ON BANKERS AND THEIR INCENTIVES

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THE NEW YORK CITY AREA CONFERENCE ON
FINANCIAL INTERMEDIATION

November 18, 2005

**(A conference jointly sponsored by the
Federal Reserve Bank of New York and the Salomon Center)**

**New York University Salomon Center
Leonard N. Stern School of Business**

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August 2005

Abstract

I model the principal-agent problem in a banking context, where the agent must not only be induced to exert costly unverifiable effort but also to exercise fiduciary discretion in lending money on behalf of an employing bank. I show that the spread in wage outcomes necessary to induce fiduciary discretion may be prohibitively expensive; instead, the bank may opt for a second-best solution where excessively risky loans are tolerated. I then show how universal banking, i.e., combining lending with investment banking, affects the basic result. On the one hand, the bank may be able to use the investment banking activities to monitor agent effort. However, where this is impossible, the cost of inducing fiduciary discretion is higher, because the necessary spread in wage outcomes is wider. In response, the bank may either forgo the universal form or adopt it but assume a more risk-seeking posture than would a pure lender. Finally, I consider banking competition and show that the greater the number of banks competing to lend to a group of borrowers, the more expensive it is to induce fiduciary discretion in agent behavior and thus the riskier the banking system becomes.

1 Introduction

There is a vast literature analyzing the principal-agent problem in economics. In corporate finance, this problem takes on an added twist, because the discipline often concerns itself with agents who invest in a fiduciary capacity. Two notable examples are the CEO, who invests shareholders' money in projects that the shareholders are not in a position to evaluate, and the banker, who lends the bank's money to borrowers whose creditworthiness only the banker may know. This essay analyzes this fiduciary principal-agent problem in a banking context and then extends to model to consider banking competition and universal banking, which I define as the combination of lending and investment banking in the same financial intermediary.

The intuition underlying the model is that the principal (who acts in the interests of the bank's owners and depositors) must offer the risk-averse agent (hereinafter, the banker) a contract that

*The author is grateful to Cristian Dezso, Konrad Grabiszewski, Kose John, Anthony Saunders, and Bernard Yeung for helpful comments and suggestions. Errors and omissions are the author's sole responsibility.

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induces the banker both to undertake the costly effort required to generate a lending opportunity and to make an appropriate lending decision given the lending opportunity's risk and reward; I call this latter aspect fiduciary discretion. Since the principal cannot distinguish ex post between the situation where the banker has rejected an opportunity as too risky and one where the banker has simply shirked, there is a fundamental conflict between inducing fiduciary discretion and the desire to limit the spread of possible wage outcomes in the face of the banker's risk aversion. In some cases, the principal may find it more cost effective to let the banker make bad lending decisions a certain portion of the time. Thus, the principal-agent problem not only raises employment costs in banking but also can lead to suboptimal lending.

I next turn to universal banking, which denotes the situation where, in addition to making loans (commercial banking), the banker is also hired to provide another non-lending service (investment banking) to a single client firm at the cost of additional unverifiable effort. It has been argued by practioners and academics that universal banking creates an economy of scope where the amount of effort required to lend and to provide other intermediation services is less than the total effort to do each separately; thus, the argument runs, the universal banking form should be efficient for intermediaries and client firms alike. However, this conclusion may change radically when principal-agent considerations are introduced into the analysis. First, it should be noted that the banker must be paid more to compensate for the extra effort, and the more risk averse the banker is, the greater the increase in compensation must be; this diseconomy of scale in banker compensation can override any economy of scope in effort. Second, the impact of universal banking on the principal's problem depends crucially on the relationship between the loan and non-lending service from the client firm's perspective.

Consider, first, the situation where the two transactions are completely independent, i.e., where the client firm can take only the loan, only the non-lending service, or both. Here, universal banking acts as a monitoring technology, relaxing the constraints of the principal-agent problem and allowing the bank to hire the banker at less cost, even though the banker is required to exert more effort; in other words, the bank pays less for more. To see this intuitively, consider a commercial bank that makes loans and, in addition, offers a low-margin service like cash management.[1] The principal cannot insist that the banker make a certain number of loans each period, because the banker would then make loans to poor credit risks; but the principal can insist that the banker win a certain number of cash management contracts. Since doing so effectively forces the banker to exert some effort by, say, traveling to meet with clients, it may prove relatively less expensive to induce the banker to exert the marginal additional effort required to market the bank's lending function as well.

Suppose, in contrast, that the loan and the non-lending service are mutually contingent. This situation could arise because the client tacitly insists that it will only do investment banking business with intermediaries that extend concomitant credit or, as I model it here, because the loan

[1] Cash management is the centralized processing of a large corporation's intrafirm and extrafirm payables and receivables so that foreign exchange and other transactions costs are minimized and interest income on cash balances is maximized.

and non-lending service are part of a larger, unitary transaction. For example, the client may be undertaking a cash acquisition, which requires both a loan to provide acquisition funds and M&A advisory services, for which a large fee can be charged; if either the loan or advisory service is not provided, the entire transaction will fail. If the banker is not sufficiently penalized for making bad loans in this situation, the banker will be tempted to "pay-to-play," i.e., to misuse the bank's lending capacity to generate fee income and thereby collect a large commission. To prevent this and induce fiduciary discretion under universal banking, the banker will have to face a larger spread in possible wage outcomes than under commercial banking. Because of the banker's risk aversion, such a contract may be prohibitively expensive. If so, there are two possible consequences. On the one hand, it may be more cost effective for the bank either to remain as a separate commercial and investment bank, or, equivalently, to hire two separate agents, one to market loans and the other to market investment banking services. This would reduce or eliminate the economy of scope in universal banking, but may nonetheless explain why, as of this writing, so many large financial intermediaries have adopted the universal banking form but have not combined the origination of loans and investment banking services within a single department. On the other hand, it could still prove profitable for the intermediary to adopt the universal banking form, but only at the cost of allowing the banker to make suboptimally risky loans some of the time; in other words, universal banks may assume a more risk-seeking posture than their commercial banking counterparts.

Finally, I turn to an analysis of competition. There is a long-standing debate in the banking literature about whether competition in the banking industry is good, because it fosters efficiency, or bad, because it gives rise to riskier lending. In what I believe is the first attempt to answer this question using a principal-agent model, I find that the more competitive a given banking market is, the more likely it is that the banker's effort will be wasted, because another bank will win the business for which the focal bank was competing. The consequence is a widening of the spread in wage outcomes required to induce fiduciary discretion, again making such lending behavior more expensive to obtain. In fact, when the level of competition reaches a certain point, at least some banks will find it preferable to let their bankers make bad lending decisions a certain portion of the time. The result is higher systemic risk in the banking system.

The remainder of the paper is organized as follows. Section 2 reviews relevant literature and the regulatory background behind universal banking in the US. Section 3 lays out the basic commercial banking model. Section 4 considers universal banking. Section 5 treats competition. Section 6 discusses extensions and possible future work. Section 7 offers empirical implications and concludes. All but the simplest proofs are in the Appendix.

2 Background & Literature Review

This essay has links with a number of existing lines of inquiry. The question of how to allocate different agents to different tasks, sometimes called "multitasking," is treated at length in a seminal paper by Holmstrom and Milgrom (1991). However, that paper is chiefly concerned with allocating a fixed number of agents to a fixed number of tasks rather than in determining the ideal number of agents in the first place. In addition, that paper does not consider the role of agent as fiduciary investor, a central issue in the present inquiry. This last issue has been treated in a general corporate finance context by John and John (1993) and, specifically with regard to bank regulation, by John, Saunders, and Senbet (2000). The differences between those papers and this one are that the former focus on conflicts between shareholders and debtholders (including depositors) whereas that conflict is assumed away here and the former posit a risk-neutral agent whereas agent risk aversion will be central to the analysis herein.

There is also a rich literature on universal banking, much of which focuses on whether lenders would be reliable underwriters. A central concern behind the Glass-Steagall Act of 1933, which prohibited commercial banks from underwriting securities in the US, was that a lender that had made a loan to a firm would have a conflict of interest as an underwriter of that firm's securities. To wit, if the firm were in financial distress and hired its lending bank as an underwriter, the bank might not wish to disclose the true state of the firm's financial condition to investors, since a successful securities issue would improve the firm's credit standing. A number of papers tackle this question. Work on the pre-Glass-Steagall era in the US includes Korszner and Rajan (1994), Puri (1994), Ang and Richardson (1994), Puri (1996), and Roten and Mullineaux (2002). Papers that consider non-US markets are Konishi (2002) and Hebb and Fraser (2002). Theoretical work in this vein includes Kanatas and Qi (1998), Puri (1999), and Kanatas and Qi (2003). The general result is that market discipline and the desire to maintain a good reputation induce banks to exert their best efforts as underwriters regardless of the potential conflict of interest. In addition, academics argue that allowing lenders to enter the securities business creates economies of scope in financial intermediation (Rajan 1996), the idea being that some of the financial analysis and marketing efforts used to make a loan could also be used to act as an M&A advisor or underwriter for the borrower. In light of these arguments, the Glass-Steagall Act was gradually weakened and eventually superseded by the Gramm-Leach-Bliley Act in 1999.

However, while it may be true that lenders make perfectly good underwriters, underwriters may not make good lenders; in fact, any non-lending fee-generating business may corrupt the lending function by creating an incentive to make risky loans. A notable example of this may have occurred in the late 1980s, when First Boston, a leading securities firm at the time, went into financial difficulty when a number of bridge loans it had made to finance client acquisitions defaulted. It is noteworthy that First Boston earned large advisory fees on the acquisitions that the bridge loans made possible; the loans and investment banking activities were thus mutually contingent parts of larger transactions, precisely the situation where I find that universal banking may lead to greater risk-seeking.

More recently, attention has turned to other kinds of interaction among multiple revenue-generating activities undertaken by the same intermediary. This work concerns, inter alia, conflicts between equity research and securities underwriting (see, for example, Ljungqvist, Marston, and Wihelm (Forthcoming)), the general provision of financial advice (Bolton, Freixas, and Shapiro

(2004)), and, closer to the spirit of this essay, the question of whether intermediaries can and do use loans as a means of winning investment banking mandates (Drucker and Puri (2002), Bharath, Dahiya, Saunders, and Srinivasan (2004), and Yasuda (2005)). These latter papers show that making a loan increases the lender's probability of being chosen to act as an underwriter in a subsequent securities offering.

Finally, there is a long-standing notion in bank regulation, particularly outside the US, that bank competition may exacerbate bank risk-seeking. One argument is the so-called "winner's curse" (Broecker 1990), where the more banks compete to make a given loan, the more likely it is that the winning bank has failed to detect a poor credit risk. Another line of argument analyzes the market for deposits, arguing that competition will drive up deposit interest rates, prompting banks to make riskier loans to generate higher returns (Allen and Gale (2000), Hellmann, Murdock, and Stiglitz (2000)). This line of analysis, however, is susceptible to the criticism that it ignores bankruptcy costs and the direct effect of competition on the rates charged borrowers; both of these factors can reverse the conclusion that competition increases banking risk (Boyd and De Nicoló (2005)). This essay adds to this literature by showing that, in an environment akin to Bertrand competition with an unknown number of competitors (Janssen and Rasmusen (2002)), increasing the number of banks increases the cost of inducing bankers to exercise fiduciary discretion. This effect may predominate in intermedation markets where employee compensation is a large part of banking costs.

3 The Model

3.1 Players

There are three players in the analysis:

3.1.1 Principal

The principal is risk neutral and seeks to maximize the profitability of a bank. One can think of the principal as the bank's CEO, where the CEO's employment contract has eliminated conflicts between shareholders and depositors (John, Saunders, and Senbet (2000)). The principal's tasks are to make an employment offer to a banker and to stipulate the terms on which the banker shall make offers of loans to potential clients.

