Federal Reserve Bank of Minneapolis
Research Department Working Paper

Historical

FINANCIAL INTERMEDIARIES

John H. Boyd and Edward C. Prescott*

Working Paper 231
PACS File 3050

July 1983

NOT FOR DISTRIBUTION
WITHOUT AUTHORS' APPROVAL

1. Introduction

This paper investigates the role of financial intermediary firms in a general equilibrium setting. We assume a simple economy in which information about real investment opportunities (called projects) is private. A simple form of financial intermediary is shown to endogenously emerge in this environment and to perform an important function not well performed by securities markets; that is, it permits the efficient production of information about projects.

A great deal has been written about financial intermediaries and there is general agreement that these firms are important. They account for about 10 percent of measured GNP and play an important role in the transmission of monetary policy. However, much of the existing analysis of these firms has been hampered by a lack of what are, in our opinion, the needed tools--that is, tools for dealing with fully-specified equilibrium structures. For example, many existing studies have developed normative models of the individual intermediary firm. Generally, some specific imperfection such as transactions costs or sloped demand functions is assumed *a priori*, and then the intermediary exploits the imperfection(s) so as to earn a profit. However, these transactions costs models are rarely put in the context of a capital market or general equilibrium.[1/] And there are many interesting issues pertaining to financial intermediaries that cannot be adequately addressed *except* in a market equilibrium context.

The Arrow-Debreu paradigm meets the criteria of fully-specified general equilibrium, but is not up to the task of treating financial intermediaries either. With price-taking by all agents, no frictions and no private information, intermediaries need not exist (a fact often noted

in the literature) since they can do nothing better or more than indivi-
dual agents can do for themselves (Fama [1980]). This paradigm has been
frequently employed in studying capital market equilibrium. Yet, the
empirically observable fact is that intermediaries do exist and are im-
portant players in virtually all capital markets.

One branch of existing literature was particularly important in
the development of our own thinking on these issues. It treats interme-
diaries as a mechanism to overcome problems in financial market effici-
ency due to asymmetrically informed borrowers and lenders. The idea is
that would-be borrowers know their own characteristics better than do
would-be lenders. Lenders can acquire this information at cost, but may
not have an incentive to do so if they cannot appropriate its value.
Leyland and Pyle [1977] discussed this problem and conjectured that fi-
nancial intermediaries might be a natural solution to it. Subsequent
work by Campbell and Kracaw [1980,1981], however, argued that interme-
diaries were subject to moral hazard problems and that their information
production would be influenced by side payments from borrowers. Thus,
some incentive compatible mechanism would have to exist for interme-
diaries, and these authors concluded that intermediaries had no compara-
tive advantage over the ultimate borrowers in this respect. As will
become clear in the following pages, our own analysis reaches quite a
different conclusion.[2]/

There are at least a few operating characteristics of financial
intermediaries which are so universal and so widely recognized that they
may be referred to as "empirical facts". Of course, it is definitional
that they borrow from one subset of agents in the economy and lend to
another. More specifically, however, intermediaries exhibit the follow-
ing characteristics.[3]/

i. They produce costly information on the attributes of would-be borrowers, which is then used to allocate loans. Most of the assets held by financial intermediaries are heterogenous, "rich" in private information, and rarely traded if traded at all.

ii. They issue their own securities which have different state contingent payoffs than claims issued by ultimate borrowers.

iii. They borrow from and lend to a large number of agents. Thus, to the extent that numbers measure diversification, they are highly diversified on both sides of their balance sheets.

It is perhaps reassuring that the primitive intermediaries which endogenously emerge in our analysis exhibit each of these characteristics.

Summary and Overview of What Follows

Briefly, the rest of the paper proceeds as follows. Section 2 specifies a two-period economy. All agents are risk neutral and identical, except that each is endowed with an investment project whose rate of return may take on two values, high or low. Some projects have a higher expected return than others, but this information is private to the individual endowed with the project. In period two, projects' returns are publicly observed. There are two production technologies, one for the single consumption good and another for information about the rate of return on investment projects. Any agent may spend his wealth endowment to obtain a signal which provides private information about the prospective rate of return on a project, his own or another's.

In Section 3 we investigate equilibrium allocations for this economy, assuming that agents have no prior information on any particular

project's return distribution, including their own. This assumption abstracts from the problem of adverse selection, and initially, we abstract from the problem of moral hazard too by assuming that all agents are pathologically honest. In this case, the efficient allocation is one which provides the same *ex ante* consumption to all agents. This allocation is defined and supported by a competitive securities market; however, a number of other arrangements would work equally well.

Next, we show that when the assumption of pathological honesty is dropped, the securities market fails. It fails in the sense that, even when the production of investment information would increase aggregate consumption, no agent will produce it. What is required is an arrangement that resembles, in a stylized way, a financial intermediary. One such arrangement is a coalition of n agents who join together to evaluate projects. In the first period, they announce an investment policy and compensation schedules for themselves and for other agents who become depositors or borrowers. It is shown that if n is sufficiently large, this arrangement supports the optimal allocation for the economy described previously (the one with pathological honesty) and therefore must be optimal in the presence of moral hazard.

In Section 4, we introduce the possibility of adverse selection by assuming that each agent has some information about the project with which he is endowed. Specifically, he is also endowed with a signal, generally imperfect, of the rate of return his project will realize if funded. This information is private. Next, we characterize an equilibrium for this economy assuming legal restrictions which prohibit the formation of intermediary-coalitions of the kind described previously. An equilibrium allocation is then defined and supported with a securities

market. In this equilibrium, as in the previous one, there is no way to realize a return on costly information and none is produced. This case does have an interesting additional feature though. The equilibrium is one which is partially separated by agent/project type, with the degree of separation determined endogenously. This is unlike most signaling models we have seen, in which agents are either perfectly separated by type, or not separated at all.

In Section 5 we drop the legal restriction on the formation of intermediary-coalitions. It is shown that under certain conditions the equilibrium is one with information production. Later, in Section 6, a numerical example is provided showing that the set of economies for which these conditions hold is nonempty. The equilibrium institutional arrangement is considerably more complicated than the previous one, but as before intermediaries are coalitions of n agents (with n large), which specify investment rules and compensations for coalition members, depositors and borrowers. It is further shown that no coalition can form and specify a different set of rules and compensations in such a way as to draw agents away from the intermediaries we describe. Thus, we contend that this arrangement is truly an equilibrium among competitive coalition intermediaries.

