Credit Derivatives, Disintermediation and Investment Decisions

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This Version: March, 2003

Abstract

The credit derivatives market provides a liquid but opaque forum for secondary market trading of banking assets. I show that when entrepreneurs rely upon the certification value of bank debt to obtain cheap bond market finance, the existence of a credit derivatives market may cause them to issue sub-investment grade bonds instead, and to engage in second-best behaviour. Credit derivatives can therefore *cause* disintermediation and thus reduce welfare. I argue that this effect can be most effectively countered by the introduction of reporting requirements for credit derivatives.
KEY WORDS: Credit derivative, monitoring, debt finance, capital structure, common agency.
JEL CLASSIFICATION: G24, G28, G34

*I should like to thank the anonymous referee, whose comments greatly improved this paper. The paper is a revised version of a chapter in my doctoral thesis. I am grateful to my supervisors, Colin Mayer and Hyun Shin, for their support and encouragement. I am also grateful to Xavier Freixas, William Wilhelm, Clara Raposa and to seminar participants in Oxford and at ISCTE (Lisbon, Portugal) for comments and discussion.

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This paper examines the consequences for the real sector of disintermediation in the debt markets. The specific phenomenon which I study is the market for *credit derivatives*. A credit derivative is a trade in which one party, the *protection buyer*, makes periodic payments to another party, the *protection seller*, in exchange for which the protection seller indemnifies the protection buyer against any losses which he experiences as a consequence of the default of some credit-risky *reference asset*[1]. Banks are thus able to pass the default risk associated with their assets on to third parties whilst simultaneously retaining legal title to the assets. The market for these derivatives has expanded very rapidly from about $180 billion in 1997 to $893 billion in 2000 (British Bankers Association, 2000).

When discussing credit derivatives, practitioners typically highlight two characteristics which differentiate them from other secondary loan markets. Firstly, bankers stress that the ease with which credit derivatives may be traded allows them to manage concentration risk in their portfolios:

> The use of credit derivatives by banks has been motivated by the desire to improve portfolio diversification (synthetically) and to improve the management of credit portfolios. (Das, 1998, p.10)

As a consequence, bank-originated loans are emerging as an asset class which is actively traded, and many bank-originated loans are now held by non-banks (Masters, 1999). Currently, only 47% of the protection sellers in the credit derivatives market are banks (British Bankers Association, 2000).

The second important feature of credit derivatives trades is that borrowers are not typically informed that their loan is the reference asset for a transaction:

> [...] there is no reason why the reference entity or any third party should become aware of the existence of the trade. For this reason, OTC contracts frequently require the fact that the trade has been entered into be kept confidential. (Jakeways, 1999, p. 58)

Bankers justify this secrecy by saying that it is necessary to protect their relationship rents:

> [...] borrowers typically are unwilling to have their debt sold. Banks fear that if they sell a loan, they may lose the opportunity for future business with the borrower. (Caouette, Altman and Narayanan, 1998, p. 305)

I examine in this paper the consequences of this market for funding and investment decisions in the real sector. I consider an economy in which entrepreneurs raise debt finance to run one of two projects and I show that in the absence of credit derivatives, some borrowers will employ bank debt to signal their intention to run a first best project. I argue that banks whose assets are highly concentrated in a particular sector will exhibit risk aversion and hence may trade with a less concentrated counterparty in the credit derivatives market in order to diversify their portfolios, as above. When a bank is sufficiently risk-averse towards a particular asset, it will entirely cover its exposure to that asset. For the issuer of such an asset, the credit derivatives market will destroy the signalling value of bank debt and he will instead issue junk bonds and run a second-best project. Although *trades* in the secondary market for bank debt will be

[1] The specific structure which I describe is a *Default Swap*. See Tavakoli (1998) for a detailed survey of credit derivative instruments and trades.

welfare-increasing the *existence* of the market will, in that it alters the decisions of corporations and reduces the volume of bank debt, be welfare-reducing.

The paper's arguments are developed as follows.

Firstly, I build a model for corporate financing which rests upon the value which insider bank-held debt creates for the dispersed holders of publicly quoted securities. This approach was first suggested by Fama (1985): the model of this paper is similar to Holmström and Tirole (1997), augmented to allow for risk averse bankers and variable project quality. I consider cash-constrained entrepreneurs who use debt to finance one of two positive net present value projects. One project has a higher NPV, while the other yields non-transferable private benefits to the entrepreneur. By monitoring their borrowers, bankers can ensure that they select the first best project. This skill is denied to the dispersed holders of bonds[2].

Banks exhibit risk aversion and bond holders do not, so bank debt will *ceteris paribus* be more expensive than bond debt. Bank finance will only be selected by entrepreneurs when a verbal *ex ante* commitment to make a first best *ex post* trading decision is not credible.

With no secondary market for credit derivatives borrowers in this model are stratified in a way which accords with recent empirical work by Cantillo and Wright (2000)[3]. First best project selection is incentive compatible for the highest quality borrowers and they therefore issue investment grade bonds. The *ex ante* optimal financing for intermediate borrowers would involve pure bond financing with a commitment to first best behaviour. For these borrowers such a commitment is not *ex post* optimal and they therefore employ mixed financing: the presence of a bank as a guarantor of first best behaviour will attract cheap bond market funds. Mixed financing is not optimal for the weakest borrowers and they therefore rely upon junk bond finance.

This intermediation model builds upon insights from the delegated monitoring literature (Campbell and Kracaw, 1980; Diamond, 1984; Mayer, 1988; Hellwig, 1991; Boot and Greenbaum, 1993). Holmström and Tirole (1997) discuss certification in the context of a discussion of capitalisation and Besanko and Kanatas (1993) examine cross-monitoring when bank monitoring effort is unverifiable and use this to determine an optimal bank to public debt ratio. The deleterious effects of bank asset liquidity have been examined in a different context by Myers and Rajan (1998). Empirical papers by James (1987), Lummer and McConnel (1989) and Datta, Iskandar-Datta and Patel (1999) support the suggestion that bank cross-monitoring creates value for dispersed claim-holders.

The second part of the paper considers the consequences of allowing trade in credit derivatives after financing has occurred. Much of the initial activity in the secondary market for bank debt was in response to inconsistencies in the regulatory framework for bank capital allocation. This paper is concerned solely with the use of credit derivatives to accomplish *risk sharing* by a bank which is concerned about illiquid and concentrated counterparty risks in its loan portfolio. To model risk sharing, I assume that the bank has a concave utility function for wealth: theoretical justification for my assumption is provided by Froot and Stein (1998), who argue

[2] Monitoring could be achieved by coalitions of bond-holders. I assume that as a consequence of coordination problems this can only occur when the members of the coalition have individually large holdings and thus exhibit risk aversion. In this case such coalitions will be indistinguishable from my banks.

[3] Cantillo and Wright demonstrate that firms operating in the safest markets tap bond markets while firms with poorer prospects typically rely upon intermediated finance. While they justify their empirical results in terms of the ability of banks to renegotiate after default they are also susceptible to explanation in terms of certification and monitoring.

that banks are capital constrained as a result of informational problems and consequently that they will act to conserve capital so as to be able to profit from future investment opportunities.

In line with current market practice, I assume that credit derivatives trades are not reported so that the banker cannot make an *ex ante* commitment to a specific protection level. In this case the banker has two choices: he can either purchase partial protection upon his asset and continue to monitor it, or he can protect his entire position and cease to monitor. The first type of trade fulfills the risk-sharing role which is usually attributed to credit derivatives trade without impairing the certification value of bank debt. The second type of trade achieves risk-sharing, but in so doing destroys the certification value of debt. In this case the entrepreneur will prefer to issue junk bonds and to run a second-best project.

