Endogenous Financial Structure in an Economy with Private Information

Kahn, James

Working Paper No. 96

August 1987

ENDOGENOUS FINANCIAL STRUCTURE
IN AN ECONOMY WITH PRIVATE INFORMATION

James A. Kahn
University of Rochester

Working Paper No. 96

April 1987, revised August 1987

I have benefited from discussions with Jeff Banks, Marcus Berliant, Marvin Goodfriend, and Torsten Persson, as well as from the comments of participants in the Money Workshop at the University of Rochester.

Abstract

Recent research has considered asymmetric information in financial markets as a possible explanation for how these markets may interact adversely with real economic variables. This paper derives equilibrium financial contracts in a model with potential adverse selection problems. The results show that if agents are allowed sufficient flexibility in structuring their financial transactions an efficient outcome is still attainable. In addition, certain patterns in financial structure emerge, as some types of arrangements are ruled out in equilibrium. Equilibrium contracts can be expressed in terms of debt and equity, with different types of agents generally issuing different types of liabilities.

Simple full-information models of credit markets have little to say about how firms decide on the structure of their financial liabilities, nor can they account for a number of phenomena that have been observed or alleged such as bank panics and credit rationing. Recent research in this area has therefore focused on markets with various kinds of private information problems. One strand of this literature (e.g. Myers and Majluf (1984), Greenwald, Stiglitz, and Weiss (1984)) has considered the financial structure question and found an unambiguous "pecking order" biased against equity finance. Another has focused on the welfare implications of imperfect credit markets, with a common theme being the potential for seriously deficient or unstable outcomes (e.g. Mankiw (1986), Diamond and Dybvig (1983)).

This paper presents a model of a simple financial market with asymmetric information that comes to strikingly different conclusions. It demonstrates that when agents are allowed sufficient flexibility in structuring their financial transactions not only is an efficient outcome attainable, but also the universal pecking order disappears. Some firms choose debt over equity, some choose equity over debt. The results suggest that the earlier conclusions are sensitive to assumptions that arbitrarily restrict market transactions.[1]

In the paper, the nature of the private information possessed by agents leads to a variety of financial arrangements ("contracts") that can support the equilibrium. A broad range of these are shown to be equivalent to particular combinations of debt and equity. More than one type of contract is generally necessary (and sufficient) to achieve an efficient allocation, although the types of contracts that emerge in equilibrium depend on the precise nature of the private information. Debt arises in this model with *ex* *ante* private information because it permits a pattern of profit distributions that distinguishes between informed and uninformed investors, and thereby provides incentives for truthful revelation beforehand. This is in contrast to the models of Diamond (1984) and Gale and Hellwig (1985) in which debt is shown to be optimal with *ex post* private information.

One unusual feature of the model is that agents may have private information both about the riskiness and the expected return of their investment opportunities. This turns out to be behind the appearance of both debt and equity; in subsequent sections it is shown that only one or the other need arise if projects differ only in risk *or* in return. In the more general case, the "financial structure" of an individual investment project--for example, the precise linear combination of debt and equity financing obtained by its "owners"--is not unique, but neither is it completely indeterminate as in the symmetric information case (e.g. Modigliani and Miller (1958), Merton (1977)). A pattern emerges in which project owners have limited flexibility in the type of financing they obtain, and that range depends on the particular (privately known) characteristics of the projects. Roughly speaking, high risk-high return projects get financed with a greater proportion of debt, but the overall relationship between capital structure and project characteristics is ambiguous. For example, equity financing is *not* (as suggested by Greenwald, Stiglitz, and Weiss (1983)) necessarily a bad signal about the expected return on the project; even if it is, this in itself does prevent it from being a viable alternative to debt, because it may also be a good signal about riskiness.

The emphasis of the paper is positive rather than normative, that is, to derive equilibrium financial arrangements. The point is not to assess the consequences of contracts that take a particular form, nor is it to derive optimal contracts--although the equilibrium concept employed in the paper has certain optimality properties (e.g. Pareto optimality). The question it seeks to answer is simply "What kinds of financial arrangements would we expect to observe?" The main body of the paper describes a simple and primitive environment with risk-neutral agents in which financial contracts can have an arbitrary structure. The notion of equilibrium employed in the paper is similar to that of Boyd and Prescott (1986): an allocation is an equilibrium if it is in the core of the economy and satisfies certain incentive compatibility constraints.

After describing the general features of the equilibrium I give an interpretation of the results that invokes debt and equity as arrangements that support the equilibrium. Section II looks at some special cases in which only one or the other type of contract is required to support the equilibrium. Section III extends the model (in a slightly simplified version) to allow for risk-aversion. The final section provides a summary and discussion of the results.

I. The Model

A. Assumptions and Notation

The setup is as follows: At time 0 a large (i.e. countably infinite) number of risk-neutral agents come into existence in possession of an equal quantity of a homogeneous non-storable investment good. Each agent also possesses knowledge (potential "ownership") of an investment project. Projects vary in terms of their probability distributions across outcomes. There are two types of projects (or agents), denoted r (risky) and s (safe), and three possible project outcomes, indexed by h (high), m (medium), and l (low). Each agent's type is private information, but project outcomes are publicly observed.

A social planner, assumed to know the population distributions of characteristics, first announces allocations of investments by each type and payoffs to each type of investor contingent on project outcomes. Individual investment portfolios may be determined randomly (as in Prescott and Townsend's (1984) lotteries) if heterogeneity is required. After the social planner's announcement individual agents decide whether to participate, or whether to drop out and form coalitions. Participating agents announce their types and are given their portfolios of investments. An agent may lie about his type if it is in his private interest to do so (given what others are doing). Even after they decide to participate to the extent of announcing their types, any agent or group of agents may drop out after their actual portfolio of investments is announced (i.e. after any lottery occurs). Investment then takes place. At time 1 the project outputs are realized, distributions of the payoffs to individual agents take place, and each agent consumes his total payoff.

Throughout the paper I will refer to informed investors in projects as "owners", uninformed investors as "outsiders." Table 1 lists the main notation to be used in describing the model. The convention will be that i and k index types (r,s) and j indexes outcomes (h,m,l).

Table 1: Notation

a_i	proportion of type i in population $(i=r,s;\ a_r+a_s=1)$
e	per capita endowment of investment good $(0 < e < 1)$
y_j	project output $(j=h,m,l;\ y_h > y_m > y_l)$
p_{ij}	probability that a type i project yields output y_j
x_{ik}	average investment by type i outsiders in type k projects
z_i	average investment by type i owners in their projects

π_{ij} payoff to type i project owner given outcome j, per unit of his investment z_i

d_{ij} payoff to outsiders (regardless of type) in a type i project with outcome j, per unit of investment

$u_{i\iota}$ $z_\iota \sum_j p_{ij}\pi_{\iota j} + \sum_k \sum_j x_{\iota k} p_{kj} d_{kj}$ $(i,\iota=r,s,b)$, the utility of a type i agent who claims to be type ι under a particular allocation rule. We will just use u_i if $\iota=i$.

The term "allocation" refers to the set $\{z,x,\pi,d\} \equiv \{z_i, x_{ik}, \pi_{ij}, d_{kj}$ $(i,k=r,s,\ j=h,m,l)\}$. u_i will denote a representative type i agent's utility from such an allocation, whereas $\hat{u}_i$ will do the same for some alternative allocation $\{\hat{z},\hat{x},\hat{\pi},\hat{d}\}$.

For simplicity I will assume that $y_l = 0$. There is a maximum investment of one unit per project. The payoff given to any agent must be non-negative with probability one. This rules out arrangements in which incentive-compatibility is achieved by use of arbitrarily large negative payments. It also rules out "non-pecuniary" penalties as in Diamond (1984).

The setup described above clearly allows for fairly general financial arrangements, although there are some restrictions implicit in the notation. For example, the distributions to outsiders $\{d_{ij}\}$ are not allowed to depend on the recipient's type. This is not essential, but it greatly simplifies the analysis. It will be clear from the results in this section that nothing would be gained by relaxing this restriction other than introducing the possibility of certain superfluous contract forms. The point is not to consider every conceivable financial arrangement that could ever arise; rather it is show that efficiency is attainable with enough flexibility, and that asymmetric information does rule out some arrangements in equilibrium that would be feasible in a complete-information environment.

I will make (except as noted otherwise) the following assumptions about the probability and population distributions:

(D1) $p_{rh} > p_{sh}$; $p_{rl} > p_{sl}$

(D2) $\overline{y}^r > \overline{y}^s$

(D3) $a_r < e$.

D1 specifies that r projects are "riskier" than s projects. D2 says that the expected return on r projects is higher than on s projects. D3 ensures that even after all r projects are invested up to capacity there will be some endowment left over that can be invested in s projects.

I will further assume that there is some small fixed cost ϵ of undertaking a project, so that in equilibrium all projects actually undertaken will be invested up to capacity. The project payoffs y_i should therefore be interpreted as net of the fixed cost for a unit investment, the gross payoff being $y_i+\epsilon$. The fixed cost is just one way to get both types of projects to require external financing; the main results do not depend on it.

