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Financial Intermediary-Coalitions

JOHN H. BOYD AND EDWARD C. PRESCOTT*

University of Minnesota, Minneapolis, Minnesota 55455, and Research Department, Federal Reserve Bank, Minneapolis, Minnesota 55480†

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In this article an environment in which the investment opportunities of agents are private information is studied and it is shown that financial intermediaries arise endogenously within that environment. It is established that financial intermediaries are part of an efficient arrangement in the sense that they are needed to support the authors' private information core allocations. These intermediaries, which are coalitions of agents, exhibit the following characteristics in equilibrium: they borrow from and lend to large groups of agents; they produce information about investment projects; and they issue claims that have different state contingent payoffs than claims issued by ultimate borrowers. *Journal of Economic Literature* Classification Numbers: 021, 026, 314.

1. INTRODUCTION

Five facts concerning real-world financial intermediaries are as follows:

(i) Financial intermediaries borrow from one subset of agents in the economy and lend to another.

(ii) Both subsets—borrowers and lenders—are typically large. Thus, to the extent that numbers represent diversification, financial intermediaries are generally well diversified on both sides of their balance sheets.

(iii) Financial intermediaries deal with borrowers whose information set may be different from theirs. In practical terms, this means that would-be borrowers often have better information concerning their own credit risk than do the intermediaries.

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(iv) Financial intermediaries produce costly information on the attributes of would-be borrowers. This information is used to allocate loans and set terms.

(v) Financial intermediaries issue claims that have state contingent payoffs different from claims issued by ultimate borrowers.

This paper analyzes a primitive environment in which financial intermediaries endogenously emerge and exhibit these five characteristics. In the environment studied, all equilibrium arrangements display these five features, except for one special case, in which diversification is unnecessary.[1]

Much has been written about financial intermediaries, and there is general agreement that these firms, which account for about 8% of U.S. gross national product, are somehow important. Despite the volume of past studies, however, research on this topic remains at a relatively primitive stage. This is primarily so because in Arrow–Debreu economies such organizations are unneeded. Until quite recently, serious analysis of intermediaries was therefore hindered by the lack of convincing general equilibrium theories that give rise to trading frictions.

An economy in which intermediaries endogenously emerge was described by Townsend [12, 13]. In this economy, intermediary-coalitions trade off gains from risk-sharing against per capita connecting (transaction) costs. If this structure has a weakness, it is that transaction costs are assumed to exist and are not explicitly related to exchange technologies nor differentiated between types of trades. Even so, our work is significantly indebted to Townsend and, following his example, we have adopted a core equilibrium concept as the most appropriate for studying intermediated environments.

Another group of studies has exploited recent advances in information economics, applying them to the study of intermediation. These are too numerous to review in detail. (See, for example, Diamond and Dybvig [3], Diamond [2], Haubrich and King [7], Ramakrishnan and Thakor [10], Smith [11], and Williamson [15].) However, their similarities to and differences from our own work should become apparent as we proceed.

In some respects, Diamond [2] is close to this study. He investigates an environment in which lenders delegate the costly monitoring of borrowers to an agent called a financial intermediary. He shows that as the intermediary agent deals with an increasing number of borrowers and lenders,

[1] By financial intermediaries, we mean commercial banks, thrift institutions, loan companies, consumer finance companies, and so forth—the so-called asset transformers (Gurley and Shaw [5]). 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.

contracting costs decline monotonically. Thus, the intermediary agent will contract with as many individuals as possible. This result, or at least a similar incentive to deal with many borrowers and lenders, is obtained in several of the other studies (for example, Ramakrishnan and Thakor [10] and Williamson [15]), as well as in our own. And like Diamond [2] and Williamson [15], we obtain this result in an environment in which all agents are risk-neutral.

There are, however, a number of important differences between our work and Diamond's. For example, our assumptions concerning information differ from his. In our analysis, there are informational asymmetries prior to contracting; thus, adverse selection is a crucial problem. Moreover, the production of information in our model is public and there are no non-pecuniary penalties. The equilibrium definitions used are different as well: following Townsend [12, 13], we employ a core equilibrium concept, whereas Diamond uses a partial equilibrium market construct. And finally, in equilibrium our intermediaries are coalitions of many agents, whereas his are single agents.

In one important respect, our environment differs from those assumed in previous studies and leads to very different conclusions. Our environment has (endowed) informational asymmetries prior to contracting and *also* the possibility of producing additional information after contracting. Only in the general case with both "sources" of information open do intermediary-coalitions emerge endogenously. That is, if either information "source" is closed (for example, by assuming all agents are identically endowed or by prohibiting information production after contracting), financial intermediaries are unnecessary, in the sense that the same allocations can be achieved with simpler market type arrangements. Thus, financial intermediary-coalitions arise to efficiently produce information in environments in which project owners have private information concerning their investment opportunities.