3.1.2 Banker

The banker is an agent for the principal. The banker is risk averse and seeks to maximize a utility function of the form $u(w) - e$, where $u(w)$ is a strictly increasing and concave function of wages w, and e is a linear cost of effort. (One can also posit a convex cost of effort without changing the results.) It is convenient to define φ as the inverse of u. The banker also has a reservation utility u^*.

3.1.3 Client

The client is risk-neutral firm that has a project requiring an investment of I. One period later, the project yields $I + r$ with probability $1 - d$ and 0 with probability d; d is effectively the default rate, and r is the project's return. With probability γ, $d = \underline{d}$, and with with probability $1 - \gamma$, $d = \overline{d}$, where $\overline{d} > \underline{d}$. Both r and d are bounded below by zero, and d is bounded above by one. For simplicity, default is assumed to result in total loss. γ is common knowledge.

3.2 Sequence of Moves

At $t = 0$, the principal offers the banker a compensation contract to develop a lending opportunity with a client firm to be identified. The contract will specify wage payments to be made by the bank to the banker and establish binding terms for making a loan offer to the client. For form's sake, I posit that the wage payments are made in period $t = 3$, but the precise timing of the payments is not material, as I am not assuming that the principal and banker have different discount rates. The payments can vary according to the state of the world as the principal perceives it; for example, the payment made when a loan is extended and repaid may differ from that when a loan is not extended or is extended but defaults. None of the payments can be negative, and payments are enforceable, i.e., the principal cannot renege.

If the banker rejects the contract offer, the game ends. Otherwise, we proceed to $t = 1$, where the banker selects the level of effort $e \in \left\{0, e^L\right\}$, where e represents both marketing and information production. If $e = 0$, no transaction opportunity will be generated. If $e = e^L$, the banker will generate a lending opportunity with a single client firm and learn d in respect of the client's project. The principal, on the other hand, does not know d and can only tell whether the client is "legitimate," i.e., is drawn from the set of clients with parameters as described above if a loan is made; this assumption implies the banker cannot exert zero effort, yet still try to pass off a miscellaneous "entity" as a proper client.

At $t = 2$, the banker decides whether to offer the client a loan according to the terms set forth in the employment contract. If the banker does offer the loan, the client will accept or reject the offer. If the offer is accepted, the loan is made. At $t = 3$, the loan, if made, is repaid or not, and the principal makes the appropriate contractual wage payment to the banker.

Period	*Moves*
$t = 0$	- Principal offers employment contract to banker, sets terms for making loan offer to client - Banker accepts or rejects offer
$t = 1$	- Banker decides on effort level - If $e = 0$, no client is found - If $e = e^L$, banker finds client and learns d
$t = 2$	- Banker decides whether to offer loan - Client accepts or rejects offer if made
$t = 3$	- Loan, if made, is repaid or defaults - Principal makes contractual payment to banker

3.3 Monopoly Commercial Banking

We will start the analysis by assuming that the bank does not face any competition. There are two kinds of contracts the principal can offer the banker:

- *Risk-seeking contract*: the banker is motivated to exert unobservable effort, but is not expected to exercise fiduciary discretion; in other words, the banker will offer a loan regardless of d.

- *Risk-averse contract*: the banker is not only motivated to exert unobservable effort but also to refrain from offering a loan when $d = \overline{d}$.

We will need the following subscripts for wages paid in different states of the world:

- w_s : the wage paid if the banker does not make a loan or execute any other transaction, "s" standing for "salary"

- w_d : the wage paid if the banker makes a loan and it defaults, "d" standing for "default"

- w_r : the wage paid if the banker makes a loan and it is repaid, "r" standing for the project's "return" when successful

The first step is to characterize the loan offer to be made to the client.

Lemma 1 *If w_r is not an increasing function of interest paid by the client to the bank, the only equilibrium in the loan offer subgame is for the principal (using the banker as proxy) to make an offer to the client of r for the interest on the loan.*

Proof. Given that w_r is not an increasing function of interest paid by the client to the bank, the principal's incentive is to maximize profits. We are then left with one-shot bargaining, where the client can do no better by not accepting the offer. ■

A key element in Lemma 1 is that the principal not have an incentive to lower revenues in an effort to lower the banker's wages. Conversely, the assumption that the banker will bid to maximize bank revenue is implicit in the determination of the set of ideal employment contracts, which I now characterize:

Proposition 2 *The ideal pure commercial banking risk-seeking and risk-averse contracts generate profits of*

$$\begin{aligned}\pi_{rs} &= \left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\left(r-w_r\right)-\left[\gamma\underline{d}+\left(1-\gamma\right)\overline{d}\right]\left(I+w_d\right)\\ \pi_{ra} &= \gamma\left[\left(r-w_r\right)\left(1-\underline{d}\right)-\left(I+w_d\right)\underline{d}\right]-\left(1-\gamma\right)w_s\end{aligned}$$

where the wages are as defined below.
(a) For the risk-seeking contract:

$$w_d = w_r = \varphi\left(u^*+e^L\right)$$

(b) For the risk-averse contract, if $u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\geq 0$*:*

$$\begin{aligned}w_r &= \varphi\left[u^*+\frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\\ w_s &= \varphi\left(u^*\right)\\ w_d &= \varphi\left[u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right],\end{aligned}$$

and if $u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\leq 0$*:*

$$\begin{aligned}w_r &= \varphi\left[\frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\\ w_s &= \varphi\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\\ w_d &= 0\end{aligned}$$

Proof. See appendix. ■

A key element in the analysis of this simple base case, and one to which we will return again and again, is that the banker's risk aversion implies that the principal will try to minimize variation in the wage payments across different states of the world, subject to the incentive constraints being satisfied. For some parameter values, the implication is that the banker will receive expected utility greater than u^*, because the non-negativity constraint on w_d forces the principal to give the banker rents in order to induce the desired behavior. Another implication is that, holding the other terms constant, an increase in $\overline{d}$ will tend to make the risk-averse contract more attractive relative to the risk-seeking contract; this is so because π_{rs} unambiguously decreases, whereas the spread between w_r and w_d narrows while the rest of the terms in the expression for π_{ra} remain unchanged, implying an increase in profitability for the bank. It is also easy to see that the risk-averse contract is sensitive to the spread between $\underline{d}$ and $\overline{d}$, with narrower spreads requiring a larger payment to induce fiduciary discretion. Finally, let us note that, as one might expect, a higher r makes the risk-seeking contract relatively more attractive.

Consider, then, some stylized markets for intermediation. Where the difference between $\underline{d}$ and $\overline{d}$ is relatively small, say in the loan market for investment grade borrowers, one would expect the banker to be paid contingent on bringing in loan business but less so on whether those loans are repaid. Where the difference is large, say in lending to highly-leveraged clients or in investing in venture capital projects (which is isomorphic to lending in this model), one would expect the banker to receive a salary and a relatively larger bonus for transactions that work out successfully in the end; in other words, wages will depend significantly on the ultimate result of investments made.

3.4 Universal Banking

This essay will consider universal banking in its most general form. In addition to a loan project, the client will also be assumed to have the need for another, unspecified non-lending service that, if performed, will generate a surplus of $\theta \geq 0$. This service could be a traditional investment banking service like M&A advisory or the public underwriting of the client's securities as well as other services traditionally performed by commercial banks like cash management or foreign exchange hedging. No subsititution is allowed between the loan and the non-lending service, although it should be easy to see that the greater the degree of substitution, the less attractive universal banking becomes. The banker may provide the non-lending service by exerting $e = e^F$. In addition, the banker may opt to provide both the loan and the non-lending service by exerting $e = e^U$. In accordance with the economy of scope that is argued to exist in universal banking, $e^U \in \left[\max\left(e^L, e^F\right), e^L + e^F\right]$.

The non-lending service can relate to the loan in two distinct ways:

- *Independent Transactions*: where the non-lending service can be executed separately from the loan
- *Dependent Transactions*: where the two transactions must be executed in tandem or not at all

There are two ways to think of the latter case. The first is simply to view the loan and non-lending service as two parts of a single, complex transaction. The second is to view the non-repeated game herein as collapsing the lives of an intermediary and client firm into a single multi-period episode. Since it is reasonable to suppose that the typical large public company will need both investment and commercial banking services over the course of its life and that the investment banking transaction performed today would not have been possible without the loan yesterday, or vice versa, treating the investment banking and lending transactions as mutually dependent may be viewed as a reasonable abstraction of reality in respect of those transactions that are important for firm growth and survival.

We will consider two market structures for each case: (a) one where there is one commercial bank (which makes the loan) and one investment bank (which provides the non-lending service), each with a single banker (or, alternatively, a single intermediary with two bankers who work completely independently), and (b) the other, where one universal bank hires a single agent to perform both functions. In the bargaining subgame where there are separate commercial and investment banks, I will assume that each offers a bid simultaneously for the price of its service and that each receives the full surplus associated with it.[2]

3.4.1 Independent Transactions

We will start by considering the ideal pure investment banking contract. The ideal pure commercial banking contract does not change. We will need the following notation:

- w_θ : the wage paid if the banker provides a service for a fee, "θ" standing for the surplus generated

Proposition 3 *Under independent transactions, the ideal pure investment banking contract generates profits of*

$$\pi_i = \theta - w_\theta,$$

with the following wages:

$$w_\theta = \varphi\left(u^* + e^F\right)$$

Proof. The bank will get profits of $\theta \geq 0$ from each transaction, net of wage costs, since the logic of Lemma 1 is equally valid here. To motivate the banker to exert effort and provide the service, the principal must offer compensation for the banker's effort, as well as meet the reservation utility. This implies the following simple program:

$$\begin{array}{ll} \max_{w_\theta} \pi_i = \theta - w_\theta & \text{s.t.} \\ u\left(w_\theta\right) - e^F \geq u^* & \text{(IR)} \\ w_\theta \geq 0 & \end{array}$$

which has the solution in the text of the Proposition. ■

Now, consider universal banking. First, note that simply using the commercial or investment banking contracts previously derived will not generally work. To see why, suppose, as is natural, that e^U exceeds both e^L and e^F. Then, if the banker is hired according to the terms of the ideal investment banking contract and exerts e^U, the banker does not get the reservation utility. Although this observation is trivial in this context, it does highlight the practical reality that in

[2] For simplicity, I ignore equilibria where the investment (commercial) bank receives more than θ (r) and the commercial (investment) bank receives less than r (θ) in the bargaining subgame; although such outcomes are theoretically possible, the focus of the present inquiry is on banker incentives and not the indeterminacy of multi-party bargaining. Including these equilibria would not qualitatively affect the results but would complicate the exposition.

order to realize the economies of scope in universal banking, the banker must be induced to exert more effort, which should intuitively result in greater cost from the principal's perspective. What is interesting in the independent transactions regime is that this greater effort may sometimes be elicited for lower cost. The reason is that the principal can require by means of the employment contract that the banker at least provide the non-lending service to receive any wages. Thus, not only does the non-lending service offer extra income, it also acts as a signal of effort.