The notion of equilibrium to be employed in the paper is a noncooperative variant of the core, adapted to allow for informational asymmetries, similar to that of Boyd and Prescott (1986). The basic idea is that an equilibrium allocation is one that cannot be blocked by a coalition. A blocking coalition is one that can make all of its members at least as well off as under the proposed allocation, and at least one member strictly better off. As in the economy as a whole (the "grand" coalition), allocations within a coalition must be feasible and incentive-compatible. It is primarily the incentive-compatibility requirements that make this a noncooperative equilibrium concept rather than a cooperative optimality criterion.

To keep matters simple only large coalitions will be considered. In contrast to an economy-wide allocation in which the relative proportions of type r and s agents is common knowledge (and hence known by the planner), a coalition cannot arbitrarily determine the type-composition of its members. A coalition whose ability to block depends on having a membership with a makeup different from that of the population (which will be characteristic of any coalition blocking a Pareto optimal allocation) must satisfy additional incentive-compatibility criteria at the level of the formation of the coalition. The additional restriction is that agents cannot be tempted to lie about their type in order to gain membership in a coalition. This is necessary to assure that a coalition ends up with the proportion of the two types that it intends to have. The assumption will be that a coalition restricts membership of a particular type i by allowing in only a portion $\hat{a}_i/a_i$ of those seeking membership who claim type i. Hence in deciding whether to be truthful or not, an agent will consider not only the allocation rule, but the membership probability as well.

The population distributions a_i, probability distributions p_{ij}, and the per capita endowment e are the social planner's data. Let $\bar{y}^i \equiv \sum_j p_{ij}y_j$, the expected payoff on a project of type i. An **equilibrium** is a set of non-negative numbers $\{z,x,\pi,d\} \equiv \{z_i, x_{ik}, \pi_{ij}, d_{kj}\ (i,k=r,s;\ j=h,m,l)\}$ that satisfies the following conditions:

Feasibility (F)

(F1) $\quad z_i + \sum_k x_{ik} \leq e \qquad (i=r,s) \qquad$ (individual feasibility)

(F2) $\quad a_i z_i + \sum_k a_k x_{ki} \leq a_i \quad (i=r,s) \qquad$ (capacity constraints)

(F3) $\quad \sum_i \sum_j \{a_i z_i \pi_{ij} + \sum_k a_k x_{ki} d_{ij} - y_j[a_i z_i + \sum_k a_k x_{ki}]\} \leq 0$

(aggregate payoff constraint)

Individual Rationality (IR)

$$u_i \geq e\bar{y}^i - (1-e)\varepsilon \quad i=r,s$$

Incentive Compatibility (IC)

$$u_i \geq u_{i\iota} \qquad i,\iota=r,s,b$$

Core Requirement: There should exist no $(\hat{a}_r, \hat{a}_s)$ with $\hat{a}_r+\hat{a}_s=1$, and some other allocation $\{\hat{z},\hat{x},\hat{\pi},\hat{d}\}$, such that the following conditions are satisfied:

(C1) F, IR, IC hold within the coalition.

(C2) If $\hat{a}_i > 0$, then $\hat{u}_i \geq u_i$ for $i=r,s$, with at least one of the two inequalities strict.

(C3) If $\hat{u}_i > u_i$, then either

(i) $\hat{a}_i \geq a_i$, or

(ii) $\hat{a}_i < a_i$ and $(\hat{a}_i/a_i)\hat{u}_i + [1-(\hat{a}_i/a_i)]u_i > \hat{u}_{ik}$, $k\neq i$.

Conditions F1-F3 ensure that physical resource constraints are not violated. The IR conditions ensure that individuals do at least as well under the allocation as in autarky. They are somewhat superfluous in light of the core requirement, though the latter is intended to refer to large coalitions. The IC conditions guarantee that truthful revelation of types is a Nash equilibrium strategy. They do not guarantee uniqueness (for example, lying might also be a Nash equilibrium), but we will see that truth-telling is a strictly dominant strategy for type r agents in this economy, so issues of multiple equilibria do not arise.

The core requirement is that no subset of agents can form a coalition that does better on its own while still satisfying the other requirements of equilibrium. Conditions C1 and C2 are standard and self-explanatory. C3 is the extra incentive-compatibility requirement for coalitions described above, namely that a coalition cannot arbitrarily specify the composition of its members, but must take into account any incentive for agents to conceal their types. The assumption is that there is no problem so long as any type made better off in a coalition has a representation at least as large as in the population as a whole. Under C3(*i*) the coalition does not restrict membership of any type that is made better off in the coalition. Thus if it makes both types strictly better off it has a membership type distribution the same as in the population as a whole; if it makes only one type strictly better off it does not restrict membership of that type, and therefore has at least the population proportion of that type. Under C3(*ii*) the coalition *does* restrict membership of a type that it makes better off; hence it must not provide any incentive for agents of that type to lie just to gain membership in the coalition. (Note that C1 only assures that $\hat{u}_{ik} \leq \hat{u}_i$, not the stronger condition in C3(*ii*).) We will see, however, that C3 will not matter under risk-neutrality, and therefore will not be needed until Section III.[2]

Another way of understanding C3 is as follows: Suppose type i is made strictly better off and type k is indifferent. Every type i agent in the population would want to join the coalition. Since type k agents are indifferent, they can be kept out so as to achieve any $\hat{a}_i > a_i$. The only way to get $\hat{a}_i < a_i$, however, is to actively keep out some agents that would like to be in the coalition. C3(*ii*) allows this, *provided* type i agents do not have incentive to claim type k in order to gain membership.

The aggregate payoff constraint F3 places no restrictions on the relation between the realized output of an individual project and the payoffs to its investors. The social planner can simply add up aggregate output and then distribute it without regard to individual investment portfolios. The core requirement is sufficiently strong, however, that nothing is gained (in terms of welfare) by severing the tie between investment and payoffs on individual projects. It turns out that for any equilibrium allocation based on the definition given above, there is another that gives the same expected consumption to all agents that satisfies a stronger condition:

$$(\text{F3}') \quad a_i z_i \pi_{ij} + \sum_k a_k x_{ki} d_{ij} \leq y_j[a_i z_i + \sum_k a_k x_{ki}] \quad (i=r,s;\ j=h,m,l)$$

(no cross-subsidization)

In other words, the unique Pareto optimum that can be implemented under F3 can also be implemented under F3'. Condition F3' is like a project-by-project constraint that says that total distributions to investors in a given project cannot exceed the *realized* output of that project. Why this more stringent requirement does not affect welfare will be clearer below, but the basic idea is that any non-trivial cross-subsidization (i.e. one that would redistribute expected consumption from one type agent to another) is not in the core. The constraint F3' will be used rather than F3 in the following derivation. The weaker condition will be adopted in Section III when risk-aversion is allowed.

B. Equilibrium

A few characteristics of any equilibrium under F3' are immediately apparent. First, F3' implies that $\pi_{il} = d_{il} = 0\ \forall i$. Second, for each type the IR and IC constraints cannot both be binding. Third, any allocation in the core must be a constrained Pareto optimum (otherwise the coalition made up of the whole economy would deviate). It therefore makes sense first to focus on allocations in which nothing is thrown away (i.e the F constraints hold with equality), all r projects are fully financed, and the minimum number of s projects (per capita) are financed with the remaining endowment.

Given $\pi_{il} = d_{il} = 0$ $\forall i$, the IR conditions can be expressed as follows:

$$(1a) \qquad z_r(p_{rh}\pi_{rh} + p_{rm}\pi_{rm}) + \sum_k x_{rk}(p_{kh}d_{kh} + p_{km}d_{km}) \geq e\bar{y}^r$$

$$(1b) \qquad z_s(p_{sh}\pi_{sh} + p_{sm}\pi_{sm}) + \sum_k x_{sk}(p_{kh}d_{kh} + p_{km}d_{km}) \geq e\bar{y}^s.$$

Let τ_i denote the proportion of type i's investment in type i projects that goes into his own project (on average), i.e. $\tau_i = z_i/(e-x_{ij})$ for $i \neq j$. Now suppose $0 < x_{sr} < e$ and $0 < x_{rs} < e$, so that each type invests positive quantities in two different types of projects. Then for an allocation to be in the core it must be the case that

$$(2a) \qquad p_{rh}d_{rh} + p_{rm}d_{rm} = \tau_s(p_{sh}\pi_{sh} + p_{sm}\pi_{sm}) + (1-\tau_s)(p_{sh}d_{sh} + p_{sm}d_{sm})$$

$$(2b) \qquad p_{sh}d_{sh} + p_{sm}d_{sm} = \tau_r(p_{rh}\pi_{rh} + p_{rm}\pi_{rm}) + (1-\tau_r)(p_{rh}d_{rh} + p_{rm}d_{rm})$$

In other words, if an agent of type i has positive investment in two different types of projects, both must yield the same expected rate of return. Otherwise a coalition could form with slightly different population ratios in which at least one type could do strictly better. For example, suppose we had