We hope this study also contributes to the general understanding of equilibrium in economies with private information prior to contracting, and thus is of interest beyond the study of intermediation per se. The equilibrium concept defined and employed here is related to that of the core, but there are two important differences necessitated by private information considerations: First, we assume that coalitions have access to a contracting technology which can preclude subsequent recontracting. Second, we assume that agents cannot be excluded from coalitions based upon private information about agents' types. For our economy, core equilibrium allocations exist and are essentially unique. Like large, pure exchange economies, the distributions of the gains from trade depend upon the relative numbers of different agent types.

Briefly, the paper proceeds as follows. In Section 2 we describe the economy. In Section 3, we define a core equilibrium concept for this class of economy. In Section 4, we conjecture that a particular Pareto-optimal allocation is the core equilibrium allocation for this environment. In Section 5, we prove that it is, and that it is essentially unique. In Section 6, this allocation is supported with competitive intermediary-coalitions. Then, we show that it *cannot* be supported with a securities market. In Section 7, three special cases are examined. In the first two, intermediary-coalitions prove to be unnecessary when agents are identically endowed (there is no adverse selection) or when information production is not possible. In both cases, the core equilibrium allocation can be supported with a securities market. The third special case is one in which intermediary-coalitions are needed to support the core equilibrium, but they need not borrow from and lend to a large number of agents. Section 8 summarizes and concludes the paper.

2. The Economy

There is a countable infinity of agents who live for two periods. In the initial period, they are endowed with one unit of time and an investment project of either a good type, $i = g$, or a bad type, $i = b$. In the first period, agents can use their endowment of time either to produce one unit of the investment good or to evaluate a project. Agents' preferences are ordered by expected consumption in the second and final period. Thus, $E\{c\}$ orders the distribution of consumption outcomes where $E\{\cdot\}$ is the expectation operator. Consumption is necessarily nonnegative—an assumption which plays an important 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. If a project is evaluated, a signal $e = b$ or $e = g$ is observed. This signal provides information about the rate of return on the project, which may be better or worse than the information provided by the 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 $(i, e, r) \in \{g, b\} \times \{g, b\} \times \{g, b\}$. Since there is a countable infinity of agents, throughout this analysis we consider the fractions of the various types, which are just the $\pi(i, e, r)$, and write resource constraints in per capita terms. For a rigorous justification of this procedure, see Green [4].

Agents know their own type $i = g$ or $i = b$ and, of course, the probabilities $\pi(i, e, r)$. They do not have the opportunity to enter into contracts before observing their i. Throughout this paper, expectations are with respect to the probability distribution defined by the $\pi(i, e, r)$. Agent type i is the only private information. The actions of evaluating and investing are publicly observed, and also publicly observed are realized project returns r, consumption outcomes c, evaluation results e, and terms of all contracts. No important result would be affected if e were private, however, since it is assumed that there exists a contracting technology whereby any agent's consumption can be made independent of the e that agent reports.

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

$$\pi\{r = g \mid i = g\} > \pi\{r = g \mid i = b\}$$

and

$$\pi\{r = g \mid i, e = g\} > \pi\{r = g \mid i, e = b\}, \qquad \text{for} \quad i \in \{b, g\}.$$

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

The following assumptions are made to restrict the analysis to the "interesting" cases—those in which there is evaluation in equilibrium and trade between classes of agents.

$$\chi E\{r \mid i = g, e = g\}\, \pi\{e = g \mid i = g\} + \chi E\{r \mid i = g\}\, \pi\{e = b \mid i = g\} > (\chi + 1)\, E\{r \mid i = g\}. \tag{2.1}$$

The left-hand side of (2.1) is the return for a group of agents who have $\chi + 1$ units of the investment good and at least two type $i = g$ projects, and who adopt the strategy of evaluating and fully funding one of their $i = g$ projects, if and only if $e = g$. Otherwise, they will fully fund another type $i = g$ project. This strategy dominates the no-evaluation strategy of unconditionally allocating the full $\chi + 1$ units of the investment good to type $i = g$ projects, the expected return of which is the right-hand side of (2.1). In other words, without the privateness of project type i, it always pays to evaluate type $i = g$ projects.

$$\chi E\{r \mid i = b, e = g\}\, \pi\{e = g \mid i = b\} + \chi E\{r \mid i = b\}\, \pi\{e = b \mid i = b\} < (\chi + 1)\, E\{r \mid i = b\}. \tag{2.2}$$

By the same logic as above, (2.2) implies that the cost of evaluating type $i = b$ projects exceeds the expected return to doing so. Without the privateness of i, it would never pay to evaluate type $i = b$ projects.

$$E\{r \mid i = g, e = b\} < E\{r \mid i = b\}. \tag{2.3}$$

The implication of (2.3) is that it is better to invest unconditionally in a type $i = b$ project than to invest in a type $i = g$ one with a bad evaluation.

$$\chi\pi\{i = g, e = g\} < 1 - \pi\{i = g\}. \tag{2.4}$$

With assumption (2.4), if all type $i = g$ projects are evaluated and all those that obtain a good evaluation are fully funded, some of the investment good will still remain. And given assumptions (2.2) and (2.3), without privateness the remainder will be unconditionally invested in type $i = b$ projects. Thus type $i = b$ will always be the "marginal" projects that may or may not be funded.