Section 7 is an aside on the problem of bribes, or side-payments, which might be paid to coalition members in exchange for their purposely misrepresenting evaluation outcomes. It is argued that this problem is a relatively trivial one for financial intermediaries, and that abstracting from it is justified. Section 8 discusses possible extensions.

In summary, a competitive equilibrium with financial intermediaries is shown to yield Pareto optimal allocations given the appropriate resource and incentive constraints, with or without adverse selection. In either case, intermediaries must lend to and borrow from a large number of agents to be successful. They produce information about investment projects and they issue their own securities with different state contingent payoffs than claims issued by ultimate borrowers. In other words, they exhibit the key characteristics of real world financial intermediaries. It is particularly interesting that they "diversify" assets and liabilities, since all agents are assumed risk-neutral.

2. The Economy

There is a countable infinity of agents that live two periods. They are endowed with one unit of time in the initial period and an investment project of either a good type $i = g$ or a bad type $i = b$ where $g > b$. Using their endowment of time they can in the first period either produce one unit of the investment good or monitor a project. Agents preferences are ordered by expected consumption in the second and final period. Thus,

$$E\{c\}$$

orders the distribution of consumptions where $E\{\ \}$ is the expectation operator. Consumption is necessarily nonnegative, an assumption which plays a central role in the analysis.

The rate of return per unit of investment in a project is either $r = b$ or $r = g$ where $g > b$ for investments x in the range $0 \leqslant x \leqslant \chi$. Here χ is the maximum investment in a project, and it is assumed that χ is large relative to an individual's one unit endowment of the investment good. The return is public information in the second period. If a project is evaluated, a signal $e = b$ or $e = g$ is observed, which is private to the evaluator. This signal provides information about the rate of return on the project, which may be better or worse than the information provided by project type. This concept will now be made precise.

Project, or agent, types (i,e,r) are identical and independent draws with $\pi(i,e,r)$ denoting the probability of type (i,e,r) ε $\{g,b\} \times \{g,b\} \times \{g,b\}$. There being a countable infinity of agents, through this analysis we consider the fractions of the various types which are just the $\pi(i,e,r)$. For a rigorous justification of this procedure see Green [1982].

Agents in this economy know their own type $i = g$ or b and, of course, the probabilities $\pi(i,e,r)$. They do not have the opportunity to enter into contracts prior to observing their i. Throughout, expectations are with respect to the probability distribution defined by the $\pi(i,e,r)$. If a project is evaluated, then the evaluator's private information about the project is e $\varepsilon\{g,b\}$. If a project is funded, the return r on the project is publicly observed in the second period.

It is further assumed that $i = g$ and/or $e = g$ signals that the return on the project will be high, or that $r = g$. Thus

$$\pi\{r=g \mid i=g\} \; \geqslant \; \pi\{r=g \mid i=b\}$$

and

$$\pi\{r=g\,|\,e=g\} > \pi\{r=g\,|\,e=b\}.$$

Finally, all the $\pi(i,e,r)$ are strictly positive so it is impossible to deduce i given the evaluation e and the return r.

The equilibrium behavior of this economy will depend upon the $\pi(i,e,r)$ parameters. Two polar cases will receive particular attention. In the first, it is assumed that i contains no information about a project's return so that adverse selection is not a problem. In the second, e provides no information about r other than that provided by i. In this case i is sufficient relative to the pair (i,e) in forecasting r, or

$$\pi(r\,|\,i,e) = \pi(r\,|\,i), \text{ for all } (i,e,r).$$

Additional conditions will be imposed which insure in both cases that there is evaluation in equilibrium. We defer their specification until, in the first case, we analyze a model in which evaluations are not private information; and in the second, in which evaluations are private but only bilateral contracts are permitted. Then the motivation for these additional conditions will become apparent.

Figure 1 below indicates the timing of various events and actions during the two periods.

Figure 1

Period 1

- All agents know whether their project is of type i = g or i = b, prior to <u>any</u> contracting opportunities.

- Agents can enter into contracts.

- Agents can evaluate.

- Investments are made.

Period 2

- Projects returns are realized and observed by all.

- Consumption occurs.

Resource constraints are that per capita investment in projects plus the fraction of the projects evaluated is constrained by per capita endowment, and that per capita consumption is constrained by per capita production of the consumption good.

(2.1) Total investment per capita + total number of evaluations per capita ≤ total endowment per capita.

(2.2) Per capita consumption ≤ Per capita production of the consumption good.

Throughout this paper the competitive equilibrium construct is employed, which requires no monopoly power. In the economies described later, with competitive financial intermediaries, this is accomplished by having a countable infinity of agents and by intermediaries being "small" in the sense that the fraction of all agents which are any intermediary's customers is zero. At the same time, intermediaries are "large" in the sense that each has a countable infinity of borrowers and lenders.[4/] As shown later, each intermediary must deal with a large number of agents in order to insure that it can meet its contractual obligations with probability one.

3. <u>Equilibrium Allocations Without Adverse Selection</u>

We first abstract from the adverse selection problem by assuming an agent's type i is independent of both the evaluation e and return r of that agent's project. This being the case, the i plays no role in the analysis and consequently is dropped in this section. It is further assumed in this section that

$$(3.1) \qquad \chi \ \pi(e=g) \ \left[E\{r|e=g\} - E\{r\} \right] > 1 \ .$$

This is required for the expected value of an evaluation of a project in which χ is invested if it receives a good evaluation (left hand side) to exceed the cost of an evaluation which is 1.

First suppose that people were pathologically honest and never lied. For this economy the social optimum, which provides the same *ex ante* welfare to all, is as follows. Fraction y of projects are evaluated, where y satisfies

$$(3.2) \qquad \chi \ \pi(e=g)y = 1-y.$$

Amount χ is invested in evaluated projects which prove to be promising; and all people have consumption lotteries with

$$(3.3) \qquad E\{c\} = \chi \ E\{r|e=g\} \ \pi(e=g)y.$$

Condition (3.2) requires that just enough projects are evaluated so that, if the good ones are funded at level χ, all the endowment of the investment good remaining after the evaluation is invested. Condition (3.3) is that per capita consumption equals per capita output of the consumption good.