Intermediate quality borrowers wishing to use mixed finance can render total protection less attractive to bankers by borrowing more from them at the financing stage than they would in a world without credit derivatives. The banker must then obtain bond market funding (I model this as a type of credit derivative in which the banker receives an *ex ante* fee), which will be more costly if the banker stops monitoring. The banker's credit derivative trading strategy is then determined by the trade-off between the benefits which he derives from total insurance and the funding costs to which this exposes him. I show that the most risk averse bankers elect to purchase total protection.

Difficulties associated with unenforceable monitoring in the wake of loan sales have been previously examined by Gorton and Pennacchi (1995) in a model in which loan sales occur because they are a cheaper form of funding than deposit taking: a risk-sharing motivation does not arise and so loan sales may be impeded by monitoring incentive compatibility problems. In my model loan sales can proceed even in the presence of such problems. Gorton and Pennacchi suggest that the selling institution may overcome the incentive compatibility problems either by issuing an implicit guarantee against default or by restricting its loan sale to a portion of its total holding of the asset. The former suggestion relies upon mis-pricing of either the guarantee or the sale as a consequence of risk-insensitive reserve requirements and does not arise in the context of my risk-sharing model. I endogenise the restriction upon the size of the sale in this paper by extending its scope to include the corporate's funding decision. Bank debt will be employed only by those corporates for whom the banks will optimally choose to perform partial loan sales. I show that even in this case, the credit derivatives market will be welfare-enhancing only if the size of the banker's initial loan to the entrepreneur is bounded below.

The banker's decision to purchase credit derivative protection in this model changes his effective terms of trade and hence is similar to a contract renegotiation. Fudenberg and Tirole (1990) examine a standard principal-agent framework within which interim renegotiation is possible and demonstrate that the optimal contract consists of a renegotiation proof menu of compensation schedules which guarantee a certain probability of effort. My model is not susceptible to contracts of this type, because the credit derivative is not transacted with one of the original parties to the transaction and imposes externalities upon them which are outside the scope of the principal agent models. My analysis is more closely related to the large literatures on collusion and common agency.

Tirole (1986) and Laffont and Martimort (1997, 2000) examine models in which contracting between a principal, a productive agent and a supervisor is subject to collusive side contracting between the agent and the supervisor, who together manipulate the information which the principal receives. Collusion in these models introduces additional group level incentive compatibility constraints. The model of this paper is in this vein, with the entrepreneur, the bank and the bond holders assuming the respective roles of the agent, the supervisor and the principal.[4] After the contracts have been signed, both the banker and the entrepreneur would prefer monitoring to cease: credit derivatives provide a mechanism which allow this to happen and so represent a form of collusive behaviour. The collusion incentive compatibility constraint in this model is that the banker prefer partial to complete hedging. As I note above, this is most likely to be satisfied when the entrepreneur is initially financed entirely by the bank. When this happens, the financial risk-bearing associated with the project is delegated to the bank. A similar result obtains in Faure-Grimaud, Laffont and Martimort (2002), where collusive inefficiencies also arise as a consequence of the trade-off between insuring a risk-averse supervisor and incentivising him to align his interests with those of the principal. In their model, an optimal collusion proof contract exists and can be implemented by delegating responsibility for contracting with the agent to the supervisor.

The collusion literature examines group incentives truthfully to report types. The collusion facilitated by credit derivatives relates to the moral hazard which surrounds the bank's monitoring and its contracts with bond-holders, the derivatives market, and the entrepreneur. The banker is thus the agent of several principals and this paper is therefore related to the literature on common agency. When the banker in this paper purchases a credit derivative from a dispersed risk-neutral investor base he inflicts a negative externality upon the existing bond-holders. When this would result in over-insurance bank lending ceases and a welfare loss ensues. Pauly (1974) examines a similar problem in a competitive insurance market where the volume of insurance purchased by any agent is uncontractible. Because the marginal cost of insurance is constant agents over-insure themselves, and in so doing, they inflict a negative externality upon other insurers which in turn affects the equilibrium price of insurance. Bernheim and Whinston (1986) also examine the externalities which contracts with one principal impose upon others. The inefficiencies in my model arise because of the externalities which credit derivative trades inflict upon non-traders: Segal (1999) provides a general treatment of this topic.

The paper is organized as follows. In section I I describe the financing procedure, the project variables, the activities of the bank and the preferences of the bank and the bond holders. In section II I develop an intermediation model in which bank finance is used to certify quality to the bond market. Section III examines the effect upon financing and project selection decisions of a market for credit derivatives. Section IV contains a discussion of my results and concludes. Some of the proofs are relegated to the appendix.

I. The Model

Consider an entrepreneur who wishes to invest in a project of size \$1. The project will return a verifiable cashflow of 0 if it fails or $R > 0$ if it succeeds. There are two types of project: G (good), and B (bad), which succeed with respective probabilities p_H and $p_L \equiv p_H - \Delta p < p_H$. Type B projects generate a non-verifiable private benefit $B > 0$ for the entrepreneur; there are no private benefits associated with type G projects. I assume that type G projects are superior

[4] Although the agent in this paper designs the *ex ante* financing contracts, he does so to satisfy the principal's requirement for a low risk project.

to type B projects and that both projects have positive net present value:

$$p_H R > p_L R + B > 1. \tag{1}$$

The assumption of positive NPV is made to facilitate the examination of the choice between bank and bond market financing in the presence of moral hazard. It may be interpreted as a statement about the relative merits of two projects for which finance may be raised: other investment opportunities are ignored.

Suppose that the entrepreneur is wealth-constrained so that he needs to raise the funds for investment by issuing debt securities. There are two sources of debt finance: a bank and a market for bonds.

Two features distinguish the bank from the bondholders. Firstly, bank debt carries tough covenants which are designed to give the bank leverage over the borrower. Such leverage is not available to the holders of securitized debt, partly because the covenants on this debt are less restrictive and partly due to coordination and free-rider problems. The bank's strong bargaining position allows it to *monitor* the borrower. The bank's monitoring activities are unverifiable and hence uncontractible - they are performed solely to increase the utility which the bank derives from extending credit. When the bank monitors a project, it can ensure that it is of type G at a fixed non-divisible cost to the bank of M.

The second differentiating feature of the bank is its risk aversion: this assumption is discussed in the introduction. I wish to examine the risk-sharing motivation for credit derivatives and so I assume that the dispersed investors in bonds and credit derivatives have no concentration problems and are risk-neutral. For a given project this will render the costs of bank loans higher than those of bonds.

The funding activities and project management process are ordered according to figure 1.

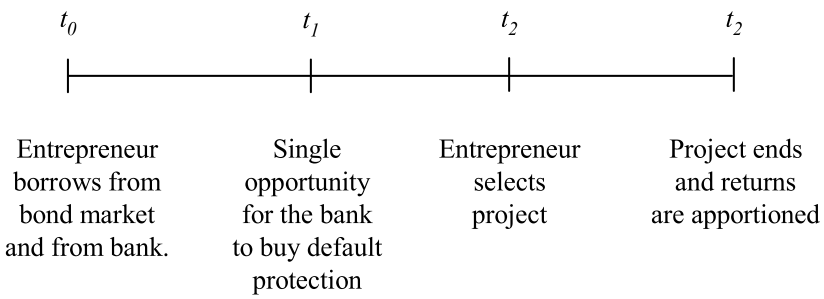

Figure 1: Funding and project management time line.

