Financial Intermediation with Risk Aversion*

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Abstract

The paper extends Diamond's (1984) analysis of financial intermediation to allow for risk aversion of the intermediary. As in the case of risk neutrality, the agency costs of external funds provided to an intermediary are relatively small if the intermediary is financing many entrepreneurs with independent returns. Even though the intermediary is adding rather than subdividing risks, the underlying large-numbers argument is *not* invalidated by the presence of risk aversion.

With risk aversion of entrepreneurs as well as the intermediary, financial intermediation provides insurance as well as finance. In contrast to earlier results on optimal intermediation policies under risk neutrality, the paper shows that when an intermediary is financing many entrepreneurs with independent returns, optimal intermediation policies must shift return risks away from risk averse entrepreneurs and impose them on the intermediary or on final investors.

Key Words: Financial Intermediation, Allocation of Risks

Journal of Economic Literature Classification Numbers: D80, G20

1 Introduction

The purpose of this paper is to study the impact of risk aversion on financial intermediation in the agency cost approach to financial relations. Two questions will be addressed: First, what is the impact of risk aversion on the *viability of financial intermediation*? Second, what is the impact of risk aversion on the *risk allocation* in a financial system based on intermediation?

The paper looks at financial intermediation as a relation involving three sets of players, intermediaries, firms and households. Much of the recent literature has tended to focus on *either* the relation between intermediaries and firms *or* the relation between intermediaries and households.[1] In presuming that this is

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[1]See, e.g., Diamond (1991), Fischer (1990), Sharpe (1990), Calomiris and Kahn (1991), Rajan (1992), Hellwig (1994), von Thadden (1992, 1995). In contrast, Besanko and Kanatas (1993) as well as Bolton and Freixas (1998) do consider intermediation as a whole; however, they take for granted that the law of large numbers can be relied upon.

sufficient for the analysis of intermediation, this literature is taking for granted that the issue of viability of financial intermediation has been resolved.

Viability is an issue because intermediation lengthens the chain of transactions and presumably widens the scope for moral hazard. Intermediated finance involves agency costs of having households provide funds to intermediaries as well as agency costs of intermediaries providing funds to firms. The viability of financial intermediation then depends on how the *overall* agency costs of intermediated finance compares to the agency costs of direct finance.[2] Without additional analysis it is usually inadequate to consider intermediary-firm relations or intermediary-household relations in isolation.

The question of viability has been addressed by Diamond (1984) and by Krasa and Villamil (1992). Assuming risk neutrality and using a large-numbers argument, they suggested that the agency costs of having households provide funds to an intermediary may be relatively small if the intermediary in turn provides funds to many entrepreneurs with stochastically independent returns. Lending to many entrepreneurs with independent returns provides the intermediary himself with a relatively riskless return pattern. This enables him to incur a return-independent payment obligation to this own financiers without much of a default risk. The agency cost of his own external finance is then negligible[3] and the assessment of intermediated finance depends solely on the agency costs associated with the intermediary's *lending* operations. The main results of Diamond (1984) or Krasa and Villamil (1992) showed that *if* the intermediary is financing and monitoring sufficiently many independent entrepreneurs, then the efficiency of intermediated finance relative to direct finance depends *only* on how the agency costs associated with the intermediary's lending operations compare to the agency costs of direct finance for the same entrepreneurs. If there is enough diversification across borrowers, a nonzero cost advantage of the intermediary in lending will outweigh the disadvantage that the intermediary's own external finance involves additional agency costs, the large-numbers argument implying that the latter are relatively negligible.

In the analysis of Diamond as well as Krasa and Villamil, the assumption of risk neutrality of the financial intermediary is used to normalize the intermediary's total return by the number of projects he finances. Whereas the intermediary's actual return corresponds to a simple sum of random returns in his dealings with entrepreneurs $i = 1, ..., N$, the law of large numbers is a statement about sums of random variables *normalized* by the number of terms in the sum. If the intermediary is risk neutral, there is no problem about formulating the intermediary's choice over lending policies in terms of normalized

[2] In this paper the question of viability of financial intermediation is addressed solely in terms of relative efficiency. I neglect the question raised by Yanelle (1997) of what this means in terms of strategic interactions in the markets for funds.

[3] This assumes that moral hazard is limited to problems of state verification and effort choice and that there is no concern about risk choices (Hellwig (1998a)). If the intermediary has discretion over the extent of diversification in his lending policy, the well known phenomenon of "excessive risk taking" induced by debt finance may preclude the intermediary's making efficient use of available diversification opportunities; Diamond's large-numbers argument may then be altogether moot (Hellwig (1998b)).

rather than actual sums of returns from different entrepreneurs: As his von Neumann-Morgenstern utility function $u(.)$ is only defined up to a monotone, affine transformation one can always replace it by $u(.)/N$, and if $u(.)$ itself is linear, this poses the problem of choosing a lending policy in terms of normalized rather than actual sums of returns over the different potential borrowers. If the intermediary is risk averse, $u(.)$ is *nonlinear*, this device is not available, and the large-numbers arguments used by Diamond (1984) as well as Krasa and Villamil (1992) cannot be applied.

From the general theory of decisions under uncertainty, it is well known that when risks are added rather than subdivided risk averse agents assessing large compounds of independent random variables may not pay much attention to the law of large numbers. Given the nonlinearities in their utility functions, they may be assigning so much weight to the losses from large negative deviations from the mean or so little weight to the gains from large positive deviations from the mean that considerations of risk affect their choices even in situations in which the law of large number might be expected to come into play (Samuelson (1963)). As Diamond (1984) himself pointed out, this raises the question how robust his result is to the introduction of risk aversion.

The present paper settles this question, showing that the main conclusion about the viability of financial intermediation is valid even when the intermediary is risk averse. The paper relies on arguments used by Nielsen (1985) and Hellwig (1995) to show that *if* a decision maker's risk preferences satisfy certain additional assumptions, the law of large numbers will be relevant for the choice between large sums of independent random variables,and the choice between such sums will be guided by expected values if only the number of summands in the compounds is sufficiently large. It so happens that, in the present context, the additional assumptions of Nielsen (1985) and Hellwig (1995) are not even needed because the contracts used by intermediaries to obtain their own finance already defuse the effects of large negative deviations that were stressed by Samuelson (1963).[4]

Indeed the paper goes a step further and shows that if there are many entrepreneurs with stochastically independent returns, an optimal intermediation policy requires the intermediary to assume approximately all risks of the entrepreneurs and, depending on his own risk preferences, to keep them or to shift them on to final investors (in an incentive-compatible way). This contrasts with the case of risk neutrality in which it is optimal for entrepreneurs to be financed by standard debt contracts, retaining as much of their return risk as is compatible with their consumption being nonnegative (Krasa (1988)). *With risk aversion, optimal intermediation policies provide final borrowers with insurance as well as finance.*

The analysis uses Diamond's (1984) model of financial contracting with intermediation as delegated monitoring. I might have used any other model from

[4] Whereas Diamond (1984) relied on Chebyshev's inequality, the argument here relies on Bernstein's inequality (Rényi (1979), p. 324) providing for exponential convergence in the law of large numbers. Exponential convergence was also used by Krasa and Villamil (1992) in their analysis of intermediation in a costly-state-verification framework.

the literature, and indeed the analysis bears directly on most of the literature's claim to be dealing with intermediation. Strictly speaking, in terms of model mechanics, it is not always clear that a paper on financial intermediation is about intermediation at all. What is labelled as "bank finance of firms", tends to be *exclusive* finance by one financier; this financier is called "bank". For strategic as well as technical reasons, there may be advantages to having exclusivity in finance.[5] However to interpret exclusive finance as "bank finance", one must presume that (i) the provision of exclusive finance to firms requires the intervention of an intermediary, and (ii) the provision of funds from households *to* the intermediary involves no further difficulties. Given the underlying view that *all* financing relations are beset by agency problems, this latter presumption requires some justification.

Such a justification must be based on a variation of Diamond's (1984) argument, with which this paper is concerned. As I have discussed elsewhere (Hellwig (1991)), Diamond's argument can be used quite mechanically to turn any model of exclusive finance into a model of intermediated finance. The present paper shows that one does not even have to consider whether the intermediaries in question might be risk averse.

In the following, Section 2 develops the basic model of incentive contracting. Sections 3 and 4 move on to the analysis of intermediation. Section 3 extends Diamond's result on the viability of intermediated finance to the case of risk aversion, showing that if the intermediary's cost of monitoring any one entrepreneur is less than the agency cost of direct finance and if the number of entrepreneurs with mutually independent project returns is sufficiently large, then the agency cost of intermediated finance is less than that of direct finance; the agency cost of the intermediary's own external finance is relatively negligible. Section 4 moves on to show that an optimal intermediation policy will involve the assumption of *all* return risks by the intermediary who relies on the law of large numbers to provide enough diversification of these risks. The last two sections consider the robustness of the analysis. Section 5 allows for the possibility that agents exhibit risk aversion with respect to default penalties as well as consumption. Section 6 extends the results of the paper to the Krasa-Villamil (1992) model of intermediation based on outcome-contingent monitoring, with households monitoring the intermediary (and bearing the costs) when he defaults as well as the intermediary monitoring entrepreneurs.

[5] Technical effects of exclusivity in the provision of finance arise from economies of scale in monitoring, see, e.g., Diamond (1984), Krasa and Villamil (1992), or von Thadden (1995). Strategic effects concern bargaining power and bargaining costs in renegotiations, see, e.g., Fischer (1990), Sharpe (1990), or Bolton and Freixas (1998). Negative effects of bargaining power from exclusivity are stressed by Rajan (1992) and von Thadden (1992). The main arguments are (p)reviewed in Hellwig (1991).

2 Incentive Contracting with Nonlinear Utility

As in Diamond (1984), a representative entrepreneur has a venture that requires a fixed investment $I > 0$ and bears a random return $\tilde{y}$. The random variable $\tilde{y}$ has a probability distribution G with a density g, which is continuous and strictly positive on the interval $[0, Y]$. The expected return $\bar{y} = \int y \; dG(y)$ of the venture is strictly greater than the cost I, i.e.,

$$\bar{y} > I. \tag{1}$$

The owner/manager of the venture, with own funds $w_E \geq 0$, wants to raise external finance, either because his own funds are too small and he needs additional funds to undertake the investment at all, or because he wants to avoid committing all of his own funds to the venture and he prefers to share the risk of the venture with others.

Outside financiers know the return distribution G, but - in contrast to the entrepreneur - they are unable to observe the realizations of the return random variable $\tilde{y}$. The agency problems caused by this information asymmetry can be reduced by the use of nonpecuniary penalties as a device to discourage misreporting of return realizations. The entrepreneur who has earned a positive return will refrain from claiming that he has not earned anything and therefore cannot pay anything if such a claim induces an appropriate penalty. As in Diamond (1984), the penalties are determined endogenously as part of the finance contract.

A finance contract is represented by a number L indicating the funds provided by outside financiers and by two functions $r(.)$ and $p(.)$ such that for any $z \in [0, Y]$, $r(z)$ is the payment to financiers and $p(z) \geq 0$ is the nonpecuniary penalty the entrepreneur suffers when he reports that his return realization is equal to z. With outside funds L, his own financial contribution to his project is $E = I - L \leq w_E$. Any excess of w_E over E is invested in an alternative asset, which bears a safe return at a gross rate of return equal to one.

Given a finance contract $(L, r(.), p(.))$, the entrepreneur's consumption is $w_E + L - I + y - r(z)$ if the true return realization is y and the reported return realization is z; the corresponding payoff realization is $u(w_E + L - I + y - r(z)) - p(z)$. A contract $(L, r(.), p(.))$ is said to be *feasible* if $w_E + L - I \geq 0$ and

$$w_E + L - I + y - r(y) \geq 0 \tag{2}$$

for all $y \in [0, Y]$, so the entrepreneur's consumption is never negative; it is *incentive compatible* if it is feasible and moreover

$$u_E(w_E + L - I + y - r(y)) - p(y) \geq u_E(w_E + L - I + y - r(z)) - p(z) \tag{3}$$

for all $y \in [0, Y]$ and all $z \in [0, Y]$ such that $w_E + L - I + y \geq r(z)$.