If all agents are pathologically honest this allocation can be supported by any of a number of arrangements, including a competitive market for shares. Suppose, for example, that fraction y of agents evaluate their projects and fraction 1 - y, who are called investors, do not. Those who evaluate their projects, and are fortunate enough to have good projects, become entrepreneurs and issue shares. For one unit of the investment good, an investor receives a share which promises to pay a fraction s of the firm's period two total output, where

$$(3.4) \quad s = y \, \pi(e=g).$$

The number of shares issued is χ for this is the amount needed to fund the project. The entrepreneur retains a claim on $1 - \chi s$ percent of the firm's period two output. Those who evaluate their projects and are unfortunate in receiving a bad evaluation consume zero. Investors receive the expected consumption specified in (3.3). Entrepreneurs receive expected consumption in (3.3) divided by $\pi(e=g)$. *Ex ante*, those who evaluate projects also have expected consumption given in (3.3). But, some are fortunate (obtain e=g and become entrepreneurs) and receive greater expected consumption after evaluation, while others are unfortunate (obtain e=b) and consume zero.

This scheme will not work if any agents are dishonest. There is an incentive for those with bad evaluations to claim otherwise and to issue shares anyway, since it is costless for them to do so. Thus, no agent who evaluates will ever announce a bad outcome, and for this reason markets for information will fail. Without more complicated contractual arrangements, there is no way to realize the gains from investing in evaluation. We next show that there is an arrangement, resembling a financial intermediary, which overcomes this problem.

Suppose a group of y agents form a coalition in period one, which is called a financial intermediary. The coalition publicly announces an investment policy, and compensation schedules for "depositors"--those agents who turn their wealth endowment over to the intermediary for investment. The investment policy is that coalition members will evaluate y projects, funding only those which receive a favorable evaluation, at a level χ. Agents whose projects are evaluated agree to deposit their unit of the investment good with the intermediary and to deliver all output of the consumption good produced to it. All depositors, including those whose projects are evaluated, are promised a payment in period two of

$$\chi \ E\{r|e=g\} \ \pi(e=g)y$$

units of the consumption good. The members of the coalition, namely the evaluators, share equally in the profits of the intermediary and in period one, before evaluation occurs, their expected consumption is defined by the lottery (3.3). This arrangement supports an optimal allocation for the world with pathological honesty--a world with fewer constraints than the one being considered. Consequently, it is necessarily optimal for the present environment, one with some agents dishonest.

We dealt with but one intermediary, but given that there are constant returns to scale in information production, and that all agents have equal access to the evaluation technology, there could equally well be many competing intermediaries. Size is *not* a matter of indifference, however, and in fact intermediaries must be large (that is, evaluate and invest in a large number of projects) to be successful. The compensation promised to depositors can be paid with certainty if and only if the

intermediary is perfectly diversified across investment projects. But if in period one depositors' compensation is less than perfectly certain, then coalition members may have an incentive to misrepresent evaluation outcomes.

Consider, for simplicity, an intermediary composed of just one evaluator and χ depositors. To invest efficiently--that is to invest in only those projects with a favorable evaluation--would require the following contractual arrangement. "If upon evaluation, $e = g$, invest χ in the project; otherwise return one unit of the investment good to each depositor." This arrangement would, obviously, require the possibility of recontracting. But in any case it would fail since the evaluator would have an incentive (known to all agents) to misrepresent an unfavorable evaluation and invest anyway.[5/]

Thus, the primitive coalition-intermediaries described here must invest in a large number of projects, and borrow from an even larger number of depositors, even though all agents are assumed risk-neutral. They mimic the other key features of financial intermediaries too; that is, they produce information on investments and issue their own differentiated claims. Importantly, their actions are specified in a period one contractual arrangement which ties the evaluation and investment activities and exploits all potential gains from trade.[6/]

4. Equilibrium Allocations With Adverse Selection

In this section the i subscript is reintroduced, resulting in an economy with adverse selection. In order to focus on this feature

exclusively, we invoke the extreme assumption that an evaluation provides no additional information about a project's return other than the information contained in i. Formally, this means that i is sufficient relative to the pair (i,e) in forecasting r, or,

$$(4.1) \qquad \pi(r|i,e) = \pi(r|i), \text{ for all } (i,e,r).$$

It is also assumed that i is never perfectly deducible from knowledge of e and r; that is

$$(4.2) \qquad 0 < \pi(i|e,r) < 1, \text{ for all } (i,e,r).$$

Thus, it can never by proved *ex post* that an agent misrepresented his type. For this economy, absent private information, there would be no reason to evaluate projects as this procedure is costly and produces no additional information to that contained in i.

Pathological Honesty

We first consider the economy with all agents pathologically honest. Assuming as we do in this section, that

$$(4.3) \qquad \chi\pi(i=g) < 1,$$

the gains from trade accrue to those with promising projects. Figure 2 depicts the supply and demand for investment funds. As can be seen from the figure, reversing inequality (4.3) results in the equilibrium or market return increasing from $E\{r|i=b\}$ to $E\{r|i=g\}$. This latter case is uninteresting, at least from our point of view, for then markets can be used to support the optimum allocation even if agents are not pathologically honest. With pathological honesty, though, all gains from trade

