply. I find that

$$\frac{\partial \widetilde{I}_0^1}{\partial \psi} > 0 \text{ and } \frac{\partial \widetilde{I}_0^3}{\partial \psi} < 0. \tag{21}$$

An increase in ψ is therefore increasing the range of the interval $\left(\bar{I}_0^1,\ \widetilde{I}_0^1\right)$ which contains those

[5] For this and the following evidence see (Adrian et al., 2012, p26 ff.).

projects that would efficiently be scrapped in the bad state but are continued when there is no commitment. The firms that become a part of this interval will decrease their bank lending and increase their bond issuance in order to obtain sufficient liquidity ex-ante.

The empirical fact that some companies substitute from bank loans towards bond issuance as bank loans get more expensive has been established by Becker and Ivashina (2011) and Adrian et al. (2012), who both analyze the financing choices of individual firms during the recent financial crisis. I argue here that this substitution may be far from perfect, since it induces inefficient investment behavior. The benefits of the dependence on the credit line, which had before constrained the continuation choice in period 1, are lost.

As shown above, a larger ψ also widens the interval $\left(\widetilde{I}_0^3,\ \bar{I}_0^3\right)$ which contains projects that would efficiently be initiated but cannot be financed because bank loans are too expensive. Companies that are pushed into this interval through an increase in ψ not only reduce bank borrowing, but also bond issuance. This possible complementarity of bank loans and bond issuance is a key result of this paper. So far theoretical research has not discussed this effect and empirical studies have not considered companies that might fall into this category.

5.4 Opportunity and Continuation Costs

The efficient threshold $\bar{I}_0$ depends on the sum of the continuation cost αI_0 and the opportunity cost δI_0. In the second best case with banks, the relative sizes of α and δ matter: Relatively small continuation costs make it more difficult to constrain continuation even when opportunity costs are large because neither the bank nor the entrepreneur benefit from saving those opportunity costs. In this case, the continuation choice has to be further constrained through a one-period loan in period 0, which needs to be paid back in $t = 1$.

While the bank loan in period 1 requires the immediacy of a credit line, the one-period loan in the beginning can be obtained through a short-term bank loan or even commercial paper. The model above therefore also characterizes the determinants of the choice of short-term debt: Firms with large continuation costs only require a credit line; firms with relatively small continuation costs but large scrapping value will also take out standard bank loans or issue commercial paper. Additionally, the profits of firms that are not only depending on a credit line but also on period 0 loans are relatively more affected by an increase in ψ, since they both their initial loan and their credit line gets more expensive.

This is another novel hypothesis arising from the model above, which has not yet been empirically analyzed. In order to do so, one could characterize sectors by continuation costs and scrapping value and analyze their financing choices. For example, pharmaceutical companies are likely to face high continuation costs even after the initial research phase. A mining company, on the other hand, may face a large investment in the beginning, namely acquiring the land and installing machines which both have some resale value, but it will require relatively small continuation investments in the future. According to the results presented here, those two kinds of companies should use different sorts of short-term financing and should be affected differently by a contraction in bank loan supply.

6 Related Literature

Since the seminal work of Modigliani and Miller (1958), thousands of papers have been written that discuss the determinants of a firm's capital structure. Most of these works focus on the financing choice between equity and debt. The model presented here considers the less studied financing choice among different debt instruments, in particular the choice between bonds and bank loans. In the following, I will give a short overview on research that uses mechanisms different from the one presented above to explain this particular financing choice. Then, I will take a more detailed look at four papers that are closely related to my model.

Several papers discussing the choice among debt instruments highlight the monitoring role of banks, which gives bank loans a cost advantage over public debt. Diamond (1984) argues that monitoring exhibits economies of scale and that banks are therefore pooling loans in order to decrease lending costs. While Diamond assumes that monitoring is necessary because of ex-post information asymmetries, Boyd and Prescott (1986) and Ramakrishnan and Thakor (1984) present similar mechanisms with ex-ante information asymmetries.

The second important strand of literature argues that banks face lower renegotiation costs in the case of bankruptcy and might therefore have a cost advantage over direct market lending. For example, see Welch (1997) and Chemmanur and Fulghieri (1994). Bolton and Scharfstein (1996) and Bergloef and von Thadden (1994) consider the effect of the number of creditors on default decisions. In these settings, market lending corresponds to a large number of creditors while bank lending includes only a small number of lenders. Asquith et al. (1994) provides an empirical study on the effects of capital structure in times of financial distress. Interestingly, they find that it is in particular the coexistence of private and public debt that impedes out-of-court renegotiation.

The mechanism presented here differs from both of these explanations; it neither assumes that banks have special monitoring abilities nor that they face lower renegotiation costs. I suggest that banks are special because of their ability to react promptly to financing needs.

It is worth highlighting that all of the theories above derive that, for any given firm, either bank or bond borrowing is optimal, not both concurrently. Empirically, a large share of firms uses both sorts of financing at the same time. For example, in the firm sample analyzed by Becker and

Ivashina (2011), 59% of all firms that issue bonds also take out bank loans. The model presented here produces that behavior endogenously.

Most closely related to the mechanism in this paper are theories on the maturity structure of corporate debt. In the following, I will discuss four different models which precede my research in order to highlight differences as well as similarities.