$0 < x_{sr} < e$ and $p_{rh}d_{rh} + p_{rm}d_{rm} > \gamma_s(p_{sh}\pi_{sh} + p_{sm}\pi_{sm}) + (1-\gamma_s)(p_{sh}d_{sh} + p_{sm}d_{sm})$. Then form a coalition with $\hat{a}_s < a_s$, $\hat{x}_{sr} > x_{sr}$, and with γ_s, γ_r, and x_{rs} unchanged. This is feasible given the smaller proportion of type s agents in the coalition. It is then possible to reduce d_{rh} and d_{rm} so that type s agents are indifferent to joining the coalition (i.e. $\hat{x}_{sr}[p_{rh}\hat{d}_{rh} + p_{rm}\hat{d}_{rm}] = x_{sr}[p_{rh}d_{rh} + p_{rm}d_{rm}]$), which in turn makes it possible to increase π_{rh} and π_{rm} and thereby leaves type r agents strictly better off.[3]

Nonetheless, the equations (2ab) do not necessarily hold if investors are at corners in their portfolios. A coalition might not then be able to form in such a way as to put more in the higher return investment. In fact it is clear from (1ab) and the distributional assumptions D1-D3 that type r must be at such a corner. Equations (2ab) cannot all hold given the IR conditions because then everyone would have to receive the same expected rate of return of at least $\overline{y}^r$. This is not feasible since some s projects are undertaken. It follows that $x_{rs} = 0$ and

$$(2b') \qquad p_{sh}d_{sh} + p_{sm}d_{sm} < \gamma_r(p_{rh}\pi_{rh} + p_{rm}\pi_{rm}) + (1-\gamma_r)(p_{rh}d_{rh} + p_{rm}d_{rm}).$$

In other words, any core allocation must have type r agents invest only in r projects, and must give them a higher return from doing so than from investing as outsiders in s projects. No coalition could then increase type r agents' investments in type r projects, since they are already at the maximum. On the other hand, s agents need not be at corners, so equation (2a) must hold.

The no-cross-subsidy constraint implies that payoffs to investors in type s projects must have an expected payoff of $\overline{y}^s$ per unit investment. Therefore we have from (2b):

$$(3a) \quad p_{rh}d_{rh} + p_{rm}d_{rm} = \gamma_s(p_{sh}\pi_{sh} + p_{sm}\pi_{sm}) + (1-\gamma_s)(p_{sh}d_{sh} + p_{sm}d_{sm}) = \overline{y}^s,$$

which means that type s agents receive no rents. In other words, the equilibrium rate of return is $\overline{y}^s$ (the return on marginal investments), and this is what type s agents receive in expectation regardless of the composition of their investment portfolio.

Now s projects are only undertaken with whatever endowment is left over after all r projects are at capacity. Furthermore, the number of s projects undertaken will be the minimum that uses up the remaining endowment. Therefore in equilibrium there will be fewer than one s project undertaken per s agent; hence not all s agents can be owners. Given this heterogeneity across s agents, together with the assumption that agents can still block any allocation even after their portfolios are announced, we must have either that

$$(3b) \qquad p_{sh}\pi_{sh} + p_{sm}\pi_{sm} = p_{sh}d_{sh} + p_{sm}d_{sm} = \overline{y}^s$$

or $z_s = 0$, in which case the values of π do not matter since no s agent invests in his own project. So without loss of generality we may assume that (3b) holds. Interpreting γ_s as the *average* share of a type s agent's investment in type s projects that is tied up in his own project, we have that γ_s must lie in the interval $[0,(e-a_r)/a_s]$, where the largest value corresponds to the case in which each s owner has no investment in s projects as outsiders.

A similar sort of indeterminacy afflicts the question of the division of r agents' investments between their own and other type r projects. Being risk-neutral, they are indifferent between putting everything in their own projects and putting some in their own and some in others' provided the expected returns are the same. Because the latter case involves essentially superfluous trades that net out (r agents simultaneously investing in other projects and obtaining additional financing for their own) the results below will focus on the case in which type r agents invest entirely in their own projects.

Although the no cross-subsidization constraint was invoked to demonstrate that type s agents receive no rents, in fact this result holds more generally. To see this, consider an allocation in which some rents go to s agents. Then there exists $\delta > 0$ such that a coalition with $\hat{a}_r = a_r + \delta$ can block this allocation. To see this, suppose that type s agents receive an average payoff of $e\overline{y}^s + \tau$, where $\tau > 0$. Let $\overline{\pi}^r$ denote the expected payment to type r agents. Then the feasibility constraint F3 (or F3') for coalitions implies

$$\text{(4a)} \qquad [\hat{a}_r\overline{\pi}_r + (1-\hat{a}_r)(\overline{y}^s + \tau)]e = \hat{a}_r\overline{y}^r + [(1-\hat{a}_r)e - \hat{a}_r(1-e)]\overline{y}^s$$

This can be solved for $\overline{\pi}^r$ to get

$$\text{(4b)} \qquad e\overline{\pi}^r = \overline{y}^r - (1-e)\overline{y}^s - e\tau(1-\hat{a}_r)/\hat{a}_r$$

Consequently a coalition with $\hat{a}_r$ in the interval $(a_r, e]$ can block an allocation with $\tau > 0$. The only allocations that cannot be blocked by a coalition that maximizes per capita output are those in which all rents go to type r agents.[4]

The following equations are budget constraints relating project payoffs to project output, project-by-project:

$$\text{(5a,b)} \quad e\pi_{rj} + (1-e)d_{rj} = y_j \quad j=h,m$$

$$\text{(6a,b)} \quad \gamma_s \pi_{sj} + (1-\gamma_s) d_{sj} = y_j \quad j=h,m.$$

The incentive-compatibility constraints now simplify to:

$$\text{(7a)} \qquad \bar{y}^r - (1-e)\bar{y}^s]/e \geq (z_s/e)(p_{rh}\pi_{sh} + p_{rm}\pi_{sm}) + ((e-z_s)/e)\bar{y}^s$$

$$\text{(7b)} \qquad \bar{y}^s \geq p_{sh}\pi_{rh} + p_{sm}\pi_{rm}$$

The left-hand sides of (7a) and (7b) are the expected payoffs under truth-telling to type r and type s agents respectively. Equation (7a) ensures that a type r agent cannot gain by claiming he is type s; (7b) similarly ensures that a type s agent does not profit by lying. The fact that a claim of type s limits the expected amount one can invest in one's own project serves to loosen the IC constraint for type r agents. If they lie, not only do they get a different payoff structure, but they cannot invest as much in their own projects.

We can now prove the following result:

Proposition 1: An equilibrium with a first-best outcome always exists.

(Proof: We can use equations (5a,b) and (6a,b) to eliminate d_{rh}, d_{rm}, d_{sh}, and d_{sm}. Further simplification of the IC constraints (6a,b) leaves us with the following conditions for equilibrium:

$$\text{(i)} \qquad p_{sh}\pi_{rh} + p_{sm}\pi_{rm} \leq \bar{y}^s$$

(ii) $p_{rh}\pi_{rh} + p_{rm}\pi_{rm} = [\overline{y}^r - \overline{y}^s(1-e)]/e.$

(iii) $p_{sh}\pi_{sh} + p_{sm}\pi_{sm} = \overline{y}^s$

(iv) $p_{rh}\pi_{sh} + p_{rm}\pi_{sm} \leq [\overline{y}^r - \overline{y}^s(1-z_s)]/z_s.$

(v) $0 \leq \pi_{rh} \leq y_h/e, \; 0 \leq \pi_{rm} \leq y_m/e$

(vi) $0 \leq \pi_{sh} \leq y_h/\gamma_s, \; 0 \leq \pi_{sm} \leq y_m/\gamma_s$

where $z_s < e$ and is limited by the number of s projects undertaken. Conditions (i) and (ii) determine the set of equilibrium values of $\pi_{r\cdot}$ (subject to the non-negativity constraints on π and d embodied in (v)), while (iii) and (iv) do the same for $\pi_{s\cdot}$ (subject to (vi)). The question of existence hinges on whether there is always at least some solution to (i)-(iv) that satisfies (v) and (vi). This is assured by the fact that the intersection of the lines given by (i) (as an equation) and (ii) (point B in Figure 1) satisfies (v) and (vi) for any value of e in the unit interval.)

Why do the informational asymmetries not prevent this economy from reaching the full-information optimum? Departure from the first-best in other models with private information generally occurs for one of two reasons. First, there may be some degree of pooling of types, which can allow inefficient investment to occur. Second, the mechanism by which separation or incentive-compatibility is enforced may itself affect welfare.[5] For example, in the early models of insurance (e.g. Rothschild and Stiglitz (1974)), the quantity of insurance protection purchased is a signal of privately known risk characteristics. Hence the separation of high- and low-risk types requires joint price-quantity contracts that preclude first-best optimality. In our case, however, neither of these problems arises. There is no pooling, and the form of the contract itself does not directly affect welfare. This will not be the case with risk-averse agents; then the optimal contract precludes first-best risk-sharing.

It should also be noted that in general neither incentive-compatibility constraint will be binding in equilibrium. Although there are contracts at extreme points in the equilibrium set that are also on the boundary of the set of incentive-compatible contracts, there is no reason for choosing one of them over any other. Here again, though, this will change in Section III when risk aversion is considered.