Figure 2
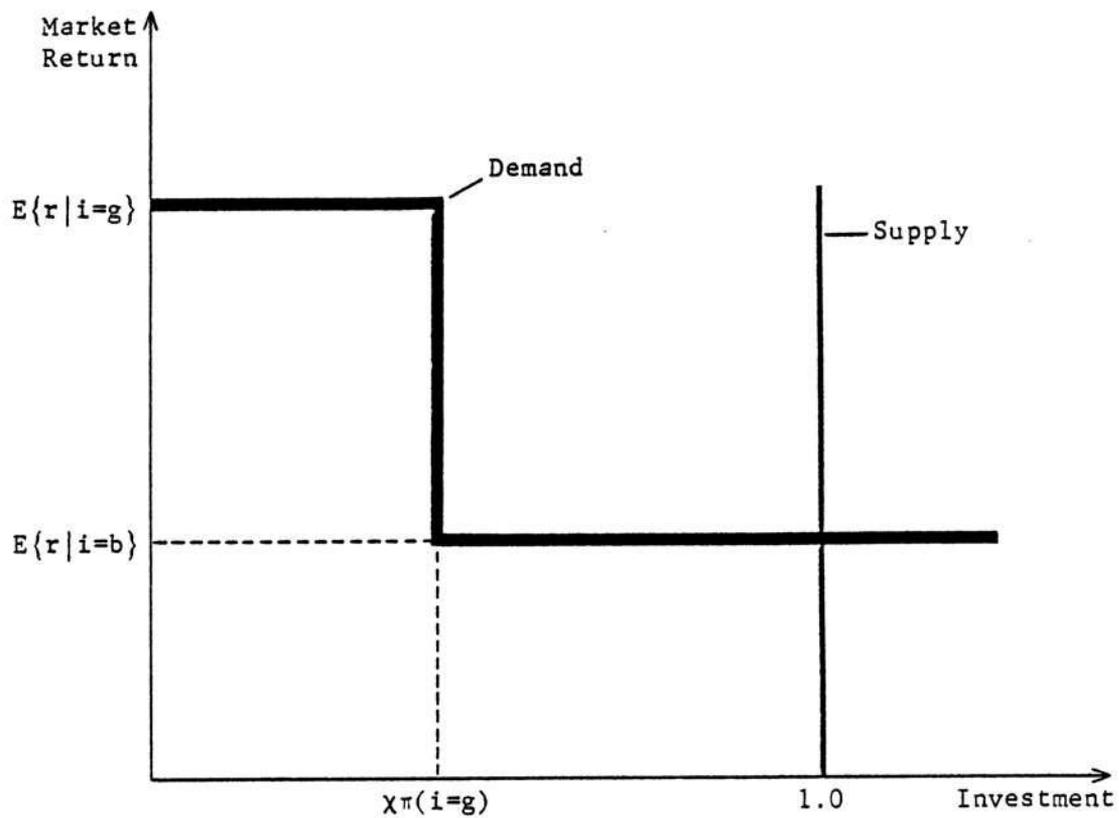
accrue to those endowed with the promising projects because these are the type in limited supply when (4.3) is satisfied. This is an important point for this principle, we shall argue, applies to environments in which i is private information and agents are not pathologically honest.

The equilibrium allocation then, in the set of feasible allocations for this environment, will be the one which maximizes the welfare of type i = g agents subject not only to the resource constraints (2.1) and (2.2) but also to an incentive feasibility constraint requiring that type i = b agents are at least as well off as under autarky. This allocation is straightforward and, for brevity, we will not set it out formally.

Private Information, but Financial Intermediaries Prohibited

We next characterize the equilibrium with both private information and legal constraints that preclude financial intermediaries, as defined previously. Our candidate for the equilibrium allocation is the solution to the program

$$(4.4) \qquad \max E\{c_{ir}|i=g\}$$
$$(x_i), (c_{ir}) \geqslant 0$$

subject to

$$(4.5) \qquad \sum_i \pi(i) E\{c_{ir}|i\} \leqslant \sum_i \pi(i)x_i E\{r|i\}$$

$$(4.6) \qquad \sum_i x_i \pi(i) \leqslant 1$$

$$(4.7) \qquad x_i \leqslant \chi$$

(4.8) $E\{c_{ir}|i\} \geq E\{c_{jr}|i\}$, for all $i,j \in \{g,b\}$

(4.9) $E\{c_{ir}|i\} \geq E\{r|i\}$, for all i.

Here x_i is investment in a project of type i and c_{ir} is consumption of a type (i,r) agent. Constraint (4.5) is that per capita consumption is bounded by per capita production. Constraint (4.6) is that per capita investment is constrained by the availability of the investment good. Constraint (4.7) is that investment in a project is bounded by χ. Constraints (4.8) are incentive constraints; namely, that it is never in the interest of agents to misrepresent their type. Finally, (4.9) is that both agent types must be at least as well off as under autarky.

The solution to this program is almost immediate. First c_{gb}, that is consumption of good type agent with a bad project realization, (i=g, r=b), may be taken to be zero. If it were not, c_{gg} could be increased and c_{gb} reduced, holding expected consumption $E\{c_{ir}|i=g\}$ fixed. This would have no affect upon the objective function or the technology constraints (4.5-4.7), and (4.9). It would introduce slack in the key incentive compability constraint

$\qquad E\{c_{br}|i=b\} \geq E\{c_{gr}|i=b\}$.

Thus, we are assuming that the parameters are such that this constraint is binding (e.g. that it is not in the interest of type i = b to claim to be of type i = g). To find the necessary and sufficient conditions to insure that it is binding, we solve the program without that constraint, and then restrict the parameters to be such that the constraint is violated, for that allocation.

If we solve the program without constraints (4.8), a solution is

$$c^o_{gg} = \frac{\chi\, E\{r|i=g\} - E\{r|i=b\}\,(\chi-1)}{\pi(r=g|i=g)}$$

$$c^o_{gb} = 0$$

$$x^o_g = \chi$$

$$c^o_{bb} = c^o_{bg} = E\{r|i=b\}$$

$(4.10)\qquad x^o_b = [1-\chi\pi(i=g)]/\pi(i=b).$

Therefore, we must restrict the parameters such that

$(4.11)\qquad E\{c_{ir}|i=b\} = c^o_{gg}\,\pi(r=g|i=b) > E\{r|i=b\},$

which is the necessary and sufficient condition for the key incentive constraint (4.8) to be binding. By selecting χ sufficiently large, this is always possible, as $E\{r|i=g\} > E\{r|i=b\}$.