Myers (1977) analyzes how the issuance of long-term risky debt can distort investment decisions. In his framework, equity holders might be unwilling to exercise profitable real options because benefits from doing so first accrue to debt holders. Crucially, Myers assumes that the exercising costs are paid for by issuing new equity. The setup above considers the opposite case in which debt finances the continuation cost. This leads, as shown above, to the opposite conclusion: Long-term debt may incentivize equity holders to exercise unprofitable growth options.

I consider the latter assumption to be more reasonable since new equity issuance is costly and time-consuming. Once one excludes the option of prompt equity issuance when the growth opportunity is realized, Myers' argument breaks apart since debt seniority assigns any asset first to debt holders, even if originally funded by equity. In that scenario, an inefficient investment decision first hurts debt holders.

Myers furthermore does not assume any scrapping value of the project. As highlighted above, the opportunity cost, which arises from forgoing the scrapping option, affects the investment decision differently than the actual continuation cost if there is debt financing. This conclusion would also hold true if one were to include a scrapping value into Myers' framework.

Hart and Moore (1995) develop a model in which the issuance of long-term debt constrains the ability of the manager to invest in the future. This constraint can be beneficial as managers are assumed to have empire-building tendencies and might therefore over-invest. On the other hand, a large amount of outstanding long-term debt could lead to under-investments if there is debt-overhang. The optimal choice of the maturity structure results from the tradeoff between these two effects. Hart and Moore focus solely on bonds, assuming that newly issued bonds are junior to outstanding long-term debt. The latter assumption is crucial for the derivation of their results. Since short-term bank loans are usually senior to public debt, their framework is not useful for discussing the choice between bank loans and bond issuance.

Diamond (1991, 1992, 1993) has a series of papers on the maturity structure of debt instruments, analyzing the financing choice of an entrepreneur with private information on his future credit prospects. Even though my model does not feature any information asymmetries, it is closely related to Diamond's framework, especially to the version in Diamond (1992). In that paper he presents a three-period model with two different types of entrepreneurs, a good type with a profitable investment opportunity, and a bad type whose project has a negative expected return.

As in my framework there is only inside equity and the entrepreneurs need to raise all investment funds by issuing either one-period or two-period debt. In the intermediate period, investors receive a noisy signal about the entrepreneur's type. At the same time, the project can be scrapped to recover a liquidation value. Similar to the mechanism presented above, even the bad type will always want to continue the project as he has nothing to lose but can gain if the project goes well.

Diamond's model differs from mine in that he assumes that there is a control rent that can only accrue to the entrepreneur. His framework also does not assume any continuation investment in period 1. Even though short-term debt is not more costly than long-term debt ($\psi = 0$), a complete dependence on one-period debt is not optimal, as it induces too much liquidation because investors do not take the lost control rent into account. Similarly to my model, financing with only long-term debt is also not optimal because the entrepreneur will continue the project too often. The entrepreneur will therefore choose an optimal mix of short-term and long-term debt, or what can also be interpreted as an optimal mix of bank debt and bond issuance. The seniority of bank debt arises as an optimality result in Diamond's framework, a result that my model fails to deliver.

My paper is both a simplification and an extension of Diamond's framework: While I do not assume any information asymmetries nor control rents, I introduce a continuation cost and the parameter ψ that measures the costliness of banking. Since my framework allows for companies that are only dependent on credit lines without taking bank loans in the initial period, I can separately determine cash holdings, bank loans and credit lines. In Diamond's model, short-term debt has to be completely refinanced in period 1, creating a one-to-one relationship between, what I call, bank loans and credit lines. The introduction of the banking cost, ψ, allows me to characterize the impact of a contraction in bank loan supply on the capital structure of different firms.

Holmström and Tirole (1998, 2013) present another model that looks very similar to the setup presented above. They also describe a three-period economy in which an entrepreneur needs to invest I at $t = 0$. In contrast to Diamond, they do not assume any liquidation value, but instead introduce an investment of ρI which is due at $t = 1$ in order to continue the project.

In their framework, the entrepreneur is unable to pledge the full value of the project to investors, which they motivate through a model of moral hazard: The entrepreneur can shirk and must therefore always be given a minimum share of the returns. This limited pledgeability may constrain the ability of the entrepreneur to obtain funds to finance the project and resembles the control value in Diamond's framework.

Holmström and Tirole assume that ρ is stochastic while I assume α to be constant; however, the qualitative results of my model do not depend on this assumption. The authors find that for a given initial investment I, there is a threshold ρ_0 such that for higher realizations of ρ, the entrepreneur cannot obtain the continuation funds in $t = 1$. This threshold is lower than the efficient continuation threshold, ρ_1, since the bank does not account for the share of the project which needs to be pledged to the entrepreneur. This effect is the same as described above for short-term debt in Diamond (1992). In order to still continue the project efficiently even if $\rho \in (\rho_0, \rho_1)$, the entrepreneur needs to secure the liquidity needed ex-ante in period 0. This liquidity could be secured through an uncontingent credit line from a bank or by buying liquid assets that can easily be sold in period 1.