At time t_0, the entrepreneur approaches the banker and the bond market for funds. The bank contract (λ, I, J) stipulates the t_0 advance λ from the bank to the entrepreneur and the t_3 repayments I and J which the entrepreneur makes in case the project succeeds or fails. The bond market contract (β, P, Q) stipulates the amount borrowed β and the repayments P and Q in case the project succeeds or fails respectively. The project type is non-verifiable and does not appear in either contract.

I assume that the bank is risk averse: as discussed in the introduction, this assumption is motivated by concerns about future credit rationing. Specifically, I assume that the banker has an amount of capital \$1 to devote to projects of the type which the entrepreneur is running.

Any uninvested capital is placed in a riskless storage technology whose returns are normalised to 0. The bank's one-period investment decisions are selected to maximise the expected value of a separable utility function

$$V(z,\rho) = u(z) - \rho \tag{2}$$

where $u(.)$ is strictly increasing, twice continuously differentiable and concave, z is end of period wealth, comprising returns from the project and uninvested bank capital, and $\rho \in \{0, M\}$ is the expenditure on monitoring. The dispersed investors in bonds derive utility z from a time 1 expected cashflow of z.

At time t_1, the bank has a single opportunity to buy protection against the risk of default by the entrepreneur, using a credit derivative. Although the bank can commit at this stage to a specific level of protection, I assume that it cannot do so at time t_0: this assumption reflects the opacity of the credit derivatives market.

At time t_2, the entrepreneur selects the project type which he will run. Although bank monitoring is not provable in a court it affects the entrepreneur's behaviour. If he is monitored then he will select the type G project. His selection will otherwise be governed by the funding costs to which he is subject.

At time t_3 the project terminates and the returns are apportioned between the various claimholders.

The solution of this game is by backward induction. At time t_2 the entrepreneur decides whether to select a good project or a bad one. If mixed financing between the bank and the bond market was originally arranged the entrepreneur would prefer to select a bad project. If the bank is still monitoring the entrepreneur then a good project will be selected. If the bank has sold its entire position through the credit derivatives market then a bad project will be selected. If non-mixed financing was originally selected then the lender rationally anticipated the entrepreneur's decision: it will depend upon the specifics of the project as detailed below.

The remainder of the analysis proceeds as follows. In section II I examine the funding and the project selection decisions of an entrepreneur when there is no credit derivatives market. I demonstrate that the highest quality borrowers can commit to run good projects and will borrow using only bonds, which I interpret as investment grade securities. Other borrowers cannot make a credible commitment to run good projects. The lowest quality borrowers will elect to issue low quality, or *junk*, bonds and to run bad projects. Borrowers of intermediate quality will elect to fund themselves partly using bank finance and partly with bonds. In this case, the *monitoring equilibrium*, bank debt acts as a *certification device* which ensures that the entrepreneur selects a good project and hence reduces his cost of funds.

In section III I examine the consequences for project selection of a credit derivatives market. When such a market exists, risk averse banks will use credit derivatives to insure themselves against losses arising from entrepreneurial default. I show that banks will either sell a fixed proportion of their initial position and continue to monitor the residual, or that they will sell their entire position and cease to monitor.

I then determine the optimal t_0 financing decision of the entrepreneur. Bank finance will only be employed as a certification device in a monitoring equilibrium. I demonstrate that for a class of entrepreneurs, no bank contract can sustain a monitoring equilibrium when there is a credit derivatives market. In this case investors will rationally anticipate loan sales and a consequential cessation of monitoring by banks. This will destroy the signalling value of bank debt so that a sub-optimal project will be selected.

II. A Precommitment Model for Corporate Financing Decisions

In this section I develop a model for corporate debt financing decisions in the absence of credit derivatives which balances the precommitment value of bank debt against its higher costs.

Banker risk aversion renders bank finance *ceteris paribus* more expensive than bond finance. The entrepreneur will therefore use bank finance only when it provides certification value. If he can make a credible commitment to first best behaviour he will issue only bonds. The cost of finance from the risk neutral bond market for a good project will be $\frac{1}{p_H}$. Certification will not be required when good project selection is incentive compatible at this rate: in other words, when $\left(R - \frac{1}{p_H}\right) p_H \geq \left(R - \frac{1}{p_H}\right) p_L + B$, or when

$$B \leq B_m \equiv \left(R - \frac{1}{p_H}\right) \Delta p.$$

When $B > B_m$ a verbal commitment by the entrepreneur to select a first best project will not be credible. In this case, he may elect to use mixed bank and bond market finance to commit to first best behaviour. He will then write respective contracts (λ, I, J) and (β, P, Q) with the bank and the bond market, as detailed in section I.

Define

$$f \equiv J + 1 - \lambda; \tag{3}$$

$$s \equiv I + 1 - \lambda. \tag{4}$$

to be the banker's net wealth after project failure and success respectively. I prove in the appendix that the banker's participation constraint binds, and that for high enough R we can assume without loss of generality that the entrepreneur will borrow precisely the \$1 cost of the project. The entrepreneur's problem is therefore to minimise the following bank cost of funds expression

$$C(f, s) \equiv p_H s + (1 - p_H) f, \tag{CoF}$$

subject to the following monitoring incentive compatibility and participation constraints:

$$u(s) - u(f) \geq \frac{M}{\Delta p}; \tag{MIC}$$

$$p_H u(s) + (1 - p_H) u(f) - M \geq u(1). \tag{IR}$$

I demonstrate in the appendix that these constraints must both bind: this is a standard result in problems of moral hazard with risk averse agents (see for example Laffont and Martimort, 2002, chapter 4). Solving IR and MIC therefore yields the solution (f^*, s^*) to the entrepreneur's problem:

$$f^* = u^{-1}\left(u(1) - \frac{M p_L}{\Delta p}\right). \tag{5}$$

$$s^* = u^{-1}\left(u(1) + \frac{M(1 - p_L)}{\Delta p}\right). \tag{6}$$

Figure 2 illustrates the monitoring and participation constraints in (f, s) space along with two iso-cost lines. Both constraints are satisfied in the region which lies above the lines labelled MIC and IR. The lowest cost solution (f^*, s^*) lies at the intersection of the two curves.

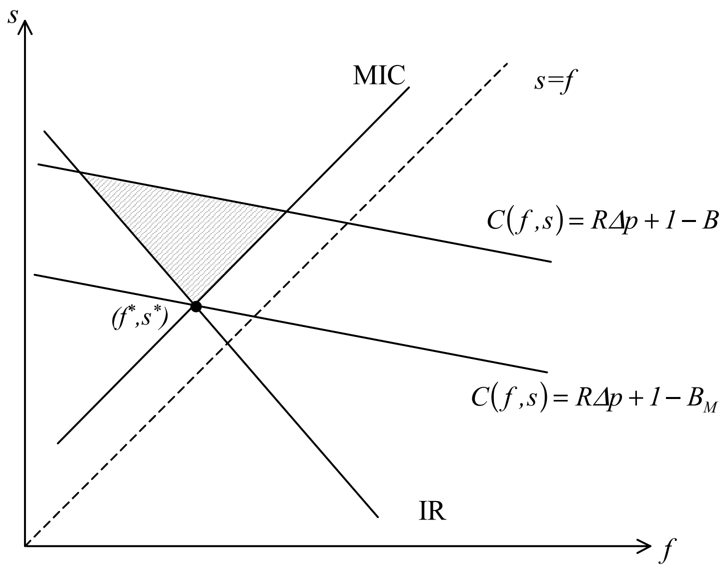

Figure 2: The certification region.