The utility function $u_E(.)$ is assumed to be strictly increasing and strictly concave as well as twice continuously differentiable on $\Re_{++}$; moreover, $u_E(0) =$

$lim_{c \to 0} u_E(c)$, with the usual conventions when $lim_{c \to 0} u_E(c) = -\infty$. Given these assumptions, standard arguments from incentive theory yield:

Proposition 1 *A finance contract* $(L, r(.), p(.))$ *satisfying (2) for all* $y \in [0, Y]$ *is incentive compatible if and only if (i) the function* $r(.)$ *is nondecreasing on* $[0, Y]$ *and (ii) for all* $y \in [0, Y]$,

$$p(y) = p(Y) + \int_y^Y u_E'(w_E + L - I + x - r(x))\, dr(x). \tag{4}$$

A proof of Proposition 1 is given in Hellwig (1998c). The proposition shows that up to a constant of integration, $p(Y)$, the penalty function $p(.)$ is entirely determined by the amount of funds L that are raised and the repayment function $r(.)$. This makes it easy to compute expected payoffs. The entrepreneur's expected payoff from an incentive-compatible contract is equal to:

$$\int_0^Y u_E(w_E + L - I + y - r(y))\, dG(y) - \int_0^Y p(y)\, dG(y). \tag{5}$$

Upon using (4) to substitute for $p(y)$ and integrating the resulting double integral by parts, one finds that this is equal to

$$\begin{aligned} &\int_0^Y u_E(w_E + L - I + y - r(y))\, dG(y) \\ &- \int_0^Y u_E'(w_E + L - I + y - r(y))\, G(y)\, dr(y) - p(Y). \end{aligned} \tag{6}$$

Funds are provided by households. For simplicity, all households are taken to have the same characteristics, an initial wealth $w_H > 0$, and a von Neumann-Morgenstern utility function $u_H(.)$. The utility function $u_H(.)$ is assumed to be strictly increasing and concave as well as twice continuously differentiable on $\Re_{++}$. Direct finance of an entrepreneur through a finance contract $(L, r(.), p(.))$ involves household h providing a share α_h of the loan L and receiving a share α_h of the repayment $r(\tilde{y})$; households are unaffected by the penalty $p(\tilde{y})$. Given that households are identical, there is no loss of generality in assuming that the shares α_H are all the same, i.e., that $\alpha_h = 1/H$ for all h, where H is the overall number of households. If the entrepreneur in question is the only one receiving funds and there is also a safe asset with a rate of return equal to one, the household's expected utility from providing finance through an incentive-compatible contract $(L, r(.), p(.))$ is equal to $E\, u_H(w_H - L/H + r(\tilde{y})/H)$. If the household's alternative is to invest the entire wealth w_H in the safe asset, he will consider the finance contract $(L, r(.), p(.))$ to be *acceptable* if and only if it satisfies the inequality

$$\int_0^Y u_H(w_H - \frac{1}{H}(L - r(y)))\, dG(y) \geq u_H(w_H). \tag{7}$$

An acceptable incentive-compatible finance contract $(L, r(.), p(.))$ is called *optimal* if it maximizes the entrepreneur's expected payoff (6) over the set of all acceptable incentive-compatible contracts.

As discussed in Hellwig (1998c) for the case when households are risk neutral, optimal finance contracts are difficult to characterize. They do not seem to have any significant qualitative properties that are robust to changes in the specification of risk preferences and/or the distribution function G. Formally the problem of choosing an optimal incentive-compatible finance contract can be treated as an optimum-control problem in which the entrepreneur's consumption

$$c(y) := w_E + L - I + y - r(y) \tag{8}$$

is the state variable and the slope of $c(.)$ the control. The problem of maximizing (6) over the set of acceptable incentive-compatible finance contracts $(L, r(.), p(.))$ is equivalent to the problem of choosing a constant $p(Y)$ and a function $c(.)$ so as to maximize

$$\int_0^Y u_E(c(y))\, dG(y) - \int_0^Y u_E'(c(y))\, G(y)\, dr(y) - p(Y) \tag{9}$$

$$= u_E(c(Y)) - \int_0^Y u_E'(c(y))\, G(y)\, dy - p(Y) \tag{10}$$

under the constraints that

$$\int_0^Y u_H(w_H + \frac{1}{H}(w_E + y - I - c(y)))\, dG(y) \geq u_H(w_H), \tag{11}$$

$$c(y) \geq 0, \tag{12}$$

and

$$c(y) - c(z) \leq y - z \tag{13}$$

for all $y \in [0, Y]$ and all $z \in [0, y]$.

Without going into details, I note the following:

- Given condition (1), if H is sufficiently large, the set of acceptable contracts is nonempty, containing in particular the contract generating the consumption pattern $c(.)$ such that $c(y) \equiv w_E$.
- If the set of acceptable contracts is nonempty, an optimal incentive - compatible contract exists. If $u_E''(.)$ is a strictly increasing function, e.g., if the entrepreneur exhibits nonincreasing absolute risk aversion, the optimal contract is unique in the sense that consumption patterns corresponding to different optimal contracts all coincide on $(0, Y]$.
- An optimal incentive-compatible contract satisfies $p(Y) = 0$. The constant of integration in (4) and (10) hurts the entrepreneur without helping his financiers.

- The consumption pattern $c(.)$ under an optimal incentive-compatible contract must satisfy a suitable analogue of Pontrygin's conditions for the given control problem. Specifically, there exist a Lagrange multiplier μ for the constraint (11) and a costate variable $\psi(.)$ such that for any $y \in [0, Y]$,

$$\frac{d\psi}{dy} \leq u_E''(c(y))\; G(y) + \mu\, u_H'(w_H + (w_E + y - I - c(y))/H)\; g(y), \quad \text{with equality if } c(y) > 0, \tag{14}$$

$$\psi(y) \geq 0, \text{ with equality unless in a neighbourhood of } y \tag{15}$$

$$c(.) \text{ is continuously differentiable with } \frac{dc}{dy} = 1,$$

$$\psi(Y) = u_E'(c(Y)) \text{ and } \psi(0) = 0. \tag{16}$$

  If $u_E''(.)$ is a strictly increasing function, these conditions, together with the constraints (11)-(13) are sufficient as well as necessary for $c(.)$ to be maximizing (10) under the given constraints.

Optimal incentive-compatible contracts are difficult to characterize because risk sharing and incentive compatibility considerations interact in intricate ways: Risk sharing considerations suggest that risks should be shifted away from the entrepreneur, e.g., by having the payment $r(y)$ be high when y is high and low when y is low, so that $c(y)$ would be somewhat insulated from variation in y. Such risk shifting though requires nonpecuniary penalties; as indicated by the second term in (6) and (9) the size of these penalties depends on $u_E'(c(y))$, which means that, at the margin, risk shifting may be undesirable and $c(y)$ may be chosen to be *sensitive* to y when $u_E'(c(y))$ is large. The tradeoff between risk sharing effects and penalties may actually give rise to interior solutions with $c(y) > 0$ and $\frac{dc}{dy} < 1$; as indicated by (14) and (15), this entails $u_E''(c(y))\; G(y) + \mu\; u_H'\; g(y) = 0$, showing that optimal consumption patterns will be quite sensitive to the specification of $u_E(.)$, $u_H(.)$, and G.

Fortunately, the analysis of this paper does not have to rely on any detailed knowledge of optimal contracts. Where *direct finance* is concerned, it will be enough to know that optimal incentive-compatible contracts exist, and that, because of the imperfectness of risk sharing and/or the use of nonpecuniary penalties, the certainty equivalents $\hat{w}_E^H$ of these contracts for the entrepreneur are strictly less than and bounded away from the sum of the entrepreneur's own initial wealth and the expected surplus generated by the project,

$$K := w_E + \bar{y} - I. \tag{17}$$

To see this, note that (11) implies

$$\int_0^Y c(y)\; dG(y) \leq K, \tag{18}$$

so for any H, $\hat{w}_E^H$ is less than the certainty equivalent $\hat{w}_E$ of the solution to the problem of maximizing (10) subject to (18), (12), and (13); because of imperfect risk sharing and/or the use of nonpecuniary penalties, $\hat{w}_E$ is certainly less than K. The difference $K - \hat{w}_E$ in turn provides a measure of the *agency cost of direct finance* in an economy with many households ($H \to \infty$) where under symmetric information the entrepreneur would obtain with perfect insurance as well as finance.

Where *indirect finance* is concerned, I shall be interested in the scope for intermediation when intermediaries are financed by optimal incentive-compatible contracts. This scope is certainly no smaller than the scope for intermediation when intermediaries are financed by simpler contracts which are not necessarily optimal. In this spirit, the formal arguments that I use will rely on contracts taking the form of *debt*.

By a *standard debt contract with minimum living allowance* ε I will understand an incentive-compatible contract $(L, r(.), p(.))$ such that for some fixed $\varepsilon \geq 0$ and $\hat{y} \in (0, Y)$, one has

$$r(y) = w_E + L - I + \min(y, \hat{y}) - \varepsilon \tag{19}$$

for all $y \in [0, Y]$. In this contract, the amount $w_E + L - I + \hat{y} - \varepsilon$ represents a return-independent debt service obligation. If the entrepreneur can meet this obligation, he does so and retains the excess of his actual return y over the critical return level $\hat{y}$ as well as the living allowance ε. If he cannot meet his obligation, he defaults and retains just the living allowance ε. For $y < \hat{y}$, incentive compatibility requires that he bear a penalty which is equivalent to the amount of money that he saves by paying $r(y)$ rather than $r(\hat{y})$. Indeed, when $r(.)$ is given by (19), the incentive compatibility condition (4), with $p(Y) = 0$, reduces to

$$p(y) = u_E'(\varepsilon) \; \max(0, \hat{y} - y). \tag{20}$$

The *ex ante* expected payoff of the entrepreneur (6) is then equal to:

$$\int_0^Y u_E(\varepsilon + \max(0, y - \hat{y})) \; dG(y) - u_E'(\varepsilon) \int_0^Y G(y) dy. \tag{21}$$

In Diamond (1984), standard debt contracts with a *zero* living allowance are shown to be optimal when the entrepreneur is risk neutral. For a given return distribution $G(.)$ whose density g is bounded away from zero, this result can be extended to the case where the entrepreneur's risk aversion is everywhere sufficiently low; however, it no longer holds when the entrepreneur's absolute risk aversion is (locally) unbounded, e.g., if $u'(0) = \infty$ (Hellwig (1998c)).

3 Intermediated Finance

To study the scope for intermediated finance, I assume that there are N entrepreneurs of the sort considered so far and $H_N = NM$ households. For simplicity, the characteristics of the entrepreneurs are taken to be all identical *ex ante*. Every entrepreneur has the same initial wealth level $w_E \geq 0$, the same von Neumann-Morgenstern utility function $u_E(.)$, and an investment project with the same investment cost I and the same return distribution $G(.)$. The return random variables $\tilde{y}_1, ..., \tilde{y}_N$ of the different entrepreneurs are assumed to be mutually independent.