We will need the following additional notation:

- $w_{d\theta}$: the wage paid if the banker provides the non-lending service in addition to making a loan, and the loan defaults
- $w_{r\theta}$: the wage paid if the banker provides the non-lending service in addition to making a loan, and the loan is repaid

Proposition 4 *The ideal universal banking risk-seeking and risk-averse contracts under independent transactions generate profits of*

$$\begin{aligned}\pi_{rs} &= \left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right](r - w_{r\theta}) - \left[\gamma\underline{d} + (1-\gamma)\overline{d}\right](I + w_{d\theta}) + \theta \\ \pi_{ra} &= \gamma\left[(r - w_{r\theta})(1-\underline{d}) - (I + w_{d\theta})\underline{d}\right] - (1-\gamma)w_\theta + \theta\end{aligned}$$

where the wages are as defined below.
(a) For the risk-seeking contract:

$$w_{d\theta} = w_{r\theta} = \varphi\left(u^* + e^U\right)$$

(b) For the risk-averse contract, if $u^* + e^F - \frac{\left(e^U - e^F\right)\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma} \geq 0$*:*

$$\begin{aligned}w_{r\theta} &= \varphi\left[u^* + e^F + \frac{\left(e^U - e^F\right)\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_\theta &= \varphi\left(u^* + e^F\right) \\ w_{d\theta} &= \varphi\left[u^* + e^F - \frac{\left(e^U - e^F\right)\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right],\end{aligned}$$

and if $u^* + e^F - \frac{\left(e^U - e^F\right)\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma} \leq 0$*:*

$$\begin{aligned}w_{r\theta} &= \varphi\left[\frac{e^U - e^F}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_\theta &= \varphi\left[\frac{\left(e^U - e^F\right)\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_{d\theta} &= 0\end{aligned}$$

Proof. See Appendix. ■

The key difference between the foregoing and the pure commercial banking risk-averse contract is that IC 1 (see the Appendix) now includes a deduction for e^F on the right hand side. In other words, the non-lending service now acts as a perfect signal that at least e^F has been exerted, whereas, under pure commercial banking, if the banker does not make a loan, the principal has no way of knowing whether the banker exerted e^L yet still failed to produce a lending opportunity with $d = \underline{d}$ or whether the banker in fact did nothing. The result is that even though e^U is unambiguously larger than both e^L and e^F, the cost to the principal of inducing e^U may be smaller; the principal would be paying less for more! This observation is formalized in the following corollary:

Corollary 5 *Under independent transactions,* $\exists \left\{\underline{d}, \overline{d} : 0 \leq \underline{d} \leq \overline{d} \leq 1\right\}$ *such that, given any set of values for the other parameters, the universal banking risk-averse contract has weakly lower wages and thus weakly higher profits than the pure commercial banking risk-averse contract.*

Proof. It is clear that if $\overline{d} - \underline{d}$ is sufficiently small, the non-negativity constraint will bind for both the universal banking and pure commercial banking risk-averse contracts. There, however, since $e^U - e^F \leq e^L$, the expected wages of the universal banking contract are lower. Lastly, we note that θ is strictly non-negative, so lower wages perforce mean higher profits. ■

The implication is that where discrimination among projects by default rate is important, even a useless non-lending service (i.e., where $\theta = 0$) may improve the bank's profitability. It is noteworthy that commercial banks have long marketed low-margin products like cash management and foreign exchange services to their clients. On the surface, it might seem that the effort and expense devoted to these products would be better expended elsewhere. However, it may be that even though these services require extra effort and yield little direct return, they still provide a form of monitoring; to wit, the fact that a banker has sold such a service to a client proves that the banker exerted at least some effort. Therefore, by requiring that a banker produce a certain number of such transactions, the principal is effectively forcing the banker to exert effort, at least some of which can be applied to marketing the bank's more profitable loans.

And yet, it remains true that even where substantial economies of scope are present, universal banking may still be suboptimal in the independent transactions environment. The reason is that the banker's risk aversion is formally equivalent to a declining marginal value of wages received; this is simply the concavity of the banker's utility function. This means that the principal must pay the banker an increasing amount for each additional increment of effort to be induced. There is thus an equivalency between agent risk aversion, unobservable effort, and a linear cost of effort on the one hand and agent risk neutrality and a convex cost of effort on the other.[3] This can be seen most clearly with the risk-seeking contract. Consider a simple example: let $e^F = e^L = 2$ and $e^U = 3 < e^F + e^L$; let $u(w) = w^{\frac{1}{a}}$, where $a = 2$; and let $u^* = 0$. Then, wages under the pure investment banking contract are 4, as they are under the pure commercial banking risk-seeking contract; however, wages are $9 > 4 + 4$ under the universal banking risk-seeking contract. It is easy to see that parameter values exist for which a monopoly commercial bank and a monopoly investment bank will be more profitable jointly than a monopoly universal bank.

[3] This formal equivalence has been observed by other authors. See Holmstrom and Milgrom (1991), who make reference to work by George Baker.

3.4.2 Dependent Transactions

We will again start by considering the ideal investment banking contract where another commercial banking intermediary is to make the loan, if one is made. Here, the contract depends on whether the other intermediary, acting as commercial bank, is implementing the risk-seeking or risk-averse contract, for with the former, the investment banking transaction can always occur, but with the latter, it will only occur if $d = \underline{d}$.

Proposition 6 *Under dependent transactions, if the related loan is made regardless of the value of d, the ideal pure investment banking contract generates profits of*

$$\pi_i = \theta - w_\theta,$$

with the following wages:

$$w_\theta = \varphi\left(u^* + e^F\right)$$

and if the related loan is only made if $d = \underline{d}$, the contract generates profits of

$$\pi_i = \gamma\left(\theta - w_\theta\right) - \left(1-\gamma\right) w_s,$$

with the following wages:

$$\begin{aligned} w_\theta &= \varphi\left(u^* + \tfrac{e^F}{\gamma}\right) \\ w_s &= \varphi\left(u^*\right) \end{aligned}$$

Proof. The first case is identical to the situation under independent transactions. In contrast, where the commercial bank is only lending when $d = \underline{d}$, the principal of the investment bank must solve the following program:

$$\begin{array}{ll} \max_{w_\theta, w_s} \pi_i = \gamma\left(\theta - w_\theta\right) - \left(1-\gamma\right) w_s & \text{s.t.} \\ \gamma u\left(w_\theta\right) + \left(1-\gamma\right) u\left(w_s\right) - e^F \geq u^* & \text{(IR)} \\ \gamma u\left(w_\theta\right) + \left(1-\gamma\right) u\left(w_s\right) - e^F \geq u\left(w_s\right) & \text{(IC)} \\ w_\theta, w_s \geq 0 & \end{array}$$

It should be clear that $w_\theta \geq w_s$. So, if the IC constraint does not bind, the principal can profitably raise w_s and lower w_θ. It then follows that the most profitable way to satisfy the IR constraint is for it to bind, with

$$\begin{aligned} w_\theta &= \varphi\left(u^* + \tfrac{e^F}{\gamma}\right) \\ w_s &= \varphi\left(u^*\right) \end{aligned}$$

■

The investment banking contract is now subject to some of the same deal risk as the commercial banking risk-averse contract, i.e., the possibility that the transaction cannot close due to poor credit quality.

From the standpoint of a universal bank, the linkage between the loan and non-lending transaction introduces a new complication; namely, if the banker is paid "too much" for the non-lending transaction, the banker will have an incentive to make bad loans to realize these higher wage outcomes. In the simple case where an investment bank "goes universal" by giving its agents lending authority without modifying the employment contract at all, it is easy to see that the banker will always lend regardless of d. Although such behavior by the principal would be irrational in this setting, one wonders how rare it is in practice.

Turning back to the formal analysis, we observe that, in contrast to the independent transactions regime, the principal cannot now use the investment banking transaction as a monitoring device. Rather, the principal must induce the banker to exert the weakly larger effort associated with universal banking, while, for the risk-averse contract, providing a sufficiently large difference between the wages in respect of repaid and defaulted loans to elicit fiduciary discretion.

Proposition 7 *Under dependent transactions, the universal banking risk-seeking and risk-averse contracts generate profits of*

$$\begin{aligned} \pi_{rs} &= \left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\left(r-w_{r\theta}\right)-\left[\gamma\underline{d}+\left(1-\gamma\right)\overline{d}\right]\left(I+w_{d\theta}\right)+\theta \\ \pi_{ra} &= \gamma\left[\left(r-w_{r\theta}\right)\left(1-\underline{d}\right)-\left(I+w_{d\theta}\right)\underline{d}+\theta\right]-\left(1-\gamma\right)w_s \end{aligned}$$

where the wages are as defined below.
(a) For the risk-seeking contract:

$$w_{d\theta} = w_{r\theta} = \varphi\left(u^*+e^U\right)$$

(b) For the risk-averse, if $u^*-\frac{e^U\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\geq 0$*:*

$$\begin{aligned} w_{r\theta} &= \varphi\left[u^*+\frac{e^U\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_s &= \varphi\left(u^*\right) \\ w_{d\theta} &= \varphi\left[u^*-\frac{e^U\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right], \end{aligned}$$

and if $u^*-\frac{e^U\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\leq 0$*:*

$$\begin{aligned} w_{r\theta} &= \varphi\left[\frac{e^U}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_s &= \varphi\left[\frac{e^U\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_{d\theta} &= 0 \end{aligned}$$

Proof. See Appendix. ■

The important point here is that this contract is the same as the straight commercial banking contract, except that the level of effort required is higher. This suggests that wages must be higher under universal banking with dependent transactions than under either pure commercial or pure investment banking. Indeed, it can be so proven.

Proposition 8 *Under dependent transactions, the expected wages under the universal banking risk-averse contract are higher than under the pure investment banking and commercial banking risk-averse contracts.*

Proof. See Appendix. ■

The implication is that even if $e^U = e^F = \max\left(e^F, e^L\right)$, i.e., even if the economy of scope in universal banking is at its maximum, a monopoly commercial bank and a monopoly investment bank may produce more joint profit than a single universal bank. The reason is that the universal banking risk-averse contract requires a greater spread in wages across different states of the world to induce the banker to exercise fiduciary discretion. Since the banker is risk averse, meeting the banker's reservation utility under these circumstances may be prohibitively expensive.

Example 9 *To illustrate, suppose* $u = w^{\frac{1}{a}}$ *and that we have the following parameter values:*

$$\begin{array}{lllllllllllll} u^* & = & 1 & e^F & = & 4 & \gamma & = & 0.5 & r & = & 45 \\ a & = & 1.8 & e^L & = & 1 & \overline{d} & = & 0.75 & I & = & 225 \\ & & & e^U & = & 4 & \underline{d} & = & 0.1 & \theta & = & 70 \end{array}$$

Then, the profitability of the various contracts is[4]

Separate Monopolies	*Universal Banking*
$\pi_i = 8.4$	$\pi_{rs} = -17.9$
$\pi_{rs} = -73.2$	$\pi_{ra} = -1.0$
$\pi_{ra} = 4.6$	

The joint profits of a monopoly commercial bank and a monopoly investment bank are $8.4+4.6 = 13$, *but a universal bank loses money.*

The salient feature of this example is that $e^F \gg e^L$. It is not unreasonable to consider that the amount of due diligence, financial analysis, and marketing involved in, say, a complex M&A transaction would mostly encompass what would be necessary to provide a concomitant loan; and yet, this is precisely the situation where a banker, not suitably dissuaded by contract, would be tempted to use that loan to effect a lucrative investment banking transaction and earn the consequent higher wages, even though that transaction might not be in the interests of the employing financial intermediary. This may well be the most serious potential problem with universal banking; it turns a principal-agent problem that revolves around inducing high effort (investment banking) into one that also requires fiduciary discretion on the part of the agent. Such discretion becomes rapidly more expensive as the underlying effort required increases.

[4] Because , $\pi_{ra} > \pi_{rs}$, π_i is calculated assuming that the commercial bank only lends when $d = \underline{d}$.

From a policy-making perspective, the higher cost of the risk-averse contract under universal banking may not be enough to dissuade an intermediary from adopting the universal form but may be enough to prompt the intermediary to move from the risk-averse to the risk-seeking contract.