With the incentive constraint binding the optimum allocation is characterized by c^*_b the market interest rate, c^*_{gg} the compensation of an entrepreneur if the project has $r=g$, and x^*_b the amount invested in each of the type $(i=b)$ projects. Now

$(4.12)\qquad c^*_b = \max\ \{E\{r|i=b\},\ c^*_{gg}\,\pi(r=g|i=b)\}$

$(4.13)\qquad \chi\,\pi(i=g) + x^*_b\,\pi(i=b) = 1$

$(4.14)\qquad c^*_{gg}\,\pi(i=g,r=g) + c^*_b\,\pi(i=b) = \chi\, E\{r|i=g\}\,\pi(i=g) +$
$$x^*_b\, E\{r|i=b\}\,\pi(i=b),$$

are the three binding constraints, which can be solved for the equilibrium c_b^*, c_{gg}^* and x_b^*. Note, further, that $x_g^* = \chi$, $c_{gb}^* = 0$, $c_{bb} = c_b^*$ and $c_{bg} = c_b^*$. This fully defines our candidate for the equilibrium allocation.

<u>Support</u>

One way in which this allocation could be supported is for all individuals with promising projects to become entrepreneurs, as well as fraction x_b^*/χ of those agents with poor projects. Entrepreneurs agree to invest their endowment of the investment good in their project and to fund the remainder of the investment, namely, $\chi - 1$, by issuing shares to investors. An entrepreneur receives compensation c_{gg}^* if $r = g$, and zero otherwise.

From (4.12), those endowed with poor projects are indifferent between becoming entrepreneurs or investors, as their expected return in either activity is c_b^*. In equilibrium, fraction x_b^*/χ of type (i=b) agents become entrepreneurs and the rest become investors. Thus, this equilibrium entails some mimicking by agents endowed with type (i=b) projects, who intentionally misrepresent that they have type (i=g). Agents actually endowed with good projects will attempt to differentiate themselves by offering to consume zero when $r = b$. But, in general, they cannot do so perfectly due to the bound on consumption, $c \geqslant 0$. Therefore, the equilibrium will be one which is *partially* separating by agent type, the degree of separation determined endogenously. This is unlike most signaling models in which agents are either perfectly separated by type, or not separated at all (See Spence [1974]). Section 6 presents a numerical example which should help to clarify this result.

Throughout this analysis it was assumed that there would be no evaluation. The reason was precisely as in the previous section; there is no way to realize a return on an investment in information if agents must produce it unilaterally and cannot form coalitions. And, as in the previous case with i public, a competitive equilibrium maximizes the welfare of those endowed with good projects, but subject to incentive and resource constraints.

5. Adverse Selection and Evaluation

In this section j denotes what type an agent reports himself to be, while i continues to denote the agent's true type. Attention is restricted to those arrangements in which it is never in the interest of anyone to misrepresent his type, the so called "simple direct mechanisms." Justification for this restriction is the revelation principle. This principle insures (for a class of economies including ours) that if a particular arrangement entails lying in equilibrium, then there exists another arrangement which does not, and which has the same equilibrium allocation.[7]

As before we conjecture that a particular Pareto optimum allocation is an equilibrium allocation with competitive intermediaries. It is the feasible allocation which maximizes the utility of type (i=g) agents subject to the constraint that it is the interest of type (i=b) to participate. Before presenting the program whose solution is this allocation, it is necessary to introduce notation to specify the direct mechanisms. This notation is:

z_i fraction of type i projects evaluated;

x_i amount invested in each type i project not evaluated;

x_{ie} amount invested in each evaluated type i project with evaluation e;

c_{ir} consumption of type i with return r not evaluated;

c_{ier} consumption of a type i with evaluation e and return r.

In addition, z denotes the pair of z_i, x the set of two x_i and four x_{ie}, and c the set of four c_{ir} and eight c_{ier}. Finally, $u_i(c,z,j)$ is the expected consumption of a type i who reports to be a type j; thus

$$u_i(c,z,j) = z_j \, E_{e,r}\{c_{jer}|i\} + (1-z_j) \, E_r\{c_{jr}|i\}.$$

The subscripts on the E operator are the random variables over which the expectation, or averaging, operator is taken.

With this notation our candidate for an equilibrium allocation is the solution to the program

$$(5.1) \qquad \max_{x,c,z \,\geqslant\, 0} \quad u_{i=g}(c,z,j=g)$$

subject to

Investment good resource constraint:

$$(5.2) \qquad E_{i,e}\left\{z_i(x_{ie}+1) + (1-z_i)x_i\right\} \leqslant 1.$$

Consumption good constraint:

$$(5.3) \qquad E_i\{u_i(c,e,j=i)\} \leqslant E_i\left\{ z_i \, E_{e,r}\{rx_{ie}|i\} + (1-z_i)E_r\{rx_i|i\} \right\}.$$

Incentive constraints:

$$(5.4) \qquad u_i(c,z,j=i) \geqslant u_i(c,z,j \neq i) \quad \text{all i}$$

(5.5) $u_i(c,z,j=i) \geqslant E_r\{r|i\}$ all i .

Other constraints:

(5.6) $z_i \leqslant 1$ all i

(5.7) $x_i \leqslant \chi$ all i

(5.8) $x_{ie} \leqslant \chi$ all i,e .

This is not a linear program but by changing variables it can be transformed into one. This can be accomplished as follows: Substitute u_{i1} for z_i, u_{i2} for $(1-z_i)$, v_{ie} for $z_i x_{ie}$, v_i for $(1-z_i) x_i$, w_{ier} for $z_i c_{ier}$ and w_{ir} for $(1-z_i)c_{ir}$. Add the linear constraints $u_{i1} + u_{i2} = 1$. Note (5.7) becomes $v_i \leqslant \chi u_{i2}$ and (5.8) $v_{ie} \leqslant \chi u_{i1}$. It is now a linear program is u,v and w.

We assume that χ is sufficiently large and e contains sufficient information about r that the solution value of this program exceeds that of the previous one, (as for the example in the next section); then, this program is interesting and not so formidable. First, all good projects are evaluated and funded independent of their evaluation outcome. Further, $c_{ger} = 0$ unless *both* $e = g$ and $r = g$. If this were not the case, slack could be introduced into the binding incentive constraint, which is the one which insures that it is not in the interest of type $(i=b)$ to claim to be of type $(i=g)$. This slack could be produced without affecting the objective function or any other constraints. Evaluating projects with $i = b$ is wasteful of resources and does not help with respect to the key incentive constraints. Consequently, no projects of type $(i=b)$ are evaluated at an optimum.