In the original 1998 version of the paper, Holmström and Tirole stated that, in the general equilibrium version of the model, intermediaries are needed to coordinate liquidity insurance and firms cannot, in general, obtain liquidity by buying a share of the market portfolio. This claim turned out to be wrong and has been corrected in the extended book version, Holmström and Tirole (2013). In their model, credit lines and ex-ante liquidity hoarding are therefore perfect substitutes, which is not the case in my framework, since free funds may incentivize the entrepreneur to continue the project inefficiently. The *contingent* credit line prevents inefficient continuation, not inefficient scrapping, as does the *uncontingent* credit line in Holmström and Tirole.

Given the perfect substitutability of credit lines and ex-ante liquidity hoarding, their framework remains silent on the financing choice among bank loans and bond issuance. In contrast to Diamond's paper, which differs only in the additional existence of an inefficient type of entrepreneur and the assumed information asymmetries, Holmström and Tirole's findings can therefore not be used to address the questions raised in this paper.

7 Discussion

In the following, I will first discuss how my results relate to recent empirical studies on the substitutability of bank loans and bond issuance. Afterward, I will present empirical evidence on alternative explanations of the choice between those two debt instruments and how these explanations can complement my analysis.

7.1 Substitution of Bank Debt with Bond Issuance

It has been argued that the recent financial crisis was driven by a contraction in bank loan supply rather than a shock to real productivity. Empirically, it is hard to disentangle a decline in bank lending due to reduced credit demand from a contraction in bank loan supply. Two recent empirical studies, Becker and Ivashina (2011) and Adrian et al. (2012), argue that a substitution from bank loans towards bond issuance is suggestive of a contraction in bank loan supply during the Great Recession: Companies which switched from bank towards bond financing seemed to have sustained some level of credit demand but were unable to satisfy this demand with bank loans.

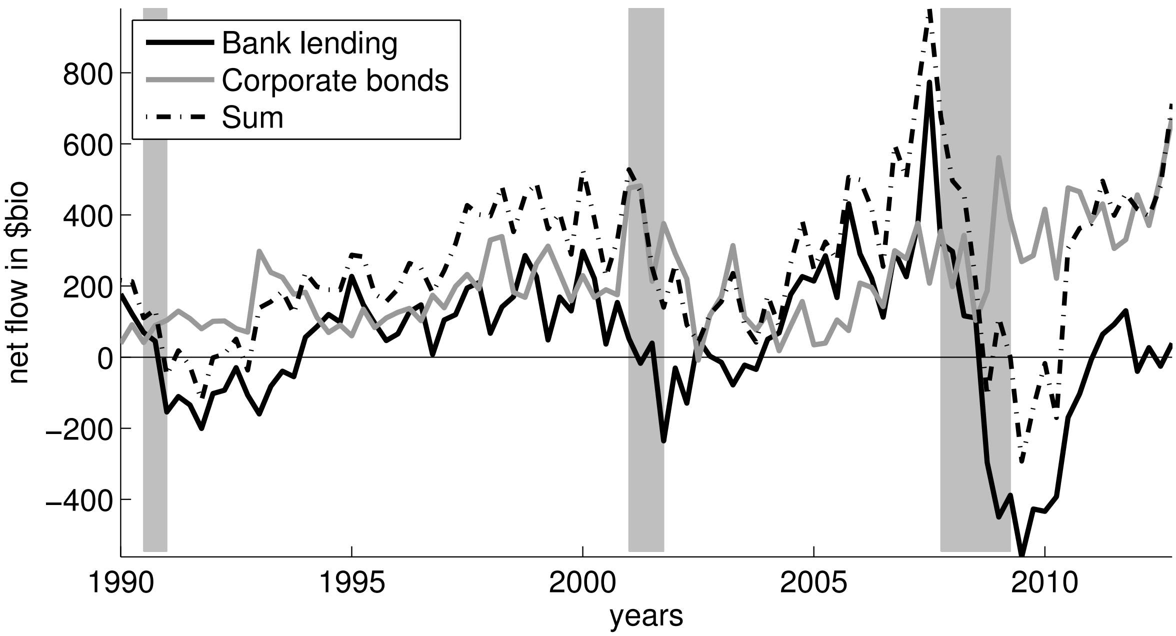

Figure 2: Flow of Funds data on corporate bank and bond lending, deflated using NIPA GDP deflator (2005 = 100). Shaded areas represent NBER recessions.

Figure 2 provides aggregate evidence on this substitution: While bank credit declined dramatically in the last recession, bond issuance picked up soon after. If both credit forms are considered perfect substitutes, one can take the sum of both credit flows and conclude that the overall decline in corporate credit was less dramatic and reversed quickly. A similar pattern, if less pronounced, is observable in the two previous recessions.

This argument is pursued in more detail by Becker and Ivashina (2011) and Adrian et al. (2012) who both analyze firm-level data. The two studies focus on credit rated companies with access to both bank and market lending and they consider the choice between bank loans and bonds conditional on positive borrowing in a certain quarter. Considering only the binary choice between bank and market borrowing, without considering quantities, they both find that in times of financial distress firms are more likely to issue bonds.