Example 10 *Alter example 9 by setting* $\overline{d} = 0.55$ *and* $\theta = 80$*, the new profitability figures are*

Separate Monopolies			*Universal Banking*		
π_i	$=$	13.4	π_{rs}	$=$	19.1
π_{rs}	$=$	-46.2	π_{ra}	$=$	-52.1
π_{ra}	$=$	0.7			

The profits of a universal bank using the risk-averse contract are 19.1*, greater than the* $13.4+0.7 = 14.1$*, the joint profits of a monopoly commercial bank and a monopoly investment bank.*

The decrease in $\overline{d}$ has made the risk-seeking contract more profitable relative to the risk-averse contract, whether under universal or pure commercial banking. However, only under universal banking is this effect and the increase in θ enough to shift the lending intermediary to a more risk-seeking posture. In this way, the greater costs of inducing fiduciary discretion and the added temptation to the principal of investment banking revenue in a universal banking environment combine to increase risk in the financial system.

3.5 Competition

In many areas of economics, economists argue that competition improves social welfare, so we are accordingly accustomed to viewing competition as benign. One of the curious aspects of the banking industry, however, at least as concerns the analysis herein, is that competition can promote risk-seeking behavior.

We will now return to pure commercial banking but assume that the banking market in question has M client firms and $P+1$ banks, each competing for business. The banks each employ one banker and neither the bankers nor the banks' respective principals know what the other bankers and principals are doing. As before, each banker will try to develop business with a single client. Now, however, the banker knows that from 1 to P other bankers from different banks may be simultaneously courting the same client. Thus, when the banker submits a bid, the behavior of other potential bidders must be considered. If a bid is rejected, we will assume that the principal cannot tell that a bid was in fact submitted.

It is useful to begin by considering how the ideal employment contracts change when there exists a certain probability that the bank will lose a given lending opportunity to a competitor and the bank cannot capture the full surplus from the loan. Specifically, denote the probability that the bank wins the right to make the loan by q and denote $\lambda \in [0,1]$ as the share of r the bank receives if the loan is repaid. Later, it will prove convenient for q to be a function of λ.

Lemma 11 *When the probability the client accepts the loan offer is q, and the bank receives interest equal to the fraction λ of r, the ideal pure commercial banking risk-seeking and risk-averse contracts generate profits of*

$$\begin{aligned}
\pi_{ndc} &= q\left\{\left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\left(\lambda r-w_r\right)-\left[\gamma\underline{d}+\left(1-\gamma\right)\overline{d}\right]\left(I+w_d\right)\right\}-\left(1-q\right)w_s \\
\pi_{dc} &= \gamma q\left[\left(\lambda r-w_r\right)\left(1-\underline{d}\right)-\left(I+w_d\right)\underline{d}\right]-\left(1-\gamma q\right)w_s
\end{aligned}$$

where the wages are as defined below.
(a) For the risk-seeking contract:

$$\begin{aligned}
w_d = w_r &= \varphi\left(u^*+\frac{e^L}{q}\right) \\
w_s &= \varphi\left(u^*\right)
\end{aligned}$$

(b) For the risk-averse contract, if $u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\geq 0$*:*

$$\begin{aligned}
w_r &= \varphi\left[u^*+\frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q}\right] \\
w_s &= \varphi\left(u^*\right) \\
w_d &= \varphi\left[u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\right],
\end{aligned}$$

and if $u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\leq 0$*:*

$$\begin{aligned}
w_r &= \varphi\left[\frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma q}\right] \\
w_s &= \varphi\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\right] \\
w_d &= 0
\end{aligned}$$

Proof. See Appendix. ■

The important point to note is that the lower q is, the greater the spread in wage outcomes; so, if $q \to 0$, the cost of employing the banker goes to infinity. Now, let us turn to the bidding subgame, starting with the case where every principal is using the risk-seeking contract. I will confine the analysis to symmetric equilibria.

Lemma 12 *Suppose that every principal offers the corresponding banker an acceptable risk-seeking contract. Then, in the bargaining subgame between the principals (using their bankers as proxies) and the clients, there exists a unique symmetric equilibrium, where the players' strategies are:*
Principal: Offer a bid of λ according to a unique[5] *continuous probability distribution $F(\lambda)$ defined*

[5] Modulo null sets.

on the interval $\lambda \in [\underline{\lambda}_{rs}, 1]$ where $\underline{\lambda}_{rs}$ is defined by the equation:

$$\begin{aligned}
& \left(\tfrac{M-1}{M}\right)^P \left\{ \left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right] r - \left[\gamma \underline{d} + \left(1-\gamma\right)\overline{d}\right] I - \varphi\left(u^* + \frac{e^L}{\left(\frac{M-1}{M}\right)^P}\right)\right\} \\
& - \left(1 - \left(\tfrac{M-1}{M}\right)^P\right)\varphi\left(u^*\right) \\
= \quad & \left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right] \underline{\lambda}_{rs} r - \left[\gamma \underline{d} + \left(1-\gamma\right)\overline{d}\right] I - \varphi\left(u^* + e^L\right)
\end{aligned}$$

Client: Accept all offers of $\lambda \leq 1$.

Proof. See Appendix. ■

The Lemma establishes that there is a unique symmetric equilbrium in the bidding subgame, and it is in mixed strategies across a continuous support. The first line in the definition of $\underline{\lambda}_{rs}$ is the profitability of bidding $\lambda = 1$, which is, of course, equal in expectation to the profitability of bidding any value on $[\underline{\lambda}_{rs}, 1]$. It is clear that as $P \to \infty$, profitability decreases and $\underline{\lambda}_{rs} \to 0$, the Bertrand outcome.

A similar result obtains when every principal uses the risk-averse contract, although the expression for the banker's wages will depend on whether the IR binds or not at different bids.

Lemma 13 *Suppose that every principal offers the corresponding banker an acceptable risk-averse contract. Then, in the bargaining subgame between the principals (using their bankers as proxies) and the clients, there exists a unique symmetric equilibrium, where the players' strategies are:*
Principal: Offer a bid of λ according to a unique continuous probability distribution $G(\lambda)$ defined on the interval $\lambda \in [\underline{\lambda}_{ra}, 1]$ where $\underline{\lambda}_{ra}$ is defined by the equation:

$$\begin{aligned}
& \gamma\left(\tfrac{M-1}{M}\right)^P \left[\left(r - \varphi\left[u^* + \frac{e^L \overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma\left(\frac{M-1}{M}\right)^N}\right]\right)\left(1-\underline{d}\right) - \left(I + \varphi\left[u^* - \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma\left(\frac{M-1}{M}\right)^P}\right]\right)\underline{d}\right] \\
& - \left(1 - \gamma\left(\tfrac{M-1}{M}\right)^P\right)\varphi\left(u^*\right)
\end{aligned}$$

or, if the IR does not bind at $\lambda = 1$,

$$\begin{aligned}
& \gamma\left(\tfrac{M-1}{M}\right)^P \left[\left(r - \varphi\left[\frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma\left(\frac{M-1}{M}\right)^P}\right]\right)\left(1-\underline{d}\right) - I\underline{d}\right] \\
& - \left(1 - \gamma\left(\tfrac{M-1}{M}\right)^P\right)\varphi\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma\left(\frac{M-1}{M}\right)^P}\right]
\end{aligned}$$

$$= \quad \gamma\left[\left(\underline{\lambda}_{ra} r - \varphi\left[u^* + \frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\left(1-\underline{d}\right) - \left(I + \varphi\left[u^* - \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\underline{d}\right] - \left(1-\gamma\right)\varphi\left(u^*\right)$$

or, if the IR does not bind at $\lambda = \underline{\lambda}_{ra}$,

$$\gamma\left[\left(\underline{\lambda}_{ra} r - \varphi\left[\frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\left(1-\underline{d}\right) - \left(I + \varphi\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\underline{d}\right]$$

Client: Accept all offers of $\lambda \leq 1$.

Proof. See Appendix. ■

There exists a third possibility, however, where principals randomize across employment contracts. Before characterizing that case, we need the following intermediate step, which characterizes the optimal deviation from the strategies described in Lemmas 12 and 13.

Lemma 14 *Suppose that every principal offers the corresponding banker an acceptable risk-seeking contract and bids as per Lemma 12; then, the most profitable bid for a principal that deviates to the risk-averse contract is* $\lambda = \underline{\lambda}_{rs}$. *Suppose that every principal offers the corresponding banker an acceptable risk-averse contract and bids as per Lemma 13; then, the most profitable bid for a principal that deviates to the risk-seeking contract is* $\lambda = 1$.

Proof. See Appendix. ■

The foregoing Lemma not only helps characterize the equilibrium of the entire game but also demonstrates the conditions necessary for every principal to offer the corresponding banker the same contract. It may be, however, that neither of the two equilibria described in Lemma 12 or 13 obtains. For those parameter values, the following Lemma characterizes the equilibrium in the bargaining subgame:

Lemma 15 *Suppose that (a) if all the principals offer an acceptable risk-seeking contract and bid according to Lemma 12, each principal would have a profitable deviation by offering the risk-averse contract, and that (b) if all the principals offer an acceptable risk-averse contract and bid according to Lemma 13, each principal would have a profitable deviation by offering the risk-seeking contract. Then, in the bargaining subgame between the principals (using their bankers as proxies) and the clients, there exists a unique symmetric equilibrium, where the players' strategies are:*
Principal: With probability α*, offer the risk-averse contract and offer a bid of* λ_{ra} *according to the distribution* $G(\lambda_{ra})$ *defined on the interval* $\lambda_{ra} \in [\underline{\lambda}_{ra}, \overline{\lambda}_{ra}]$ *and with probability* $1-\alpha$*, offer the risk-seeking contract and offer a bid of* λ_{rs} *according to the distribution* $F(\lambda_{rs})$ *defined on the interval* $\lambda_{rs} \in [\underline{\lambda}_{rs} = \overline{\lambda}_{rs}, 1]$.
Client: Accept all offers of $\lambda \leq 1$.

Proof. See Appendix. ■

These Lemmas can now be assembled into a proposition that characterizes the equilibrium for the entire game.

Proposition 16 *The following cases characterize a symmetric subgame perfect equilibrium under competition where all the principals offer acceptable employment contracts with probability* 1*. At least one case is valid for all parameter values. Only one case will be an equilibrium except where there is equality in profitability between the risk-seeking and risk-averse contracts at a bid of* $\lambda = 1$[6]*:*
1. All the principals offer the risk-seeking contract and bid according to Lemma 12 and it is not profitable for a principal to deviate by offering the risk-averse contract and bidding $\underline{\lambda}_{rs}$.

[6] This would be a knife-edge case.

2. All the principals offer the risk-averse contract and bid according to Lemma 13 and it is not profitable for a principal to deviate by offering the risk-seeking contract and bidding $\lambda = 1$.
3. All the principals randomize between the contracts as described in Lemma 15.

Proof. The first statement follows from the Lemmas cited. The second statement follows since Lemma 15 incorporates every scenario where the other two cases do not obtain. The third statement is a consequence of Lemma 14. In other words, wherever it would not be profitable to deviate from the case 2 equilibrium, it must be profitable to deviate from the case 1 equilibrium by bidding $\underline{\lambda}_{rs}$. ■

Corollary 17 *Where the equilibria in Proposition 16 would result in losses, if we let $P^* < P$ be the maximum number of banks that could profitably participate in the market according to the terms of Proposition 16, it is an equilibrium for P^* principals of those banks to do so, while the remaining principals make unacceptable offers.*[7]

There are a number of implications from this analysis. First of all, as case 3 makes clear, even in the absence of bank heterogeneity, there may be heterogeneity in the employment contract used. This makes using employment contracts as a means of typecasting financial intermediaries dubious. Second, intermediaries that use the risk-averse contract will underbid those that do not. The risk-averse employment contract endows the principals with superior information about their clients, allowing the principals to bid lower, i.e., the principals know that loans will only be made to "good" borrowers. From another perspective, Lemma 14 shows that principals offering the risk-averse contract face a higher ex ante cost of bidding and losing, and so must bid lower to reduce the probability this will happen, i.e., they cannot "afford" to lose. Regardless of the interpretation, however, the fact that some principals do this does not mean that the risk-averse contract is "better" for the client firms, because the viability of the strategy is contingent on enough other financial intermediaries using the risk-seeking contract. If "too many" principals used the risk-averse contract under this scenario, a principal would have a profitable deviation. Third, as competition increases, i.e., as P increases with M fixed, the probability of being underbid at a given bid of λ increases; this makes the risk-averse contract relatively more expensive and thus lowers the probability that it is used in equilibrium. The implication is that, regardless of the other parameter values, if P is large enough, the equilibrium described by Proposition 16, case 2 where every principal offers the banker the risk-averse contract is not sustainable. The consequence is that competition may induce banks to make riskier loans before the point is reached where some banks withdraw from the market. We can formalize this observation thus:

Proposition 18 *For any given $M, \exists P'$ such that $\forall P > P'$, it is more profitable for the principal to offer the banker the risk-seeking contract and bid $\lambda = 1$ in the bargaining subgame than to offer the risk-averse contract, and the equilibrium with all the principals offering the risk-averse contract is not feasible.*

[7] There is also an equilibrium where the principals randomize over the decision to make an acceptable offer (i.e. enter the market), but we will not develop that equilibrium here.