Using these facts, $z_g^* = 1$ and $z_b^* = 0$ while $x_{gg}^* = x_{gb}^* = \chi$. At the optimum all other variables are zero except for x_b^* , c_{ggg}^*, c_{bg}^* and c_{bb}^* . The solution to the problem is not unique. Given any solution, changes in c_{bg}^* and c_{bb}^* which do not alter type (i=b) expected consumption yield alternative optimal allocations. Consequently, only $c_b^* \equiv E_r\{c_{ir}^* | i=b\}$ is uniquely determined. It, along with c_{ggg}^* and x_b^*, remain to be determined.

These three elements can be deduced from knowledge of the binding constraints. First, constraint (5.2) is binding, so

(5.9) $\chi \, \pi(i=g) + x_b^* \, \pi(i=b) + \pi(i=g) = 1.$

Second, incentive constraint (5.4) with i=b and j=g, or constraint (5.5) with i=b, is binding

(5.10) $c_b^* = \max \left\{ E\{r|i=b\}, \, c_{ggg}^* \, \pi(e=g, r=g | i=b) \right\}$

as is resource constraint (5.3), or,

(5.11) $c_{ggg}^* \, \pi(i=g, e=g, r=g) + c_b^* \, \pi(i=b) =$

$$x_b^* \, E\{r|i=b\} \, \pi(i=b) + \chi \, E\{r|i=g\} \, \pi(i=g).$$

Equations (5.9) – (5.11) have a unique solution which is nonnegative.

Note that this allocation does not maximize per capita consumption. Some resources, namely $\pi(i=g)$ of the investment good, are allocated to evaluation which provides no additional information about a project's return to that contained in i. It is however, an efficient allocation given the resource *and* incentive feasibility constraints. Remember, also, that for this allocation to be the optimum, the resulting value of the objective function (5.1) must exceed the value of that for

program (4.4-4.9). The numerical example in the next section established that the set of parameters for which this holds is nonempty. Essentially if e is a sufficiently good indicator of r, and χ is sufficiently large, this will be the case.

Supporting the Allocation with Financial Intermediaries

A financial intermediary is a coalition of agents of type (i=b) who choose to be evaluators, say n agents where n is large. In period one, the intermediary commits itself to the following policy.

i. For each unit of the investment good deposited with it, the intermediary agrees to deliver c_b^* units of the consumption good the next period. These investors (depositors) give the intermediary the right to invest in their project and to receive the entire output if the intermediary chooses to invest. Total deposits are limited to $n[\chi\ \pi(i=g) + x_b^*\ \pi(i=b)]$.

ii. The intermediary agrees to evaluate n projects, the owners of which must deliver a unit of the investment good prior to the evaluation. The intermediary agrees to fund each of the n projects evaluated. Project owners (entrepreneurs) are promised c_{ggg}^* units of the consumption good next period if the project has evaluation e = g and return r = g, and zero otherwise. The intermediary also guarantees that of all projects evaluated, the fraction $\pi(e=g|i=g)$ will receive a good evaluation.

iii. Members of the coalition are the residual claimants and share equally in profits.

This, we claim, is an equilibrium arrangement that will naturally arise as the result of competition among intermediaries. (Recall that agents have identical access to the information technology and therefore free entry into the business of intermediation). No coalition can form and commit itself to a set of rules that would attract type ($i=g$) agents away from intermediaries of the type specified above. Suppose hypothetically, that a newly formed coalition attempted to offer type ($i=g$) agents compensation in excess of c^*_{ggg}. This would immediately violate condition (5.10) and give type ($i=b$) agents an incentive to mimic; an incentive which could only be offset by increasing c^*_b. But, of course, it is not possible to increase both c^*_{ggg} and c^*_b, since the allocation defined above was itself a Pareto optimum. Thus, it is impossible to attract away agents endowed with good projects. For that matter, it is also impossible to attract away type ($i=b$) agents since an intermediary composed only of them could do no better than the autarky solution. Thus, we contend that the arrangement described above is, indeed, an equilibrium among competitive coalition intermediaries.

In a sense, it is important that the intermediary can commit itself, in advance, to monitor projects of those who claim to be type ($i=g$). By construction, only those who indeed have promising projects will so claim in equilibrium, and as a result, monitoring is unnecessary and wasteful *ex post*. This *ex post* inefficiency, however, is a necessary part of the *ex ante* efficient arrangement. If it were not part of the technology to so commit, our arrangement would not constitute an equilibrium.

But, whether or not it is possible to commit in this way is not crucial to our theory. If it were not feasible, then there would be additional constraints in the Pareto optimum program and the resulting solution would differ. The relevant Pareto optimum for this alternative economy would also require financial intermediaries for its support. The only important difference would be that some type $(i=b)$ projects would be evaluated. Then, the choice of whether or not to be an entrepreneur would not perfectly reveal an agent's type. In either case, the key equilibrium condition is that the expected return to type $(i=b)$ agents be the same, whether they choose to be investors, evaluators or entrepreneurs. And in either case, the entrepreneur's compensation schedule is structured so that the difference in expected consumption of a potential entrepreneur for the two agent types be maximal. The second allocation would also be Pareto optimal given the environment, and could not be Pareto dominated by a social planner who, like the intermediaries, could not precommit future actions.

Nor is it crucial to our theory that e provides no information in addition to that contained in i, as was assumed in deriving (5.9-5.11). If this assumption were dropped, the equilibrium allocation would still be the solution to program (5.1-5.8). Depending on the parameter values, projects of type $(i=g,e=b)$ might or might not be funded. Similarly, some projects of type $(i=b)$ might be evaluated and funded in equilibrium, if and only if their $e = g$. In all these cases, financial intermediaries of the sort defined above will endogenously arise to support the solution to the program.

In summary, in this environment, too, competitive financial intermediaries support a Pareto optimal allocation which maximizes the

welfare of type (i=g) agents. As before, they produce investment infor-
mation, issue their own securities different than the claims issued by
entrepreneurs, and diversify the liability and asset sides of their bal-
ance sheets. And each of these features is an essential part of the
equilibrium arrangement.