Becker and Ivashina (2011) use this variation in debt instrument choices to develop a measure of bank loan supply and show that this measure also predicts bank borrowing for companies without a credit rating. Adrian et al. (2012) highlight the fact the compositional shift from bank to bond financing is accompanied by rising credit costs for both bank and market borrowing. They provide a theoretical model in which rising default risk reduces the size of the banking sector, which is subject to a value-at-risk constraint. Bond investors have to pick up credit demand and need to be compensated with higher risk premia. In their model, it is the rise in risk premia, rather than the contraction in credit supply, that affects the economic outcome.

The theoretical model presented above complements the analysis of both papers. The model replicates the substitution from bank to bond lending as the cost of bank loans rises. As ψ rises from $\underline{\psi}$ to $\overline{\psi}$, companies in the interval $\left(\tilde{I}_0^1(\overline{\psi}), \tilde{I}_0^1(\underline{\psi})\right)$ substitute their bank loans with bond issuance. These companies then have to finance their liquidity needs ex-ante, substituting a credit line with cash hoarding. As the credit line would only have been used with probability p, actual credit levels rise. In fact, Adrian et al. (2012) find that less leveraged firms exhibit higher credit levels during, rather than before, the crisis.[6]

While my model features the substitution from bank to bond borrowing, it also highlight the fact that this substitution is not perfect. In this framework, bank lending constrains investment choices and companies switching towards full bond financing then make less efficient continuation choices. Since bond investors have to be compensated for the rising default risk as entrepreneurs start making less efficient investment decisions, this mechanism offers another explanation for rising costs of bond financing when bank loans become more expensive.

Becker and Ivashina (2011) and Adrian et al. (2012) both focus on firms that continue issuing credit in the crisis. They do so in order to identify a reduction in bank loan supply, since companies not issuing credit might limit bank borrowing either due to a decline in bank loan supply or in credit demand. I argue that rising costs of bank loans may not only reduce bank lending, but also direct market lending since bank loans may complement bond issuance. This effect is empirically much harder to identify. It has, however, important implications, since some companies might then lose access to direct market lending as bank loans get more expensive, which would further amplify the original credit contraction.

Going back to the aggregate credit flows pictured in Figure 2, my model has two important implications: Bank loans and bond issuance are imperfect substitutes and can be complements. The dashed line summing up both flows may hide two opposing effects: A contraction in bank loan supply induces some companies to increase their bond issuance and their total credit volume when substituting credit lines for bonds, while forcing other companies to not only reduce their bank loans but also their market borrowing. Focusing only on the former effect underestimates the adverse effect of a contraction in bank loan supply.

7.2 Monitoring and Renegotiation

The model presented here differs from previous research on the choice between bonds and bank loans by neither assuming that banks have better monitoring abilities nor that they face lower

[6](Adrian et al., 2012, p.24)

renegotiation costs in the case of default. Furthermore, I do not assume that there exist any information asymmetries among borrower and lenders. With that said, I do not argue that these assumption are unreasonable.

There is evidence that banks face lower information asymmetries. James (1987) and Lummer and McConnell (1989) find that the stocks of companies which are entering new and especially renewed bank loan agreements experience a positive excess return around the time of the agreement. They conclude that bank loans are therefore conveying information to capital markets. While most theories and empirical studies remain silent on how banks are exerting their monitoring powers, Norden and Weber (2010) show that data on bank account activity contains information on default probabilities, giving banks an advantage in credit provision.

The observed seniority of bank debt seems to contradict the importance of this monitoring role since banks should have higher incentives to monitor if their loans were junior to other debt instruments. Theories explaining the observed seniority structure usually argue that bank seniority induces more efficient continuation decisions when the company is in financial distress, as, for example, in Longhofer and Santos (2000).

The importance of renegotiation costs is supported by empirical evidence suggesting that companies with low credit ratings are more dependent on bank financing, as shown by Asquith et al. (1994).

The banks' advantage in monitoring and renegotiation further strengthens the argument that bond issuance is an imperfect substitute for bank loans. My model focuses on the efficiency gains through immediacy, but one could incorporate the monitoring and renegotiation abilities into a more comprehensive framework. The efficiency losses induced by a contraction in bank loan supply would then be even larger since companies substituting bank loans with bond issuance are less monitored and will act more inefficiently in the case of default.

8 Conclusion

The model presented here determines the financing choice of an entrepreneur who has access to a project which requires an initial investment and further funding in the near future. New information might render the continuation of the project unprofitable in which case the project can be aborted to recover a scrapping value. I show that the entrepreneur may continue the project inefficiently if he has permanent access to the funds needed for continuation. The dependence on a contingent credit line constrains the continuation choice of the entrepreneur and increases ex-ante and ex-post efficiency. If the continuation costs are relatively small, the entrepreneur can commit to efficient scrapping by issuing short-term bank debt or commercial paper in the initial period.

I find that very profitable firms will only issue bonds, while less profitable and information-sensitive projects need to depend on contingent bank loans. Profitable firms will feature large cash holdings if continuation costs are high. Less profitable firms with relatively small continuation costs but large scrapping value will issue short-term debt in the initial period and not hold any liquid funds.

This focus on immediacy distinguishes this paper from the preceding research presented previously and the joint determination of bank loans, credit lines, bond issuance and cash holdings provides room for further empirical research.