Given existence, the next step is to characterize the set of equilibria in more detail. There generally is not a unique equilibrium in terms of π and d, but all equilibria are the same in terms of the expected payouts to each type. The following extended example gives some insight into what the equilbria look like.

Example 1: Suppose $e = 0.3$, $y_h = 2$, $y_m = 1$, $a_r = 0.2$, and the probabilities p_{ij} are

	h	m	l
r	0.6	0.1	0.3
s	0.1	0.8	0.1

Then we have $\overline{y}^r = 1.3$, $\overline{y}^s = 1.0$. Any equilibria in this economy are convex combinations of the following pairs (which represent the endpoints of the two line segments AB and CD in Figure 1):

Table 2: Equilibrium Contingent Payoffs

	h	m	l
$\pi_{r\cdot}$	$(\frac{1}{0.3}, \frac{.957}{0.3})$	$(0, \frac{.255}{0.3})$	$(0,0)$
$d_{r\cdot}$	$(\frac{1}{0.7}, \frac{1.043}{0.7})$	$(\frac{1}{0.7}, \frac{.745}{0.7})$	$(0,0)$
$\pi_{s\cdot}$	$(\frac{1.037}{.125}, 0)$	$(\frac{.027}{.125}, \frac{.156}{.125})$	$(0,0)$
$d_{s\cdot}$	$(\frac{.963}{.875}, \frac{2}{.875})$	$(\frac{1.973}{.875}, \frac{.844}{.975})$	$(0,0)$

In each case type r agents invest 0.3 in their own projects and obtain 0.7 externally. The second half of the table is based on the assumption that each type s agent invests 0.175 in r projects, and then enters a lottery in which with probability .875 he invests the remaining 0.125 in another s project; with probability .125 he invests in his own project and obtains .875 externally. Per capita expected output is 0.360, whereas under autarky it would be 0.318 (ignoring fixed costs).

In the equilibrium corresponding to the first of each pair, type r agents receive a net payoff of 1 with outcome h, and 0 otherwise. They pay a total of 1 per project to outside investors with either the h or m outcome. In the other endpoint of the equilibrium set the pattern is similar but less extreme: type r agents receive a little less in h and a little more in m, while outside investors' payoffs strictly increase with the outcome of the project. It is easy to check that in any equilibrium the expected payoff to each type r agent is 0.6 (2 per unit of investment) and is 0.3 (1 per unit of investment) to each type s.

The situation for s projects is a little trickier. There are equilibria in which the owner actually does better under y_m than under y_h. The reason this happens is because type s agents claim that y_h is relatively unlikely for them, so payoffs that are concentrated in the more likely state m are consistent with incentive-compatibility. If we were arbitrarily to restrict contracts to be non-decreasing in y, then, for example, the second equilibrium would have $\pi_{sh} = \pi_{sm} = 0.139/0.125$, $d_{sh} = 1.861/0.875$, $d_{sm} = 0.861/0.875$.

It turns out that all of the equilibria with monotonic payoffs in this example represent convex combinations of debt and equity contracts. The key point, however, is that the type of finance obtained by each type of agent is constrained by the presence of private information. Let us define debt and equity contracts in general as follows: A project owner of type i who invests his own endowment e and obtains 1-e externally for a unit investment in his project has an external debt ratio of θ, interest rate R, and a price of equity V, if his net return $e\pi_{ij}$ ($j=h,m,l$) has the form

$$(8) \qquad e\pi_{ij} = \left\{1 - \frac{(1-\theta)(1-e)}{V[e+(1-\theta)(1-e)]}\right\}\cdot\max\,[y_j - R\theta(1-e), 0] \qquad 0 \le \theta \le 1,$$

and the total payoff to outside investors $d_{ij}(1-e) = y_j - e\pi_{ij}$. A contract with $\theta=1$ has the owner borrow (1-e) with limited liability at a rate R. A contract with $\theta=0$ has the owner sell shares in the project at a price of V per share (i.e. the value of the shares held by outsiders is V(1-e)). Values of θ between 0 and 1 represent combinations of external debt and equity finance.

With regard to the example, we are looking for values of (θ,R,V) such that the contingent payoffs given by (8) correspond to the equilibria in Table 2. It also seems most plausible to require each component of the contract (i.e. the debt and equity components considered separately) to have the same expected return. That is, a project financed by both debt and equity ought to yield the same expected return to both debtholders and outside shareholders. Otherwise the two liabilities could only be issued as a package. In the example this means that both debt and equity should yield outside investors an expected payoff of 1.

First consider r projects. It is easy to see that the first endpoint of the equilibrium set given in Table 2 (point A in Figure 1) corresponds to a contract with $\theta=1$ and $R=1/0.7$ (0.7 is the probability of repayment of the debt), i.e. 100 percent debt. Although the price of equity need not be determined, its shadow value would be approximately the expected return per share, which is 2. Debtholders for a given project receive a total of $R(1-e) = 1$ if the project payoff is y_h or y_m, zero otherwise; project owners get the residual.

The contract corresponding to the other endpoint (point B in Figure 1) is not as obvious, but if there is one it clearly must be some mixture of debt and equity. The solution can be found in two steps: First, solve the following two equations for θ and Q:

$$(2-\theta)Q + \theta = 1.043$$

$$(1-\theta)Q + \theta = 0.745.$$

These equations represent the returns to outside investors in the h and m outcomes, imposing the requirement that $R=1/0.7$ (this is necessary for debt to have an expected return of 1). The first term is the equity component. Q is the share of the project's residual payoffs that goes to outside shareholders; it satisfies $Q \equiv \frac{(1-\theta)(1-e)}{V[e+(1-\theta)(1-e)]}$, where in this case $e=0.3$. The second term θ is the payment to debtholders.

The solution to the above system turns out to be $\theta = 0.636$, $V = 1.54$.

This means that the second endpoint corresponds to external financing that is 63.6 percent debt (with an interest rate of $1/0.7 - 1$) and 36.4 percent equity (sold at a price of 1.54 per share). Any further lowering of the debt-equity ratio is not an equilibrium because type s agents would have an incentive to lie and claim they are of type r.

A similar exercise for the s projects shows that they can be financed with as much as approximately 100 percent debt (at a rate of $1/.9 - 1$) and as little as 0 percent debt. These correspond respectively to points D and C in Figure 2. The reason 100 percent debt finance is possible in this example is only because type s agents have at most a 0.125 probability of investing in their own projects. This keeps type r agents (who have the most to gain from investing in their own projects) from claiming type s in order to obtain lower interest rates on their debt.

Thus in the example we have a situation in which equilibrium financial structure corresponds to external financing that is mostly or entirely debt for r projects, possibly all equity for s projects. The intuition for this result is as follows: At a given interest rate, type r agents have more to gain by issuing debt than type s agents because r projects are riskier. Investors know this and demand a higher interest rate on the debt, which further discourages type s agents from issuing debt. In this case the debt is also a signal of high return to shareholders as well, which leads to a price of equity V that exceeds unity. If type r projects were financed with a too low a proportion of debt (i.e. below 0.636), the penalty of the high interest rate would not be big enough to offset the reward of the high price of equity; type s agents would have incentive to lie, and the equilibrium would break down. This limits the extent to which type r projects can be financed with equity.

There is a limited sense in which only one type of contract (debt) is necessary to achieve the efficient outcome in this example, given that type s projects can be financed with debt as well. Even so, different interest rates are used, and incentive-compatibility is enforced by having type s projects undertaken only with probability 0.125. Moreover this is not a general characteristic of this model, only one that happens to be a feature of this particular example. For example, making a_r smaller (so that more type s agents can be owners) would work in the direction of making 100 percent debt finance infeasible for s agents. The probability of being an owner would be higher, and thus some equity would have to be issued to discourage type r agents from claiming type s in order to be able to borrow at the "safe" rate.

The following result holds more generally:

Proposition 2: Debt finance for r projects and equity finance for s projects is always an equilibrium, provided default only occurs in state l.

The proof of this proposition is simply a matter of verifying that the two types of contracts satisfy all of the requirements of equilibrium. The condition that default only occur in state l is given by the following:

$$\text{(D4)} \qquad y_m \geq (1-e)\overline{y}^s/(p_{rh}+p_{rm})$$

Condition (D4) is sufficient for Proposition 2 but may not be necessary.

To summarize the results of this section, privately observed differences in project characteristics result in an equilibrium in which financial structure is not arbitrary but serves as a mechanism for self-selection of different agent types. The *ex ante* Pareto optimum can be achieved with linear combinations of debt and equity contracts. Neither debt nor equity by itself is a contract that can support the equibrium.

It is not hard to see the possibilities if cross-subsidization is allowed. The simplest thing for the social planner to do is to treat type r agents as before, while promising a certain $\overline{y}^s$ to any agent claiming to be type s. This begins to look a bit like Leland and Pyle's (1977) partial equilibrium model in which owners of better projects signal quality by their willingness to hold more equity in their own projects. The Leland-Pyle result hinges on risk-aversion, though, and on the particular contract forms they assume (equity and "risk-free" debt).