Proof. The last statement of the proposition follows immediately from the first statement. To prove the first statement, refer to the proof of Lemma 14 where we compare the change in profitability of the risk-seeking and risk-averse contracts as q increases. It is obvious from inspection that regardless of whether the IR constraint binds or does not bind under the risk-averse contract, if q is sufficiently close to 0, the expected wages paid under the risk-averse contract can be made to exceed those paid under the risk-seeking contract by any finite amount. Since the other discrepancies between the profitability of the two contracts are finitely bounded, the proof is completed by observing that $q \longrightarrow 0$ as $P \longrightarrow \infty$. ■

The proposition also suggests that where there is a banking "boom" in the sense that the number of banks interested in making loans to a given sector of the economy increases, credit screening efforts will decline. The risk-seeking contract can be thus interpreted as "lending with the herd." Similar herding into the Internet sector also seemed to characterize much venture capital investing during the late 1990s; as noted, the model is equally applicable to venture capitalists that invest the money of others rather than their own.

4 Extensions & Future Work

4.1 Interdependence of Investment & Commercial Banking

Since the model on universal banking produces very different conclusions depending on whether the non-lending service and loan are mutually contingent or not, one might seek to combine the two cases into a single model, where each case would arise with a certain probability. A related extension would be to posit that only a subset of the clients need both a non-lending service and a loan, with the balance just needing one or the other. The principal's problem is an order of magnitude more complex under these contracting environments, because the number of possible states of the world is substantially larger. For example, the principal might seek to induce the banker to be risk-seeking whenever the client does need a non-lending service and risk-averse otherwise. There are over a dozen permutations. It would be interesting to see whether the more complex contracting environment yielded deeper insights into the ideal employment contract under various market conditions. On the other hand, this would come at the cost of a substantial loss in tractability and clarity, and the basic conclusions derived herein would not change; namely, where the non-lending service is needed with a high degree of probability and transactions are independent, universal banking can reduce the cost of solving the principal's problem even though the banker undertakes more effort, and where transactions are dependent, inducing prudent lending behavior may be prohibitively expensive under universal banking.

4.2 Deposit Insurance

It has been argued before that deposit insurance and other forms of bank investor protection distort the incentives of bank shareholders and executives, encouraging risk-seeking beyond the socially optimal level through the phenomenon of "risk-shifting." It is easy to extend the framework of the model herein to verify these effects.

Let us assume that the bank's capital is effectively segregated between equity, which notably includes profit and loss, and the remainder, which provides the funds for loan principal I. This assumption spares us from accounting for the increase in the bank's capital from income (r) on each loan repaid. Let us further assume that the bank operates simultaneously in N separate identical markets, hiring a different banker for each, and that only the first $\widetilde{N} \leq N$ defaults result in a loss of I each, because defaults in excess of this number will trigger some form of public reimbursement of investor losses. This is how deposit insurance and other bank bailouts typically work; small losses are borne by the bank, but losses above a certain level induce an injection of public funds, which are often used to give a partial reimbursement to depositors and other creditors.

To start, observe that a bank will not adopt different employment contracts across markets.

Proposition 19 *With deposit insurance, the principal of a monopoly lending bank, whether commercial or universal, will offer bankers the same employment contract in all markets. The expected benefit to the bank (or its investors) from deposit insurance is, for the risk-seeking and risk-averse contracts respectively,*

$$I \sum_{i=\widetilde{N}+1}^{N} \left[\left(i - \widetilde{N}\right) \binom{N}{i} \left(\gamma \underline{d} + (1-\gamma)\overline{d}\right)^{i} \left(1 - \gamma \underline{d} - (1-\gamma)\overline{d}\right)^{N-i} \right]$$

and

$$I \textstyle\sum_{i=\widetilde{N}+1}^{N} \left[\left(i - \widetilde{N}\right) \binom{N}{i} \left(\gamma \underline{d}\right)^{i} \left(1 - \gamma \underline{d}\right)^{N-i} \right]$$

Proof. It should be clear that the expected benefit from deposit insurance increases with the number of loans made. Likewise, the relative value of the risk-seeking contract vis-à-vis the risk-averse contract increases with the number of loans made, since the risk-seeking contract is more likely to give rise to a defaulted loan and thus a reimbursement. Suppose, then, that the principal offers the bankers the risk-seeking contract in every market. If the principal could profitably deviate by offering the risk-averse contract in one market, it would remain profitable to so deviate again, and so on, until the principal were offering the risk-averse contract everywhere. In a similar fashion, if the principal has a converse deviation from offering the risk-averse contract across all markets, the principal will do better still to switch every contract to the risk-seeking contract.

For the second statement of the proposition, note that the stochastic number of defaults is described by the binomial distribution. The two equations with the summation signs are the expected value of the principal on loans in respect of which both (a) a default occurs and (b) the bank receives a reimbursement of principal lost. ■

Example 20 *If we return to the parameter values from Example 9 and let $N = 30$ and $\widetilde{N} = 8$,* *then the implicit subsidies on a per market (banker) basis are*

$$\begin{array}{lcl} \frac{I}{N}\sum_{i=\widetilde{N}+1}^{N}\left[\left(i-\widetilde{N}\right)\binom{N}{i}\left(\gamma\underline{d}+(1-\gamma)\,\overline{d}\right)^{i}\left(1-\gamma\underline{d}-(1-\gamma)\,\overline{d}\right)^{N-i}\right] & = & 35.9 \\ \frac{I}{N}\sum_{i=\widetilde{N}+1}^{N}\left[\left(i-\widetilde{N}\right)\binom{N}{i}\left(\gamma\underline{d}\right)^{i}\left(1-\gamma\underline{d}\right)^{N-i}\right] & \approx & 0 \end{array}$$

and the new profitability figures are

Separate Monopolies			*Universal Banking*		
π_i	$=$	8.4	π_{rs}	$=$	18.0
π_{rs}	$=$	-37.3	π_{ra}	$=$	-1.0
π_{ra}	$=$	4.6			

The profitability of the risk-averse contract only changes marginally (after the first decimal place). In contrast, the profitability of the risk-seeking contract has substantially increased, but only under universal banking is the change enough to induce the principal to move to the risk-seeking contract. The additional incentive to make risky loans to which universal banking gives rise accounts for the difference. Note that the problem persists where a single universal bank hires two agents, one for the non-lending function and the other to make loans. Such a universal bank would in this case earn 14.5*, with* 51.9 *coming from the non-lending service and* -37.3 *coming from the risk-seeking lending contract after the implicit subsidy of deposit insurance. (The increase in profitability of the investment banking contract arises because* θ *is earned more often and the wage contract is riskless and thus less expensive.) Although this is not quite what the bank would earn with one banker, it is still enough to induce a move to the risk-seeking contract.*

4.3 Competitive Universal Banking

It is natural to ask how competition would affect universal banking. One issue is whether, in this context, all banks would adopt the same organizational form; another question is whether it would be a profitable for the principal of a universal bank to require that a client purchase both intermedation services or none at all. Although these questions are beyond the scope of the present analysis, the model does allow us to observe that, under dependent transactions, the effects of universal banking and competition will combine to shrink still more the subset of the parameter space where it is an equilibrium for all the principals to offer the risk-averse contract. In other words, there exist parameter values for which neither competition at a given intensity under pure commercial banking nor universal banking under monopoly ($P = 0$) would present enough of an inducement for some or all of the intermediaries to make loans when $d = \overline{d}$; and yet, competition and universal banking together would have this effect. This suggests that it may be unwise to rely solely on economic Darwinism to resolve the question of organizational form in financial intermediation.

4.4 Richer Contracting Environment

It would be straightforward to expand the model to include a number of parameters, including exogenous monitoring technologies, substitutability between lending and the non-lending service (as if the latter represented a public capital-raising activity), and collateral. The effects of these parameters is sufficiently clear, however, that the added insight would not justify the additional complexity.

4.5 Career Concerns

The analysis herein assumed away bankers' career concerns. This means that the worst "punishment" a banker can receive is merely a zero wage. In contrast, the more bankers worry about their reputations, as would occur in a dynamic game for instance, the less likely bankers will be to misuse their employers' capital to generate higher wages. At the same time, however, if there is an active labor market for banking professionals and it is not apparent to potential employers which bankers are responsible for the bad loans their current employers make, reputational concerns may have little impact.

5 Conclusion

The analysis herein has a number of testable implications. First, where a loan is tied to an underlying investment banking transaction, the temptation of earning investment banking revenue and the cost of inducing the banker to exercise fiduciary discretion may make banks less reliable as screeners of credit quality. Therefore, the stylized fact from the banking literature that the granting of a loan provides a quality signal for the borrower may not obtain to the same degree in a universal banking context. In contrast, where there is no link between the non-lending service and the loan, universal banking is a boon for intermediary, client, and society alike. We should therefore observe greater adoption of ancillary services, the less - not more - these services are tied to the investment of bank capital, precisely the opposite of what intuition might otherwise suggest. It is perhaps for this reason that low or even zero-margin products like cash management have remained part of traditional lenders' product portfolios.

From a human resources standpoint, the implication of this analysis is that as large investment banks add lending and venture capital to their product portfolios, compensation contracts for senior bankers should move from being straightforward bonuses contingent only on business as it is brought in to contracts with payment schedules stretching several years into the future, if not directly linked to specific loans and investments, then at least to generally coincide with their tenure. Such contracts will keep bankers "on the hook" for the performance of capital outlays that bankers may not have explicitly authorized but could have at least influenced. In addition, although I have not posited an exogenous monitoring technology in this paper, the analysis does suggest that since using compensation contracts to control banker behavior may become more expensive under universal banking, spending on monitoring could well increase.

The analysis of competition showed that banks whose principals offer the banker the risk-averse contract underbid those that do not. One would therefore expect that banks that devote more resources to credit appraisal and risk management would tend to charge lower rates of interest to clients than those that do not. However, as noted above, we should not infer from this that it would be an equilibrium for every bank to make these expenditures. The analysis also suggests that banking crises will tend to occur not in heavily concentrated, oligopolistic settings, but rather where intermediaries compete intensely for business. It is noteworthy in this connection that the US has historically had a larger number of banks per capita and has also experienced a disproportionate number of banking crises (Gorton and Winton (2002)). Recent crises such as those concerning the Savings and Loan industry and the First Boston bridge loans were also characterized by fairly intense competition among intermediaries.

Finally, on a deeper level, this essay demonstrates that when the principal-agent problem is incorporated into the analysis, the conclusions about what is best for economic agents and social welfare can change dramatically. To wit, we would naturally assume that where universal banking produces economies of scope, universal banking would be desirable from both the intermediaries' and society's perspective; on the other hand, where those economies of scope are not present, universal banking would not be beneficial to anyone. We have seen, however, that universal banking can alter the principal-agent problem in such a way that economies of scope become diseconomies and economies are created where they had not previously existed. Likewise, we tend to assume competition is benign. But where competition alters the principal-agent problem, competition may introduce risk into the financial system. These results have implications for the theory of the firm and industrial policy.