In the absence of financial intermediation, each entrepreneur i will receive direct finance through an incentive-compatible contract $(L_i, r_i(.), p_i(.))$ as discussed in the preceding section. Assuming that for $i = 1, 2, ..., N$, these contracts are shared shared evenly between households, any one household with initial wealth w_H and von Neumann-Morgenstern utility function $u_H(.)$ will obtain the expected payoff $Eu_H(w_H + \sum_{j=1}^{N}(r_j(\tilde{y}_j) - L_j))/NM)$, and is willing to accept his share of the contract $(L_i, r_i(.), p_i(.))$ for entrepreneur i if and only if

$$\int u_H(w_H + \frac{1}{NM}\sum_{j=1}^{N}(r_j(y_j) - L_j))\, dG(y_1)...dG(y_N)$$

$$\geq \int u_H(w_H + \frac{1}{NM}\sum_{\substack{j=1 \\ j\neq i}}^{N}(r_j(y_j) - L_j))\, dG(y_1)...dG(y_N). \tag{22}$$

Taking Taylor expansions and using the independence of returns across entrepreneurs, one can rewrite (22) in the form

$$\int_0^Y r_i(y_i)\, dG(y_i) \geq L_i + o(1/NM) \tag{23}$$

where $o(1/NM)$ is a term that goes to zero as NM goes out of bounds. Thus if there are many households providing funds to the entrepreneur, condition (22) is slightly stronger than the requirement that $\int_0^Y r_i(y_i)\, dG(y_i) \geq L_i$, i.e., that the expected debt service covers the opportunity cost of the loan L_i. In view of (8), this in turn is equivalent to condition (18), the condition that the entrepreneur's expected consumption be no greater than $K = w_E + \bar{y} - I$. When the number of households is large, the certainty equivalent of an optimal incentive-compatible direct-finance contract will therefore be approximately equal to, but slightly less than $\hat{w}_E$, the certainty equivalent of a consumption pattern that maximizes (10) subject to (18), (12), and (13). As discussed above, $\hat{w}_E$ is strictly less than K; here as in Section 2, the difference $K - \hat{w}_E > 0$ provides a measure of the agency cost of direct finance when there are many households.

As an alternative to direct finance, I consider the possibility that any one entrepreneur i obtains a loan L_i from an intermediary, whom he promises to repay an amount $\pi_i(\tilde{y}_i) \leq w_E + L_i - I + \tilde{y}_i$ when returns are realized. The intermediary monitors the entrepreneur's returns so incentive compatibility is not an issue in choosing the repayment specification. However, to monitor entrepreneur i, the intermediary must spend A units of money.[6] These resources must be committed at the time of the initial investment, i.e., before the return $\tilde{y}_i$ is actually realized. They comprise the costs of making the information about $\tilde{y}_i$ verifiable to the courts if this should be necessary for contract enforcement.

Given that *ex ante* the entrepreneurs are all alike, there is no loss of generality in assuming that loans and repayment obligations will be the same for all of them. A *lending policy* of the intermediary is then given by a pair $(L, \pi(.))$ such that L is the loan offered to any one entrepreneur and $\pi(.)$ is the repayment function. Given a lending policy $(L, \pi(.))$, the intermediary himself earns the gross return $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$. This is assumed to be unobservable by outside financiers.[7] The intermediary's own financing problem is therefore a special case of the financing problem under asymmetric information that was studied in Section 2, with $\tilde{y}$ replaced by $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$ and the investment I replaced by the intermediary's expenditures $NL + NA$ for finance and for monitoring. A *finance contract for the intermediary* will be a triple $(D,\ r_I(.),\ p_I(.))$ such that D is the total deposit of final investors with the intermediary, $r_I(.)$ is a function indicating the dependence of the intermediary's repayment on his own return $\tilde{z}$, and $p_I(.)$ is a function indicating the nonpecuniary penalties suffered by the intermediary in order to establish incentive compatibility of the contract. The combination of a lending policy $(L, \pi(.))$ and a finance contract $(D,\ r_I(.),\ p_I(.))$ for the intermediary will be referred to as an *intermediation policy.*

An intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ will be called *feasible* if the lending policy $(L, \pi(.))$ satisfies $w + L - I \geq 0$ and

$$w + L - I + y - \pi(y) \geq 0 \tag{24}$$

for all $y \in [0, Y]$, and if moreover the finance contract $(D,\ r_I(.),\ p_I(.))$ of the intermediary is feasible; an intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ is called *incentive compatible* if it is feasible, and moreover the intermediary's finance contract $(D,\ r_I(.),\ p_I(.))$ is incentive-compatible, i.e., if and only if for all z and $\bar{z}$ in the range of the random variable $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$, one has either

$$\begin{aligned} &u_I(w_I + D - NL - NA + z - r_I(z)) - p_I(z) \\ &\geq u_I(w_I + D - NL - NA + z - r_I(\bar{z})) - p_I(\bar{z}) \end{aligned} \tag{25}$$

[6] The assumption that monitoring costs are expended in the form of money rather than effort is not essential for the analysis. Indeed since monitoring costs in the form of money add to the intermediary's financing requirements, this assumption makes it more difficult to establish the viability of intermediation. If monitoring costs were expended in the form of effort, Proposition 2 would be that much easier to establish.

[7] Given the assumption that monitoring provides information about $\tilde{y}_i$ that is verifiable by the courts, this assumption may seem problematic. As in Diamond (1984), the underlying notion here is that w_H is on the order of $1/M$, so on the order of M households are needed to finance one entrepreneur's investment I. If M is a large number, making the result of monitoring $\tilde{y}_i$ verifiable by M investors may be prohibitively costly, much costlier than making it verifiable by just the courts.

or $w_I + D - NL - NA + z < r_I(\bar{z})$; here $u_I(.)$ is the intermediary's von Neumann-Morgenstern utility function and w_I is his own initial wealth.

The utility function $u_I(.)$ is assumed to have the same properties as the entrepreneurs' utility function $u_E(.)$, i.e., it is strictly increasing and strictly concave as well as twice continuously differentiable on $\Re_{++}$; moreover, $u_I(0) = \lim_{c \to 0} u_I(c)$, with the usual conventions when $\lim_{c \to 0} u_I(c) = -\infty$.

Given these assumptions, Proposition 1 implies that an intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ for the intermediary is incentive compatible if and only if the function $r_I(.)$ is nondecreasing and moreover for all z and $\bar{z}$ in the range of the random variable $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$, one has:

$$p_I(z) = p_I(\bar{z}) + \int_z^{\bar{z}} u_I'(w_I + D - NL - NA + x - r_I(x))\, dr_I(x). \tag{26}$$

An incentive-compatible intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ generates the expected payoffs

$$\int u_E(w_E + L - I + y - \pi(y))\, dG(y) \tag{27}$$

for entrepreneurs $i = 1, 2, ..., N$,

$$\begin{aligned}\int [u_I(w_I + D - NL - NA + \textstyle\sum_{i=1}^{N} \pi(y_i) - r_I(\sum_{i=1}^{N} \pi(y_i)))\\ -p_I(\textstyle\sum_{i=1}^{N} \pi(y_i))]\, dG(y_1)...dG(y_N)\end{aligned} \tag{28}$$

for the intermediary, and

$$\int u_H(w_H + \frac{1}{NM}(r_I(\textstyle\sum_{i=1}^{N} \pi(y_i)) - D))\, dG(y_1)...dG(y_N) \tag{29}$$

for households as the final investors. The intermediation policy $(L, \pi(.), D,\ r_I(.),$ $p_I(.))$ is said to be acceptable to the intermediary, if his expected payoff (28) is at least as great as $u_I(w_I)$, his payoff in the absence of intermediation; the policy is acceptable to final investors if their expected payoff (29) is at least as great as $u_H(w_H)$. An incentive-compatible intermediation policy that is acceptable to both, households and the intermediary, is called *viable.*

The first major result of this paper is now stated as:

Proposition 2 *Assume that the cost A of monitoring an entrepreneur is strictly less than the agency cost $K - \hat{w}_E$ of direct finance when there are many households. Then for any sufficiently large N, there exists a viable incentive-compatible intermediation policy $(L^N, \pi^N(.), D^N,\ r_I^N(.),\ p_I^N(.))$ which makes entrepreneurs strictly better off than any incentive-compatible contract for direct finance that is acceptable to households.*

Proof. It will be useful to sketch the basic idea before giving any details. The desired intermediation policies will be specified as policies under which for some sufficiently small $\varepsilon > 0$, (i) the entrepreneurs are left with the safe consumption $\hat{w}_E + \varepsilon$, and (ii) the intermediary obtains the funds he needs to finance his lending and monitoring through a *debt contract* with a minimum living allowance $w_I + \varepsilon$ and a debt service obligation $\hat{y}^N = N(\bar{y} - \varepsilon)$. Under these intermediation policies, entrepreneurs are trivially better off than under direct finance, so the only question is whether these policies are viable. The intermediary defaults on the obligation $N(\bar{y} - \varepsilon)$ to final investors if and only if $\sum \tilde{y}_i < N(\bar{y} - \varepsilon)$ or, equivalently,

$$\frac{1}{N} \sum_{i=1}^{N} \tilde{y}_i < \bar{y} - \varepsilon. \tag{30}$$

By Bernstein's inequality (see, e.g., Rényi (1979), p. 324), the probability of this event goes to zero, *exponentially* in N, as N becomes large. From (20), with $u_I(.)$ in the place of $u_E(.)$ and the given living allowance and debt service obligation, one also sees that the intermediary's penalty in the event of default is bounded above by $u_I'(w_I + \varepsilon)\, \hat{y}^N = u_I'(w_I + \varepsilon)\, N(\bar{y} - \varepsilon)$, which increases just linearly in N.[8] Therefore, as N goes out of bounds, the expected value of the intermediary's nonpecuniary penalty must go to zero and must eventually be outweighed by the fact that the given intermediation policy provides him with the consumption $w_I + \varepsilon + \max[0, \sum \tilde{y}_i - N(\bar{y} - \varepsilon)] > w_I$. As for the final investors, as N goes out of bounds and the probability of default vanishes, their receipts, normalized by N, converge almost surely to $\bar{y} - \varepsilon$. Given that the monitoring cost A is less than the agency cost of direct finance, this turns out to be enough to cover the opportunity cost of their funds provided that $\varepsilon > 0$ is sufficiently small.

To make the argument precise, let $\Delta := K - \hat{w}_E - A$ denote the difference between the agency cost of direct financewhen there are many households and the monitoring cost A, and set $\varepsilon := \Delta/5$. For any N, consider the intermediation policy $(L^N, \pi^N(.), D^N,\ r_I^N(.),\ p_I^N(.))$ where

$$L^N = I - w_E + \hat{w}_E + \varepsilon, \tag{31}$$

$$\pi^N(y) \equiv y, \tag{32}$$

$$D^N = NL^N + NA + \varepsilon, \tag{33}$$

[8] This argument parallels the one underlying Proposition 1, p. 467, of Nielsen (1985) or Theorem 2, p. 305, of Hellwig (1995), see also Section 5 below. Whereas those papers start from a given von Neumann-Morgenstern utility function that is defined on all of $\Re$, the analysis here has the intermediary's consumption restricted to $\Re_+$ and uses nonpecuniary penalties to define the intermediary's attitudes to large shortfalls of his returns from his debt service obligations.

$$r_I^N(z) \equiv \min[z, N(\bar{y} - \varepsilon)], \tag{34}$$

$$p_I^N(z) \equiv u_I'(w_I + \varepsilon)\ \max[0, N(\bar{y} - \varepsilon) - z]. \tag{35}$$

As mentioned above, this involves a standard debt contract for the intermediary with minimum living allowance $w_I + \varepsilon$ and debt service obligation $N(\bar{y} - \varepsilon)$. By Proposition 1, this contract is incentive-compatible: (34) ensures that $r_I^N(.)$ is nondecreasing, and (35) ensures that $p_I^N(.)$ and $r_I^N(.)$ satisfy (4). A final investor's expected payoff from the given intermediation policy is

$$\int u_H(w_H + \frac{1}{NM}(r_I(\textstyle\sum_{i=1}^N \pi(y_i)) - D^N))\ dG(y_1)...dG(y_N)$$

$$\geq \int u_H(w_H + \frac{1}{M}(\min[\frac{1}{N}\textstyle\sum_{i=1}^N y_i, \bar{y} - \varepsilon] - L^N - A - \varepsilon))dG(y_1)...dG(y_N).$$

By the law of large numbers, in combination with Lebesgue's bounded - convergence theorem, for any sufficiently large N, this is at least as great as

$$\begin{aligned} & u_H(w_H + \frac{1}{M}(\bar{y} - 2\varepsilon - L^N - A - \varepsilon)) \\ = {} & u_H(w_H + \frac{1}{M}(\bar{y} - I + w_E - \hat{w}_E - A - 4\varepsilon)) \\ = {} & u_H(w_H + \frac{1}{M}(\Delta - 4\varepsilon)) > u_H(w_H), \end{aligned} \tag{36}$$

and the intermediation policy is acceptable to final investors.