II. Alternative Assumptions

In this section I consider alternatives to the distributional assumptions D1-D3. The analysis will be applied in turn to two limiting cases of the previous assumptions: equal expected output for each type of project, and equal probability of zero output for each type. These are common simplifying assumptions (e.g. Stiglitz and Weiss (1981), Leland and Pyle (1977), Greenwald, Stiglitz, and Weiss (1983)), but the results here will highlight the dangers of combining such assumptions with restrictions on the form of the financial contract.

A. Equal Expected Output

Suppose now that $\overline{y}^r = \overline{y}^s \equiv \overline{y}$. In this case it will not matter which projects are financed, but there will still be some restrictions on equilibrium financial structures. The main restriction is that the expected returns to all types of projects and all types of investors have to be the same. Incentive-compatibility constraints must also be satisfied. So we have

$$p_{ih}\pi_{ih} + p_{im}\pi_{im} = p_{jh}d_{jh} + p_{jm}d_{jm} = \overline{y} \quad \forall i,j=r,s$$

$$p_{ih}\pi_{ih} + p_{im}\pi_{im} \geq p_{jh}\pi_{ih} + p_{jm}\pi_{im} \quad \forall i,j=r,s$$

We also have the feasibility constraints F1-F3'. This gives us as before a system of six equations and eight unknowns, along with a number of inequalities that have to be satisfied. The solution is depicted in Figure 2. The important difference in this case is summarized in the following proposition.

Proposition 3: If $\overline{y}^r = \overline{y}^s$, then it is posible to support the equilibrium with a single contract that is equivalent to 100 percent equity finance.

The contract represented by point B in Figure 2 is easily seen to be $\pi_{ij}=d_{ij}=y_j$ for $i=r,s$, $j=h,m,l$. There are of course other equilibria in which each type of investor obtains financing with a different type of contract. What this means is that if projects differ only in riskiness, the unique *single* contract that supports the equilibrium is 100 percent equity. Yet this is exactly the setting in which many authors (e.g. Stiglitz and Weiss (1981), Keeton (1978), Jaffee and Russell (1976)) have analyzed debt contracts. This result, together with the others in this paper, suggests that debt arises when it is needed to support the equilibrium. Further justification is required for the assumption that credit contracts are exclusively debt when theory suggests they should be exclusively equity.

B. Equal Default Risk

Now suppose that $p_{rl} = p_{sl}$ and return to the assumption that $\overline{y}^r > \overline{y}^s$. We will see that once again the equilibrium can be supported by a single contract, in this case debt, provided default occurs only in state l. The intuition is that since the informational asymmetry is confined to the expected return dimension, equity finance suffers from adverse selection problems while debt does not.

Let the ϕ denote the probability of repayment of the debt $p_{\cdot h} + p_{\cdot m}$. A debt contract satisfies the following:

$$(9) \qquad d_{ih} = d_{im} = \overline{y}^s/\phi \quad i=r,s$$

with $\{\pi_{ij}\}$ determined by (3a,b) and (5a,b). This contract satisfies the requirements of equilibrium as given in the proof of Proposition 1. Here again is a case in which one contract form (debt) arises in equilibrium because it works where others (e.g. equity) do not.

III. Risk Aversion

The assumption of risk-neutrality has simplified the analysis by making an agent's expected utility from entering into a financial contract equivalent simply to its expected payoff. It is also the reason for the large number of contracts that are consistent with equilibrium. In this section I investigate the question of how risk-aversion might shrink (or otherwise affect) the set of equilibrium contracts.

First consider type s agents. Since nothing is gained by requiring a type s agent to have more than a negligible stake in his own project, clearly they should just receive $e\overline{y}^s$ with probability one. This amounts to a share in the proceeds from a fully diversified portfolio of type s projects and outside investment in type r projects, each component of which has an expected rate of return of $\bar{y}^s$. This could be accomplished by, for example, a financial intermediary that pays a rate $\bar{y}^s$ in return for agents' endowments and projects. The intermediary would in effect take over the type s projects (i.e. be the residual claimant), although the original project owners might still be paid a competitive wage to implement the projects.[6]

Type r agents will clearly have to bear risk, since any arrangement that yields a certain payoff greater than $\bar{y}^s$ will induce type s agents to lie. It is not, however, the willingness to bear risk per se that is crucial for incentive-compatibility (as in, e.g., Leland and Pyle, 1977). This is clear from the analysis in Sections I and II. There type s agents did not care about risk; the unattractiveness of the contracts for type r projects to type s agents was because they would yield a lower expected payoff.

In keeping with the notation of previous sections, suppose that type r agents invest z_r in their own projects (with contingent payments of π_{rh} and π_{rs}) and $e-z_r$ in a risk-free asset composed of a diversified portfolio of type r investments. Suppose also that their preferences over uncertain outcomes can be described by their expected utility using a concave utility function u defined on certain payments. Then agents' expected utilities will be

$$(10) \qquad Eu^r = p_{rh}u[z_r\pi_{rh} + (e-z_r)\bar{\pi}^r] + p_{rm}u[z_r\pi_{rm} + (e-z_r)\bar{\pi}^r] + p_{rl}u[z_r\pi_{rl} + (e-z_r)\bar{\pi}^r]$$

$$(11) \qquad Eu^s = u(e\bar{y}^s),$$

where, as before, $\bar{\pi}^r \equiv p_{rh}\pi_{rh} + p_{rm}\pi_{rm} + p_{rl}\pi_{rl}$. The payoffs $(\pi_{rh}, \pi_{rm}, \pi_{rl})$

must satisfy the constraint that what is leftover for distribution to type s investors has an expected rate of return of $\overline{y}^s$, that is,

$$\text{(12)} \qquad e\overline{\pi}^r = \overline{y}^r - \overline{y}^s(1-e)$$

Note that $z_r > 0$ amounts to a mean-preserving spread in the distribution of a type r agent's end-of-period wealth. The more important factor in achieving incentive-compatibility, however, is the tilt of the payoff structure toward the h outcome. As in the risk-neutral case, the equilibrium will involve type r agents getting more in the event their project yields y_h. This contract is unattractive to type s agents, for whom the y_h outcome is less likely.

It is somewhat easier to handle this problem if it is reformulated as follows. We can let α_i denote $z_r\pi_{ri} + (e-z_r)\overline{y}^s$ $(i=h,m)$ and solve for the set of $\{\alpha_i\}$ that maximizes type r utility subject to feasibility and incentive-compatibility constraints. It is clear intuitively that the incentive-compatibility constraint for type s agents will be strictly binding now, since any slack would imply that type r agents could attain some combination of higher return or lower risk without tempting any type s agents to misrepresent themselves. This was not the case before when the equilibrium maximized type r agents' expected return without regard to risk.

It will also turn out to simplify matters greatly to set $p_{rm} = p_{sm} = 0$, so that there are only two outcomes. In order to have $\overline{y}^r > \overline{y}^s$ we must then replace assumption D1 by the assumption that $p_{rh} > p_{sh}$. The fact that s projects now have a greater probability of a bad outcome does not really matter because s projects will all be pooled anyway, and therefore will effectively be risk-free.

The problem for the social planner, then, is

$$\max_{\alpha_h,\alpha_l} Eu^r = p_{rh}u(\alpha_h) + p_{rl}u(\alpha_l)$$

subject to

$$(13) \qquad p_{sh}u(\alpha_h) + p_{sl}u(\alpha_l) \leq u(e\overline{y}^s)$$

$$(14) \qquad p_{rh}\alpha_h + p_{rl}\alpha_l = [\overline{y}^r - \overline{y}^s(1-e)]$$

Condition (13) is the IC constraint for s agents. The reason type s agents do not get any rents in equilibrium is basically the same here as under risk-neutrality: Suppose type s agents receive $e(\overline{y}^s+\tau)$, $\tau > 0$. Then the constraints corresponding to (13) and (14) faced by a coalition with $\hat{a}_r$ type r agents become

$$(13') \qquad p_{sh}u(\alpha_h) + p_{sl}u(\alpha_l) \leq u(e(\overline{y}^s+\tau))$$

$$(14') \qquad p_{rh}\alpha_h + p_{rl}\alpha_l = \overline{y}^r - \overline{y}^s(1-e) - e\tau(1-\hat{a}_r)/\hat{a}_r.$$

Clearly the IC constraint is relaxed for $\tau > 0$, leaving room for increasing α_h and/or α_l relative to what would be obtainable with (13) and (14) by having $\hat{a}_r > a_r$. Thus once again a coalition with $\hat{a}_r$ in the interval $(a_r, e]$ can block any allocation with that has $\tau > 0$. The feasibility condition (14) incorporates this result that type s agents receive $e\overline{y}^s$ in the optimal allocation.

Substituting equation (14) into the maximand and differentiating yields the first-order condition

$$(15) \qquad u'(\alpha_l) - u'(\alpha_h) = \lambda\left\{ \frac{p_{sl}}{p_{rl}} u'(\alpha_l) - \frac{p_{sh}}{p_{rh}} u'(\alpha_h)\right\}$$

where λ is the shadow price of the IC constraint. Equations (13)-(15) are necessary conditions for the $\{\alpha_i\}$ to be equilibrium values.