6 Appendix: Proof of Propositions

Proof of Proposition 2: For the risk-seeking contract, we have the following program:

$$\begin{aligned}
&\max_{w_r,w_d} \pi_{rs} = \left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\left(r-w_r\right)-\left[\gamma\underline{d}+\left(1-\gamma\right)\overline{d}\right]\left(I+w_d\right) \quad \text{s.t.}\\
&\left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]u\left(w_r\right)+\left[\gamma\underline{d}+\left(1-\gamma\right)\overline{d}\right]u\left(w_d\right)-e^L\geq u^* \qquad \text{(IR)}\\
&w_r, w_d \geq 0
\end{aligned}$$

Given the concavity of the banker's utility function, it is most cost effective to set w_r equal to w_d, and there is no problem with incentive compatibility in doing so, since the banker is not expected to discriminate among loan opportunities. Thus, the solution is

$$w_d = w_r = \varphi\left(u^*+e^L\right)$$

With the risk-averse contract, the bank must offer the banker compensation for exercising fiduciary discretion. That implies the following program, which notably now includes w_s for those states of the world where the banker elects not to make a loan offer:

$$\begin{array}{ll}
\max_{w_r,w_s,w_d} \pi_{ra} = \gamma \left[(r - w_r)(1-\underline{d}) - (I + w_d)\underline{d} \right] - (1-\gamma) w_s & \text{s.t.} \\
\gamma \left[u(w_r)(1-\underline{d}) + u(w_d)\underline{d} \right] + (1-\gamma) u(w_s) - e^L \geq u^* & \text{(IR)} \\
\gamma \left[u(w_r)(1-\underline{d}) + u(w_d)\underline{d} \right] + (1-\gamma) u(w_s) - e^L \geq u(w_s) & \text{(IC 1)} \\
u(w_r)(1-\underline{d}) + u(w_d)\underline{d} \geq u(w_s) & \text{(IC 2)} \\
u(w_r)\left(1-\overline{d}\right) + u(w_d)\overline{d} \leq u(w_s) & \text{(IC 3)} \\
w_r, w_s, w_d \geq 0 &
\end{array}$$

IC 1 means the banker has no incentive to exert zero effort and collect w_s. IC 2 and IC 3 imply the banker will discriminate among loan opportunities. But IC 1 makes IC 2 redundant. Clearly, $w_r \geq w_s$ and $w_r \geq w_d$. This implies $w_s \geq w_d$ or IC 3 would be violated. Now, if, at a given potential solution, IC 1 is slack, the principal could increase profits by lowering w_r and raising w_s. To see this, first note that the slackness of IC 1 means the principal can in fact lower w_r and raise w_s, by, say, keeping the left hand side of IC 1 constant, without violating any of the other constraints. But, then, the concavity of the banker's utility function implies that the amount the bank saves (in expectation) by lowering w_r must exceed the probability-weighted increase in w_s required to compensate the banker in expected utility. In other words, since the banker receives more in expected utility per dollar spent in expectation on w_s than per dollar so spent on w_r, any contract that moves these payments closer to each other is, ceteris paribus, more cost effective for the bank. Thus, IC 1 must bind. A similar argument implies that if IC 3 is not binding, the bank can lower expected wage payments by increasing w_d and lowering w_r (or w_s). Let us turn to individual rationality; if the IR constraint does not bind, the bank could lower all three payments unless this causes a violation of the non-negativity constraint. Suppose for the moment that the IR constraint does bind. We can now use the IR, IC 1, and IC 3 constraints to solve for the optimal contract. Obviously, $w_s = \varphi(u^*)$. Then, from the IR and IC 3 constraints we have the following system of equations:

$$\begin{array}{rcl}
u(w_r)(1-\underline{d}) + u(w_d)\underline{d} & = & u^* + \frac{e^L}{\gamma} \\
u(w_r)\left(1-\overline{d}\right) + u(w_d)\overline{d} & = & u^*
\end{array}$$

with the solution:

$$\begin{array}{rcl}
w_r & = & \varphi\left[u^* + \frac{e^L \overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma} \right] \\
w_s & = & \varphi(u^*) \\
w_d & = & \varphi\left[u^* - \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma} \right]
\end{array}$$

However, by this formulation, w_d may be negative. If so, we can set w_d to zero and use the fact that IC 1 must still bind to solve for w_r and w_s:

$$\begin{aligned} w_r &= \varphi\left[\frac{e^L}{(\overline{d}-\underline{d})\gamma}\right] \\ w_s &= \varphi\left[\frac{e^L(1-\overline{d})}{(\overline{d}-\underline{d})\gamma}\right] \\ w_d &= 0 \end{aligned}$$

Proof of Proposition 4: For the risk-seeking contract, we have the following program:

$$\begin{aligned} &\max_{w_{r\theta},w_{d\theta}} \pi_{rs} = \left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right](r-w_{r\theta}) - \left[\gamma\underline{d} + (1-\gamma)\overline{d}\right](I+w_{d\theta}) + \theta \quad \text{s.t.} \\ &\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right]u(w_{r\theta}) + \left[\gamma\underline{d} + (1-\gamma)\overline{d}\right]u(w_{d\theta}) - e^U \geq u^* \quad \text{(IR)} \\ &w_{r\theta}, w_{d\theta} \geq 0 \end{aligned}$$

This case is solved the same way as the corresponding commercial banking contract, yielding

$$w_{d\theta} = w_{r\theta} = \varphi\left(u^* + e^U\right)$$

With the risk-averse contract, the principal must again offer the banker compensation for exercising fiduciary discretion, but here the banker cannot earn an income without exerting at least e^F. So, we have the following program:

$$\begin{aligned} &\max_{w_{r\theta},w_\theta,w_{d\theta}} \pi_{ra} = \gamma\left[(r-w_{r\theta})(1-\underline{d}) - (I+w_{d\theta})\underline{d}\right] - (1-\gamma)w_\theta + \theta \quad \text{s.t.} \\ &\gamma\left[u(w_{r\theta})(1-\underline{d}) + u(w_{d\theta})\underline{d}\right] + (1-\gamma)u(w_\theta) - e^U \geq u^* \quad \text{(IR)} \\ &\gamma\left[u(w_{r\theta})(1-\underline{d}) + u(w_{d\theta})\underline{d}\right] + (1-\gamma)u(w_\theta) - e^U \geq u(w_\theta) - e^F \quad \text{(IC 1)} \\ &u(w_{r\theta})(1-\underline{d}) + u(w_{d\theta})\underline{d} \geq u(w_\theta) \quad \text{(IC 2)} \\ &u(w_{r\theta})\left(1-\overline{d}\right) + u(w_{d\theta})\overline{d} \leq u(w_\theta) \quad \text{(IC 3)} \\ &w_{r\theta}, w_\theta, w_{d\theta} \geq 0 \end{aligned}$$

As with the risk-averse commercial banking contract, IC 1 and IC 3 must bind, yielding

$$\begin{aligned} u(w_{r\theta})(1-\underline{d}) + u(w_{d\theta})\underline{d} &= u(w_\theta) + \frac{e^U-e^F}{\gamma} \\ u(w_{r\theta})\left(1-\overline{d}\right) + u(w_{d\theta})\overline{d} &= u(w_\theta) \end{aligned}$$

with the solution:

$$\begin{aligned} w_{r\theta} &= \varphi\left[u^* + e^F + \frac{\left(e^U-e^F\right)\overline{d}}{(\overline{d}-\underline{d})\gamma}\right] \\ w_\theta &= \varphi\left(u^* + e^F\right) \\ w_{d\theta} &= \varphi\left[u^* + e^F - \frac{\left(e^U-e^F\right)\left(1-\overline{d}\right)}{(\overline{d}-\underline{d})\gamma}\right] \end{aligned}$$

Or, if this would make $w_{d\theta}$ negative:

$$\begin{aligned} w_{r\theta} &= \varphi\left[\frac{e^U - e^F}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_{\theta} &= \varphi\left[\frac{\left(e^U - e^F\right)\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right] \\ w_{d\theta} &= 0 \end{aligned}$$

Proof of Proposition 7: The risk-seeking contract here is identical to that under independent transactions. The risk-averse contract requires the solution to the following program:

$$\begin{aligned} &\max_{w_{r\theta},w_s,w_{d\theta}} \pi_{ra} = \gamma\left[\left(r - w_{r\theta}\right)\left(1-\underline{d}\right) - \left(I + w_{d\theta}\right)\underline{d} + \theta\right] - \left(1-\gamma\right)w_s \quad \text{s.t.} \\ &\gamma\left[u\left(w_{r\theta}\right)\left(1-\underline{d}\right) + u\left(w_{d\theta}\right)\underline{d}\right] + \left(1-\gamma\right)w_s^{\frac{1}{a}} - e^U \geq u^* \qquad \text{(IR)} \\ &\gamma\left[u\left(w_{r\theta}\right)\left(1-\underline{d}\right) + u\left(w_{d\theta}\right)\underline{d}\right] + \left(1-\gamma\right)w_s^{\frac{1}{a}} - e^U \geq u\left(w_s\right) \qquad \text{(IC 1)} \\ &u\left(w_{r\theta}\right)\left(1-\underline{d}\right) + u\left(w_{d\theta}\right)\underline{d} \geq u\left(w_s\right) \qquad \text{(IC 2)} \\ &u\left(w_{r\theta}\right)\left(1-\overline{d}\right) + u\left(w_{d\theta}\right)\overline{d} \leq u\left(w_s\right) \qquad \text{(IC 3)} \\ &w_{r\theta}, w_s, w_{d\theta} \geq 0 \end{aligned}$$

It is immediate that this program is substantively the same as that used to determine the corresponding contract under pure commercial banking, with the obvious changes in notation noted.

Proof of Proposition 8: Consider first the commercial banking risk-averse contract. That the proposition is true when the IR constraint does not bind for either the commercial banking or the universal banking risk-averse contract is immediate from the fact that $e^U \geq e^L$. The proposition must also be true when the IR constraint binds for the former but not for the latter, since the solution when the IR constraint binds is dominant from the principal's perspective. Inspection also makes it clear that the IR constraint must bind for the commercial banking risk-averse contract if the constraint binds for the universal banking risk-averse contract. The final step is then to show that the proposition holds when the IR constraint binds for both contracts; this is tantamount to showing that the derivative of expected wages in respect of e^L is positive. Thus, we have:

$$\begin{aligned} E\left[w\right]_{ra} &= \gamma\left\{\varphi\left[u^* + \frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\left(1-\underline{d}\right) + \varphi\left[u^* - \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\underline{d}\right\} + \left(1-\gamma\right)\varphi\left(u^*\right) \\ \frac{\partial E\left[w\right]_{ra}}{\partial e^L} &= \frac{1}{\left(\overline{d}-\underline{d}\right)}\left\{\varphi'\left[u^* + \frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\left(1-\underline{d}\right)\overline{d} - \varphi'\left[u^* - \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\left(1-\overline{d}\right)\underline{d}\right\} \geq 0 \end{aligned}$$

since $\left(1-\underline{d}\right)\overline{d} \geq \left(1-\overline{d}\right)\underline{d}$ and φ' is an increasing function.