As for the financial intermediary, his expected payoff from the intermediation policy $(L^N, \pi^N(.), D^N,\ r_I^N(.),\ p_I^N(.))$ is

$$\begin{aligned} \int & [u_I(w_I + D^N - NL^N - NA + \textstyle\sum_{i=1}^N \pi(y_i) - r_I(\sum_{i=1}^N \pi(y_i))) \\ & -p_I(\textstyle\sum_{i=1}^N \pi(y_i))]\ dG(y_1)...dG(y_N) \end{aligned}$$

$$\begin{aligned} = \int & u_I(w_I + \varepsilon + N \max[\textstyle\sum_{i=1}^N y_i/N - \bar{y} + \varepsilon, 0])\ dG(y_1)...dG(y_N) \\ & - \int_0^{N(\bar{y}-\varepsilon)} u_I'(w_I + \varepsilon)\ \Pr\{\textstyle\sum_{i=1}^N \tilde{y}_i \leq z\}\ dz \end{aligned}$$

$$\geq u_I(w_I + \varepsilon) - u_I'(w_I + \varepsilon)\ N(\bar{y} - \varepsilon)\ \Pr\{\textstyle\sum_{i=1}^N \tilde{y}_i/N \leq \bar{y} - \varepsilon\}. \tag{37}$$

By Bernstein's inequality, there exists a constant $A(\varepsilon) > 0$ such that for any N

$$\Pr\{\textstyle\sum_{i=1}^N \tilde{y}_i/N \leq \bar{y} - \varepsilon\} \leq 2\ e^{-NA(\varepsilon)}. \tag{38}$$

Hence (37) implies that the intermediary's expected payoff from the intermediation policy $(L^N, \pi^N(.), D^N,\ r_I^N(.),\ p_I^N(.))$ is no less than

$$u_I(w_I + \varepsilon) - 2\ u_I'(w_I + \varepsilon)\ N(\bar{y} - \varepsilon)\ e^{-NA(\varepsilon)}. \qquad (39)$$

Since $\lim_{N\to\infty} Ne^{-NA(\varepsilon)} = 0$, it follows that for any sufficiently large N, this is larger than $u_I(w_I)$, the intermediary's payoff if he remains inactive. In combination with (36), this shows that for any sufficiently large N the policy $(L^N, \pi^N(.), D^N,\ r_I^N(.),\ p_I^N(.))$ is viable.

Finally, an entrepreneur's payoff from the given intermediation policy is:

$$\int u_E(w_E + L^N - I + y - \pi^N(y))\ dG(y) = u_E(\hat{w}_E + \varepsilon). \qquad (40)$$

As discussed above, the acceptability condition (22) for an incentive-compatible contract for direct finance is somewhat stronger than the break-even condition (23), so by definition of $\hat{w}_E$, the entrepreneur's expected payoff from any incentive-compatible and acceptable contract for direct finance cannot be greater than $u_E(\hat{w}_E)$. Since $u_E(\hat{w}_E) < u_E(\hat{w}_E+\varepsilon)$, the intermediation policy $(L^N, \pi^N(.),$ $D^N,\ r_I^N(.),\ p_I^N(.))$ fulfils the claim made in the proposition. ■

Proposition 2 is exactly Diamond's result, generalized to allow for risk aversion of the entrepreneurs and the intermediary. With risk aversion, as with risk neutrality, delegation costs, i.e., the agency costs associated with the intermediary's own finance contract, are negligible if the number of independent projects financed by the intermediary is sufficiently large. As in Diamond (1984), *the relative assessment of intermediated finance and direct finance then hinges only on the comparison of the intermediary's monitoring costs with the agency costs of direct finance when there are many final investors.*

4 Intermediation and Risk Sharing

In the preceding analysis, intermediation provides for insurance as well as finance. The intermediation policy considered in (31)-(35) shifts all return risks from entrepreneurs to the intermediary. This suggests that intermediated finance may be advantageous because it provides for risk sharing, so the entrepreneurs may profit from intermediation even in situations where w exceeds I and it would be feasible to do without external finance altogether. The entrepreneurs want somebody else to share their risks; as a way to achieve this, intermediation with monitoring may be more effective or cheaper than direct finance with incentive contracting.

Following up on this observation, the present section looks at the allocation of risks under optimal intermediation policies. Given that different classes of agents are involved, "optimality" here is ambiguous and depends on whose interests one is concerned with. I will consider two classes of Pareto-optimal policies, entrepreneur-oriented policies and intermediary-oriented policies. An *optimal entrepreneur-oriented intermediation policy* will be one that maximizes the entrepreneurs' expected payoff subject to the condition that the policy be viable, i.e., that the intermediary's and the final investors' expected payoffs be at least equal to their payoffs in the absence of intermediation. An *optimal intermediary-oriented intermediation policy* will be one that maximizes the intermediary's expected payoff subject to the condition that the entrepreneurs and the final investors be at least as well off as they are in the absence of intermediation.

Under either notion of optimality, a detailed characterization of optimal intermediation policies seems out of the question. Optimality of an intermediation policy requires that the finance contract $(D,\ r_I(.),\ p_I(.))$ for the intermediary be an optimal incentive-compatible contract when the intermediary's own return from the entrepreneurs he finances is given by the random variable $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$. As discussed in Section 2, this implies that the form of the aggregate claim $r_I(\tilde{z})$ of the household sector on the intermediary depends on the distribution of $\tilde{z} = \sum_{i=1}^{N} \pi(\tilde{y}_i)$ as well as the participants' risk preferences. Even if the distribution of the intermediary's claim $\pi(\tilde{y}_i)$ on an individual entrepreneur has a simple form, such structure is lost as one looks at the sums $\sum_{i=1}^{N} \pi(\tilde{y}_i)$ for different N.

Even without a detailed characterization of optimal policies it is however possible to show that *any optimal intermediation policy must provide entrepreneurs with approximately full insurance of their return risks if the number of entrepreneurs N is large.* Equivalently, if $(\hat{L},\ \hat{\pi}(.))$ is a lending policy that does *not* provide the borrower with full insurance, any intermediation policy involving this lending policy will be dominated if N is sufficiently large.

The argument does not just rely on the intermediary's passing return risks on to the final investors. The intermediation policies that will be used to show that intermediation policies involving the lending policy $(\hat{L},\ \hat{\pi}(.))$ are dominated actually involve *debt finance* of the intermediary, with default probabilities of the intermediary going to zero as N becomes large. Asymptotically, under these policies, the intermediary will be bearing all risk in the economy as diversification across entrepreneurs makes him able and willing to assume all return risks - even though he is risk averse and indeed his risk aversion may be bounded away from zero.

Proposition 3 *Assume that if c is sufficiently large, the intermediary's absolute risk aversion, $-u_I''(c)/u_I'(c)$, is bounded above. Assume further that $w_E + \bar{y} - I - A > \bar{w}_E$ where $\bar{w}_E = \max(w_E, \hat{w}_E)$ is the best the entrepreneur can do in the absence of intermediation. For any N that is large enough so that there exists a viable intermediation policy which provides entrepreneurs with expected payoffs greater than or equal to $\bar{w}$, let $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ be an optimal intermediary-oriented intermediation policy and consider the induced consumption pattern $c^{*N}(\tilde{y}_i)$ of entrepreneur i, where, for any $y \in [0, Y]$,*

$$c_E^{*N}(y) = w_E + L^{*N} - I + y - \pi^{*N}(y). \tag{41}$$

As N goes out of bounds, $c_E^{*N}(\tilde{y}_i)$ converges in distribution to the nonrandom constant $\bar{w}_E$.

Proof. In the first step of the proof I give an upper bound on the intermediary's expected payoff under the policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$. Let

$$\tilde{c}_I^{*N} := w_I + D^{*N} - NL^{*N} - NA + \sum_{i=1}^{N} \pi^{*N}(\tilde{y}_i) - r_I^{*N}(\sum_{i=1}^{N} \pi^{*N}(\tilde{y}_i)) \quad (42)$$

be the intermediary's consumption random variable under this policy. Given that the intermediary is risk averse, by inspection of (28), one finds that for any N, his expected payoff under the policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ is bounded above by $u_I(E\tilde{c}_I^{*N})$, the payoff he would obtain if he got $E\tilde{c}_I^{*N}$ for sure, without any nonpecuniary penalties. Given that the final investors' utility function is also concave, by inspection of (29), one also finds that acceptability of the policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ to final investors requires

$$D^{*N} - Er_I^{*N}(\sum_{i=1}^{N} \pi^{*N}(\tilde{y}_i)) \leq 0. \quad (43)$$

Upon combining (42) with (43) and (41), one therefore obtains

$$\begin{aligned} E\tilde{c}_I^{*N} &\leq E[w_I - NL^{*N} - NA + \textstyle\sum_{i=1}^{N} \pi^{*N}(\tilde{y}_i)] \\ &= w_I + N(w_E + \bar{y} - I - A) - \textstyle\sum_{i=1}^{N} Ec_E^{*N}(\tilde{y}_i) \\ &= w_I + N(K - A - \int_0^Y c_E^{*N}(y)\, dG(y)). \end{aligned} \quad (44)$$

For any N, the intermediary's expected payoff from the optimal intermediary-oriented policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ is thus no larger than $u_I(w_I + N(K - A - \int_0^Y c_E^{*N}(y)\, dG(y)))$.

Now suppose that the proposition is false. Then for any i, there exists a subsequence $\{c_E^{*N'}(\tilde{y}_i)\}$ of consumption patterns that fails to converge to $\bar{w}$ in distribution. Given the strict concavity of $u_E(.)$ and the entrepreneurs' participation constraint

$$\int_0^Y u_E(c_E^{*N}(y))\, dG(y) \geq u_E(\bar{w}_E) \quad (45)$$

this implies that for some $\eta > 0$ one has

$$\int_0^Y c_E^{*N'}(y)\, dG(y) \geq \bar{w}_E + \eta \quad (46)$$

and hence, from (44),

$$E\tilde{c}_I^{*N'} \leq \bar{c}_I^{N'} := w_I + N'(K - A - \bar{w}_E - \eta) \quad (47)$$

for all N'. The intermediary's expected payoff from the optimal policies $(L^{*N'}, \pi^{*N'}(.), D^{*N'}, r_I^{*N'}(.), p_I^{*N'}(.))$ is thus bounded above by $u_I(\bar{c}_I^{N'}) = u_I(w_I + N'(K - A - \bar{w}_E - \eta))$, for any N'. I will show that this is not compatible with the presumed optimality of the intermediation policies $(L^{*N'}, \pi^{*N'}(.), D^{*N'}, r_I^{*N'}(.), p_I^{*N'}(.))$ when N' is large.

For any N', consider an alternative intermediation policy such that:

$$L^{N'} = I - w_E + \bar{w}_E, \tag{48}$$

$$\pi^{N'}(y) \equiv y, \tag{49}$$

$$D^{N'} = N'(L^{N'} + K - \bar{w}_E - \eta), \tag{50}$$

$$r_I^{N'}(z) \equiv \min[z,\ N'(\bar{y} - \eta/2)] \tag{51}$$

$$p_I^{N'}(z) \equiv u_I'(\bar{c}_I^{N'})\ \max[0,\ N'(\bar{y} - \eta/2) - z]. \tag{52}$$

Under this alternative intermediation policy, the intermediary finances entrepreneurs and provides them with a safe consumption equal to $\bar{w}_E$. The intermediary itself is financed by a debt contract with a debt service obligation equal to $N'(\bar{y} - \eta/2)$ and a minimum living allowance equal to the upper bound $\bar{c}_I^{N'}$ on his expected consumption under the presumed optimal policy $(L^{*N'}, \pi^{*N'}(.), D^{*N'}, r_I^{*N'}(.), p_I^{*N'}(.))$.