Recent studies provide evidence on a contraction of bank loan supply during the financial crisis of 2007-2009. They focus their empirical analyses on large credit-rated companies that were able to substitute bank loans with bond issuance. The paper at hand complements this evidence by arguing that this substitution is not perfect since the dependence on bank loans may increase efficiency. I furthermore argue that one cannot compare bank and bond credit volumes because bond issuance increases debt levels one-to-one while the substituted credit lines only appear as actual credit when they are drawn on. The model also shows that some companies will not only decrease bank borrowing when bank loans get more expensive but will also reduce direct market lending. This effect amplifies the original contraction in bank credit.

While the model presented here describes a very specific interaction of bank loans and bond issuance, this paper makes a broader point: banks offer services to borrowers that go beyond simple credit provision. Their ability to provide liquidity and immediacy, be it by market presence, maturity transformation or timely monitoring abilities, increases the efficiency of investment decisions. This increase in efficiency can have a positive externality on direct market lending, such that bank loans may complement rather than substitute public debt. A contraction in bank loan supply can then not only force some companies to shift their financing towards bond issuance, thereby inducing less efficient investment decisions, but it can also limit the access to direct market lending for other firms. Considering changes in overall credit levels during crisis periods will therefore underestimate the adverse effects of a contraction in bank loan supply.

From a policy perspective, this paper argues that it is not sufficient to strengthen public debt markets and ease access to bond issuance for a broader range of firms in order to reduce the impact of a banking crisis. Banks provide crucial services that cannot be easily replaced by public debt markets. Policy makers should focus their efforts on the soundness of the banking system; specifically, on a low and stable ψ as defined in this model.

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Appendix

Proposition 1. *The optimal investment decision depending on I_0 can be summarized by three different thresholds, $\bar{I}_0^1$, $\bar{I}_0^2$ and $\bar{I}_0^3$, which satisfy*

$$\forall I_0 > \bar{I}_0^1 : \; \bar{\pi}_0^{G0}(I_0) > \bar{\pi}_0^{GB}(I_0),$$

$$\forall I_0 > \bar{I}_0^2 : \; \bar{\pi}_0^{00}(I_0) > \bar{\pi}_0^{GB}(I_0),$$

$$\forall I_0 > \bar{I}_0^3 : \; \bar{\pi}_0^{00}(I_0) > \bar{\pi}_0^{G0}(I_0).$$

In particular,

$$\bar{I}_0^1 = \frac{(1-q)}{(\delta+\alpha)}, \; \bar{I}_0^2 = \frac{pq + (1-p)(1-q)}{1+\alpha}, \; \textit{and } \bar{I}_0^3 = \frac{pq}{1+p\alpha-(1-p)\delta}.$$

Proof. The existence of these thresholds follows from the fact that

$$\frac{\partial \bar{\pi}_0^{GB}}{\partial I_0} = -1-\alpha, \; \frac{\partial \bar{\pi}_0^{G0}}{\partial I_0} = (1-p)\delta - p\alpha - 1, \; \textit{and } \frac{\partial \bar{\pi}_0^{00}}{\partial I_0} = 0,$$

such that

$$\frac{\partial \bar{\pi}_0^{GB}}{\partial I_0} < \frac{\partial \bar{\pi}_0^{G0}}{\partial I_0} < \frac{\partial \bar{\pi}_0^{00}}{\partial I_0}.$$

□

Lemma 1. *With bond issuance and full commitment, the continuation strategy is feasible for all I_0 that satisfy $I_0 \leq \bar{I}_0^2$. The scrapping strategy is feasible for all $I_0 \leq \bar{I}_0^3$.*

Proof. There is a maximum amount of possible expected repayments in period 2 for both strategies. When the project is always continued, it must be the case that

$$B_0 R_0^{02} \leq (pq - (1-p)(1-q)),$$

and when the the project is scrapped in period 1 in the bad state, it is required that

$$B_0 R_0^{02} \leq pq + (1-p)(\delta I_0 + \alpha I_0).$$

Given that $B_0 = I_0 + \alpha I_0$, it is straightforward to show that for $I_0 > \bar{I}_0^2$, the continuation strategy is not financeable, and that for $I_0 > \bar{I}_0^3$, the scrapping strategy is not financeable, which mirrors the optimal financing choice in Proposition 1. □

Lemma 2. *Given Assumption 1, both strategies are feasible in the neighborhood of $\bar{I}_0^1$. Furthermore,*

$$\begin{aligned} \hat{\pi}_0^{GB} > \hat{\pi}_0^{G0} > 0 \qquad & \forall I_0 < \bar{I}_0^1, \\ \hat{\pi}_0^{G0} \geq \hat{\pi}_0^{GB} > 0 \qquad & \forall I_0 \in \left[\bar{I}_0^1,\ \bar{I}_0^2\right), \\ \hat{\pi}_0^{G0} > 0 \qquad & \forall I_0 \in \left[\bar{I}_0^2,\ \bar{I}_0^3\right). \end{aligned}$$

Proof. The first part follows directly from Lemma 1 and Assumption 1.

In order to calculate the profits, notice that the maximum repayments can be achieved by setting $B_0 Z_0^{02} = 1$. Any repayment promise with $B_0 Z_0^{02} > 1$ results in the same repayment, such that I can assume w.l.o.g. that $\max(1 - B_0 Z_0^{02}, 0) = 1 - B_0 Z_0^{02}$ and $\min\left(B_0 Z_0^{02},\ 1\right) = B_0 Z_0^{02}$.