The entrepreneur will select a contract (λ, I, J) which subjects him to monitoring only if his expected return from doing so exceeds that which he can obtain by financing himself with junk bonds and running a second best project: when $p_H R - C(f,s) \geq p_L \left(R - \frac{1}{p_L}\right) + B$, or

$$C(f,s) \leq R\Delta p + 1 - B.$$

The points satisfying this requirement lie below the higher iso cost line in figure 2. Any contract in the shaded region will therefore both ensure that the good project is undertaken and will be incentive compatible for the entrepreneur. I will refer to this region as the *certification region*. When B is sufficiently high the certification region will be empty and the entrepreneur will prefer to borrow using junk bonds and to run a bad project. The critical level B_M is illustrated in figure 2 and is the solution to $C(f^*, s^*) = R\Delta p + 1 - B_M$:

$$B_M \equiv R\Delta p + 1 - \left\{ p_H u^{-1}\left(u(1) + \frac{M(1-p_L)}{\Delta p}\right) + (1-p_H)\, u^{-1}\left(u(1) - \frac{Mp_L}{\Delta p}\right)\right\}.$$

Note that

$$\begin{aligned}\frac{\partial B_M}{\partial M} &= \frac{-p_H(1-p_L)}{\Delta p u'\left\{u^{-1}\left(u(1) + \frac{M(1-p_L)}{\Delta p}\right)\right\}} + \frac{(1-p_H)\,p_L}{\Delta p u'\left\{u^{-1}\left(u(1) - \frac{Mp_L}{\Delta p}\right)\right\}} < 0;\\ \frac{\partial B_M}{\partial R} &= \Delta p > 0,\end{aligned}$$

so that the number of projects for which mixed finance will occur decreases as the cost of monitoring increases and increases as the return R from successful projects increases.

Finally, I consider the entrepreneur's specific contract choice. He can achieve the payout (f^*, s^*) using any contract (λ, I, J) which satisfies equations 3 and 4: both he and the banker are indifferent between all such contracts. He will finance the remaining $1 - \lambda$ using a bond contract under which he repays $-J$ after project failure and $\frac{1-\lambda-J(1-p_H)}{p_H}$ after project success. I assume that $J = 0$: a detailed discussion of this assumption appears at the end of this section.

In this case equations 6 and 5 indicate that an optimal contract is $(\lambda, I, J) = (\lambda^*, I^*, 0)$, with

$$\lambda^* = 1 - u^{-1}\left(u(1) - M\frac{p_L}{\Delta p}\right); \quad (7)$$

$$I^* = u^{-1}\left(u(1) + \frac{M(1-p_L)}{\Delta p}\right) - u^{-1}\left(u(1) - \frac{Mp_L}{\Delta p}\right). \quad (8)$$

I summarise the discussion of optimal financing patterns below:

PROPOSITION 1 *Suppose that there is no trade in credit derivatives. Then entrepreneurial financing and investment decisions will depend upon the private benefits B of the second best project as follows:*

1. *If $B \leq B_m$ the entrepreneur will be financed solely through investment grade bonds with yield $\frac{1}{p_H}$ and will select a good project;*
2. *If $B_m < B \leq B_M$ the entrepreneur will employ mixed bank and bond finance and will run a good project. He will borrow λ^* from a bank and will repay I^* if the project succeeds, and he will issue $(1 - \lambda^*)$ bonds at a rate $\frac{1}{p_H}$;*
3. *If $B > B_M$ the entrepreneur will issue only sub investment grade bonds at rate $\frac{1}{p_L}$ and will elect to run a bad project.*

The dividing line B_M between good and bad project selection is decreasing in the cost M of monitoring and is increasing in the return R from a successful project.

Proposition 1 is consistent with observed financing patterns. The highest quality borrowers are those for whom B is less than B_m. These borrowers are able to finance themselves by issuing investment grade bonds, which have a low cost of funds. Lower quality borrowers ($B_m < B \leq B_M$) can still issue high grade bonds, but must also employ banks to certify the quality of their projects. We can regard their bonds as having a lower investment grade rating. I say that such entrepreneurs are in a *monitoring equilibrium*. Entrepreneurs for whom the temptation to expropriate funds is the highest ($B > B_M$) will not find it optimal to give up their private benefits in exchange for the certification which a bank loan provides and will instead finance themselves using high yielding, or *junk*, bonds.

One aspect of the above discussion is worth emphasising. In practice, financiers are unwilling to lend more than the entrepreneur requires to run the project, for fear of creating free cash flow agency problems (Jensen and Meckling, 1976). Moreover, the danger of entrepreneurial expropriation of funds renders impractical contracts which promise non-zero payments in the wake of project failure. Although these problems are not explicitly modelled in this paper, they are reflected in financing constraint 2 below, which is obeyed by the optimal contract $(\lambda^*, I^*, 0)$.

FINANCING CONSTRAINT 2 *The entrepreneur's financing choices must satisfy the following conditions:*

1. *The entrepreneur must not borrow more than the* \$1 *cost of his project;*
2. *The entrepreneur cannot sign contracts which promise positive payments in the wake of project failure.*

For specificity, I restrict myself in the remainder of the paper to contracts which satisfy this constraint. An unconstrained entrepreneur could select a contract under which the banker received a payment J in the wake of project failure. J would be supplied by the bond market and would be distributed by the entrepreneur. This payment might be expected to reduce the net cost of funds by providing insurance to the risk averse banker. In fact, the ability to make payments of this type does not affect the cost of funds:

LEMMA 3 *Financing constraint 2 can be imposed without loss of generality.*

Proof. As shown above, the relevant choice variables are the banker's net wealth in the wake of project failure and success. These must be selected so as to satisfy at minimum cost both participation and monitoring constraints: the payment level f^* and the difference $(s^* - f^*)$ which accomplish this depend upon the costs of monitoring and the banker's preferences $u(.)$ as in equations 5 and 6, and not upon the quantity λ^* which is lent. λ^* can therefore be selected to as to ensure that $J = 0$. □

III. Credit Derivatives and Monitoring Equilibria

I now consider the consequences of opening a time t_1 credit derivative market where the banker can buy default protection from a dispersed and risk neutral investor base. The analysis is in two parts. Firstly, I demonstrate that, unless the entrepreneur faces more severe financing constraints than constraint 2 above, credit derivatives will not increase welfare. Secondly, I show that credit derivatives may destroy monitoring incentives and hence *reduce* welfare.

I adopt in this section the terminology of the credit derivatives market and refer to the banker's counterpart in the credit derivative trade as the *protection seller*. A credit derivative contract (ϕ, r_u, r_d) requires the banker to pay a time t_1 fee ϕ in exchange for which he receives a time t_3 payment from the protection seller of r_u if the entrepreneur succeeds and of r_d if the entrepreneur fails. Credit derivative trades are not public knowledge and the bank cannot commit at time t_0 to trade a specific credit derivative contract.

A. The Welfare Consequences of Credit Derivatives

Suppose that after the time t_0 contract with the entrepreneur, the banker has net wealth f_E in case the project fails and s_E in case it succeeds, as in section II. After a credit derivative trade (ϕ, r_u, r_d), the banker's net wealth in case of project failure and success respectively will be (f_{CD}, s_{CD}):

$$\begin{aligned} f_{CD} &\equiv f_E + r_d - \phi; \\ s_{CD} &\equiv s_E + r_u - \phi. \end{aligned}$$

The banker will be prepared to trade the credit derivative and to continue to monitor provided (f_{CD}, s_{CD}) lies in the certification region of figure 2. The banker's monitoring will be anticipated by the (competitive) protection seller, who will charge $\phi = p_H r_u + (1 - p_H) r_d$ for the derivative. In this case, note that

$$p_H f_{CD} + (1 - p_H) s_{CD} = p_H f_E + (1 - p_H) s_E = C(f_E, s_E),$$

so that (f_{CD}, s_{CD}) and (f_E, s_E) lie on the same iso-cost line.