The timing of various events and actions during the two periods is shown in Table I.

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:

$$\text{Total investment per capita} + \text{Total number of evaluations per capita} \leqslant \text{Total endowment per capita}. \tag{2.5}$$

$$\text{Per capita consumption} \leqslant \text{Per capita production of the consumption good}. \tag{2.6}$$

DEFINITION. An intermediary-coalition is a group of $n \geqslant 1$ agents which publicly announces rules for its members. These rules specify each member's actions, including investing, evaluating, and contracting with nonmembers, as well as members' consumption outcomes. A large coalition is one with n infinite.

Discussion. It may be helpful to think of an intermediary-coalition as first announcing group rules and then contracting with nonmembers

TABLE I

Event or Action
During Period 1
All agents know whether their project type is $i = g$ or $i = b$ prior to any contracting opportunities.
Agents can enter into contracts. Agents can evaluate.
Agents make investments.
During Period 2
Projects' returns are realized.
Consumption occurs.

according to those rules. The rules themselves may be viewed as complex contracts involving many agents. As will be demonstrated, the optimal rules condition the consumption outcomes of coalition members on *group* experience as well as on observables for individual members—something that cannot be done with bilateral (two-agent) contracts.

An intermediary-coalition is therefore a group of agents that jointly evaluate projects, invest in projects, and share project returns. They might be called "firms," "joint ventures," or "cooperatives," for in this primitive environment there is little to distinguish among these organizational forms. They are not, however, "firms" in the Arrow–Debreu sense of a technology specified as a subset of the commodity space.[2]

Throughout this paper, no intermediary-coalition has any monopoly power. In the economies described later—those with competing intermediary-coalitions—this is accomplished by having a countable infinity of agents and by intermediaries being "small" in the sense that the fraction of all agents that deals with any intermediary is zero. At the same time, intermediaries are "large" in the sense that each has a countable infinity of borrowers and lenders.

3. Definition of Equilibrium

In this section, j denotes what type an agent reports himself to be, while i denotes the agent's true type. Attention is restricted to those arrangements in which it is never in the agent's interest to misrepresent his type, the so-called simple direct mechanisms. Our justification for this restriction is the revelation principle, which ensures, for a class of economies including ours, that if a particular arrangement entails dishonesty in equilibrium, then there exists another arrangement which does not and which has the same equilibrium allocation.[3]

It is necessary to introduce some additional 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

[2] Our intermediary-coalitions could also be viewed as a nexus of contracts (Coase [1]) or as an arrangement to economize on transaction costs (Williamson [14]).

[3] See Harris and Townsend [6]. If agents were not risk-neutral, it would be necessary to consider consumption lotteries contingent upon the observables, as in Prescott and Townsend [8, 9]. 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.

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

c_{ir} = consumption of a type-i project with return r, not evaluated

c_{ier} = consumption of a type-i project 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 agent who reports to be a type j; thus,

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

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

DEFINITION. An allocation (c^O, x^O, z^O) is an equilibrium if no large coalition of agents, with fractions $\pi^d(i)$ of agent types i, can achieve a *different* allocation (c^d, x^d, z^d) which satisfies (3.1)–(3.3) below.

[We shall refer to this subset of agents, indicated with the d-superscript, as a "deviant," or breaking, coalition. Note that because the coalition is large (that is, $n = \infty$), $\pi^d(e, r \mid i) = \pi^d(i)\, \pi(e, r \mid i)$; or conditional on i, the coalition's population fractions are representative of the entire population.]