It is then possible to calculate Z_0^{02} as $Z_0^{02} = \frac{1}{(pq-(1-p)(1-q))}$ when the project is always continued and $Z_0^{02} = \frac{1}{pq} - \frac{(1-p)}{pq}\frac{(\delta I_0 + \alpha I_0)}{I_0(1+\alpha)}$, when the project is scrapped in the bad state.

This allows the calculation of

$$\begin{aligned} \hat{\pi}_0^{GB} &= (pq + (1-p)(1-q))\left(1 - I_0(1+\alpha)\frac{1}{(pq-(1-p)(1-q))}\right) \ \forall I_0 < \bar{I}_0^2, \\ \hat{\pi}_0^{G0} &= pq\left(1 - I_0(1+\alpha)\left(\frac{1}{pq} - \frac{(1-p)}{pq}\frac{(\delta I_0 + \alpha I_0)}{I_0(1+\alpha)}\right)\right) \ \forall I_0 < \bar{I}_0^3. \end{aligned}$$

Some algebra then reveals the above relations.

Given Assumption 1 I know that $\bar{I}_0^1 < \bar{I}_0^2 < \bar{I}_0^3$. □

Lemma 3. *For all I_0 and α such that*

$$I_0 \in \left(\frac{1-q}{\alpha(1+\psi)},\ \frac{p\left((2q-1) + \frac{1-q}{1+\psi}\right)}{(1-(1-p)\delta + p\alpha)}\right),$$

and

$$\alpha \geq \bar{\alpha}^1 = \frac{(1-q)(1-(1-p)\delta)}{p(2q-1)(1+\psi)},$$

an optimal financing of the scrapping strategy is given by

$$B_0 = (1+\alpha)I_0 - \frac{1-q}{1+\psi},\ \textit{and}\ L_0 = 0,$$

as well as

$$L_{1|G} = \frac{1-q}{1+\psi} \text{ and } L_{1|B} = 0.$$

The contracted rates on the bank loan L_1 and the bond are then given by

$$\tilde{Z}^{12}_{1|G} = \frac{1+\psi}{q} \text{ and } Z^{02}_0 = \frac{1}{pq} - \frac{1-p}{pq} \frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right)}.$$

Proof. The objective of the entrepreneur, when financing the scrapping strategy, is to keep financing costs as low as possible, while satisfying the constraint given in Equation 18. In order to so, he has to minimize bank financing. His optimization problem can be rewritten as

$$\min \ L_0 + L_1 \tag{22}$$

subject to

$$L_1 = \alpha I_0 + \tilde{Z}^{01}_0 L_0 - (B_0 + L_0 - I_0), \tag{23}$$

$$0 \leq B_0 + L_0 - I_0, \tag{24}$$

$$\frac{q}{(1+\psi)} \geq L_1 > \frac{1-q}{(1+\psi)}. \tag{25}$$

L_1 is increasing in L_0 such that the entrepreneur will want to choose L_0 as small as possible for every choice of L_1. He will then choose the smallest L_1 satisfying the above constraints, which implies choosing L_1 marginally larger than $\frac{1-q}{1+\psi}$.
In the interval $I_0 \in \left(\frac{1-q}{\alpha(1+\psi)}, \frac{q}{\alpha(1+\psi)}\right)$ this implies choosing

$$L_0 = 0 \tag{26}$$

and

$$B_0 = (1+\alpha)I_0 - \frac{1-q}{1+\psi}. \tag{27}$$

For this strategy the bond holder's participation constraint is

$$\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right) = pq\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right) Z^{02}_0 + (1-p)\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right), \tag{28}$$

such that

$$Z_0^{02} = \frac{1}{pq} - \frac{1-p}{pq} \frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left((1+\alpha) I_0 - \frac{1-q}{1+\psi}\right)} \tag{29}$$

This strategy is only feasible as long as

$$B_0 Z_0^{02} < 1 - \frac{1-q}{q}. \tag{30}$$

Plugging Eqs. 27 and 29 into Eq. 30 yields

$$I_0 < \frac{p\left((2q-1) + \frac{1-q}{1+\psi}\right)}{(1-(1-p)\,\delta + p\alpha)}. \tag{31}$$

Now I have two upper bounds on I_0, but some algebra shows that as long as $\alpha < 1$ is is true that

$$\frac{p\left((2q-1) + \frac{1-q}{1+\psi}\right)}{(1-(1-p)\,\delta + p\alpha)} < \frac{q}{\alpha\,(1+\psi)}. \tag{32}$$

Further algebra shows that the interval $I_0 \in \left(\frac{1-q}{\alpha(1+\psi)}, \frac{p\left((2q-1)+\frac{1-q}{1+\psi}\right)}{(1-(1-p)\delta+p\alpha)}\right)$ is empty if

$$\alpha < \bar{\alpha}^1 = \frac{(1-q)\,(1-(1-p)\,\delta)}{p\,(2q-1)\,(1+\psi)}. \tag{33}$$