6. A Numerical Example

In this section, we briefly present a numerical example, show-
ing solutions to programs (4.4-4.9) and (5.1-5.8). For simplicity, we
shall refer to the former as the "no intermediary solution" and to the
latter as the "intermediary solution." Assume the following parameter
values:

$$\pi(i=g) = .01$$
$$\pi(e=g \mid i=b) = .60$$
$$\pi(e=g \mid i=g) = .95$$
$$\pi(r=g \mid i=g) = .90$$
$$\pi(r=g \mid i=b) = .05$$
$$r_g = 2$$
$$r_b = 1$$
$$\chi = 50.$$

This set of probabilities can be used to derive all the $\pi(i,e,r)$ para-
meters, given that e and r are independently distributed conditional upon
i. From the above $E(r \mid i=g) = 1.9$ and $E(r \mid i=b) = 1.05$.

The no intermediary solution is characterized by the following values:

$$x^*_g = 50$$

$$x^*_b = .50505$$

$$c^*_b = 1.2607$$

$$c^*_{gg} = 25.214.$$

Expected consumption of type (i=g) agents is 22.692, and thus, both classes of agents prefer this solution to autarky. [Since $c^*_b > E(r|i=b)$, and $E(c_{ir}|i=g) > E(r|i=g)$]. Since $\chi = 50$ and $\pi(i=g) = .01$, only one half of total investment can be in type (i=g) projects. The other half will be in projects offered by mimics, who dishonestly claim to have type (i=g) projects. The expected return to mimicking is $\pi(r=g|i=b) \, c^*_{gg} = 1.2607$, and therefore, these agents are indifferent between engaging in this activity and investing, as required for equilibrium.

For the same parameters, the intermediary solution is characterized by the following values:

$$x^*_g = 50$$

$$x^*_b = .49495$$

$$c^*_b = 1.1486$$

$$c^*_{ggg} = 38.288.$$

Expected consumption of type (i=g) agents is 32.736, so both classes prefer this solution to autarky. However, expected consumption of type (i=g) agents is greater here than it is in the previous case, and thus, if financial intermediaries can be formed, they will be. Put another way, the intermediary solution is a Pareto optimum for this economy,

unless it is prohibited. Note than in the intermediation case, all agents which represent themselves as type $(i=g)$ are actually of that type; in other words, there is no mimicking. A fraction, $\pi(e=b|i=g) = .05$, of $(i=g)$ agents get zero consumption even if the project realizes a a good return. However, no type $(i=g)$ agent knows *ex ante* if he will be among this five percent group, and this is part of the mechanism which results in an *ex ante* efficient allocation.

7. On Side Payments

In the preceding analysis we did not deal with the possibility of side-payments to evaluators, in exchange for their intentionally mis-representing evaluation outcomes. Campbell and Kracaw [1980, 1981], however, have argued that precisely because of this possibility, finan-cial intermediaries have no comparative advantage (over ultimate bor-rowers) in the production of investment information. Thus, this problem merits comment, and here we deal with it at two levels: first, in the specific context of the economy specified in Section 2, and second, more generally.

Side payments to evaluators, in exchange for their purposely misrepresenting evaluation outcomes at the expense of other coalition members, would surely be illegal. Therefore, parties to contracts invol-ving such payments would not have recourse to the court system.[8] And in the two period world we have considered, multi-period or sequential con-tracts are impossible. Without the possibility of recontracting *or* court actions, such contracts would be strictly unenforceable and agents would

never enter into them. Consider the following simple examples. If a bribe were paid in advance to an intermediary evaluator, he would have no further incentive to misrepresent the evaluation outcome; rather he would have a disincentive to misrepresent, as misrepresentation is costly to the coalition. On the other hand, if the misrepresentation were made in advance, the borrower would have no further incentive to pay the bribe.

In a more general multi-period environment though, would-be thieves can enter into contracts that are self-enforcing because it is beneficial to both parties to perform as agreed. Then, bribery can admittedly be a problem and some resources must be allocated to its control. Misrepresenting credit risks in exchange for side-payments is usually a criminal activity in this context, and just agreeing to engage in the activity may constitute conspiracy. This means that both parties can be subject to criminal prosecution. Such arrangements may therefore result in more costly outcomes, such as jail sentences, which cannot be included in private contracts. Resultantly, a low level of monitoring may be sufficient to render such activities unprofitable.

There are other, less extreme, practices that intermediaries also employ to minimize bribery. An evaluation is sometimes split among many evaluators, or the identity of the evaluator kept secret from the potential borrower. This makes criminal conspiracies difficult. Another common practice is for loan committees to review applications which have been approved by individual loan officers, before funds are released. Performance of loan officers is typically monitored over time, including the number and cost of bad loans that the officers approved. In other words, there is a good deal of monitoring both before and after a loan is made.

In our view, the problem of side-payments to evaluators is a relatively trivial one for financial intermediaries, being not unlike the problem of check-out clerks stealing from supermarket tills. For this reason, abstracting from it in an economic model of financial intermediaries, we think, is justified.

8. Some Possible Extensions

For the examples considered there are but two possible returns and but two possible evaluation outcomes. This did facilitate the characterization of the equilibrium allocations but played no essential role in the analysis. The program (5.1-5.8) whose solution is the equilibrium allocation, is not changed if the sets of possible e and r are expanded.[9] Extending the results to the case in which the evaluation e provides information in addition to that contained in type i concerning return r is also immediate. The equilibrium allocation that is supported by the competitive intermediaries is again the solution to program (5.1-5.8).[10]

An extension which does not appear to be so straightforward is one in which there are more than two i-types. The problems that arise in competitive analysis of economies with adverse-selection are now apparent (see Prescott and Townsend [1981]). With the Rothschild-Stiglitz [1976] construct, competitive equilibria frequently fail to exist. With the Spence [1974] approach, existence of an equilibrium is not a problem but multiplicity of equilibria is, and many equilibria are not efficient. With but two types, our adverse-selection competitive intermediary con-

struct is plagued neither by nonexistence nor multiplicity of equilibria problems. In addition, it yields a Pareto optimal allocation. How to extend the concept to many types is still an open question and is the subject of ongoing research. Such an extension, if successful, will not overturn any of the conclusions of this paper however. Financial intermediaries will necessarily display the same key characteristic that they do for the two special cases considered here.