$u_i^d > u_i^O$, for some type i. (Here, u_i^a denotes the utility of a type-i agent resulting from allocation a.) (3.1)

$$\text{If } u_i^d < u_i^O, \text{ then } \pi^d(i) = 0, \tag{3.2a}$$

$$\text{if } u_i^d = u_i^O, \text{ then } \pi^d(i) \leqslant \pi(i), \tag{3.2b}$$

and

$$\text{if } u_i^d > u_i^O, \text{ then } \pi^d(i) \geqslant \pi(i). \tag{3.2c}$$

Investment good resource constraint:

$$\sum_e \sum_i \pi^d(i)\, \pi(e \mid i)[z_i(x_{ie} + 1) + (1 - z_i)\, x_i] \leqslant 1. \tag{3.3a}$$

Consumption good constraint:

$$\sum_i \pi^d(i)[u_i(c, z, j = i)] \leqslant \sum_i \pi^d(i)[z_i E_{e,r}\{r x_{ie} \mid i\} + (1 - z_i) E_r\{r x_i \mid i\}]. \tag{3.3b}$$

Incentive constraints:

$$u_i(c, z, j=i) \geqslant u_i(c, z, j \neq i) \quad \text{for all } i$$
$$u_i(c, z, j=i) \geqslant E_r\{r \mid i\} \quad \text{for all } i. \tag{3.3c}$$

Other constraints:

$$z_i \leqslant 1 \quad \text{for all } i$$
$$x_i \leqslant \chi \quad \text{for all } i \tag{3.3d}$$
$$x_{ie} \leqslant \chi \quad \text{for all } i, e.$$

Discussion. Conditions (3.1) and (3.2a) require that, to attract members, a deviant coalition must make at least some of its members better off and none worse off. Condition (3.2b) deals with ties. It states that when agents of type i are indifferent between an O-allocation and a d-allocation, some of them may go to the deviant coalition. However, as indicated by (3.2c), the deviant coalition cannot attract higher-than-population proportions of type-i agents unless it makes them strictly better off. Conditions (3.3a)–(3.3d) are resource, incentive, and nonnegativity constraints, respectively. It is important to note that in the resource constraints (3.3a) and (3.3b), the average is with respect to the type-i population fractions in the deviant coalition.

4. A Conjectured Equilibrium Allocation

In this section, we conjecture that a particular Pareto-optimal allocation is an equilibrium allocation as defined above.[4] It is the feasible allocation which maximizes the utility of type $i=g$ agents, subject to the constraint that it is in the interest of type $i=b$ to participate. (In Section 5, we prove the conjecture and also prove that the equilibrium allocation is essentially unique.)

Our candidate for an equilibrium allocation is the solution to the program

$$\max_{x,c,z \geqslant 0} u_g(c, z, j=g), \tag{4.1}$$

subject to the investment good resource constraint

$$E_{i,e}\{z_i(x_{ie}+1)+(1-z_i)\,x_i\} \leqslant 1; \tag{4.2}$$

[4] Here and throughout this paper, by "Pareto optimal" we mean optimal subject to incentive and resource constraints.

the consumption good constraint

$$E_i\{u_i(c, z, j=i)\} \leqslant E_i\{z_i E_{e,r}\{rx_{ie} \mid i\} + (1-z_i) E_r\{rx_i \mid i\}\}; \tag{4.3}$$

the incentive constraints

$$u_i(c, z, j=i) \geqslant u_i(c, z, j \neq i) \qquad \text{for all } i \tag{4.4}$$

$$u_i(c, z, j=i) \geqslant E_r\{r \mid i\} \qquad \text{for all } i; \tag{4.5}$$

and the other constraints

$$z_i \leqslant 1 \qquad \text{for all } i \tag{4.6}$$

$$x_i \leqslant \chi \qquad \text{for all } i \tag{4.7}$$

$$x_{ie} \leqslant \chi \qquad \text{for all } i, e. \tag{4.8}$$

Although not a linear program, it can be transformed into one by changing variables as follows: substitute 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 $(1-z_i)c_{ir}$. Note that (4.7) becomes $v_i \leqslant \chi(1-z_i)$ and (4.8) becomes $v_{ie} \leqslant \chi z_i$. It is now a linear program in z, v, and w. Solution values are denoted with an asterisk.

If we use assumptions (2.1)–(2.4), this program is interesting and not so formidable. First, all good projects are evaluated and are fully funded if and only if $e=g$. 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—the one which ensures 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 $x^*_{gg}=\chi$. 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 the expected consumption of type $i=b$ agents yield alternative optimal allocations. Consequently, only $c^*_b \equiv E_r\{c^*_{ir} \mid i=b\}$ is uniquely determined. It, along with c^*_{ggg} and x^*_b, remains to be determined.