It is not generally possible to obtain closed-form solutions for this problem, but for a given value of λ we can at least characterize the solution. From equation (15) we have

$$(16) \qquad u'(\alpha_h) = u'(\alpha_l)\theta,$$

where $\theta \equiv (1 - \lambda \frac{p_{sl}}{p_{rl}})/(1 - \lambda \frac{p_{sh}}{p_{rh}})$. Assuming that $\theta > 0$, these expressions have straight-forward interpretations. If we had $\lambda = 0$, or if type s and type r agents were alike (i.e. $p_{rh} = p_{sh}$), then $\theta = 1$ and perfect insurance is achieved. Thus it is clear that under the assumptions of this paper perfect insurance is impossible, since the IC constraint would have to be violated. Thus $\lambda > 0$ and $\theta < 1$. Intuitively, type r agents distinguish themselves by holding a non-negligible portion of their portfolio in their own projects. In doing so they get a higher return, but also bear some risk. This is depicted in Figure 3. Type r agents prefer point A to the risk-free allocation at point B, whereas type s agents are indifferent between the two.

There is also the possibility that the "pooled" outcome in which all returns are shared equally is preferred to the above arrangement. If the proportion of type s agents in the population is small enough, then type r agents will prefer a risk-free pooled return to the higher risky return achieved in the "separating" equilibrium (since not much in terms of expected return is lost by pooling), and the equilibrium breaks down. This is a well-known problem with the Nash equilibrium concept in this sort of model (see, for example, Rothschild and Stiglitz (1974), Riley (1978)) and remains a potential problem here. In Figure 3 this situation is illustrated by point C, which represents a possible pooled return. Note however that condition C3 is applicable in this case: a coalition with $\hat{a}_s$ small cannot necessarily block with a pooled allocation, because type s agents would have to be discriminated against in forming the coalition. The fact that both types receive the same allocation in the coalition means that C3(*ii*) cannot be satisfied (that is, $\hat{a}_s < a_s$ would always induce a type s agent to claim type *r* in order to get into the coalition), and C3(*i*) implies that $\hat{a}_s \geq a_s$. This means that it is possible to rule out this particular blocking coalition if a_s is sufficiently large. It should also be also be noted that this breakdown does not arise in the risk-neutral case, and is therefore unlikely to be a problem (given the assumption that $a_s > 1-e$) for small or moderate degrees of risk-aversion.

IV. Conclusions

This paper has demonstrated that while informational asymmetries can have an effect on financial structure by ruling out certain arrangements, there is no general rule or pecking order that holds for all firms. Moreover, granting economic agents sufficient flexibility in the kinds of contracts they can enter into may allow an economy to reach the first-best despite adverse selection problems.

Recent research in this area (e.g. Boyd and Prescott (1986), Prescott and Townsend (1984)) has considered the question of whether constrained Pareto optimal outcomes can be achieved with decentralized markets, or whether some kind of large coordinating institution such as a financial intermediary is necessary.[7] The feature of equilibria in Section I that appears inconsistent with decentralized markets is the quantity restriction on type s agents' internal financing of their projects. The reason this is important is not because of the fixed cost of undertaking a project; the small-scale coordination required to minimize those costs is a different question. It is important because the fact that only some fraction of type s agents invest in their own projects in equilibrium was shown to expand the set of contracts that could be used in equilibrium--the quantity restriction made it easier to enforce incentive-compatibility. In the example both types of agents could finance with debt at different interest rates because the quantity restriction made it unattractive for a type r agent to lie in order to get a lower interest rate. Complete decentralization (that is, an equilibrium in which securities can be freely and anonymously bought and sold at market prices) is not feasible at all.[8] Some sort of quantity restriction, or at least the observability of investment portfolios and/or financial structure, is necessary in order to achieve an efficient outcome.

Notes

1. Stiglitz and Weiss (1981) and Leland and Pyle (1977), for example, assume that contractual arrangements take particular forms. On the other hand, Gale and Hellwig (1985) and Diamond (1984) both derive debt as an optimal contract, but only with *ex post* asymmetric information.

2. C3 is weaker than the corresponding condition in Boyd and Prescott (1986), which simply does not allow $\hat{a}_i < a_i$ if $\hat{u}_i > u_i$.

3. The requirement is actually slightly stronger than indicated in (2ab): The equations must hold for a given payoff structure $\{\pi, d\}$ if it is *possible* to find any interior $\{x, z\}$ that lead to the same final allocation. The conditions (2ab) represent complementary slackness conditions in the corresponding social planner's problem of maximizing output subject to the constraints given by F, IR, IC, and the core requirement. Hence it is necessary but not sufficient to have corner solutions for one of the equations not to hold.

4. Think of an allocation in which s agents receive rents via transfers. The blocking coalition has relatively fewer s agents, so it can provide them with the same level of utility while leaving more for the r agents. Only if each r agent captures his entire surplus does it not pay for a coalition to form that increases the relative numbers of type r agents.

5. Standard signaling models are generally of this type, because for signaling to be viable it is necessary that the signaling mechanism affect the utility of the signaler. In this paper the choice of contract does affect utility, but the equilibrium choices are first-best.

6. This kind of arrangement ignores any moral hazard problems that might arise from agents having no stake in the outcome of their projects. An

extension of the model to account for that sort of phenonemenon is beyond the scope of this paper.

7. The more interesting results pertaining to financial intermediation would be those that did not depend on the presence of fixed costs.

8. Such a completely decentralized competitive market is apparently what Ross (1977) has in mind when he argues that financial structure must be irrelevant from the point of view of informing the market.