By construction, the alternative policy $(L^{N'}, \pi^{N'}(.), D^{N'}, r_I^{N'}(.), p_I^{N'}(.))$ provides entrepreneurs with the payoff $u_E(\bar{w}_E)$, so it satisfies their participation constraint. As for the final investors, their expected payoff is

$$\int u_H(w_H + \frac{1}{N'M}(r_I^{N'}(\textstyle\sum_{i=1}^{N'} \pi^{N'}(y_i)) - D^{N'}))\ dG(y_1)...dG(y_{N'})$$

$$= \int u_H(w_H + \frac{1}{M}(\min[\frac{1}{N'}\textstyle\sum_{i=1}^{N'} y_i, \bar{y} - \frac{\eta}{2}] - \frac{D^{N'}}{N'})\ dG(y_1)...dG(y_{N'}).$$

The law of large numbers in combination with Lebesgue's bounded convergence theorem ensures that for any sufficiently large N', this is no less than

$$u_H(w_H + \frac{1}{M}(\bar{y} - \frac{3\eta}{4} - (L^{N'} + K - \bar{w}_E - \eta))$$

$$= u_H(w_H + \frac{1}{M}(I - w_E - L^{N'} + \bar{w}_E + \frac{\eta}{4}) > u_H(w_H), \tag{53}$$

as required for acceptability to final investors.

Finally, the intermediary's expected payoff from the intermediation policy (48)-(52) is

$$\int [u_I(w_I + D^{N'} - N'L^{N'} - N'A + \sum_{i=1}^{N'} \pi^{N'}(y_i) - r_I^{N'}(\sum_{i=1}^{N'} \pi^{N'}(y_i)))$$
$$-p_I^{N'}(\sum_{i=1}^{N'} \pi^{N'}(y_i))]\ dG(y_1)...dG(y_{N'})$$

$$= \int u_I(\bar{c}_I^{N'} + \max[\sum_{i=1}^{N} y_i - N'(\bar{y} - \eta/2), 0])\ dG(y_1)...dG(y_{N'})$$
$$- \int_0^{N'(\bar{y}-\eta/2)} u_I'(\bar{c}_I^{N'})\ \Pr\{\sum_{i=1}^{N'} \tilde{y}_i \leq z\}\ dz$$

$$\geq u_I(\bar{c}_I^{N'}) + [u_I(\bar{c}_I^{N'} + N'\eta/4) - u_I(\bar{c}_I^{N'})]\ \Pr\{\sum_{i=1}^{N'} \tilde{y}_i/N' \geq \bar{y} - \eta/4\}$$
$$-u_I'(\bar{c}_I^{N'})\ N'(\bar{y} - \eta/2)\ \Pr\{\sum_{i=1}^{N'} \tilde{y}_i/N' \leq \bar{y} - \eta/2\}. \tag{54}$$

The assumption on the intermediary's risk aversion implies that for some $\sigma > 0$, one has $-u_I''(c)/u_I'(c) \leq \sigma$ for any sufficiently large c. By a straightforward integration, it follows that

$$u_I(\bar{c}_I^{N'} + N'\eta/4) \geq u_I(\bar{c}_I^{N'}) + u_I'(\bar{c}_I^{N'}) \frac{1 - e^{-\sigma\eta N'/4}}{\sigma} \tag{55}$$

for any sufficiently large N', at which point (54) implies that the intermediary's expected payoff under the alternative intermediation policy $(L^{N'}, \pi^{N'}(.), D^{N'}, r_I^{N'}(.), p_I^{N'}(.))$ is bounded below by

$$u_I(\bar{c}_I^{N'}) + u_I'(\bar{c}_I^{N'}) \frac{1 - e^{-\sigma\eta N'/4}}{\sigma} \Pr\left\{\frac{1}{N'} \sum_{i=1}^{N'} \tilde{y}_i \geq \bar{y} - \frac{\eta}{4}\right\}$$
$$-u_I'(\bar{c}_I^{N'})\ N'(\bar{y} - \frac{\eta}{2})\ \Pr\left\{\frac{1}{N'} \sum_{i=1}^{N'} \tilde{y}_i \leq \bar{y} - \frac{\eta}{2}\right\}. \tag{56}$$

Now the law of large numbers implies that $\Pr\left\{\sum_{i=1}^{N'} \tilde{y}_i/N' \geq \bar{y} - \eta/4\right\}$ converges to one as N' becomes large. Moreover, Bernstein's inequality (Rényi (1979), p. 324) implies that $\Pr\left\{\sum_{i=1}^{N'} \tilde{y}_i/N' \leq \bar{y} - \eta/2\right\}$ converges to zero, exponentially in N', and $N'(\bar{y} - \eta/2)\ \Pr\left\{\sum_{i=1}^{N'} \tilde{y}_i/N' \leq \bar{y} - \eta/2\right\}$ converges to zero as N' becomes large. But then for any sufficiently large N', (56) must exceed $u_I(\bar{c}_I^{N'}) + u_I'(\bar{c}_I^{N'})/2\sigma$, and the intermediary's expected payoff from the policy $(L^{N'}, \pi^{N'}(.), D^{N'}, r_I^{N'}(.), p_I^{N'}(.))$ must be strictly greater than $u_I(\bar{c}_I^{N'})$. Given that $u_I(\bar{c}_I^{N'})$ has been shown to be an upper bound on his expected payoff from the policy $(L^{*N'}, \pi^{*N'}(.), D^{*N'}, r_I^{*N'}(.), p_I^{*N'}(.))$, it follows that the policy $(L^{*N'}, \pi^{*N'}(.), D^{*N'}, r_I^{*N'}(.), p_I^{*N'}(.))$ cannot be optimal. The assumption that $c_E^{*N}(\tilde{y}_i)$ fails to converge in distribution to $\bar{w}$ has thus led to a contradiction and must be false. ■

A key element in the proof of Proposition 3 is the endogeneity of the intermediary's minimum living allowance. As indicated by (52) and (54), in the alternative intermediation policies $(L^{N'}, \pi^{N'}(.), D^{N'}, r_I^{N'}(.), p_I^{N'}(.))$, the intermediary's living allowance is equal to $\bar{c}_I^{N'}$, which goes out of bounds with N'. This is important because it implies that the marginal-utility weights in the nonpecuniary default penalties go to zero as N' becomes large. As indicated by (56), this in turn is crucial for the assessment that nonpecuniary default penalties are negligible relative to the consumption gains from the alternative intermediation policies. If the marginal-utility weights in the nonpecuniary default penalties were independent of the number of entrepreneurs the intermediary finances, this assessment would not be valid any more. Although the consumption gains from the alternative intermediation policies would be large, their effects on the intermediary's utility might be small relative to their effects on penalty costs as, e.g., with absolute risk aversion bounded away from zero, his utility itself would be bounded above. If the intermediary were constrained to finance himself by debt contracts with an exogenously given living allowance, the conclusion of Proposition 3 would therefore not generally be true.[9]

Interestingly, the analogous result for optimal entrepreneur-oriented intermediation policies does not require these endogenous living allowances. Like the proof of Proposition 2, the proof of the following proposition relies on intermediation policies that involve debt finance of the intermediary with a fixed minimum living allowance that is independent of the number of entrepreneurs.

Proposition 4 *For any N that is large enough so that a viable intermediation policy exists, let $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ be an optimal entrepreneur-oriented intermediation policy, and consider the induced consumption pattern $c_E^{*N}(\tilde{y}_i)$ of entrepreneur i, where, for any $y \in [0, Y]$, $c_E^{*N}(y) \equiv w_E + L^{*N} - I + y - \pi^{*N}(y)$, as in (41). As N goes out of bounds, $c_E^{*N}(\tilde{y}_i)$ converges in distribution to the nonrandom constant $K - A$.*

Proof. I first show that for any N, one has

$$\int_0^Y c_E^{*N}(y)\, dG(y) \leq K - A. \tag{57}$$

As discussed in the proof of Proposition 3, for any N, the intermediary's expected payoff from the policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ is bounded above by $u_I(E\tilde{c}_I^{*N})$ where $\tilde{c}_I^{*N}$ is given by (42) and is the intermediary's consumption random variable under the given optimal intermediation policy. Therefore the intermediary's participation constraint requires $E\tilde{c}_I^{*N} \geq w_I$, and hence, by (42),

$$D^{*N} + \textstyle\sum_{i=1}^N E\pi^{*N}(\tilde{y}_i) \geq N(L^{*N} + A) + Er_I^{*N}(\textstyle\sum_{i=1}^N \pi^{*N}(\tilde{y}_i)). \tag{58}$$

Given that, as discussed in the proof of Proposition 3, the final investors' participation constraint implies $Er_I^{*N}(\sum_{i=1}^N \pi^{*N}(\tilde{y}_i)) \leq D^{*N}$, (58) yields

$$\textstyle\sum_{i=1}^N E\pi^{*N}(\tilde{y}_i) = NE\pi^{*N}(\tilde{y}_1) \geq N(L^{*N} + A). \tag{59}$$

[9] For a systematic discussion of this issue, see Hellwig (1995), Section 3, as well as Section 5 below.

Therefore (41) implies:

$$\begin{aligned} Ec_E^{*N}(\tilde{y}_i) &= w_E + L^{*N} - I + \bar{y} - E\pi^{*N}(\tilde{y}_i) \\ &\leq w_E + L^{*N} - I + \bar{y} - L^{*N} - A \\ &= K - A, \end{aligned} \tag{60}$$

as claimed.

Now consider the entrepreneurs' expected payoff, $\int u(c^{*N}(y))\, dG(y)$, from the intermediation policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$. From (57) and the concavity of $u_E(.)$, one has:

$$\int_0^Y u_E(c^{*N}(y))\, dG(y) \leq u_E(K - A) \tag{61}$$

for all N. Moreover the argument in the proof of Proposition 2, with $\hat{w}$ replaced by $K - A - \eta$, shows that for any $\eta > 0$ and any sufficiently large N, there exists a viable intermediation policy $(L^N, \pi^N(.), D^N, r_I^N(.), p_I^N(.))$ that satisfies

$$\int_0^Y u_E(c^N(y))\, dG(y) \geq K - A - \eta.$$

This in turn implies that the optimal entrepreneur-oriented intermediation policy $(L^{*N}, \pi^{*N}(.), D^{*N}, r_I^{*N}(.), p_I^{*N}(.))$ must satisfy

$$\int_0^Y u_E(c^{*N}(y))\, dG(y) \geq K - A - \eta \tag{62}$$

for any $\eta > 0$ and any sufficiently large N. From (61) and (62), it follows that $\int_0^Y u_E(c^{*N}(y))\, dG(y)$ converges to $u_E(K-A)$ as N goes out of bounds. In view of (57) and the strict concavity of $u_E(.)$, this is only possible if the consumption patterns $c_E^{*N}(\tilde{y}_i)$ converge in distribution to the constant $K - A$ as N goes out of bounds. ■

Proposition 4 should be compared to a result of Krasa (1988) showing that *under risk neutrality* an optimal entrepreneur-oriented intermediation policy will necessarily involve *debt finance* of entrepreneurs with repayment functions $\hat{\pi}^N(.)$ of the form

$$\hat{\pi}^N(y) = w_E + \hat{L}^N - I + \min(y, \hat{y}^N), \tag{63}$$

without any living allowance and corresponding consumption patterns $\hat{c}^N(.)$ of the form

$$\hat{c}^N(y) = \max(0, y - \hat{y}^N). \tag{64}$$

Krasa's result is based on the observation that nonpecuniary penalties in the intermediary's own finance contract induce a kind of quasi risk aversion on the side of the financial intermediary. A mean preserving spread in the returns available to the intermediary will put more weight on the tails of the intermediary's return distribution, including the lower tail where bankruptcy penalties are needed to preserve incentive compatibility of the contract. A mean-preserving spread in the returns available to the intermediary will therefore raise expected nonpecuniary penalties in the intermediary's own finance contract and, other things being equal, lower the intermediary's expected net payoff. Given this quasi risk aversion of the intermediary and given the risk neutrality of entrepreneurs, an optimal intermediation policy will leave as much risk with the entrepreneurs as possible. Given the feasibility constraint (24), this criterion singles out the consumption pattern (64) which corresponds to debt finance of the entrepreneurs without any living allowance.[10]

In contrast, Proposition 4 shows that when the entrepreneurs as well as the intermediary are risk averse the risk allocation may be reversed. If there are enough entrepreneurs for the law of large numbers to come into play, an optimal entrepreneur-oriented intermediation policy leaves little risk with the entrepreneurs and instead places all risks with the intermediary and/or the final investors. Because of the large-numbers effect, the intermediary's concern for the lower tail of the distribution, which is at the heart of Krasa's argument, is outweighed by the entrepreneurs' desire to get rid of risk altogether.