These three elements can be deduced from knowledge of the binding constraints. First, constraint (4.2) is binding, so

$$\chi\pi(i=g, e=g) + x^*_b \pi(i=b) = 1 - \pi(i=g). \tag{4.9}$$

Second, incentive constraint (4.4) with $i=b$ and $j=g$, or constraint (4.5) with $i=b$, is binding, so

$$c_b^* = \max\{E\{r \mid i=b\}, c_{ggg}^* \pi(e=g, r=g \mid i=b)\}, \tag{4.10}$$

as is resource constraint (4.3), or

$$\begin{aligned} &c_{ggg}^* \pi(i=g, e=g, r=g) + c_b^* \pi(i=b) \\ &\quad = x_b^* E\{r \mid i=b\}\, \pi(i=b) + E\{\chi r \mid i=g, e=g\}\, \pi(i=g, e=g). \end{aligned} \tag{4.11}$$

Equations (4.9)–(4.11) have a unique solution which is nonnegative. We are particularly interested in parameter values for which $c_b^* > E\{r \mid i=b\}$, for then, as shown in Section 6, securities markets cannot be used to support this allocation. If χ is sufficiently large, if e provides sufficiently little information concerning r for type $i=b$, and if $\pi(i=g)$ is sufficiently small, then $c_b^* > E\{r \mid i=b\}$. An example in Section 6 establishes that the set of parameters for which this holds is nonempty.

5. Proof That the Candidate Allocation Is the (Essentially) Unique Core Equilibrium Allocation

PROPOSITION 1. *The allocation defined by the solution to the program (4.1)–(4.8) is an equilibrium allocation. [Following our notational convention, this is called a *-allocation and* $u_i^* \equiv u_i(c^*, z^*, j=i)$.]

Proof. By construction, both types of agents weakly prefer the *-allocation to autarky. Thus, to attract any agents, a d-coalition must attract some agents of both types. This, in turn, requires that some agents be made better off, by condition (3.1), and no agents be made worse off, by (3.2a). Since the *-allocation is itself a Pareto optimum, the d-coalition must therefore attract higher-than-population proportions in the sense that $\pi^d(g) > \pi(g)$. From (3.2b) and (3.2c), to attract higher-than-population proportions requires that $u_g^d > u_g^*$ and $u_b^d = u_b^* = c_b^*$. However, these expected consumptions are not incentive feasible. If the expected consumption of a type-g agent is higher in the d-coalition than in the *-coalition, then by (4.10), $u_b(c^d, z^d, j=g) > c_b^*$. Every type-$b$ agent would want to join the d-coalition and misrepresent project type. Thus, a d-coalition cannot simultaneously satisfy (3.1)–(3.3), and Proposition 1 is proved.

PROPOSITION 2. *The *-allocations are the only equilibrium allocations.*

Proof. Any allocation that is not a Pareto optimum could be broken by a deviant coalition of the whole. Thus, without loss of generality, we restrict our attention to Pareto-optimal allocations. Now consider any Pareto-optimal allocation *other than* a *-allocation. We call this a "p-allocation." If some Pareto-optimal allocation results in utilities u_b^p and u_g^p, then there exists an allocation which also results in these utilities with $c_{br}^p = u_b^p$, for all r; $c_{gb}^p = 0$; and $c_{ger}^p = 0$, unless $e = g$ and $r = g$. Further, c_{gg}^p and c_{ggg}^p may be set so that the expected utility of type $i = g$ agents is the same, whether or not they are evaluated. Note that $z_b^p = 0$, since Pareto optimality requires that no type $i = b$ projects are evaluated and, of course, that $x_{gg}^p = \chi$ and $\chi_{gb}^p = 0$.

To break any p-allocation, we construct a deviant coalition with the following properties: The fraction of type $i = g$ agents is increased until it is just high enough that investment in type $i = b$ projects is driven to zero. This will occur when

$$\pi^d(i=g) = [1 - \pi(i=g, e=g)\, z_{gg}^p]/[1 + \chi - \pi(i=g, e=g)(z_{gg}^p + \chi)]. \quad (5.1)$$

All incremental type $i = g$ projects (those in excess of population proportions) are evaluated and, if $e = g$, funded at level χ. Owners of these projects are assigned the same consumptions as other type $i = g$ agents whose projects are evaluated. By adding and evaluating type $i = g$ projects, investment funds can be reallocated from projects with low expected returns to ones with high expected returns. Production of the consumption good increases by an amount that exceeds the consumption of the incremental type $i = g$ agents. Consequently, there will be slack, say $\delta > 0$, in the consumption good constraint—that is, constraint (4.3) with $\pi^d(\cdot)$ fractions of agent types.

Now, let $c^\theta = \theta c^p + (1 - \theta)\, c^*$ for $0 < \theta < 1$. Next, increase every component of c^θ by $\varepsilon > 0$ where

$$\varepsilon = \theta(u_b^p - u_b^*). \quad (5.2)$$

Choose a θ such that $\varepsilon < \delta$. The resulting consumption contract (which is a 12-tuple) is denoted c^d. Other elements of contract d are $x_{gg}^d = \chi$, $\chi_{gb}^d = 0$, $x_b^d = 0$, $z_b^d = 0$, and

$$z_{gg}^d = [1 + \pi(i=g, e=g)(\chi z_{gg}^p - z_{gg}^p - \chi)]/[1 - \pi(i=g, e=g)\, z_{gg}^p] \quad (5.3)$$

where z_{gg}^d is the value of z_{gg} which solves the investment resource constraint, given that $\pi^d(i=g)$ satisfies (5.1) and all other variables in the d contract are set as specified.