If the banker elects to continue monitoring, he can use the credit derivative market to position himself at any point (f, s) which lies on the iso-cost line which passes through (f_E, s_E). His utility after doing so will therefore be

$$p_H u(s) + (1 - p_H) u(f) = p_H u\left(\frac{p_H s_E + (1 - p_H)(f_E - f)}{p_H}\right) + (1 - p_H) u(f).$$

The derivative of this expression with respect to f is $(1 - p_H)(u'(f) - u'(s)) > 0$, so the highest possible expected utility for a banker who continues to monitor is attained where the iso-cost line intersects MIC. Since this point has the same cost to the entrepreneur as the contract (f_E, s_E) it could equally as well have been achieved through the initial contract. I have therefore proved the following:

PROPOSITION 4 *If the banker continues to monitor in the wake of a credit derivatives contract he will use the credit derivative contract to move his payoffs along an iso cost line until his monitoring constraint binds. If certification occurs its cost is unaffected by the presence of a credit derivatives market.*

Proposition 4 demonstrates that when the MIC line is attainable in the t_0 contract between banker and entrepreneur, credit derivatives cannot increase welfare. This applies even when financing constraint 2 is in force. Credit derivatives are welfare increasing only if for some reason outside the model the t_0 contract (f, s) between banker and entrepreneur is constrained to lie to the left (as shown in figure 2) of the MIC line. When constraint 2 is imposed,[5] this is equivalent to a lower bound upon the lending λ of the bank. As I observe in the introduction, credit market practitioners suggest that such a bound is required to ensure that information gathering is incentive compatible and hence to maintain strong relationships with their borrowers. It might equally arise as a consequence of high fixed costs associated with bond market access, which are not modelled in this paper. When a bound of this nature arises, credit derivatives will serve the risk-sharing role which is usually attributed to them and will allow certification to be achieved at the minimum cost $p_H s^* + (1 - p_H) f^*$, *provided continued bank monitoring is incentive compatible in the presence of a credit derivatives market.* I examine this condition in section III.B.

B. Credit Derivatives and Monitoring Incentive Compatibility

If after the time t_0 contract (f_E, s_E) with the entrepreneur the banker elects to trade credit derivatives so that his monitoring IC constraint is violated, the risk neutral protection seller will offer him any credit derivative trade which guarantees him an expected payoff of $p_L s_E + (1 - p_L) f_E$. Amongst all such contracts the highest possible expected utility for the risk averse banker is $u(p_L s_E + (1 - p_L) f_E)$, attained when the payments after project success and failure are the same.

Suppose an entrepreneur wishes at time t_0 to obtain bank certification. He must find the cheapest contract (f, s) on an iso cost line $\mathcal{L}$ which passes through the certification region for which at time t_1 the banker prefers the contract at the intersection of $\mathcal{L}$ and MIC to a sure

[5] Recall from lemma 3 that this is without loss of generality.

payment of $S(f,s) \equiv p_L s + (1-p_L) f$. At any point (f,s) on the iso cost line $C(f,s) = \gamma$,

$$S(f,s) = S\left(\frac{\gamma - p_H s}{1-p_H}, s\right) = p_L s + \frac{1-p_L}{1-p_H}(\gamma - p_H s).$$

The derivative of this expression with respect to s is $-\frac{\Delta p}{1-p_H} < 0$. Given an iso cost line $\mathcal{L}$ the entrepreneur will therefore pick the feasible contract which lies furthest to the left (as shown in figure 2) on that line, so as to render complete hedging as unattractive as possible.

The intuition for the above conclusion is easiest to see when (without loss of generality) financing constraint 2 is imposed. In this case $\lambda = 1 - f$. Progressing to the left along an iso-cost line is therefore equivalent to borrowing as much as possible from the banker and as little as possible from the bond market. The banker's credit derivative then serves two roles: firstly, by facilitating risk-sharing between the banker and the bond market it alters the banker's risk profile; and secondly, it provides the banker with funding at the bond market rate of $\frac{1}{p_H}$ for some of the loan which he has made.

When the banker elects at time t_1 to cover all of his risks under his t_0 loan and to cease monitoring, he imposes a negative externality upon the bond holders who rely upon his monitoring. By forcing the banker to provide more of the initial loan (i.e. by selecting a low f or equivalently a high λ), the entrepreneur forces the banker to internalise as much as possible of the costs of his monitoring cessation, because in this case he will be forced to fund his excess lending at $\frac{1}{p_L}$ rather than at $\frac{1}{p_H}$.

To determine whether the banker will continue to monitor when a credit derivatives market exists, we therefore require an upper bound on s; equivalently, we require a lower bound on f. I will assume that $f \geq 0$: in other words, that the banker will not trade a t_0 contract which may in some states of the world force him to return to the capital markets. This assumption is in line with my rationale for banker risk aversion. An algebraic justification follows from acceptance of financing constraint 2, which implies that $\lambda \leq 1$ and hence that $f = 1 - \lambda + J \geq 0$. When $f = 0$ the banker is lending the whole of the \$1 which the project requires and hence is fully internalising the costs of his cessation of monitoring.

When $f \geq 0$ certification can occur only if there is an iso cost line $\mathcal{L}$ passing through the certification region such that the banker prefers the intersection point (f,s) of $\mathcal{L}$ and MIC to a certain payment of $p_L \bar{s}$, where $(0, \bar{s})$ is the intersection of $\mathcal{L}$ with the line $f = 0$.

The above reasoning is illustrated in figure 3. Suppose that the time t_0 contract between the entrepreneur and the banker lies on the iso cost line $\mathcal{L}$. If the banker elects to continue to monitor then he will use a credit derivative to give himself time t_3 wealth (f,s), where $\mathcal{L}$ intersects MIC. If he elects not to monitor then he can position himself anywhere along the line $p_L s + (1-p_L) f = C$ which passes through the time t_0 contract. Two such lines are illustrated in figure 3. The entrepreneur wishes to select the initial contract which minimises the value of C and hence renders monitoring as attractive as possible. The lines $p_L s + (1-p_L) f = C$ have lower slope than $\mathcal{L}$ and it is immediately apparent from the diagram that the entrepreneur will select $(0, \bar{s})$, which has the lowest feasible value for f on $\mathcal{L}$. In this case a banker who elects not to monitor will choose to be fully insured and so will trade credit derivatives so as to give himself an effective contract C_H, as indicated in the figure.

Since (f,s) lies on MIC, $u(s) - u(f) = \frac{M}{\Delta p}$, and as $\mathcal{L}$ is an iso cost line we know that $\bar{s} = \frac{1}{p_H}(p_H s + (1-p_H) f)$. Let (f^*, s^*) and (f^M, s^M) mark the extremities of the intersection between MIC and the certification region, as in figure 3. Bank certification is achievable in