Figure 1

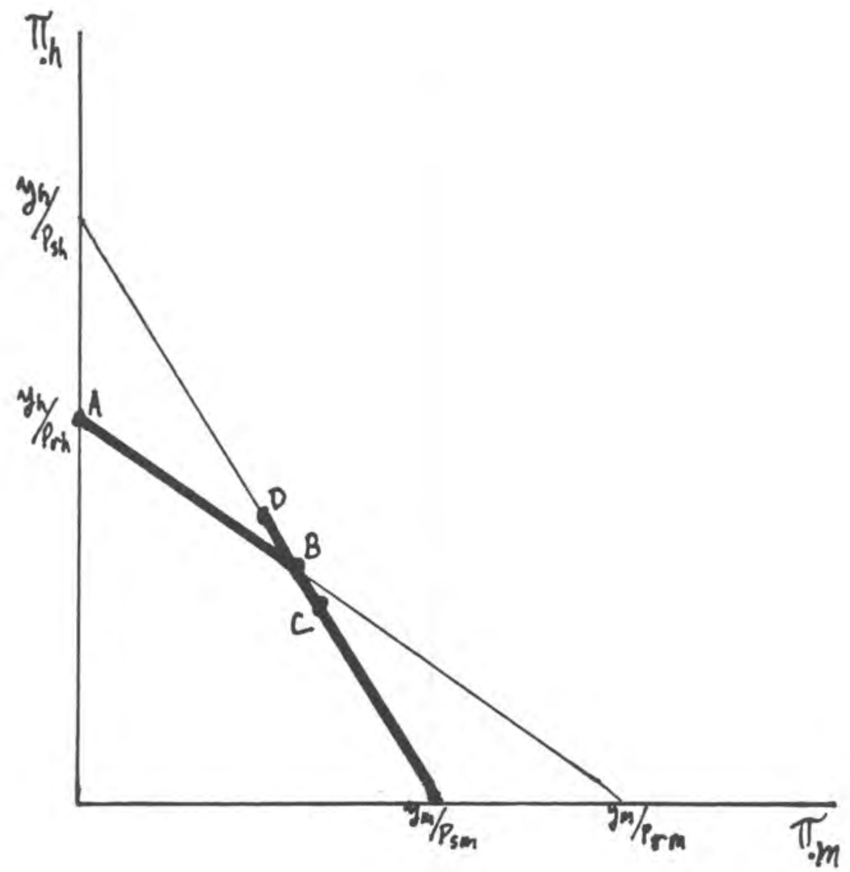


Figure 2

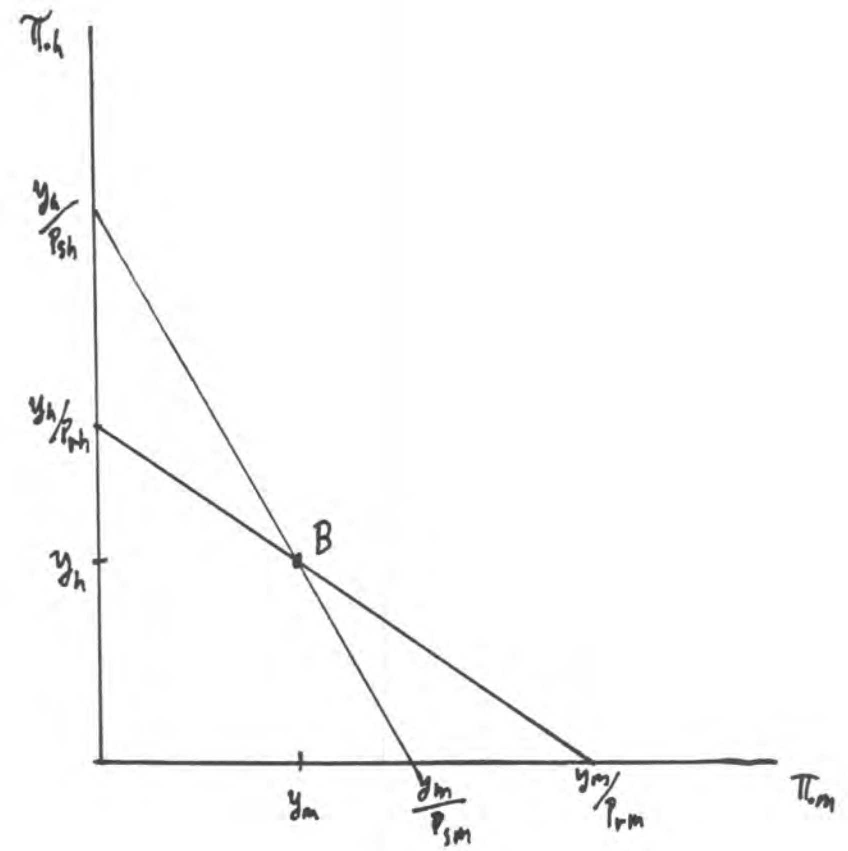
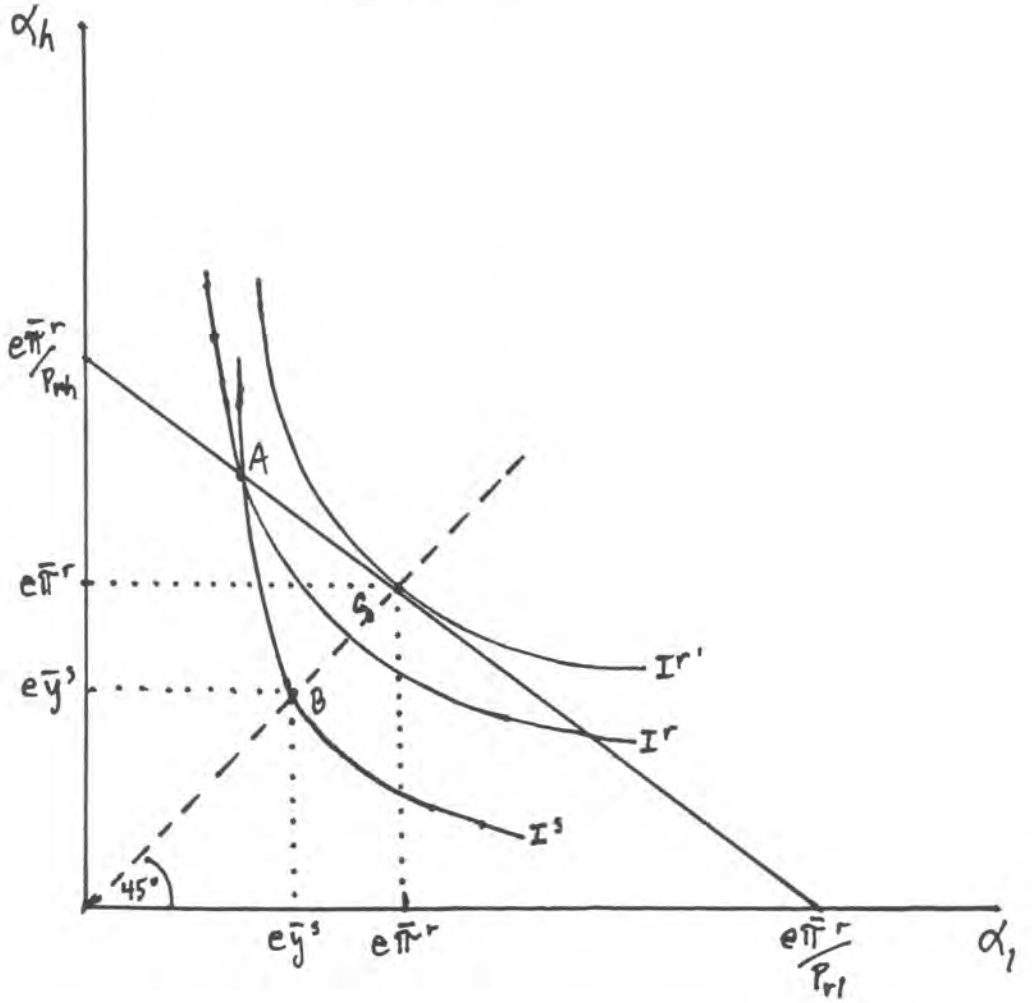


Figure 3



α_h
$e\bar{\pi}^r / P_{rh}$
A
$e\bar{\pi}^r$
$e\bar{y}^s$
B
S
$I^{r'}$
I^r
I^s
45°
$e\bar{y}^s$
$e\bar{\pi}^r$
$e\bar{\pi}^r / P_{rl}$
α_l

References

Bernanke, B. "Non-Monetary Effects of the Financial Collapse in the Propagation of the Great Depression," *American Economic Review* 73 (1983).

Boyd, J. and E. Prescott, "Financial Intermediary Coalitions," *Journal of Economic Theory* 38 (1986), 211-232.

Diamond, D., "Financial Intermediation and Delegated Monitoring," *Review of Economic Studies* 51 (1984), 393-414.

Diamond, D. and P. Dybvig, "Bank Runs, Deposit Insurance, and Liquidity," *Journal of Political Economy* 91 (1983), 401-419.

Gale, Douglas, and M. Hellwig, "Incentive-Compatible Debt Contracts: The One-Period Problem," *Review of Economic Studies* 52 (1985), 647-664.

Greenwald, B., J. Stiglitz, and A. Weiss, "Informational Imperfections in the Capital Market and Macroeconomic Fluctuations," *American Economic Review* 74 (Papers and Proceedings, May 1984), 194-199.

Leland, H. and D. Pyle, "Informational Asymmetries, Financial Structure, and Financial Intermediation," *Journal of Finance* 32 (1977), 371-387.

Mankiw, N., "The Allocation of Credit and Financial Collapse," *Quarterly Journal of Economics* 101 (1986).

Merton, R., "On the Pricing of Contingent Claims and the Modigliani-Miller Theorem," *Journal of Financial Economics* 5 (1977), 241-249.

Miller, M. and F. Modigliani, "The Cost of Capital, Corporation Finance, and the Theory of Investment," *American Economic Review* 48 (1958), 261-297.

Myers, S. and N. Majluf, "Corporate Financing Decisions When Firms Have Investment Information that Investors Do Not," *Journal of Financial Economics* 13 (1984), 187-220.

Prescott, E. and R. Townsend, "Pareto Optima and Competitive Equilibria with Adverse Selection and Moral Hazard," *Econometrica* 52 (1984), 21-45.

Riley, J. "Informational Equilibrium," *Econometrica* 47 (1979), 331-359.

Ross, S. "The Determination of Financial Structure: The Incentive-Signaling Approach," *Bell Journal of Economics* 8 (1977), 23-40.

Rothschild, M. and J. Stiglitz, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," *Quarterly Journal of Economics* 90 (1976), 629-650.

Stiglitz, J. and A. Weiss, "Credit Rationing in Markets with Imperfect Information," *American Economic Review* 71 (1981), 393-410.

Rochester Center for Economic Research
University of Rochester
Department of Economics
Rochester, NY 14627

1986-87 DISCUSSION PAPERS

WP#33 OIL PRICE SHOCKS AND THE DISPERSION HYPOTHESIS, 1900 - 1980
by Prakash Loungani, January 1986

WP#34 RISK SHARING, INDIVISIBLE LABOR AND AGGREGATE FLUCTUATIONS
by Richard Rogerson, (Revised) February 1986

WP#35 PRICE CONTRACTS, OUTPUT, AND MONETARY DISTURBANCES
by Alan C. Stockman, October 1985

WP#36 FISCAL POLICIES AND INTERNATIONAL FINANCIAL MARKETS
by Alan C. Stockman, March 1986

WP#37 LARGE-SCALE TAX REFORM: THE EXAMPLE OF EMPLOYER-PAID HEALTH INSURANCE PREMIUMS
by Charles E. Phelps, March 1986

WP#38 INVESTMENT, CAPACITY UTILIZATION AND THE REAL BUSINESS CYCLE
by Jeremy Greenwood and Zvi Hercowitz, April 1986

WP#39 THE ECONOMICS OF SCHOOLING: PRODUCTION AND EFFICIENCY IN PUBLIC SCHOOLS
by Eric A. Hanushek, April 1986

WP#40 EMPLOYMENT RELATIONS IN DUAL LABOR MARKETS (IT'S NICE WORK IF YOU CAN GET IT!)
by Walter Y. Oi, April 1986

WP#41 SECTORAL DISTURBANCES, GOVERNMENT POLICIES, AND INDUSTRIAL OUTPUT IN SEVEN EUROPEAN COUNTRIES
by Alan C. Stockman, April 1986

WP#42 SMOOOTH VALUATIONS FUNCTIONS AND DETERMINANCY WITH INFINITELY LIVED CONSUMERS
by Timothy J. Kehoe, David K. Levine and Paul R. Romer, April 1986

WP#43 AN OPERATIONAL THEORY OF MONOPOLY UNION-COMPETITIVE FIRM INTERACTION
by Glenn M. MacDonald and Chris Robinson, June 1986