The c^θ contract satisfies incentive constraints (4.4) and (4.5) because the constraints are linear in c, and c^θ is a convex combination of c^p and c^*, which both satisfy these constraints. Adding ε to all elements of c increases both sides of (4.4) by ε and cannot violate the inequality. It adds ε to the left-hand side of (4.5) and cannot violate that inequality either. Contract d is resource and incentive feasible with $\pi^d(\cdot)$ fractions of agent types. As $u_b^d = u_b^p$, $u_g^d > u_g^p$, $\pi^d(i=g) > \pi(i=g)$, and $\pi^d(i=b) < \pi(i=b)$, requirements (3.1) and (3.2) for a blocking group are satisfied as well. Thus, the p-allocation is broken by the d-allocation, and Proposition 2 is proved.

6. The Core Equilibrium Allocation Can Be Supported with Large Intermediary-Coalitions, But Not with a Securities Market

An institutional arrangement that supports the core allocation is one with large coalitions of type $i=b$ agents. In period one, each coalition commits to the following policy:

— Each coalition member will evaluate one project.

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

— The coalition agrees to evaluate n projects, whose owners must deliver a unit of the investment good prior to investing. Coalition members use their endowments for evaluation. The coalition agrees to fund each of the $n\pi(e=g \mid i=g)$ projects with good evaluations. (Recall that this activity is publicly observable.) Project owners (entrepreneurs) are promised c_{ggg}^* units of the consumption good in the next period if the project has evaluation $e=g$ and return $r=g$, and zero units if otherwise.

— After it has fully invested in all the type $i=g, e=g$ projects it obtains, the coalition invests any remaining funds in type $i=b$ projects of depositors (or coalition members).

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

The fraction of type $i=b$ agents that become coalition members is $\pi(i=g)/\pi(i=b)$. This ensures that there are just enough of them to evaluate all type $i=g$ projects. The remaining type $i=b$ agents become depositors, and all type $i=g$ agents contract with a coalition. This arrangement is incentive and resource feasible, and the core allocation results. Consequently, it is a core equilibrium and there can be no blocking coalitions.

We do not claim that this is the only institutional arrangement that could support the core-equilibrium allocation. For example, coalitions could be composed of agents who act as depositors and hire other type $i=b$ agents to do the evaluations. It does appear, however, that small (finite-sized) intermediary-coalitions cannot support the core. For reasons of technical efficiency, it is essential that the actual fraction of type $i=g$, $e=g$ projects obtained by *each* coalition not be too large; for if any coalition obtains too many good projects, not all of them can be fully funded. And with small coalitions this problem occurs with positive probability. Further, the problem cannot be circumvented by evaluating prior to contracting (and thus perfectly sorting so as to obtain exact population proportions at each coalition). With that arrangement, there is an incentive for some type $i=b$ agents to misrepresent their type and "mimic" the type $i=g$. (Such mimicking will be discussed in detail shortly.) Nor can the problem be overcome by permitting individual agents to recontract after initial coalition formation—say, by having some of them split off and form new coalitions. Every type $i=b$ agent who becomes a coalition member or depositor publicly reveals his type and cannot expect to obtain expected consumption exceeding $E\{r \mid i=b\}$ if recontracting is necessary.

Admittedly, if there are separate organizations which provide insurance to small intermediary-coalitions (insurance against obtaining other-than-population proportions of project types), the core equilibrium allocation can be supported with small intermediary-coalitions. However, the insurers themselves must necessarily be large, and thus this arrangement is hardly different than one with large intermediary-coalitions.[5]

[5] If there were a legal or technological constraint limiting the maximum value of n, then the equilibrium would be one in which that constraint was binding for all intermediary-coalitions. The constraint would be costly, since not all type $i=g, e=g$ projects could be fully funded. Period two consumption of coalition members and/or depositors would also be uncertain. An interesting question posed by Douglas Diamond is, Can the core allocation be supported by an arrangement with nondiversified (that is, finite-sized) coalitions, along with a post-evaluation credit market in which only coalitions can participate? The answer is no. The law of one price dictates that the deposit interest rate c_b^* and the interest rate in the post-evaluation credit market r^* be the same. But this is not possible in equilibrium, because if $r^*=c_b^*$, evaluating agents could realize a higher utility than c_b^*, which is the core utility for type $i=b$ agents. They could do so by following a strategy of accepting no depositors. If a coalition of size n evaluated n projects and at least one obtained an $e=g$ evaluation, the evaluating agents' post-evaluation utility would exceed c_b^*. If no evaluations with $e=g$ were obtained, they could still lend their n units of the investment good at the post-evaluation market rate r^* and realize utility c_b^*. Thus, with this strategy, their pre-evaluation expected utility would strictly exceed c_b^* if $r=c_b^*$. This contradiction shows that the post-evaluation markets cannot overcome the need for diversified (i.e., large) coalitions to support the core allocation.