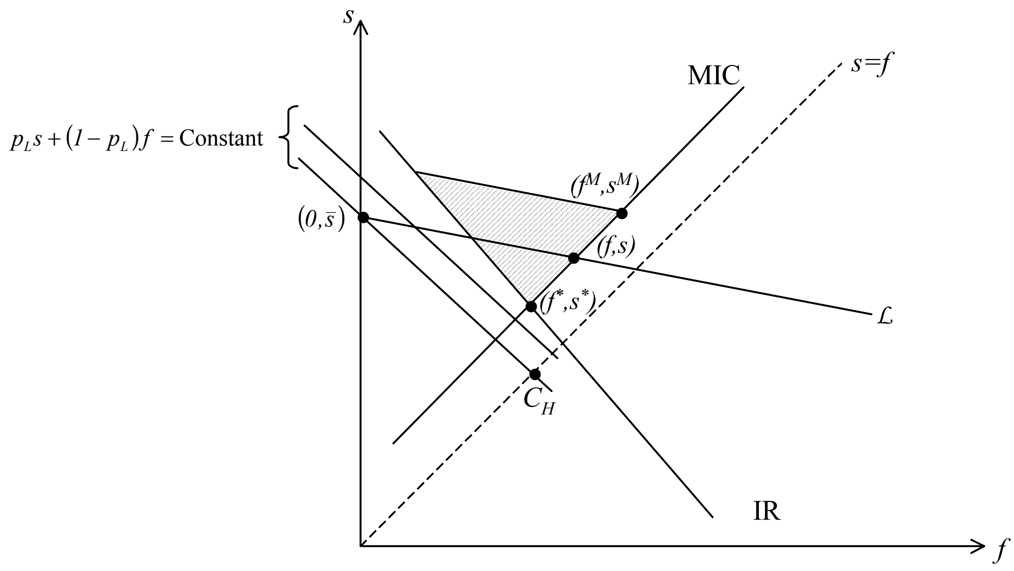

Figure 3: Payoff choices for the banker: $(0, \bar{s})$ is achievable without monitoring, or (f, s) with monitoring.

the presence of an opaque credit derivatives market if and only if there exists $f \in \left[f^*, f^M\right]$ for which

$$\begin{aligned} p_H u(s) + (1 - p_H) u(f) - M - u(p_L \bar{s}) &\geq 0, \\ \text{i.e. } u(f) + p_L \frac{M}{\Delta p} - u\left(\frac{p_L}{p_H}\{p_H s + (1 - p_H) f\}\right) &\geq 0. \end{aligned} \tag{9}$$

When $p_L = p_H$, the last term in this expression reduces to

$$-u\left(p_L u^{-1}\left(u(f) + \frac{M}{\Delta p}\right) + (1 - p_L) f\right) < -u(f) - p_L \frac{M}{\Delta p},$$

where the inequality follows from the strict concavity of $u(.)$, so condition 9 is not satisfied. It follows from the continuity of $u(.)$ that for small enough Δp or for sufficiently concave $u(.)$ (i.e. for sufficiently risk averse bankers), bank certification cannot be achieved when there is an opaque credit derivatives market. To obtain a clearer picture of the relevant factors here, I take second order expansions of the relevant terms to obtain the following:

Proposition 5 *Monitoring equilibria cannot be sustained in the presence of an opaque credit derivatives market if and only if the bank's absolute risk aversion* $R_A(x) \equiv -\frac{u''(x)}{u'(x)}$ *satisfies the following condition for every* (f, s) *on the segment of MIC which lies between* (f^*, s^*) *and* $\left(f^M, s^M\right)$*:*

$$R_A(C(f, s)) > \frac{2p_H \Delta p C(f, s) - 2p_H^2 M / u'(C(f, s))}{\Delta p^2 C^2(f, s) + p_H^3 (1 - p_H)(s - f)^2}. \tag{10}$$

Proof. In the appendix. □

Expression 10 implies that credit derivatives will destroy certification value whenever for every (f, s) on the intersection of MIC and the certification region,

$$M > \frac{\Delta p C(f, s) u'(C(f, s))}{p_H}.$$

The intuition for this is that for a high cost M of monitoring, the incentive payment which the banker receives to induce monitoring must be high. The utility gain which the risk averse banker receives from purchasing complete insurance in the credit derivatives market and ceasing to monitor will be correspondingly high and will outweigh the benefits which he would derive from continued monitoring.

Proposition 5 immediately yields a simpler sufficient condition for the destruction of certification value. Monitoring equilibria are not sustainable in the presence of an opaque credit derivatives market if the bank's relative risk aversion $R_R(x) \equiv -x\frac{u''(x)}{u'(x)}$ satisfies equation 11 along the intersection between MIC and the certification region:

$$R_R(C(f,s)) > \frac{2p_H}{\Delta p}. \tag{11}$$

I conclude this section by discussing time t_0 contracts when monitoring equilibria are sustainable.

Lemma 6 *Monitoring equilibria are not sustainable in the presence of an opaque credit derivatives market when the t_0 contract between the bank and the entrepreneur lies on MIC.*

Proof. Let (f,s) lie on MIC. Then the banker's expected utility from continued monitoring is $u(f) + \frac{p_L M}{\Delta p}$ and from hedging is $u(p_L s + (1-p_L) f)$.

$$u(p_L s + (1-p_L) f) - \left(u(f) + \frac{p_L M}{\Delta p}\right)$$
$$= u\left(p_L u^{-1}\left(u(f) + \frac{M}{\Delta p}\right) + (1-p_L) f\right) - \left(u(f) + \frac{p_L M}{\Delta p}\right),$$

which is greater than 0 because $u(.)$ is concave. □

It follows that if condition 9 is satisfied for some (f,s) on MIC in the certification region, then the time t_0 contract between the entrepreneur and the banker must be such that some credit derivative trade is inevitable at time t_1. This trade ensures that the banker's post project wealth (f,s) lies on MIC.

The conclusions of section III are summarised in proposition 7.

Proposition 7

1. *A credit derivative market can be welfare increasing only if the size of bank loans is bounded below;*
2. *If the banker's absolute risk aversion satisfies condition 10 along the intersection between MIC and the certification region then monitoring equilibria are not sustainable in the presence of an opaque credit derivative market. Intermediate quality entrepreneurs will switch from good to bad projects and will finance themselves with junk bonds;*
3. *If condition 9 is satisfied for some (f,s) in the certification region then the credit derivatives market will not alter project selection decisions. Intermediate quality entrepreneurs will increase the quantity which they borrow from their banks. Time t_0 credit derivatives will restore bank utility to its level without a credit derivatives market.*[6]

[6] This observation relies upon two features of the model. Firstly, it is important that the market for credit derivatives is not perfectly competitive. When the banker treats the price of insurance as fixed, he will over-insure himself (Pauly, 1974) and the credit derivatives market will always destroy monitoring incentives. For

Part (3) of this proposition states that when credit derivative *trades* actually occur they will be welfare increasing, in that they make the bankers better off, increasing their utility levels to those which would have obtained at time t_0 without credit derivatives and possibly still higher if the bank loan size constraint of part (1) exists. Monitoring of these bank loans will not cease and so other agents will not be adversely affected. This is the risk-sharing effect to which practitioners point when justifying trade in credit derivatives.

However, the *existence* of the credit derivatives market will preclude monitoring equilibria for all of the entrepreneurs identified in part (2) of the proposition and hence will reduce social welfare.

IV. Discussion and Conclusion

In this section I review my argument, discuss its implications and finally make a policy recommendation.

The market for credit derivatives is often justified on the basis that it enables risk-sharing. In section III.A I showed that this effect can only be welfare-increasing when there is a lower bound on the size λ of the bank's loan to the entrepreneur. Credit derivatives are otherwise at best welfare neutral.

The difficulty with the risk-sharing rationale for credit derivatives is that it ignores the wider role of bank debt as a bonding device for lower quality credits. I demonstrated in section II that some borrowers will use some bank funding to signal quality of project to the bond market and hence to secure a lower cost of funds. This will ensure that they make a first-best investment decision.