WP#44 JOB MOBILITY AND THE INFORMATION CONTENT OF EQUILIBRIUM WAGES: PART 1, by Glenn M. MacDonald, June 1986

WP#45 SKI-LIFT PRICING, WITH APPLICATIONS TO LABOR AND OTHER MARKETS
by Robert J. Barro and Paul M. Romer, May 1986, revised April 1987

WP#46 FORMULA BUDGETING: THE ECONOMICS AND ANALYTICS OF FISCAL POLICY UNDER RULES, by Eric A. Hanushek, June 1986

WP#48 EXCHANGE RATE POLICY, WAGE FORMATION, AND CREDIBILITY by Henrik Horn and Torsten Persson, June 1986

WP#49 MONEY AND BUSINESS CYCLES: COMMENTS ON BERNANKE AND RELATED LITERATURE, by Robert G. King, July 1986

WP#50 NOMINAL SURPRISES, REAL FACTORS AND PROPAGATION MECHANISMS by Robert G. King and Charles I. Plosser, Final Draft: July 1986

WP#51 JOB MOBILITY IN MARKET EQUILIBRIUM by Glenn M. MacDonald, August 1986

WP#52 SECRECY, SPECULATION AND POLICY by Robert G. King, (revised) August 1986

WP#53 THE TULIPMANIA LEGEND by Peter M. Garber, July 1986

WP#54 THE WELFARE THEOREMS AND ECONOMIES WITH LAND AND A FINITE NUMBER OF TRADERS, by Marcus Berliant and Karl Dunz, July 1986

WP#55 NONLABOR SUPPLY RESPONSES TO THE INCOME MAINTENANCE EXPERIMENTS by Eric A. Hanushek, August 1986

WP#56 INDIVISIBLE LABOR, EXPERIENCE AND INTERTEMPORAL ALLOCATIONS by Vittorio U. Grilli and Richard Rogerson, September 1986

WP#57 TIME CONSISTENCY OF FISCAL AND MONETARY POLICY by Mats Persson, Torsten Persson and Lars E. O. Svensson, September 1986

WP#58 ON THE NATURE OF UNEMPLOYMENT IN ECONOMIES WITH EFFICIENT RISK SHARING, by Richard Rogerson and Randall Wright, September 1986

WP#59 INFORMATION PRODUCTION, EVALUATION RISK, AND OPTIMAL CONTRACTS by Monica Hargraves and Paul M. Romer, September 1986

WP#60 RECURSIVE UTILITY AND THE RAMSEY PROBLEM by John H. Boyd III, October 1986

WP#61 WHO LEAVES WHOM IN DURABLE TRADING MATCHES by Kenneth J. McLaughlin, October 1986

WP#62 SYMMETRIES, EQUILIBRIA AND THE VALUE FUNCTION by John H. Boyd III, December 1986

WP#63 A NOTE ON INCOME TAXATION AND THE CORE by Marcus Berliant, December 1986

WP#64 INCREASING RETURNS, SPECIALIZATION, AND EXTERNAL ECONOMIES: GROWTH AS DESCRIBED BY ALLYN YOUNG, By Paul M. Romer, December 1986

WP#65 THE QUIT-LAYOFF DISTINCTION: EMPIRICAL REGULARITIES by Kenneth J. McLaughlin, December 1986

WP#66 FURTHER EVIDENCE ON THE RELATION BETWEEN FISCAL POLICY AND THE TERM STRUCTURE, by Charles I. Plosser, December 1986

WP#67 INVENTORIES AND THE VOLATILITY OF PRODUCTION by James A. Kahn, December 1986

WP#68 RECURSIVE UTILITY AND OPTIMAL CAPITAL ACCUMULATION, I: EXISTENCE, by Robert A. Becker, John H. Boyd III, and Bom Yong Sung, January 1987

WP#69 MONEY AND MARKET INCOMPLETENESS IN OVERLAPPING-GENERATIONS MODELS, by Marianne Baxter, January 1987

WP#70 GROWTH BASED ON INCREASING RETURNS DUE TO SPECIALIZATION by Paul M. Romer, January 1987

WP#71 WHY A STUBBORN CONSERVATIVE WOULD RUN A DEFICIT: POLICY WITH TIME-INCONSISTENT PREFERENCES by Torsten Persson and Lars E.O. Svensson, January 1987

WP#72 ON THE CONTINUUM APPROACH OF SPATIAL AND SOME LOCAL PUBLIC GOODS OR PRODUCT DIFFERENTIATION MODELS by Marcus Berliant and Thijs ten Raa, January 1987

WP#73 THE QUIT-LAYOFF DISTINCTION: GROWTH EFFECTS by Kenneth J. McLaughlin, February 1987

WP#74 SOCIAL SECURITY, LIQUIDITY, AND EARLY RETIREMENT by James A. Kahn, March 1987

WP#75 THE PRODUCT CYCLE HYPOTHESIS AND THE HECKSCHER-OHLIN-SAMUELSON THEORY OF INTERNATIONAL TRADE by Sugata Marjit, April 1987

WP#76 NOTIONS OF EQUAL OPPORTUNITIES by William Thomson, April 1987

WP#77 BARGAINING PROBLEMS WITH UNCERTAIN DISAGREEMENT POINTS by Youngsub Chun and William Thomson, April 1987

WP#78 THE ECONOMICS OF RISING STARS by Glenn M. MacDonald, April 1987

WP#79 STOCHASTIC TRENDS AND ECONOMIC FLUCTUATIONS by Robert King, Charles Plosser, James Stock, and Mark Watson, April 1987

WP#80 INTEREST RATE SMOOTHING AND PRICE LEVEL TREND-STATIONARITY
by Marvin Goodfriend, April 1987

WP#81 THE EQUILIBRIUM APPROACH TO EXCHANGE RATES
by Alan C. Stockman, revised, April 1987

WP#82 INTEREST-RATE SMOOTHING
by Robert J. Barro, May 1987

WP#83 CYCLICAL PRICING OF DURABLE LUXURIES
by Mark Bils, May 1987

WP#84 EQUILIBRIUM IN COOPERATIVE GAMES OF POLICY FORMULATION
by Thomas F. Cooley and Bruce D. Smith, May 1987

WP#85 RENT SHARING AND TURNOVER IN A MODEL WITH EFFICIENCY UNITS OF HUMAN CAPITAL
by Kenneth J. McLaughlin, revised, May 1987

WP#86 THE CYCLICALITY OF LABOR TURNOVER: A JOINT WEALTH MAXIMIZING HYPOTHESIS
by Kenneth J. McLaughlin, revised, May 1987

WP#87 CAN EVERYONE BENEFIT FROM GROWTH? THREE DIFFICULTIES
by Herve' Moulin and William Thomson, May 1987

WP#88 TRADE IN RISKY ASSETS
by Lars E.O. Svensson, May 1987

WP#89 RATIONAL EXPECTATIONS MODELS WITH CENSORED VARIABLES
by Marianne Baxter, June 1987

WP#90 EMPIRICAL EXAMINATIONS OF THE INFORMATION SETS OF ECONOMIC AGENTS
by Nils Gottfries and Torsten Persson, June 1987

WP#91 DO WAGES VARY IN CITIES? AN EMPIRICAL STUDY OF URBAN LABOR MARKETS
by Eric A. Hanushek, June 1987

WP#92 ASPECTS OF TOURNAMENT MODELS: A SURVEY
by Kenneth J. McLaughlin, July 1987

WP#93 ON MODELLING THE NATURAL RATE OF UNEMPLOYMENT WITH INDIVISIBLE LABOR
by Jeremy Greenwood and Gregory W. Huffman

WP#94 TWENTY YEARS AFTER: ECONOMETRICS, 1966-1986
by Adrian Pagan, August 1987

WP#95 ON WELFARE THEORY AND URBAN ECONOMICS
by Marcus Berliant, Yorgos Y. Papageorgiou and Ping Wang, August 1987

WP#96 ENDOGENOUS FINANCIAL STRUCTURE IN AN ECONOMY WITH PRIVATE INFORMATION
by James Kahn, August 1987

To order copies of the above papers complete the attached invoice and return to Christine Massaro, W. Allen Wallis Institute of Political Economy, RCER, 109B Harkness Hall, University of Rochester, Rochester, NY 14627. Three (3) papers per year will be provided free of charge as requested below. Each additional paper will require a $5.00 service fee which must be enclosed with your order. For your convenience an invoice is provided below in order that you may request payment from your institution as necessary. Please make your check payable to the **Rochester Center for Economic Research**. **Checks must be drawn from a U.S. bank and in U.S. dollars**.

W. Allen Wallis Institute for Political Economy

Rochester Center for Economic Research, Working Paper Series

OFFICIAL INVOICE

Requestor's Name ______________________________

Requestor's Address ______________________________

____

____

____

Please send me the following papers free of charge (**Limit: 3 free per year**).

WP# ______ WP# ______ WP# ______

I understand there is a $5.00 fee for each additional paper. Enclosed is my check or money order in the amount of $__________. Please send me the following papers.

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______

WP# ______ WP# ______ WP# ______