A Securities Market Arrangement Cannot Support the Core Equilibrium Allocation

Another possible arrangement is a decentralized one in which some agents become "entrepreneurs," issue securities to other agents called "investors," and use the proceeds to fund their projects. We now consider such an arrangement. First, we define a security. Next, we describe the securities market equilibrium allocation, one that is Pareto-inferior to the core equilibrium allocation. Finally, we show that the core equilibrium allocation cannot be supported with a securities market.

DEFINITION. A security is a contract which in period one specifies the following:

— An amount $x \in [0, \chi]$ to be invested in a particular project indexed $e \in \{0, g, b\}$, where $e = 0$ corresponds to no evaluation.

— The consumption of the project's owner in period two. This could be contingent on the owner investing some amount in the project and on the project's return realization $r \in \{g, b\}$.

— Some share of the project's output, net of the owner's compensation, if any, that the security holder will receive in period two.

With a securities market arrangement, any agent can become an entrepreneur and issue securities in order to fund his project. A constraint on the contract offered investors is that the expected return must be at least the market rate of interest r^*. The expected return is conditional upon the investor's information set, and the key element in that information set is the offered contract. For example, if only type $i = g$ agents issue a particular security, then investors will assume that an agent offering that security is of type $i = g$. Less obvious, if the fraction of all agents that are of type i and that offer a particular security is θ_i, then investors' conditional probability of an agent being type i is $\theta_i/(\theta_g + \theta_b)$, for $i \in \{g, b\}$. In other words, it is assumed that agents use equilibrium population proportions in forming probability assessments.

If a security of type s is issued by a type-i agent, the issuer's resulting expected utility is denoted $u_i(s)$. Market equilibrium requires that each issuer of a security select from the set of offered securities one which maximizes his expected utility. Let the u_i^* be the maximum utilities. A final condition for a securities market equilibrium is that it not be in the interest of any agent to offer a security not in the offered set. More formally, no (i, s) exists for which $u_i(s) > u_i^*$, $u_j(s) \leqslant u_j^*$ for $j \neq i$, and for which the expected return to investors (who assume the issuer is of type i) is at least r^*

A securities market equilibrium exists for this economy and has the following characteristics:

— All type $i=g$ agents evaluate their projects and, if $e=g$, issue securities, each of which provides share $1/\chi$ of the project's return, less the return-contingent compensation of the entrepreneur. The entrepreneur's compensation is zero if $r=b$ and c_g^* if $r=g$.

— Some type $i=b$ agents mimic the type $i=g$; that is, they evaluate their projects and, if $e=g$, issue shares. The other type $i=b$ agents become investors. Let m_b^* be the fraction of type $i=b$ agents that choose to mimic and to evaluate their projects.

Then r^*, m_b^*, and c_g^* are determined by the following equilibrium conditions, which have straightforward economic interpretations. Mimicking type $i=b$ agents receive the same expected return as investors:

$$r^* = \pi(e=g, r=g \mid i=b)\, c_g^*. \tag{6.1}$$

The demand for the investment good equals the supply:

$$\chi[\pi(i=g, e=g) + m_b^* \pi(i=b, e=g)] = 1 - \pi(i=g) - m_b^* \pi(i=b). \tag{6.2}$$

Per capita consumption equals per capita output:

$$\begin{aligned} r^* \pi(i=b) + c_g^* \pi(i=g, e=g, r=g) \\ = \pi(i=g, e=g)\, E\{\chi r \mid i=g, e=g\} \\ + m_b^* \pi(i=b, e=g)\, E\{\chi r \mid i=b, e=g\}. \end{aligned} \tag{6.3}$$

These linear equations have a unique solution in the three variables.

As the following numerical examples will demonstrate, the market allocation can be different than, and inferior to, the core equilibrium allocation in the interesting cases in which the core equilibrium utility level of type $i=b$ agents exceeds $E\{r \mid i=b\}$. In the core allocation, fraction x_b^* of type $i=b$ projects are funded without evaluation. Given assumption (2.2), this is required for technical efficiency. In the market allocation, however, some type $i=b$ projects are evaluated. This results in a misallocation of resources, at least relative to the core.