For the investment banking contract, if the statement is true when $e^U = e^F$, the statement will obviously remain true when $e^U > e^F$. In addition, if the proposition is true when the IR constraint binds for the universal banking risk-averse contract, the proposition must remain true when the constraint does not bind. So, let us consider expected wages under the universal banking risk-averse contract when the IR constraint binds and $\varphi\left(w\right) \rightarrow w$:

$$E\left[w\right]_{dc}|_{\varphi(w)\rightarrow w} = u^* + \frac{e^U}{\gamma}$$

This clearly reaches its minimum at the limit case of $\gamma \to 1$, where the expected wages for the universal bank equal those paid by the pure investment bank if and only if $e^U = e^F$ and are otherwise larger. Now, if $e^U = e^F$, $\gamma \to 1$, and the loan is made, the wages for the investment bank are a weighted average of the possible wages of the universal banking contract, and if a loan is not made, the wages are the same. But $\varphi(w)$ is strictly convex. The wages under the universal banking risk-averse contract are thus the weighted average of a convex transformation, while the wages under the investment banking contract are a convex transformation of the weighted average. So, by Jensen's inequality, the expected wages under the universal banking contract must be higher than those under the investment banking contract.

Proof of Lemma 11: For the risk-seeking contract, we have the following program:

$$
\begin{array}{ll}
\max_{w_r,w_s,w_d} \pi_{ndc} = q\left\{\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right](\lambda r - w_r) - \left[\gamma \underline{d} + (1-\gamma)\overline{d}\right](I + w_d)\right\} & \\
-(1-q)\, w_s & \text{s.t.} \\
q\left\{\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right]u(w_r) + \left[\gamma \underline{d} + \gamma \overline{d}\right]u(w_d)\right\} + (1-q)\,u(w_s) - e^L \geq u^* & \text{(IR)} \\
q\left\{\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right]u(w_r) + \left[\gamma \underline{d} + \gamma \overline{d}\right]u(w_d)\right\} + (1-q)\,u(w_s) - e^L \geq u(w_s) & \text{(IC)} \\
w_r, w_s, w_d \geq 0 &
\end{array}
$$

Again, it is most cost effective to set w_r equal to w_d, since the banker is not expected to discriminate among loan opportunities. Making this substitution, however, leaves us with a program that is formally equivalent to the investment banking contract under dependent transactions where $d = \underline{d}$. Thus, the solution is

$$
\begin{aligned}
w_d \quad = \quad w_r \quad &= \quad \phi\left(u^* + \tfrac{e^L}{q}\right) \\
w_s \quad &= \quad \phi(u^*)
\end{aligned}
$$

For the risk-averse contract, the new program is:

$$
\begin{array}{ll}
\max_{w_r,w_s,w_d} \pi_{dc} = \gamma q\left[(\lambda r - w_r)(1-\underline{d}) - (I + w_d)\,\underline{d}\right] - (1-\gamma q)\, w_s & \text{s.t.} \\
\gamma q\left[u(w_r)(1-\underline{d}) + u(w_d)\,\underline{d}\right] + (1-\gamma q)\, w_s^{\frac{1}{a}} - e^L \geq u^* & \text{(IR)} \\
\gamma q\left[u(w_r)(1-\underline{d}) + u(w_d)\,\underline{d}\right] + (1-\gamma q)\, w_s^{\frac{1}{a}} - e^L \geq u(w_s) & \text{(IC 1)} \\
u(w_r)(1-\underline{d}) + u(w_d)\,\underline{d} \geq u(w_s) & \text{(IC 2)} \\
u(w_r)\left(1-\overline{d}\right) + u(w_d)\,\overline{d} \leq u(w_s) & \text{(IC 3)} \\
w_r, w_s, w_d \geq 0 &
\end{array}
$$

which is clearly substantively the same as the original pure commercial banking risk-averse contract with γ replaced by γq. Thus, the solution is:

$$
\begin{aligned}
w_r \quad &= \quad \varphi\left[u^* + \tfrac{e^L \overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q}\right] \\
w_s \quad &= \quad \varphi(u^*) \\
w_d \quad &= \quad \varphi\left[u^* - \tfrac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\right]
\end{aligned}
$$

or if w_d is negative under the foregoing:

$$\begin{aligned} w_r &= \varphi\left[\frac{e^L}{(\bar{d}-\underline{d})\gamma q}\right] \\ w_s &= \varphi\left[\frac{e^L\left(1-\bar{d}\right)}{(\bar{d}-\underline{d})\gamma q}\right] \\ w_d &= 0 \end{aligned}$$

Proof of Lemma 12:[8] If every principal has hired a banker according to the same terms, and those terms provide adequate incentive to pursue business with a particular subset of identical clients of cardinality M, the probability that a given banker will target a particular client is simply $1/M$. Therefore, from a given principal's perspective, the probability distribution of the number of additional offers p a given client will receive can be described by the binomial distribution:

$$p \sim \frac{P!}{p!\,(P-p)!}\left(\frac{1}{M}\right)^p\left(\frac{M-1}{M}\right)^{P-p}$$

Now, $\lambda \in [0,1]$, as bids below this range result in losses, and bids above it would be rejected. It is claimed that there can be no pure strategy equilibrium. Suppose in contrast, there were such an equilibrium. If the highest bid therein is $\lambda' > 0$, the bank with the next highest bid could deviate to $\lambda' - \epsilon$ and strictly increase profits. On the other hand, $\lambda' = 0$ cannot be an equilibrium either, because any bank could deviate to a higher bid and earn positive profits where $p = 0$.

Let us show that there can be no mass points in the support of $F(\lambda)$. Suppose instead that there were a mass point at $\lambda' > 0$ for a given bank. Then, there must exist an interval $\left(\lambda' - \epsilon, \lambda'\right]$ where the other banks will not bid, because they can increase their probability of winning by a discrete amount proportionate to the mass point while costing themselves a de minimus amount in lost revenue. But if none of the other principals bid in this interval, the first principal has no reason to bid λ', a contradiction. Nor can there be a mass point at $\lambda' = 0$, since, as argued above, a principal could profitably deviate by transferring the mass to a strictly positive number less than or equal to 1.

We will show that, under symmetry, the support of $F(\lambda)$ must be continuous. Suppose, by way of contradiction, that there were an interval $\left[\lambda', \lambda''\right]$ where none of the principals bid but where the principals bid less than λ' with positive probability. Then, given that there are no mass points in the support of $F(\lambda)$, there must be an $\epsilon > 0$ such that each principal would find it profitable to transfer the probability measure of its bidding function from the interval $\left(\lambda' - \epsilon, \lambda'\right)$ to λ'', a contradiction.

Thus, λ is continuously distributed on some interval $\left[\underline{\lambda}_{rs}, \overline{\lambda}\right]$. We know that $F(\underline{\lambda}) = 0$ and that $F\left(\overline{\lambda}\right) = 1$, implying bidding $\overline{\lambda}$ is dominated by bidding 1 unless $\overline{\lambda} = 1$. Further, expected profit must be equal for every $\lambda \in [\underline{\lambda}_{rs}, 1]$. Since the bank only wins with a bid of 1 if $p = 0$, we can use

[8] The argument is similar to the one presented in Janssen and Rasmussen (2002), but is presented here in full since it will prove useful in subsequent exposition of the model.

Lemma 11 to write

$$\begin{aligned}\pi_{rs}|_{\lambda=1} &= \left(\tfrac{M-1}{M}\right)^P \left\{\left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right] r - \left[\gamma \underline{d} + \left(1-\gamma\right)\overline{d}\right] I - \varphi\left(u^* + \frac{e^L}{\left(\frac{M-1}{M}\right)^P}\right)\right\} \\ &\quad - \left(1-\left(\tfrac{M-1}{M}\right)^P\right)\varphi\left(u^*\right)\end{aligned}$$

We can then solve for $\underline{\lambda}_{rs}$ by setting the foregoing expression equal to:

$$\left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\underline{\lambda}_{rs} r - \left[\gamma \underline{d} + \left(1-\gamma\right)\overline{d}\right] I - \varphi\left(u^* + e^L\right)$$

If we let $q\left(\lambda\right)$ be the probability of having a bid accepted given λ, we have

$$\begin{aligned} q\left(\lambda\right) &\sim \left[\sum_{p=0}^{P}\binom{P}{p}\left(\tfrac{1}{M}\right)^p\left(\tfrac{M-1}{M}\right)^{P-p}\left(1-F\left(\lambda\right)\right)^p\right] \\ &= \left[\left(\tfrac{1}{M}\right)\left(1-F\left(\lambda\right)\right)+\left(\tfrac{M-1}{M}\right)\right]^P \end{aligned}$$

by the binomial theorem, and across the support of λ:

$$\begin{aligned}\pi_{rs}|_{\lambda=1} = \pi_{rs}|_{\lambda} &= q\left(\lambda\right)\left\{\left[\gamma\left(1-\underline{d}\right)+\left(1-\gamma\right)\left(1-\overline{d}\right)\right]\lambda r - \left[\gamma \underline{d} + \left(1-\gamma\right)\overline{d}\right] I - \varphi\left(u^* + \frac{e^L}{q(\lambda)}\right)\right\} \\ &\quad - \left(1-q\left(\lambda\right)\right)\varphi\left(u^*\right) \\ \lambda &= \frac{\frac{\pi_{ndc}|_{\lambda=1}+(1-q(\lambda))\varphi(u^*)}{q(\lambda)} + \left[\gamma\underline{d}+(1-\gamma)\overline{d}\right]I + \varphi\left(u^*+\frac{e^L}{q(\lambda)}\right)}{\left[\gamma(1-\underline{d})+(1-\gamma)\left(1-\overline{d}\right)\right]r}\end{aligned}$$

Note that the RHS of the foregoing expression for λ is decreasing in q.

Now, $F\left(\lambda\right)$ is a continuous function of q which is a continuous function of λ, meaning $F\left(\lambda\right)$ is a continuous function of λ. Moreover, q is decreasing in $F\left(\lambda\right)$, and at $\lambda = \underline{\lambda}, F\left(\lambda\right) = 0$ and at $\lambda = 1, F\left(\lambda\right) = 1$. Thus, $F\left(\lambda\right)$ is well defined and satisfies the properties of a cumulative distribution function.

To complete the proof, observe that the client should always accept the lowest bid lower than 1.

Proof of Lemma 13: The first part of the proof is analogous to that of Lemma 12. Here, however, there are two possible wage schedules. So, we write

$$\begin{aligned}\pi_{ra}|_{\lambda=1} &= \gamma\left(\tfrac{M-1}{M}\right)^P\left[\left(r-\varphi\left[u^*+\frac{e^L\overline{d}}{(\overline{d}-\underline{d})\gamma\left(\frac{M-1}{M}\right)^N}\right]\right)\left(1-\underline{d}\right)-\left(I+\varphi\left[u^*-\frac{e^L\left(1-\overline{d}\right)}{(\overline{d}-\underline{d})\gamma\left(\frac{M-1}{M}\right)^P}\right]\right)\underline{d}\right] \\ &\quad - \left(1-\gamma\left(\tfrac{M-1}{M}\right)^P\right)\varphi\left(u^*\right)\end{aligned}$$

or, as the case may be,

$$\begin{aligned}\pi_{ra}|_{\lambda=1} &= \gamma\left(\tfrac{M-1}{M}\right)^P\left[\left(r-\varphi\left[\frac{e^L}{(\overline{d}-\underline{d})\gamma\left(\frac{M-1}{M}\right)^P}\right]\right)\left(1-\underline{d}\right)-I\underline{d}\right] \\ &\quad - \left(1-\gamma\left(\tfrac{M-1}{M}\right)^P\right)\varphi\left[\frac{e^L\left(1-\overline{d}\right)}{(\overline{d}-\underline{d})\gamma\left(\frac{M-1}{M}\right)^P}\right]\end{aligned}$$

We can then solve for $\underline{\lambda}_{ra}$ by setting the appropriate foregoing expression equal to:

$$\gamma\left[\left(\underline{\lambda}_{dc}r-\varphi\left[u^{*}+\frac{e^{L}\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)(1-\underline{d})-\left(I+\varphi\left[u^{*}-\frac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\underline{d}\right]-(1-\gamma)\,\varphi\left(u^{*}\right)$$

or, as the case may be,

$$\gamma\left[\left(\underline{\lambda}_{dc}r-\varphi\left[\frac{e^{L}}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)(1-\underline{d})-\left(I+\varphi\left[\frac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma}\right]\right)\underline{d}\right]$$