5 Risk Aversion With Respect to Default Penalties

In this section, I consider to what extent the preceding results depend on the specification of nonpecuniary penalties. In Sections 3 and 4 payoffs were assumed to be additively separable in default penalties and consumption. This assumption is quite special. It is to some extent justified if one can identify nonpecuniary default penalties with losses of future opportunities that are due to adverse interventions of creditors. With intertemporal additive separability of utility, one can then interpret $p_I(z)$ as a conditional expectation of the present value of these losses when the intermediary reports the return realization z. This conditional expectation depends on the final investors' reactions to the report z, namely, the (conditional) probability with which they intervene to impose those future opportunity losses on the intermediary as well as the actual losses when they do intervene (see, e.g., Povel and Raith (1999)).

However, if one thinks of default penalties in terms of debtor's prison, loss of social standing, and the like, it is no longer clear that additive separability is a suitable assumption, nor even what a suitable assumption might be. Additive separability has the awkward implication that the debtor is risk neutral with respect to the penalty. For a given pair $(\tilde{c}, \tilde{p})$ of state-contingent consumption

[10] That debt is the optimal financial contract for a risk neutral entrepreneur and a risk averse financier under perfect information had also been shown by Freixas, see Freixas and Rochet (1997), p. 92ff.

and nonpecuniary penalty, the expected utility $Eu_I(\tilde{c}) - E\tilde{p}$ depends on $\tilde{p}$ *only* through its expected value. One may therefore wonder what happens to the results of Sections 3 and 4 if the intermediary exhibits risk aversion with respect to nonpecuniary penalties as well as consumption.

Without any pretense of generality, I investigate this question for the case when the intermediary's von Neumann-Morgenstern utility function $u_I(.)$ is defined on the entire real line rather than just $\Re_+$ and his expected payoff from a given pair $(\tilde{c}, \tilde{p})$ of state-contingent consumption and nonpecuniary penalty is equal to $Eu_I(\tilde{c} - \tilde{p})$. In this specification the nonpecuniary penalty is defined in terms of equivalent units of consumption losses, and the intermediary's risk aversion affects his assessment of the penalty just as it affects his assessment of his consumption. Special though it is, this formulation turns out to be convenient for illustrating when and why the specification of default penalties may make a difference to the analysis of financial intermediation with risk aversion.

Given the utility specification $u_I(c-p)$, the intermediary's payoff expectation (28) from an intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ (with monitoring committed *ex ante*) is replaced by

$$\int u_I[w_I + D - NL - NA + \sum_{i=1}^{N} \pi(y_i) - r_I(\sum_{i=1}^{N} \pi(y_i)) \\ -p_I(\sum_{i=1}^{N} \pi(y_i))]\ dG(y_1)...dG(y_N). \quad (65)$$

The question is how this modification affects the viability of intermediation and the comparative assessment of intermediation policies by the intermediary.

To answer this question, I note that with the utility specification $u_I(c - p)$ a standard debt contract with bankruptcy point $\hat{z}$ for the intermediary is incentive-compatible if the penalty function satisfies

$$p_I(z) = \max(0, \hat{z} - z) \quad (66)$$

for all realizations z of the intermediary's gross return.[11] Thus the intermediation policy $(L, \pi(.), D,\ r_I(.),\ p_I(.))$ that is given by (31)-(34) and (66) with $\hat{z} = N(\bar{y} - \varepsilon)$ is incentive-compatible in this setting. The intermediary's expected payoff from this policy is equal to

$$\int u_I(w_I + \varepsilon + \sum_{i=1}^{N} y_i - r_I(\sum_{i=1}^{N} y_i) \\ -p_I(\sum_{i=1}^{N} y_i))\ dG(y_1)...dG(y_N)$$

$$= \int u_I(w_I + \varepsilon + \sum_{i=1}^{N} y_i - N(\bar{y} - \varepsilon))\ dG(y_1)...dG(y_N) \quad (67)$$

since obviously $r_I(z) + p_I(z) = N(\bar{y} - \varepsilon)$ for all z.

[11] As in Diamond (1984), one can actually show that regardless of the specification of the intermediary's lending policy, it is optimal for him to be financed by a standard debt contract with a zero living allowance and penalty function (66).

The question of whether in this setting the intermediation policy $(L, \pi(.), D, r_I(.), p_I(.))$ is acceptable to the intermediary is thus equivalent to the question of whether an expected-utility maximizer with von Neumann-Morgenstern utility function $u_I(.)$ defined on the entire real line is willing to accept any sufficiently large compound of the independent, identically distributed gambles $\tilde{y}_i - \bar{y} + \varepsilon,\ i = 1, 2, ...$, with the common expected value $\varepsilon > 0$. This is precisely the question treated by Nielsen (1985). According to his main result (Proposition 1, p.467, see also Theorem 2, p.305, in Hellwig (1995)), the acceptability of any sufficiently large compound of the independent, identically distributed gambles $\tilde{y}_i - \bar{y} + \varepsilon,\ i = 1, 2, ...$, can be affirmed regardless of other properties of the distribution of $\tilde{y}_i - \bar{y} + \varepsilon$ *if and only if* $u_I(.)$ satisfies the following:

Condition 5 *For any* $\lambda > 0$, *there exists* $\underline{c} \in \Re$ *such that for any* $c - p < \underline{c}$, $u_I(c-p) \geq -e^{\lambda c}$, *i.e., as* $c - p$ *goes to* $-\infty$, $u_I(c-p)$ *does not go exponentially fast to* $-\infty$.

To understand the role of this condition, recall that the analysis of the viability of financial intermediation rests on Bernstein's inequality implying that in an $N-$fold compound of independent, identically distributed random variables, the probability of an outlier of order of magnitude N is small, exponentially in N. If the negative weights assigned to negative outliers of order of magnitude N grow less than exponentially with N, any effect of these outliers on the decision maker's assessment of the compound will be swamped by the mean $N\varepsilon$ going out of bounds as N becomes large. In contrast, if the negative weights assigned to negative outliers of order of magnitude N are exponentially large, these outliers need not become negligible as N goes out of bounds. The decision maker's assessment of any large compound of the gambles $\tilde{y}_i - \bar{y} + \varepsilon$ will then depend on the details of the "tradeoff" of probabilities becoming exponentially small and negative weights becoming exponentially large as N becomes large.

If the intermediary's utility function $u_I(.)$ satisfies Nielsen's condition, the conclusions of this paper about the viability of intermediation and about optimal entrepreneur-oriented intermediation policies remain valid without change, i.e., if monitoring is committed *ex ante* and monitoring costs are less than the agency costs of direct finance, then for large N, intermediation is viable (Proposition 2) and optimal entrepreneur-oriented intermediation policies provide entrepreneurs with approximately full insurance of their return risks (Proposition 4). If monitoring is chosen *ex ante*, but can be made contingent on returns, the analogous conclusions from Section 6 apply, i.e., when N is large, optimal entrepeneur-oriented intermediation policies provide entrepreneurs with approximately the optimal incentive-compatible contracts that they would obtain in contracting with a risk neutral non-wealth-constrained financier.

In contrast, the asymptotic characterization of optimal *intermediary-oriented* intermediation policies in Proposition 3 does not carry over to the present setting *unless* the intermediary's utility function $u_I(.)$ satisfies a further condition. The choice of an intermediation policy to maximize the intermediary's payoff expectation under participation constraints for entrepreneurs and households goes beyond the question of acceptability, i.e., the comparison of a given intermediation policy with the initial position of the intermediary. This choice requires a comparison of different policies all of which provide the intermediary with positive net benefits. As the number of entrepreneurs N increases, the base on which the intermediary collects this benefit is increased and the intermediary experiences a positive income effect. This income effect in turn will influence his attitude towards the risks inherent in different lending policies. In consequence, even if Nielsen's condition holds, it is *not* generally true that if only there are enough entrepreeneurs, his relative assessment of two lending policies will *only* depend on the expected net returns per borrower. Risk considerations may drive his choice between lending policies regardless of how large the number of loan clients may be.

For the abstract decision problem of an expected-utility maximizer with von Neumann-Morgenstern utility function $u_I(.)$ choosing between two compounds of independent, identically distributed gambles, Hellwig (1995) introduces the additional

Condition 6 *For any* $\nu > 0$ *and any* $\alpha \in (0,1)$ *there exists* $\hat{c} \in \Re_+$ *such that* $u_I(c) - u_I(\alpha c) \geq -e^{-\nu c} + e^{-\alpha \nu c}$ *for all* $c \geq \hat{c}$.

In combination with Condition 5 and concavity of $u_I(.)$ on $\Re_+$, Condition 6 is necessary and sufficient to ensure that in choosing between the two compounds $\sum \tilde{X}_i$, $\sum \tilde{Y}_i$, the decision maker will exhibit a preference for the one with the higher mean, regardless of other properties of the distributions of $\tilde{X}_i$ and $\tilde{Y}_i$, if only the number of gambles N in each compound is sufficiently large (see Theorems 4, p. 310, and 5, p. 312, in Hellwig (1995)). Given this result, it is easy to see that the asymptotic characterization of optimal intermediary-oriented intermediation policies in Proposition 3 will remain valid in the present setting, with (65) rather than (28) determining the intermediary's assessment of intermediation policies, *if and only if* the intermediary's utility function $u_I(.)$ satisfies Condition 6 as well as Nielsen's (1985) Condition 5.

Condition 6 is just slightly weaker than the assumption that the intermediary's degree of absolute risk aversion, $-u_I''(c-p)/u_I'(c-p)$, goes to zero as $c - p$ goes out of bounds.[12] As the number of loan clients becomes large, any intermediation policy that enables him to earn a strictly positive expected return per loan client will eventually make his final consumption exceed any given bound with a probability arbitrarily close to one. If his risk aversion goes to zero as his consumption goes out of bounds, this means that his evaluation of such intermediation policies involves almost exclusively that part of the domain of his utility function where his risk aversion is small. Asymptotically his choices between intermediation policies are then driven *only* by the means of returns per loan client that the policies generate; being "risk neutral in the limit", he is

[12] Similarly, Nielsen's condition is just slightly weaker than the condition that the intermediary's degree of absolute risk aversion go to zero as c converges to $-\infty$. Both Nielsen's condition and Hellwig's condition are violated if absolute risk aversion is everywhere bounded away from zero.

willing to avail himself of any risk premium that risk averse entrepreneurs are willing to provide in return for being delivered from return risks.

In summary, if the utility specification $u_I(c) - p$ is replaced by the specification $u_I(c-p)$, which allows for risk aversion with respect to the penalty p as well as the level of consumption c, all the major results of this paper remain valid provided that (i) the behaviour of $u_I(.)$ at large negative values of $c - p$ does not induce the decision maker to attach exponentially large weight to extreme negative outliers, and (ii) the behaviour of $u_I(.)$ at large positive values of $c - p$ does not induce the decision maker to attach exponentially small weight to large positive gains from following the intermediation policy that maximizes his expected return. It seems reasonable to conjecture that suitable adaptations of these conditions will be necessary and sufficient to ensure the validity of analogous results under other utility specifications as well, i.e., to ensure that if monitoring costs are less than the agency costs of direct finance, then asymptotically, as the number of entrepreneurs to be financed goes out of bounds, intermediation becomes viable and optimal intermediation policies involve the assumption of all return risks by the intermediary.