□

Lemma 4. *For all I_0 such that*

$$I_0 \in \begin{cases} \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi}, \ \frac{1-q}{\alpha(1+\psi)}\right) & if\ \alpha \geq \bar{\alpha}^1 \\ \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi}, \ \frac{p(2q-1)+\frac{1-q}{1+\psi}\left(\frac{1}{1+\psi}-(1-p)\right)}{\left(1+\frac{1}{1+\psi}\alpha-(1-p)(\delta+\alpha)\right)}\right) & otherwise \end{cases}$$

a optimal financing of the scrapping strategy is given by

$$B_0 = I_0 - \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right),\ \textit{and}\ L_0 = \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right),$$

as well as

$$L_{1|G} = \frac{1-q}{1+\psi}\ \textit{and}\ L_{1|B} = 0.$$

The contracted rates on the bank loans L_0 and $L_{1|G}$ and the bond are then given by

$$\tilde{Z}_0^{01} = 1+\psi,\ \tilde{Z}_{1|G}^{12} = \frac{1+\psi}{q} \text{ and } Z_0^{02} = \frac{1}{pq} - \frac{1-p}{pq}\frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left((1+\alpha)I_0 - \frac{1-q}{1+\psi}\right)}.$$

Proof. The entrepreneur is again choosing the sum of L_1 and L_0 to be as small as possible. However, the financing needs in period 1 are smaller than required by the constraint specified in Equation 18. He therefore needs to take out a loan in period 0 in order to increase his financing needs in period 1.

His financing needs in period 1 are given by

$$L_1^{\text{cont}} = \alpha I_0 + \tilde{Z}_0^{01} L_0 - (B_0 - I_0 - L_0)\,, \tag{34}$$

and it is required that

$$L_1^{cont} \geq \frac{1-q}{1+\psi}. \tag{35}$$

Equation 35 will bind and combined with Equation 34 I find that

$$\tilde{Z}_0^{01} L_0 = \frac{1-q}{1+\psi} - \alpha I_0. \tag{36}$$

He will now choose

$$I_0 = B_0 + L_0, \tag{37}$$

as a larger RHS would only reduce his financing needs in period 1 and therefore require an even higher value of L_0.

Therefore,

$$B_0 = I_0 - \frac{1}{\tilde{Z}_0^{01}}\left(\frac{1-q}{1+\psi} - \alpha I_0\right). \tag{38}$$

The loan rate on L_0 is defined through the banker's participation constraint, given by

$$L_0(1+\psi) = pL_0\tilde{Z}_0^{01} + (1-p)\min\left(L_0\tilde{Z}_0^{01},\ \delta I_0\right). \tag{39}$$

As long as $L_0\tilde{Z}_0^{01} < \delta I_0$ I find that

$$\tilde{Z}_0^{01} = 1+\psi. \tag{40}$$

In that case,

$$L_0 = \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right). \tag{41}$$

For this case to hold it is required that

$$I_0 > \frac{1}{\alpha+\delta}\frac{1-q}{1+\psi}. \tag{42}$$

So for all

$$I_0 \in \left(\frac{1}{\alpha+\delta}\frac{1-q}{1+\psi}, \frac{1}{\alpha}\frac{1-q}{1+\psi}\right) \tag{43}$$

the entrepreneur could possibly finance the scrapping strategy by setting

$$L_0 = \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right) \text{ and } B_0 = I_0 - L_0. \tag{44}$$

Notice that the lower bound of this interval is even smaller than needed, as for all $I_0 \leq \frac{1}{\alpha+\delta}(1-q)$ continuation is always optimal and there is no need to induce the scrapping strategy.

I still have to check under which conditions the bond holder is willing to finance this strategy. His participation constraint now becomes

$$B_0 = pqB_0Z_0^{02} + (1-p)\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right), \tag{45}$$

because

$$\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi} < \delta I_0 - L_0 < I_0 - L_0 = B_0 < B_0 Z_0^{02}. \tag{46}$$

Plugging in for B_0 I find that

$$Z_0^{02} = \frac{1}{pq} - \frac{1-p}{pq}\frac{\left(\delta I_0 + \alpha I_0 - \frac{1-q}{1+\psi}\right)}{\left(I_0 - \frac{1}{1+\psi}\left(\frac{1-q}{1+\psi} - \alpha I_0\right)\right)}. \tag{47}$$

It is then required that

$$B_0 Z_0^{02} \leq 1 - \frac{1-q}{q}, \tag{48}$$

which is satisfied whenever

$$I_0 \leq \frac{p\left(2q-1\right) + \frac{1-q}{1+\psi}\left(\frac{1}{1+\psi} - (1-p)\right)}{\left(1 + \frac{1}{1+\psi}\alpha - (1-p)\left(\delta+\alpha\right)\right)}. \tag{49}$$

I find that $\frac{1-q}{\alpha(1+\psi)}$ is larger than $\frac{p(2q-1)+\frac{1-q}{1+\psi}\left(\frac{1}{1+\psi}-(1-p)\right)}{\left(1+\frac{1}{1+\psi}\alpha-(1-p)(\delta+\alpha)\right)}$ when

$$\alpha > \frac{(1-q)\left(1-(1-p)\,\delta\right)}{p\,(2q-1)\,(1+\psi)}, \tag{50}$$

which is the same threshold as found in Equation 33.