If we again let $q(\lambda)$ be the probability of having a bid accepted given λ, we have

$$q(\lambda) \quad \sim \quad \left[\left(\tfrac{1}{M}\right)(1-G(\lambda))+\left(\tfrac{M-1}{M}\right)\right]^{P}$$

and across the support of λ:

$$\begin{aligned}
\pi_{ra}|_{\lambda=1}=\pi_{ra}|_{\lambda} \quad &= \quad \gamma q(\lambda)\left[\left(\lambda r-\varphi\left[u^{*}+\tfrac{e^{L}\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right)(1-\underline{d})-\left(I+\varphi\left[u^{*}-\tfrac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right)\underline{d}\right] \\
&\quad -(1-\gamma q(\lambda))\,\varphi\left(u^{*}\right) \\
\lambda \quad &= \quad \tfrac{1}{r}\left\{\frac{\tfrac{1}{\gamma q(\lambda)}\left(\pi_{ndc}|_{\lambda=1}+(1-\gamma q(\lambda))\varphi(u^{*})\right)+\left(I+\varphi\left[u^{*}-\tfrac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right)\underline{d}}{(1-\underline{d})}+\varphi\left[u^{*}+\tfrac{e^{L}\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right\}
\end{aligned}$$

or, as the case may be,

$$\lambda \quad = \quad \tfrac{1}{r}\left\{\frac{\tfrac{1}{\gamma q(\lambda)}\left(\pi_{ndc}|_{\lambda=1}+(1-\gamma q(\lambda))\varphi\left[\tfrac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right)+I\underline{d}}{(1-\underline{d})}+\varphi\left[\tfrac{e^{L}\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\right\}$$

Again, the RHS of the foregoing expressions for λ are decreasing in q. To see this, consider the first expression. $\frac{1}{\gamma q(\lambda)}\left(\pi_{ra}|_{\lambda=1}+(1-\gamma q(\lambda))\,\varphi\left(u^{*}\right)\right)$ is clearly decreasing in q. To sign the remaining terms, we can differentiate (ignoring the $\frac{1}{r}$), yielding

$$\frac{e^{L}}{q^{2}\left(\overline{d}-\underline{d}\right)\gamma}\left(\varphi'\left[u^{*}-\tfrac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\tfrac{\underline{d}}{1-\underline{d}}-\varphi'\left[u^{*}+\tfrac{e^{L}\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\overline{d}\right)$$

At $\varphi(w)\rightarrow w$, this expression reduces to

$$\frac{e^{L}}{q^{2}\left(\overline{d}-\underline{d}\right)\gamma(1-\underline{d})}\left[\left(1-\overline{d}\right)\underline{d}-(1-\underline{d})\,\overline{d}\right]<0$$

so, where $\varphi(w)$ is strictly convex, the negative portion receives even greater relative weight. For the second expression, the assertion is clearly true if the part corresponding to w_s is decreasing in q. This part can be written as

$$\varphi\left[\frac{e^{L}\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\frac{\left(\frac{1}{\gamma q(\lambda)}-1\right)}{1-\underline{d}}$$

Differentiating yields

$$\frac{1}{1-\underline{d}}\left\{-\frac{1}{\gamma q(\lambda)^2}\varphi\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]-\left(\frac{1}{\gamma q(\lambda)}-1\right)\varphi'\left[\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)}\right]\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q(\lambda)^2}\right\}<0$$

since $\gamma q(\lambda) \in (0,1)$.

The rest of the proof proceeds as in Lemma 12.

Proof of Lemma 14: For principals using the risk-seeking contract as per Lemma 12, the profitability per transaction executed is increasing in λ, whether $d = \overline{d}$ or $d = \underline{d}$. As λ moves from 1 to $\underline{\lambda}$, $F(\lambda)$ declines (and thus the probability of winning the bid increases) just fast enough to offset the decline in profitability per transaction. Consider, in contrast, the risk-averse contract where the IR constraint binds. If $d = \overline{d}$, the expected profit is simply $-\varphi(u^*)$ regardless of λ, i.e., the expected profit does not change. So, if we can show that when $d = \underline{d}$, the expected profitability of the risk-averse contract declines more slowly than that of the risk-seeking contract, it must be the case that the relative profitability of the risk-averse contract increases as λ declines, or, equivalently, as $q(\lambda)$ increases.

When $d = \underline{d}$, the only difference in profit between the risk-averse and risk-seeking contracts is found in the wages. Thus, when the IR constraint is satisfied under the risk-averse contract, signing $\left(\frac{\partial \pi_{ra}}{\partial q} - \frac{\partial \pi_{rs}}{\partial q}\right)|_{d=\underline{d}}$ is a matter of signing

$$\varphi'\left[u^*+\frac{e^L\overline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q}\right]\frac{e^L\overline{d}(1-\underline{d})}{\left(\overline{d}-\underline{d}\right)\gamma q^2}-\varphi'\left[u^*-\frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}\right]\frac{e^L\left(1-\overline{d}\right)\underline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q^2}-\varphi'\left(u^*+\frac{e^L}{q}\right)\frac{e^L}{q^2}$$

If we let $\varphi(w) \to w$, this reduces to

$$\begin{aligned}\frac{e^L\overline{d}(1-\underline{d})}{\left(\overline{d}-\underline{d}\right)\gamma q^2}-\frac{e^L\left(1-\overline{d}\right)\underline{d}}{\left(\overline{d}-\underline{d}\right)\gamma q^2}-\frac{e^L}{q^2} &= \\ \frac{e^L}{q^2}\left(\frac{1}{\gamma}-1\right) &> 0\end{aligned}$$

and since φ is strictly convex, the positive portion of the expression will receive even greater relative weight.

To complete the argument, we turn to the case where the IR constraint does not bind. Then, the above expression reduces to

$$\varphi'\left[\frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma q}\right]\frac{e^L(1-\underline{d})}{\left(\overline{d}-\underline{d}\right)\gamma q^2}-\varphi'\left(u^*+\frac{e^L}{q}\right)\frac{e^L}{q^2}$$

and, since the IR constraint does not bind,

$$u^*+\frac{e^L}{q} \quad < \quad \frac{e^L\left(1-\overline{d}\right)}{\left(\overline{d}-\underline{d}\right)\gamma q}+\frac{e^L}{q} \quad < \quad \frac{e^L}{\left(\overline{d}-\underline{d}\right)\gamma q}$$

Lastly, we note that, when the IR constraint does not bind, if $d = \overline{d}$, the profitability of the risk-averse contract is increasing in q because of the reduction in w_s.

The same argument in reverse establishes the second statement of the Lemma.

Proof of Lemma 15: First, for the conditions of the Lemma to obtain, the banks must be losing money on the risk-seeking contract when $d = \overline{d}$, for otherwise, the risk-seeking contract is always more profitable. To see this, note that as was shown before, if the IR constraint binds under the risk-averse contract, then even if $\varphi(w) \to w$, the risk-seeking contract has larger expected wages $\left(\left(u^* + \frac{e^L}{\gamma}\right)\right.$ versus $\left.\left(u^* + e^L\right)\right)$. As the expected wages are in effect a weighted average, Jensen's inequality implies that the disparity will only increase under the convex transformation induced by the assumed functional form of $\varphi(w)$. The case where the IR constraint does not bind follows immediately from the fact that the wage scale where the IR constraint does bind is weakly less expensive for the bank.

Second, by the arguments used in Lemma 12, $G(\lambda_{ra})$ must be continuous on $\left[\underline{\lambda}_{ra}, \overline{\lambda}_{ra}\right]$ and $F(\lambda_{rs})$ must be continuous on $[\underline{\lambda}_{rs}, 1]$; likewise, neither distribution has any mass points. Now, the profitability of offering the banker the risk-seeking contract and bidding $\lambda = 1$ can be used to calculate $\underline{\lambda}_{ra}$, as in Lemma 13.

At $\lambda = \underline{\lambda}_{rs}$, the bid will be accepted provided that no other banker submitting a bid to the same client has been hired according to the terms of the risk-averse contract. Let

$$\begin{aligned} Q(\alpha) &= \left[\sum_{p=0}^{P} \binom{P}{p} \left(\frac{1}{M}\right)^p \left(\frac{M-1}{M}\right)^{P-p} (1-\alpha)^p\right] \\ &= \left[\frac{M-\alpha}{M}\right]^P \end{aligned}$$

This expression is decreasing in α. We then have:

$$\begin{aligned} \pi_{rs}|_{\lambda=1} &= Q(\alpha)\left\{\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right]\lambda r - \left[\gamma \underline{d} + (1-\gamma)\overline{d}\right] I - \varphi\left(u^* + \frac{e^L}{Q(\alpha)}\right)\right\} \\ &\quad - (1 - Q(\alpha))\,\varphi(u^*) \\ \underline{\lambda}_{rs} &= \frac{\frac{\pi_{ndc}|_{\lambda=1} + (1-Q(\alpha))u^{*a}}{Q(\alpha)} + \left[\gamma \underline{d} + (1-\gamma)\overline{d}\right] I + \left(u^* + \frac{e^L}{Q(\alpha)}\right)^a}{\left[\gamma(1-\underline{d}) + (1-\gamma)\left(1-\overline{d}\right)\right] r} \end{aligned}$$

Consider the profitability of deviating to the risk-averse contract and bidding $\underline{\lambda}_{rs}$. We have by assumption that at $\alpha = 0 \Rightarrow Q(\alpha) = 1$, such a deviation is profitable. As α increases and therefore Q decreases, $\underline{\lambda}_{rs} \to 1$, and the profitability of the risk-seeking contract remains constant; yet, from the logic of Lemma 14, the relatively profitability of the risk-averse contract must be declining. Therefore, given the continuity of both profit functions in Q, either deviating is still profitable at $\alpha = 1$ or there must be an $\alpha \in (0,1)$ where the profits are equal. But we have by assumption that at $\alpha = 1$, deviating from the risk-averse contract to the risk-seeking contract is profitable with a bid of 1. So, $\exists\ \alpha \in (0,1), \underline{\lambda}_{ndc} \in (\underline{\lambda}_{dc}, 1)$ where the profits of the two employment contracts are equal and bidding below (above) $\underline{\lambda}_{rs}$ is strictly dominated for a principal implementing the risk-seeking (risk-averse) contract.

It can be shown that the distribution functions F and G have the appropriate properties using the same arguments as before, since the support of the two distributions do not overlap. Here, we have

$$\begin{array}{rcl} \lambda_{ra} & \sim & \left[\sum_{p=0}^{P} \binom{P}{p} \left(\frac{1}{M}\right)^{p} \left[1-\alpha+\alpha\left(1-G\left(\lambda_{ra}\right)\right)\right]^{p} \left(\frac{M-1}{M}\right)^{P-p}\right] \\ & = & \left[\left(\frac{1}{M}\right)\left(1-G\left(\lambda_{ra}\right)\right)+\left(\frac{M-1}{M}\right)\right]^{P} \end{array}$$

and

$$\begin{array}{rcl} \lambda_{rs} & \sim & \left[\sum_{p=0}^{P} \binom{P}{p} \left(\frac{1}{M}\right)^{p} \left[\left(1-\alpha\right)\left(1-F\left(\lambda_{rs}\right)\right)\right]^{p} \left(\frac{M-1}{M}\right)^{P-p}\right] \\ & = & \left[\left(\frac{1}{M}\right)\left(1-\alpha\right)\left(1-F\left(\lambda_{rs}\right)\right)+\left(\frac{M-1}{M}\right)\right]^{P} \end{array}$$

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