In the analysis of Sections 2-4, there was no need to impose the analogues of Conditions 5 and 6 as explicit assumptions. An analogue of Condition 5 was implicit in the fact that the specifications (34), (35) and (51), (52) of debt contracts used in the proof of Propositions 2 - 4 involve nonpecuniary penalties growing *linearly* with shortfalls of returns from debt service obligations. A substitute for Condition 6 was implicit in the specification (51), (52) of debt contracts involving living allowances that are large and nonpecuniary penalties that are small if the number of entrepreneurs financed by the intermediary is large; this neutralizes the income effects of the intermediary's financing many entrepreneurs and earning positive expected returns from all of them. Indeed if living allowances in debt contracts were taken to be exogenous, the conclusion of Proposition 3 would not in general be true; in this case, Condition 6 would again be necessary (and, with Condition 5, sufficient) for optimal intermediary-oriented intermediation policies to be asymptotically assuming all risks from entrepreneurs.

The preceding discussion raises the intriguing possibility that for certain specifications of the intermediary's preferences the asymptotic characterization of risk sharing under optimal intermediation policies may depend on the relative bargaining strengths of entrepreneurs and the intermediary. In those cases where Condition 5 is satisfied, but Condition 6 is not, optimal intermediation policies will asymptotically involve a full transfer of return risks from entrepreneurs to the intermediary if the bargaining power lies with the entrepreneurs, but *not* if it lies with the intermediary. The characterization of optimal intermediary-oriented intermediation policies in such cases is an intriguing topic for further research.

6 Financial Intermediation With Outcome - Contingent Monitoring

To conclude the paper, I show that the main results are also valid in the financial-intermediation model of Krasa and Villamil (1992) in which *all* return verification problems are handled by monitoring. Whereas the analysis so far has relied on a monitoring technology with an *ex ante* commitment of resources by the intermediary, Krasa and Villamil assume that monitoring can be conditioned on the borrower's report about the returns that he has obtained, so resources devoted to monitoring are only determined *ex post*, after the actual state has been realized. In their model, an intermediary financing N entrepreneurs through standard debt contracts, with monitoring in the event of default, is himself financed by standard debt with monitoring in the event of default.

The key assumption is that when a borrower receives funds from several investors, then in the event of default each one of them has to monitor and incur monitoring costs. Under direct finance, this involves $N\hat{H}_N$ possible instances of monitoring where N is the number of entrepreneurs and $\hat{H}_N \leq NM$ is the number of final investors providing funds to any one entrepreneur. Under intermediated finance, there are only N possible instances of monitoring of entrepreneurs by the intermediary and $H_N = NM$ possible instances of monitoring of the intermediary by final investors. If N is large, the latter are negligible because, by the law of large numbers, the probability of default by the intermediary is exponentially small, and the aggregate (!) expected cost of households monitoring the intermediary is negligible. Thus the intervention of the intermediary reduces expected overall monitoring costs:

The present section shows that the results of Sections 3 and 4 carry over to this model. Indeed the case for intermediation as an institution to support risk sharing is strengthened. For suppose that N is large, implying that there are many firms and many households. To save on monitoring costs, for large N, the number $\hat{H}_N$ of households lending to any one firm directly will be much smaller than the total number $H_N = NM$, and the different borrowers' risks will not be spread evenly across households. With intermediation, return risks are aggregated by the intermediary and shared evenly between households.

An intermediation policy is again given by a combination of a lending policy and a finance contract for the intermediary. A lending policy is now given by a triple $(L, \pi(.), B_E(.))$ such that, as before, L is the size of the loan provided by the intermediary to any one entrepreneur and $\pi(.)$ is the entrepreneur's repayment function; $B_E(.)$ is a function that indicates whether the report of a return realization y by the entrepreneur is followed by monitoring $(B_E(y) = 1)$ or not $(B_E(y) = 0)$. Similarly, a finance contract for the intermediary is now given by a triple $(D, r_I(.), B_I(.))$, where D is the total deposit of final investors with the intermediary, $r_I(.)$ is the intermediary's repayment function, and $B_I(.)$ is a function indicating at what return realizations the intermediary is monitored.

An intermediation policy $(L, \pi(.), B_E(.), D, r_I(.), B_I(.))$ is called *incentive-*

compatible if both, the lending policy and the finance contract for the intermediary are incentive-compatible. As discussed by Townsend (1979) or Gale and Hellwig (1985), incentive compatibility of the lending policy $(L, \pi(.), B_E(.))$ is equivalent to the requirement that $\pi(y) \leq R_E$ for all y and some constant $R_E \geq 0$, with equality whenever $B_E(y) = 0$. Similarly, incentive compatibility of the finance contract $(D, r_I(.), B_I(.))$ for the intermediary is equivalent to the requirement that $r_I(z) \leq R_I$ for all z and some constant $R_I \geq 0$, with equality whenever $B_I(y) = 0$. The numbers R_E and R_I are usually interpreted as debt service obligations, and the events $\pi(.) < R_E$ and $r_I(.) < R_I$ as "default", with monitoring, i.e., $B_E(y) = 1$ and $B_I(z) = 1$, in the event of default.

Given an incentive-compatible intermediation policy $(L, \pi(.), B_E(.), D, r_I(.), B_I(.))$, the participants' expected payoffs are

$$\int u_E(w_E + L - I + y - \pi(y)) \, dG(y) \tag{68}$$

for entrepreneurs,

$$E \, u_I(w_I + D - N(L + A) + \tilde{z} - r_I(\tilde{z})) \tag{69}$$

for the intermediary, and

$$E \, u_H(w_H + \frac{1}{NM}(r_I(\tilde{z}) - D) - B_I(\tilde{z}) \, A) \tag{70}$$

for households, where

$$\tilde{z} := \textstyle\sum_{i=1}^{N} [\pi(\tilde{y}_i) + (1 - B_E(\tilde{y}_i))A] \tag{71}$$

is the intermediary's gross return. I assume $w_H > A + \frac{1}{M}(I + A)$, so with $u_H(.)$ defined on $\Re_+$, (70) is actually well specified.

The entrepreneurs' payoff specification (68) is the same as (27). The intermediary's payoff specification (69), (71), differs from the previous specification (28) in two respects: First, his return random variable $\tilde{z}$ includes not only the payments $\pi(\tilde{y}_i)$ from entrepreneurs $i = 1, 2, ..., N$, but also, for $i = 1, 2, ..., N$, the savings $(1 - B(\tilde{y}_i))A$ in monitoring costs that occur at those outcomes where he does *not* have to monitor entrepreneur i. Second, the intermediary does not suffer a cost from defaulting. Default costs take the form of monitoring costs of the financiers;, as shown by the term $B_I(\tilde{z})A$ in (70), default by the intermediary imposes this cost on each household. Note that whereas the net financial return $(r_I(\tilde{z}) - D)/NM$ of a household becomes small as the number of households $H_N = NM$ goes out of bounds, the monitoring cost A that the household bears in the event of default by the intermediary, which was not present in (29), is independent of H_N; this reflects the notion that each household does his own monitoring, without any sharing of monitoring costs across households.

As before, an incentive-compatible intermediation policy is called *viable* if (i) the intermediary's expected payoff (69) is no less than $u_I(w_I)$ and (ii) the final investors' expected payoff (70) is no less than $u_H(w_H)$. In the remainder of this section I will argue that if N is sufficiently large, then (i) a viable intermediation policy exists and (ii) any optimal intermediation policy will involve a lending policy that is close to a Pareto-efficient finance contract for an entrepreneur and a fictitious risk-neutral financier who does not face a binding wealth constraint. These are the analogues of the Propositions 2 - 4.

The lending policies associated with optimal intermediation policies will usually *not* provide entrepreneurs with full insurance of their return risks - even asymptotically as N goes out of bounds. Full insurance of an entrepreneur's return risks by the financier is usually not Pareto-efficient even if the financier is risk neutral. Full insurance of return risks would require monitoring in all states; in the present context, with the flexibility to condition monitoring on reported outcomes, this may be undesirable. It is usually advantageous to monitor the entrepreneur *only* when his return realizations are low and to save on monitoring costs at high return realizations. The scope for transferring return risks to the financier is thereby reduced, but this disadvantage may be outweighed by the savings in monitoring costs.

The point is familiar from Townsend (1979), see also Gale and Hellwig (1985): In contracting between a risk averse entrepreneur and a risk-neutral, non-wealth-constrained financier, any contract is dominated by a "debt contract"[13] $(L, \pi(.), B_E(.))$ such that for some $R_E \geq 0, \varepsilon \geq 0$, and $\hat{y} \geq 0$, $\pi(y) = R_E$ and $B_E(y) = 0$ if and only if $y \geq \hat{y}$; moreover $\pi(y) = w_E + L - I + y - \varepsilon$ for all $y < \hat{y}$. Under such a contract, the entrepreneur's consumption is $c_E(y) = \varepsilon$ if $y < \hat{y}$, and $c_E(y) = w_E + L - I + y - R_E = c_E(\hat{y}) + y - \hat{y}$ if $y \geq \hat{y}$. This is completely determined by the three numbers $\hat{y}, \varepsilon$, and $c_E(\hat{y})$, so his overall expected payoff takes the form:

$$U_E(\hat{y}, \varepsilon, c_E(\hat{y})) = u_E(\varepsilon)\ G(\hat{y}) + \int_{\hat{y}}^{Y} u_E(c_E(\hat{y}) + y - \hat{y})\ dG(y). \tag{72}$$

The fictitious risk-neutral financier's expected payoff from such a contract, net of expected monitoring costs, is

$$U_F(\hat{y}, \varepsilon, c_E(\hat{y})) = w_E - I + \int_0^Y \min(y, \hat{y}) - (\varepsilon + A)G(\hat{y}) - c_E(\hat{y})(1 - G(\hat{y})). \tag{73}$$

As indicated by (72), the entrepreneur obtains full insurance on $[0, \hat{y})$ and no insurance at all on $[\hat{y}, Y]$. The choice of $\hat{y}$ thus determines the extent of risk sharing as well as the incidence of monitoring. A Pareto-optimal choice of $\hat{y}, \varepsilon$,

[13] This use of the term "debt contract", taken from Townsend (1979), is not quite standard: Default consumption ε may - and at an optimum will - exceed the smallest nondefault consumption $c_E(\hat{y})$. This is ruled out if, following Innes (1990), one assumes that a borrower can destroy returns unnoticed before he is monitored, leaving the financiers to monitor just what is left. This assumption generates the additional incentive constraint that $c_E(.)$ be a nondecreasing function, in particular, $\varepsilon \leq c_E(\hat{y})$. At a Pareto-optimal contract, this constraint is binding, and the finance contract takes the form of a *standard* debt contract with living allowance ε. For this specification too it is easy to show that $\hat{y} = Y$ cannot be optimal.

and $c_E(\hat{y})$ has to satisfy the first-order conditions

$$u'_E(\varepsilon)(1 - G(\hat{y})) = \int_{\hat{y}}^{Y} u'_E(c_E(\hat{y}) + y - \hat{y})\, dG(y) \tag{74}$$

and

$$u_E(\varepsilon) - u_E(c_E(\hat{y})) - u'_E(\varepsilon)(\varepsilon - c_E(\hat{y})) \leq u'_E(\varepsilon)A, \tag{75}$$

the latter inequality being strict *only* if $\hat{y} = 0$. The left-hand side of (75) indicates the marginal risk-sharing benefit of an increase in $\hat{y}$, the right-hand side the marginal effect of such an increase on expected monitoring costs. One easily sees that it cannot be Pareto-optimal to have $\hat{y} = Y$: For any $\hat{y}$ close to Y, (74) would imply that $c_E(\hat{y})$ is close to ε and hence that the marginal risk-sharing benefit of an increase in $\hat{y}$, the left-hand side of (75), is strictly less than the marginal effect on expected monitoring costs on the right-hand side of (75).