The introduction of credit derivatives affects this process by taking from bond investors the benefits associated with bank monitoring. Compelling the bank to offer the debt which it sells firstly to the bond holders as in a rights issue will not mitigate this effect. When a bank ceases to monitor a wealth *destruction* occurs as its counterparties in the debt sales will not be able to replicate its monitoring effort. Proposition 5 demonstrates that such a wealth destruction is inevitable whenever the lender is sufficiently risk averse. Bond investors will anticipate this destruction and bank debt will lose its certification value. In consequence, entrepreneurs will react to the credit derivatives market by substituting junk bond finance for mixed finance, and reducing the quality of their projects.

Credit derivatives are welfare reducing in my model unless the initial bank loan to the entrepreneur is constrained to be of a given size. To find an explanation for their use we must therefore look beyond the risk-sharing role which I have analysed. Recent papers about exit from venture capital deals by Faure-Grimaud and Gromb (1999) and by Aghion, Bolton and Tirole (2000) suggest that one possible rationale for credit derivatives may be that they allow bankers early exit from investments. The liquidity motive for trade is consistent with my assumption that bankers face a significant cost of outside funds, but in my model liquidity needs and monitoring incentives cannot be simultaneously satisfied. In the above papers the value of the monitor's claim is determined by the market so that exit occurs at a fair price (and

informational reasons however, one can argue that the credit insurance industry is likely to be oligopolistic. Secondly, the assumption that there are two effort levels is important. With a continuum of effort levels, the introduction of a credit derivatives market would result in strictly lower levels of monitoring. In other words, one can argue that the model presented here provides a best case analysis of the welfare effects of credit derivative market opacity.

liquidity therefore enhances incentives). This could be achieved if the banker held an equity-like claim whose liquidation value was dependent upon a time t_1 signal of the entrepreneur's project type, so that exit occurred only after monitoring. Such signals are provided in Aghion, Bolton and Tirole's model by a market intermediated monitoring service which they refer to as a "speculative monitor." In the credit markets, such a service is provided by the ratings agencies, who provide a monitoring service which is paid for by borrowers[7]. This argument is however undermined by the observed nature of bank loans, for which repayment is seldom contingent upon rating agency reports.

If, as this paper suggests, credit derivatives cause disintermediation and a reduction in bank monitoring, can the ratings agencies supply substitute monitoring services? The importance of ratings has increased in recent years, particularly in continental Europe where monitoring has traditionally been provided by banks. This is in line with a reduction in the validity of bank certification, as predicted by my model, and is also supportive of the argument in the preceding paragraph. However, I argue that for three reasons, ratings agencies can provide only a partial substitute for bank monitoring. The guarantee of confidentiality which a bank provides may encourage its clients to reveal more information to it (Bhattacharya and Chiesa, 1995)[8]; if the information revealed through monitoring is too detailed to contract upon then the delegation of decision-making to the lender is optimal (Boot, Greenbaum and Thakor, 1993); banks are better able to perform Pareto-improving renegotiation than dispersed bond-holders (Berlin and Mester, 1992; Gorton and Kahn, 2000).[9] Although disintermediation will result in an increased role for the ratings agencies, a reduction in the quality of projects which intermediate quality borrowers perform can therefore still be anticipated. Some evidence exists which is consistent with my findings: a significant increase in the volume of credit derivatives trades in Europe has coincided with a tenfold increase in junk bond issuance[10].

As discussed in the introduction, *de facto* risk aversion is often cited as a rationale for credit derivatives trade and it has an important role to play in my model. When banks are performing credit derivatives for reasons other than a desire to share risk (for example, to take advantage of inconsistencies in capital adequacy regulations), the problems which I discuss will not arise. In fact Gorton and Pennacchi (1995) demonstrate that in this case, secondary market trades in debt are consistent with a continued certification role. An assumption of bank risk aversion is not however unreasonable. Banks acquire information and hence the ability to monitor as a consequence of long-term relationships. When lending is relationship-driven, banks suffer from concentration of risks and in consequence display risk aversion towards the assets of the counterpart.

My funding model is closely related to that of Holmström and Tirole (1997), in which borrowers are stratified not by the quality of their projects, but by their capital endowment.

[7] See Cantor and Packer (1994) for a survey of the operation of the ratings agencies.

[8] Ratings agencies are distinct from the claimants who must take action when covenants are broken. Although agencies could sign confidentiality agreements with bond issuers, doing so would force bond holders to rely solely upon ratings and would thus reduce the effectiveness of the agency's monitoring in comparison with that of a bank.

[9] Several papers demonstrate that debt renegotiation may be undesirable. Rajan (1992) and von Thadden (1995) examine models in which during renegotiations the bank may expropriate surplus from successful projects by threatening to withhold funds. Bolton and Scharfstein (1996) show that when entrepreneurs wish to commit *ex ante* to liquidate their projects in bad states bond debt is optimal precisely because it cannot be renegotiated. In these circumstances the case against ratings agencies is weakened, but it retains some validity when there is a need for the monitor to be in a position to act upon his information.

[10] 'Europe: A credit market in waiting', *International Financing Review* 1237, 1998.

Holmström and Tirole demonstrate that firms with low levels of capital will rely upon mixed finance to obtain funds. One can envision a simple extension of my model in which firms are further distinguished by their capital allocation. In this case, a sufficiently high capital endowment would insulate a firm from the effects which I have described. A possible consequence of financial disintermediation might therefore be improved capitalisation of the real sector.

Other authors have explained the choice between bank and bond finance without regard to cross-monitoring. I conclude my discussion with a brief consideration of the consequences of an opaque credit derivatives market for some of their models. Diamond (1991) shows how bank monitoring can substitute for firm reputation. My argument suggests that a credit derivatives market might render such a substitution impossible and hence might render reputation acquisition harder. Boot and Thakor (1997) argue that market mechanisms are better for resolving informational problems relating to project quality, while banking relationships are most appropriate when the informational problem relates primarily to moral hazard. I have shown that the latter role for banks is eroded when credit derivative purchase dominates monitoring. Bolton and Freixas (2000) provide a model in which banks are better able to renegotiate loans when borrowers are financially fragile, but are also more expensive, as a consequence of costly capital adequacy requirements. Weaker borrowers will use bank finance. A simple extension of my argument implies that bankers who elect to purchase protection on loans will have no incentive to expend resources on renegotiation in the wake of a default and hence that the credit derivatives market will again lead to reduced levels of bank-originated debt.

The value destruction which I have identified is a consequence of the banker's inability to precommit *ex ante* to retain assets when it is not *ex post* incentive compatible to do so. This is a result of the opacity of the credit derivatives market, just as the entrepreneur's commitment problems are a consequence of information asymmetries which exist between himself and his investors.

An obvious policy suggestion arises. If bankers were required to report all credit derivatives trades then they could write contracts which included punishments for excessive purchases of insurance. They could therefore commit to the provision of monitoring services so that the risk-sharing benefits of the market could be combined with effective mixed financing packages. Market players respond to this suggestion by arguing that disclosure would cause unnecessary damage to borrower relationships and hence might prevent risk-sharing from occurring atall. I have demonstrated that borrowers have a valid claim to be informed of the actions of their bankers and that communication failures are themselves eroding relationships.

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Detailed Proofs for Section II

Recasting the problem in net wealth terms. As discussed in section I, the entrepreneur will write a contract (λ, I, J) with the bank which stipulates the t_0 advance λ and the repayments I and J in case of project success and failure respectively, and will write a corresponding contract (β, P, Q) with the bond market.