As above,

$$\tilde{Z}^{12}_{1|G} = \frac{1+\psi}{q}. \tag{51}$$

□

Proposition 4. *Denote with π^{cont} the profit of always continuing the project, and with π^{scrap} the profit when scrapping is induced by a bank loan. Given Assumptions 1 and 2, there are two threshold values $\widetilde{I}^1_0$ and $\tilde{I}^3_0$ which satisfy*

$$\begin{aligned} \forall I_0 < \widetilde{I}^1_0 : &\qquad \pi^{cont} > \pi^{scrap} > 0, \\ \forall I_0 < \tilde{I}^3_0 &\qquad \pi^{scrap} > 0. \end{aligned}$$

Furthermore,

$$\bar{I}^1_0 < \widetilde{I}^1_0 < \widetilde{I}^3_0 < \bar{I}^3_0.$$

In particular,

$$\widetilde{I}^1_0 = \begin{cases} \frac{(1-q)((1-p)+\psi)}{(1+\psi)(1-p)(\delta+\alpha)} & if\ \ \alpha > \max\left(\bar{\alpha}^1,\ \bar{\alpha}^2\right), \\ \frac{(1-q)\left((1-p)+\frac{2\psi+\psi^2}{1+\psi}\right)}{(1+\psi)(1-p)(\delta-\alpha)+\psi\alpha} & otherwise, \end{cases}$$

with

$$\bar{\alpha}^2 = \frac{(1-p)\delta}{\psi},$$

and $\tilde{I}^3_0$ as defined above.

Proof. Profit of scrapping strategy with banks is given by

$$\pi^{scrap} = \begin{cases} pq\left(1-\frac{1-q}{q}-\left((1+\alpha)I_0-\frac{1-q}{1+\psi}\right)\left(\frac{1}{pq}-\frac{1-p}{pq}\frac{\left(\delta I_0+\alpha I_0-\frac{1-q}{1+\psi}\right)}{\left((1+\alpha)I_0-\frac{1-q}{1+\psi}\right)}\right)\right) & \text{if } I_0 \in \left(\frac{1-q}{\alpha(1+\psi)},\ \widetilde{I}^3_0\right], \\ pq\left(1-\frac{1-q}{q}-\left(I_0-\frac{1}{1+\psi}\left(\frac{1-q}{1+\psi}-\alpha I_0\right)\right)\left(\frac{1}{pq}-\frac{1-p}{pq}\frac{\left(\delta I_0+\alpha I_0-\frac{1-q}{1+\psi}\right)}{\left(I_0-\frac{1}{1+\psi}\left(\frac{1-q}{1+\psi}-\alpha I_0\right)\right)}\right)\right) & \text{otherwise.} \end{cases} \tag{52}$$

The profit of always continuing is given by

$$\pi^{cont} = (pq + (1-p)(1-q)) - I_0 (1+\alpha) \;\; \forall I_0 < \bar{I}_0^2. \tag{53}$$

Given Assumption 2 and given that $\frac{\partial \pi^{cont}}{\partial I_0} < \frac{\partial \pi^{scrap}}{\partial I_0}$, it is known that there is a unique value $\widetilde{I}_0^1$ with

$$\pi^{scrap}\left(\widetilde{I}_0^1\right) = \pi^{scrap}\left(\widetilde{I}_0^1\right) \tag{54}$$

and

$$\widetilde{I}_0^1 < \widetilde{I}_0^3. \tag{55}$$

Because π_{scrap} is concave and because at all points $\frac{\partial \pi^{cont}}{\partial I_0} < \frac{\partial \pi^{scrap}}{\partial I_0}$, I find $\widetilde{I}_0^1$ as the maximum value of the two values $\widetilde{I}_0^{1A}$ and $\widetilde{I}_0^{1B}$ that solve

$$\pi^{cont}\left(\widetilde{I}_0^{1A}\right) = \pi^{scrap}\left(\widetilde{I}_0^{1A}\right) \mid I_0 \in \left(\frac{1-q}{\alpha(1+\psi)}, \; \widetilde{I}_0^3\right], \tag{56}$$

and

$$\pi^{cont}\left(\widetilde{I}_0^{1B}\right) = \pi^{scrap}\left(\widetilde{I}_0^{1B}\right) \mid I_0 \notin \left(\frac{1-q}{\alpha(1+\psi)}, \; \widetilde{I}_0^3\right]. \tag{57}$$

Some algebra shows that

$$\widetilde{I}_0^{1A} = \frac{(1-q)\left((1-p) + \frac{2\psi+\psi^2}{1+\psi}\right)}{(1+\psi)(1-p)(\delta+\alpha) + \psi\alpha}. \tag{58}$$

$$\widetilde{I}_0^{1B} = \frac{(1-q)((1-p)+\psi)}{(1+\psi)(1-p)(\delta+\alpha)}, \tag{59}$$

I can furthermore show that $\widetilde{I}_0^{1A} < \widetilde{I}_0^{1B}$ as long as

$$\alpha > \frac{(1-p)\delta}{\psi}. \tag{60}$$

For $\widetilde{I}_0^{1B}$ to be the relevant threshold it is then still required that

$$\alpha > \frac{(1-q)(1-(1-p)\delta)}{p(2q-1)(1+\psi)}. \tag{61}$$

□