The main result of this section is now given as:

Proposition 7 *Assume that the set of triples $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) > 0$ is nonempty, and let U_E^* be the supremum of $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$ over this set.*[14] *Then for any $\eta > 0$ and any sufficiently large N, there exists a viable intermediation policy $(L^N, \pi^N(.), B_E^N(.), D^N, r_I^N(.), B_I^N(.))$, which provides entrepreneurs with a payoff no less than $U_E^* - \eta$.*

Proof. Fix $\eta > 0$ and choose $(\hat{y}, \varepsilon, c_E(\hat{y}))$ so that $U_E(\hat{y}, \varepsilon, c_E(\hat{y})) \geq U_E^* - \eta$ and $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) > 0$. For any N, let $(L, \pi(.), B_E(.))$ be the loan contract corresponding to this triple $(\hat{y}, \varepsilon, c_E(\hat{y}))$, i.e., let $L = I$, $\pi(y) = w_E + y - \varepsilon$ and $B_E(y) = 1$ if $y < \hat{y}$, and let $\pi(y) = w_E + \hat{y} - c_E(\hat{y})$ and $B_E(y) = 0$ if $y \geq \hat{y}$. Further, set $\delta := U_F(\hat{y}, \varepsilon, c_E(\hat{y}))/2$ and, for any N, specify the finance contract $(D^N, r_I^N(.), B_I^N(.))$ for the intermediary so that $D^N = N(I + A)$,

$$r_I^N(z) \equiv \min(z, N(I + A + \delta)), \tag{76}$$

and $B_I^N(z) = 1$ if $z < N(I + A + \delta)$, $B_I^N(z) = 0$ if $z \geq N(I + A + \delta)$. Clearly this contract is incentive-compatible.

Given this specification of a loan contract for entrepreneurs and a finance contract for the intermediary, consider the intermediation policy $(L, \pi(.), B_E(.), D^N, r_I^N(.), B_I^N(.))$. By (68) - (73), expected payoffs from this intermediation policy are $U_E(\hat{y}, \varepsilon, c_E(\hat{y})) \geq U_E^* - \eta$ for entrepreneurs,

$$Eu_I(w_I + \max(0, \tilde{z} - N(I + A + \delta)) \tag{77}$$

[14] This supremum is not necessarily a maximum of $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$ under the constraint that $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) \geq 0$. The right-hand of (73) may be nonmonotonic in $\hat{y}$. The Pareto frontier may therefore be nonmonotonic, and there may exist a triple $(\hat{y}, \varepsilon, c_E(\hat{y}))$ such that $U_E(\hat{y}, \varepsilon, c_E(\hat{y})) > U_E^*$ and $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) = 0$, with $U_F \leq 0$ on some open neighbourhood of $(\hat{y}, \varepsilon, c_E(\hat{y}))$.

for the intermediary, and

$$Eu_H(w_H + \frac{1}{M}\min[\frac{\tilde{z}}{N} - (I+A), \delta] - B_I^N(\tilde{z})A) \tag{78}$$

for households, where $\tilde{z}$ is again given by (71).

By (77), the given intermediation policy is obviously acceptable to the intermediary. Further, by the law of large numbers, the term $\tilde{z}/N$ in (78) converges almost surely to $E[\pi(\tilde{y}_i) + (1 - B_E(\tilde{y}_i))A]$ as N goes out of bounds By (72), for the given specification of the loan contract $(L, \pi(.), B_E(.))$, this is equal to $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) + I + A = 2\delta + I + A$. The term $\min[\frac{\tilde{z}}{N} - (I+A), \delta]$ in (78) thus converges almost surely to δ as N goes out of bounds. At the same time, the term $B_I^N(\tilde{z})A$ in (78) converges almost surely to zero. By Lebesgue's dominated-convergence theorem, it follows that the households' expected payoff (78) converges to $u_H(w_H + \delta/M)$. Since this is greater than $u_H(w_H)$, it follows that for any sufficiently large N, the intermediation policy $(L, \pi(.), B_E(.), D^N, r_I^N(.), B_I^N(.))$ is acceptable to households, and hence is viable. This completes the proof of Proposition 7. ■

Proposition 7 has two easy corollaries, which provide the analogues of Propositions 2 and 3 in Sections 3 and 4:

Corollary 8 *Assume that the set of triples $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) > 0$ is nonempty, and that $w_H < I - w_E$ so that more than one household is required to finance an entrepreneur's investment. Then for any sufficiently large N, there exists a viable intermediation policy which makes entrepreneurs strictly better off than any acceptable finance contract they can directly obtain from households.*

Proof. Let $(L, r_E(.), B_E(.))$ be an incentive-compatible contract for financing entrepreneur i that is acceptable to households when there are $\hat{H}_N$ of them sharing it. This contract provides participating a household h with the expected payoff

$$Eu_H(w_H + \tilde{x}_h + \frac{1}{\hat{H}_N}(r_E(\tilde{y}_i) - L) - B_E(\tilde{y}_i)A), \tag{79}$$

where $\tilde{x}_h$ is the household's aggregate net return from other contracts, and by assumption, $\tilde{x}_h$ is independent of $\tilde{y}_i$. Acceptability requires that (79) be no less than $Eu_H(w_H + \tilde{x}_h)$. Given that $u_H(.)$ is concave and $\tilde{x}_h$ and $\tilde{y}_i$ are independent, this in turn requires that

$$Er_E(\tilde{y}_i) - L - \hat{H}_N EB_E(\tilde{y}_i)A \geq 0. \tag{80}$$

Since more than one household is required to finance the entrepreneur's investment, $\hat{H}_N \geq 2$, and (80) implies

$$Er_E(\tilde{y}_i) - L - 2EB_E(\tilde{y}_i)A \geq 0. \tag{81}$$

The entrepreneur's expected payoff from the contract $(L, r_E(.), B_E(.))$ is therefore bounded above by the maximum payoff that he can get from contracting with a fictitious risk-neutral financier when the monitoring cost of that financier is $2A$ rather than A. As noted above, the results of Townsend (1979) or Gale and Hellwig (1985) imply that in contracting with a risk-neutral financier any contract is dominated by a "debt contract" with monitoring if and only if $\tilde{y}_i < \hat{y}$, a living allowance ε when monitoring occurs and a debt service obligation $w_E + \hat{y} - c_E(\hat{y})$ when monitoring does not occur. The entrepreneur's payoff expectation from this "debt contract" is $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$, the fictitious risk-neutral financier's payoff expectation, with monitoring cost $2A$ rather than A is $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) - G(\hat{y})A$.

The entrepreneur's expected payoff from the contract $(L, r_E(.), B_E(.))$ is therefore bounded above by the maximum of $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$ over the set of triples $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) \geq G(\hat{y})A$. By inspection of (73),with $w_H < I - w_E$ and hence $0 < I - w_E$, the constraint $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) \geq G(\hat{y})A$ can only be satisfied if $\hat{y} > 0$, hence $G(\hat{y}) > 0$. The maximum of $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$ over the set of triples $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) \geq G(\hat{y})A$ is therefore strictly less than U_E^*, the supremum of $U_E(\hat{y}, \varepsilon, c_E(\hat{y}))$ over the set of triples $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) > 0$. Given this observation, the corollary follows immediately from Proposition 7. ■

Corollary 9 *Assume that $w_E < I$ and that there exists exactly one triple $(\hat{y}, \varepsilon, c_E(\hat{y}))$ for which $U_E(\hat{y}, \varepsilon, c_E(\hat{y})) = U_E^*$ and $U_F(\hat{y}, \varepsilon, c_E(\hat{y})) = 0$. For any N that is large enough so that a viable intermediation policy exists, let $(L^{*N}, \pi^{*N}(.)$, $B_E^{*N}(.)$, D^{*N}, $r_I^{*N}(.)$, $B_I^{*N}(.))$ be an optimal entrepreneur-oriented intermediation policy, and consider the induced consumption pattern $c_E^{*N}(\tilde{y}_i)$ of entrepreneur i, where, for any $y \in [0, Y]$, $c_E^{*N}(y) \equiv w_E + L^{*N} - I + y - \pi^{*N}(y)$, as in (41). As N goes out of bounds, $c_E^{*N}(\tilde{y}_i)$ converges in distribution to the random variable $c_E^{*\infty}(\tilde{y}_i)$, where, for any $y \in [0, Y], c_E^{*\infty}(y) = \varepsilon$, if $y < \hat{y}$, and $c_E^{*\infty}(y) = y - \hat{y} + c_E(\hat{y}) \quad$ if $y \geq \hat{y}$.*

Proof. Given that $u_I(.)$ and $u_H(.)$ are concave, by (69) and (70), viability of the policy $(L^{*N}, \pi^{*N}(.), B_E^{*N}(.), D^{*N}, r_I^{*N}(.), B_I^{*N}(.))$ implies

$$D^{*N} - N(L^{*N} + A) + E\tilde{z} - Er_I^{*N}(\tilde{z}) \geq 0 \tag{82}$$

and

$$\frac{1}{NM}(Er_I^{*N}(\tilde{z}) - D^{*N}) - EB_I^{*N}(\tilde{z})A \geq 0. \tag{83}$$

Upon combining (82) and (83), one sees that the policies $(L^{*N}, \pi^{*N}(.), B_E^{*N}(.)$, D^{*N}, $r_I^{*N}(.)$, $B_I^{*N}(.))$ satisfy

$$\frac{1}{N}E\tilde{z} - (L^{*N} + A) \geq M\ EB_I^{*N}(\tilde{z})\ A,$$

hence

$$E\pi^{*N}(\tilde{y}_i) - L^{*N} - EB_E^{*N}(\tilde{y}_i)A \geq M\ EB_I^{*N}(\tilde{z})\ A. \tag{84}$$

Along the lines of the argument in the proof of the previous corollary, it follows that for any N the entrepreneurs' expected payoff from the intermediation policies $(L^{*N}, \pi^{*N}(.), B_E^{*N}(.), D^{*N}, r_I^{*N}(.), B_I^{*N}(.))$ is less than U_E^*. In view of Proposition 7, this implies that that the entrepreneurs' expected payoffs from the intermediation policies $(L^{*N}, \pi^{*N}(.), B_E^{*N}(.), D^{*N}, r_I^{*N}(.), B_I^{*N}(.))$ actually converge to U_E^* as N becomes large. Given the uniqueness of the loan contract generating the payoff pair $(U_E^*, 0)$, the corollary follows immediately. ■

A similar analogue is available for Proposition 3. This is left to the reader. It should be noted that, as in the proof of Proposition 3, the argument requires the intermediary's living allowances to be set endogenously, as a function of N.

To conclude, I note that this section has actually introduced *two* modifications of the basic model of Sections 2-4, namely outcome-contingent monitoring of entrepreneurs by the intermediary and outcome-contingent monitoring of the intermediary by final investors. There was not inherent necessity to introduce both modifications jointly. One might also have considered, e.g., a model in which (i) the intermediary employs outcome-contingent monitoring of entrepreneurs and (ii) the final investors are protected by nonpecuniary penalties imposed on the borrower when he reports low return realizations. It is easy to check that with suitable reformulations, the main results of the paper will again be valid in such a model. By comparison to Proposition 2, the case for intermediation would actually be strengthened because the ability to condition monitoring on outcomes provides more flexibility for intermediated finance. The standard of comparison for intermediated versus direct finance in this case would not simply be given by the monitoring cost A, but by the difference between the entrepreneurs' first-best payoff $u_E(w_E + \bar{y} - I)$ and the supremum U_E^* in contracting with a fictitious risk-neutral partner when the incidence of monitoring is chosen optimally; the analogue of Proposition 2 will hold whenever U_E^* exceeds $u_E(\hat{w}_E)$, the best the entrepreneur can get under direct finance.

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