His problem is to select these contracts to maximise the following expected payoff:

$$p_H (R + \beta + \lambda - 1 - I - P) + (1 - p_H) (\beta + \lambda - 1 - J - Q), \tag{12}$$

subject to the following constraints:

$$\beta + \lambda \geq 1; \tag{13}$$
$$R + \beta + \lambda - 1 \geq I + P; \tag{14}$$
$$\beta + \lambda - 1 \geq J + Q; \tag{15}$$
$$u (I + 1 - \lambda) - u (J + 1 - \lambda) \geq \frac{M}{\Delta p}; \tag{16}$$
$$pu (I + 1 - \lambda) + (1 - p_H) u (J + 1 - \lambda) - M \geq u (1); \tag{17}$$
$$p_H P + (1 - p_H) Q \geq \beta. \tag{18}$$

Equations 13, 14 and 15 are budget constraints which state respectively that the entrepreneur must have sufficient funds to cover the cost of the investment, and to cover his financing obligations after project success and failure. The entrepreneur will only select mixed financing when it dominates the strictly positive returns which he can obtain from pure bond finance and so at most one of equations 14 and 15 can bind.

Equation 16 is the banker's monitoring incentive compatibility constraint: this must be satisfied if the bank loan is to have certification value. Equations 17 and 18 are the respective participation constraints for the banker and for the bond market: in both cases, the entrepreneur must offer an expected return which is at least as good as that provided by the storage technology.

The solution will use the lowest cost feasible bond contract with the (risk neutral and competitive) bond market. The only constraint on the bond market is equation 18, which will therefore bind. The entrepreneur's objective function becomes

$$p_H (R + \lambda - 1 - I) + (1 - p_H) (\beta + \lambda - 1 - J), \tag{19}$$

in which the terms of the bond contract do not appear.

The risk-neutral entrepreneur can borrow at a fair price as much as he wishes from the competitive risk-neutral bond market. One would therefore expect a solution to the above problem to exist in which the entrepreneur borrowed no more that his start-up costs of \$1. This is true for sufficiently for sufficiently high R, because bond finance does not affect the banker's objective (equation 19) or the monitoring and participation constraints. To see this, suppose that $\left\{ \left(\bar{\lambda}, \bar{I}, \bar{J}\right), \left(\bar{\beta}, \bar{P}, \bar{Q}\right) \right\}$ solves the entrepreneur's optimisation problem. Replace $\left(\bar{\beta}, \bar{P}, \bar{Q}\right)$ by $\left(\beta', P', Q'\right)$, where $\beta' = 1 - \bar{\lambda}$, $Q' = -\bar{J}$ and $P' = \frac{1 - \bar{\lambda} + (1 - p_H)\bar{J}}{p_H}$. The objective function and equations 16 and 17 are unaffected by this change. Conditions 13 and 15 now bind and condition 18 continues to do so. It follows that $\left\{ \left(\bar{\lambda}, \bar{I}, \bar{J}\right), \left(\beta', P', Q'\right) \right\}$ is an optimal contract provided condition 14 is satisfied: in other words, provided

$$R \geq \bar{I} + \frac{1 - \bar{\lambda} + (1 - p_H)\,\bar{J}}{p_H}. \tag{20}$$

This is equivalent to a requirement that R is large enough to cover the costs of optimal financing. It is convenient and does not materially affect the results to assume that this is the case:

ASSUMPTION 8 *The return R on a successful project satisfies equation 20 for some solution $\{(\bar{\lambda}, \bar{I}, \bar{J}), (\bar{\beta}, \bar{P}, \bar{Q})\}$ to the entrepreneur's optimisation problem. Consequentially, we can assume without loss of generality that the budget constraints 13 and 15 both bind.*[11]

With assumption 8 it is sufficient to consider only the banker's net wealth figures f and s, as in section II.

Monitoring and Participation Constraints Bind. Since by assumption 8, equations 13 and 15 both bind, we can re-write the entrepreneur's objective 19: his problem is to select s and f to maximise the cost of funds expression CoF subject to equation 14, and to equations 16 and 17, which appear in section II as MIC and IR. Let μ_b, μ_m and μ_i be the Lagrangian multipliers corresponding to these constraints. The first order conditions for this problem are

$$p_H(1+\mu_b) - (\mu_m + p_H\mu_i)\,u'(s) = 0; \tag{focs}$$

$$(1-p_H)(1+\mu_b) + (\mu_m - (1-p_H)\,\mu_i)\,u'(f) = 0. \tag{focf}$$

I observe above that at most one of equations 14 and 15 can bind. Since by assumption 8, equation 15 binds, equation 14, equivalently, BC, cannot, so μ_b must be zero. It follows immediately that

$$\mu_m = p_H(1-p_H)\left\{\frac{1}{u'(s)} - \frac{1}{u'(f)}\right\} > 0;$$

$$\mu_i = \frac{p_H}{u'(s)} + \frac{1-p_H}{u'(f)} > 0.$$

At the optimum the bank's monitoring and participation constraints therefore bind.

Proof of Proposition 5

Bank certification can be achieved if and only if condition 9 is satisfied for some (f,s) on the segment of MIC which lies between (f^*, s^*) and (f^M, s^M). This condition may be written as

$$\left\{u(f) - u(C(f,s)) + \frac{p_L M}{\Delta p}\right\} + \left\{u(C(f,s)) - u\left(\frac{p_L}{p_H}C(f,s)\right)\right\} \geq 0. \tag{21}$$

[11] Even when this assumption is not true, the shadow price of additional capital is 0. This can be demonstrated by solving the entrepreneur's optimisation problem directly. Rewrite equation 15 as $\lambda - \frac{p_H}{1-p_H}\beta - 1 - J + \frac{p_H}{1-p_H}P \geq 0$. Let μ_1, μ_2 and μ_3 be the respective Lagrangian multipliers for the budget constraints 13, 14 and 15. The first order conditions for β and P are

$$\mu_1 + \mu_2 - \frac{p_H}{1-p_H}\mu_3 = 0; \tag{focβ}$$

$$-\mu_2 + \frac{p_H}{1-p_H}\mu_3 = 0, \tag{foc$P$}$$

which together imply that $\mu_1 = 0$, as required. This is similar to the capital structure irrelevance result of Modigliani and Miller (1958) and follows in this model from the banker's ability to resolve agency problems and from my assumption that all project returns are costlessly verifiable.

Write $u(C(f,s)) - C(u(f), u(s))$ as $p_H [u(C(f,s)) - u(s)] + (1-p_H)[u(C(f,s)) - u(f)]$ and take a Taylor Series expansion to second order to obtain

$$u(C(f,s)) = C(u(s), u(f)) - \frac{1}{2} p_H (1-p_H)(s-f)^2 u''(C(f,s)). \tag{22}$$

A Taylor series expansion to second order of the second curly bracketed term yields

$$u(C(f,s)) - u\left(\frac{p_L}{p_H} C(f,s)\right) = \frac{\Delta p}{p_H} C(f,s) u'(C(f,s)) + \frac{1}{2} \frac{\Delta p^2}{p_H^2} C^2(f,s) u''(C(f,s)). \tag{23}$$

Substituting equations 22 and 23 into equation 21 provides the following alternative condition for certification:

$$\begin{aligned} &- p_H (u(s) - u(f)) + \frac{p_L M}{\Delta p} + \frac{\Delta p C(f,s)}{p_H} u'(C(f,s)) \\ &\qquad + \frac{1}{2}\left(\frac{\Delta p^2}{p_H^2} C^2(f,s) + p_H(1-p_H)(s-f)^2\right) u''(C(f,s)) \geq 0. \end{aligned}$$

Rearranging this yields the following:

$$-\frac{u''(C(f,s))}{u'(C(f,s))} \leq \frac{2 p_H \Delta p C(f,s) - 2 p_H^2 M / u'(C(f,s))}{\Delta p^2 C^2(f,s) + p_H^3 (1-p_H)(s-f)^2}.$$

Taking the contrapositive of this requirement yields proposition 5.