Footnotes

[1]/The only important exception to this statement we have seen is a study by Townsend [1978]. He assumes fixed and known transaction costs and shows how, in a general equilibrium setting, these costs may be minimized by an arrangement where one agent acts as an "intermediary" for some others.

[2]/So, too, does a recent paper by Diamond [1982], which treats intermediaries as the agents of lenders, hired to monitor borrowers. He concludes that such delegated monitoring arrangements result in Pareto superior resource allocations, thus providing a positive role for financial intermediary firms.

[3]/By financial intermediaries, we mean commercial banks, thrift institutions, loan companies, consumer finance companies, etc.--the so-called "asset transformers." (Gurley and Shaw [1956]) We do not include security brokers, dealers and exchanges. These are perhaps better described as an arrangement for executing security transactions by providing payment, delivery and accounting, as well as a system for arriving at a price.

[4]/This can be accomplished, for example, as follows. Let n, n $\epsilon\{1,2,3 \ . \ . \ . \ \}$ index agents, and consider the sequence $\{1,1,2,1,2,3,1,2,3,4,1 \ . \ . \ . \ \}$. Agent n is assigned to intermediary k, for $k = 1,2,3 \ . \ . \ . \ $, if the n-th element of this sequence is k. Note the fraction of agents in any intermediary is zero.

In most of the environments considered here each intermediary must have a countable infinity of borrowers and lenders. We chose to examine this limiting case because it is simplest. At the cost of some added complexity, however, we could modify our environments slightly and

obtain essentially the same results with a large but finite constraint on the size of intermediaries. Readers interested in this problem should see Diamond [1982].

5/ If we allow for the possibility of sequential evaulation and recontracting, there is another intermediary arrangement, different than that described in the text, which achieves exactly the same investment allocations and expected consumption. An intermediary composed of one evaluator and χ investors employs the following rule: "If upon evaluation e = g, invest χ in the project. Otherwise add one more investor and evaluate again. Continue this process until e = g is obtained and then invest χ." Each coalition member, including the evaluator, is compensated proportionally to his wealth remaining at the time of a successful evaluation. This arrangement works in the present environment where it results in an intermediary of finite expected size. We thank Ken Cone for pointing out this fact. If the environment is made slightly more complicated, however, (as in Section 5) the arrangement fails.

6/ This structure is related to the one considered by Prescott and Townsend [1980], but differs in that a coalition-intermediary is needed, rather than an entity that receives or delivers goods based upon agents' statements of type. Here, optimal coalitions or syndicates (see Holmstrom [1982]) rather than just optimal contracts (see Townsend [1979]) arise, as the result of competitive behavior. The intermediary or firm can also be viewed as a nexus of contracts (Coase [1937]) or as an arrangement to economize on transaction costs (Williamson [1975]).

7/ See Harris and Townsend (1981). If agents were not risk neutral it would be necessary to consider consumption lotteries contingent upon the observables as in Prescott and Townsend (1980, 1981). If

it were not part of the technology to precommit to evaluation subsequent to the report of type, the revelation principle would fail and the analysis would be more difficult.

[8]/ By the so called "clean hands doctrine" the courts will not knowingly enforce illegal contracts, even if parties entered into them willingly.

[9]/ There, of course, must be additional population consistency constraints of the (5.3) variety.

[10]/ Another possible modification would be to permit correlation among project returns. This is a relatively easy extension if project returns depend on common events which are publicly observed. It does not disturb any of the major conclusions presented in this paper. (See Diamond, [1982]).

BIBLIOGRAPHY

Campbell, Tim S. and William A. Kracaw, "Information Production, Market Signaling and the Theory of Financial Intermediation," The Journal of Finance, September 1980, pp. 863-82.

_____, "Sorting Equilibria in Financial Markets: The Incentive Problem," Journal of Financial and Quantitative Analysis, November 1981, pp. 477-94.

Coase, R. H., "The Nature of the Firm," Economics NS 1937, 4: pp. 386-405, repv. in G. J. Stigler and K. E. Bouldings, etc; Readings in Price Theory. Homewood, Illinois: Richard D. Irwin Inc. 1952.

Diamond, Douglas W., "Financial Intermediation and Delegated Monitoring," Center for Security Prices, University of Chicago Work Paper No. 82, August 1982.

Fama, Eugene F., "Banking in the Theory of Finance," Journal of Monetary Economics, 6, 1980, pp. 39-57.

Green, Edward J., "Notes on Incentives and Welfare in Credit Markets," California Institute of Technology Working Paper, December 1982.

Gurley, John G. and Edward S. Shaw, "Financial Intermediaries and the Savings-Investment Process," The Journal of Finance, May 1956, pp. 259-275.

Harris, Milton and Robert M. Townsend, "Resource Allocation Under Asymmetric Information," Econometrica 49, January 1981, pp. 33-64.

Holmstrom, Bengt, "Moral Hazard in Syndicates," Northwestern University Working Paper, April 1982.

Leyland, Hayne E. and David H. Pyle, "Informational Asymmetrics, Financial Structure, and Financial Intermediation", The Journal of Finance, May 1977, pp.371-88.

Prescott, Edward C. and Robert M. Townsend, "Pareto Optima and Competitive Equilibria With Moral Hazard and Adverse Selection," Carnegie-Miller Working Paper, revised June 1981, forthcoming, Econometrica.

_____, "General Competitive Analysis in an Economy With Private Information," University of Minnesota Working Paper, revised February 1980, forthcoming International Economic Review.

Rothschild, Michael and Joseph Stiglitz, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfection Information," Quarterly Journal of Economics, 90, November 1976, pp. 629-649.

Spence, Michael A., Market Signaling: Information Transfer in Hiring and Related Screening Processes, Harvard University Press, Cambridge, Massachusetts, 1974.

Townsend, Robert M., "Intermediation With Costly Bilateral Exchange," Review of Economic Studies 45, 1978, pp. 417-425 (1978).

_____, "Optimal Contracts and Competitive Markets With Costly State Verfications," Journal of Economic Theory 21, 1979, pp. 265-293.

Williamson, Oliver E., Markets and Hierarchies, A Study in the Economics of Internal Organization," New York Free Press: 1975.