The question is, Could a securities market arrangement support an allocation in which there is positive investment in type $i=b$ projects without evaluation? The answer is no, for the interesting cases. For this to occur, some type $i=b$ agents would have to issue securities without evaluation. But given assumptions (2.1) and (2.2), "no evaluation" is a perfect signal of (bad) type. Potential investors would know with certainty that these projects had expected return $E\{r \mid i=b\} < r^*$, and there would be no demand for their securities. It follows that intermediary-coalitions are "needed" to support the core allocation, an allocation which Pareto-dominates the decentralized securities market equilibrium allocation.

Numerical Examples

Figure 1 sets out the parametric assumptions for some numerical examples. With these parameters, which satisfy (2.1)–(2.4), the core equilibrium allocation, which is the solution to (4.1)–(4.8), is $x_b^* = 0.818$, $c_b^* = 1.441$, $c_{ggg}^* = 14.407$, and $u_g^* = 10.373$. The expected consumption of type $i = g$ agents is 10.373, and the expected consumption of type $i = b$ is 1.441. Since $E\{r \mid i = g\} = 3.7$ and $E\{r \mid i = b\} = 1$, both classes of agents prefer this allocation to autarky.

The securities market equilibrium allocation, which satisfies (6.1)–(6.3), is $m_b^* = 0.0744$, $r^* = 1.372$, $c_g^* = 13.72$, and $u_g^* = 9.878$. The expected consumption of type $i = g$ agents is now 9.878 and of type $i = b$ agents is 1.372. Both classes would prefer this allocation to autarky, but both are worse off than in the core allocation. This is due to the 7.44% of type $i = b$ agents

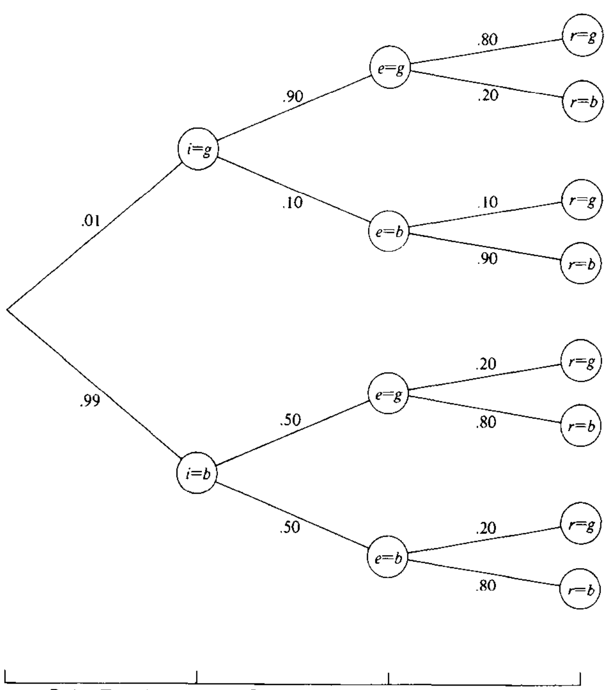

FIG. 1. Parameters for the numerical examples. The parameters are $\chi = 20$, $r_g = 5$, $r_b = 0$, and the probabilities shown above.

who evaluate their projects even though, by assumption, $\pi(r=g \mid i=b, e=g)=\pi(r=g \mid i=b, e=b)$. This diverts resources from productive investment and reduces the equilibrium consumption of all.

7. Three Special Cases

Three special cases merit brief discussion. The first is when all agents are initially alike or, equivalently, when i is independent of (e, r). In this case, information may be produced through evaluation but is, of course, public. Since i is suppressed, there is no private information whatsoever. Assumptions (2.2), (2.3), and (2.4) are necessarily dropped, but assumption (2.1)—with i suppressed—is maintained. The Pareto-optimal equilibrium allocation is still the solution to (4.1)–(4.8), but is much simplified when the i index is suppressed. Slightly redefining z^* to be the fraction of all projects evaluated, the solution is now characterized by two conditions which have simple economic interpretations.

The demand for the investment good equals the supply:

$$z^* \chi \pi(e=g)=1-z^*. \tag{7.1}$$

Per capita consumption equals per capita output:

$$c^*=z^* \chi \pi(e=g)\, E\{r \mid e=g\}. \tag{7.2}$$

In equilibrium, fraction z^* of projects are evaluated and fully funded if $e=g$, and all agents obtain expected consumption of c^*. With no private information, this allocation can obviously be supported by a securities market or a number of other arrangements. Intermediary-coalitions are not needed.

Second, consider the case in which evaluation is prohibited or, equivalently, e is independent of (i, r). Assumptions (2.1)–(2.3) are dropped, but (2.4)—with e suppressed—is maintained. The solution to (4.1)–(4.8) now defines a different Pareto-optimal core equilibrium allocation, characterized by three equations similar to (6.1)–(6.3).[6]

Type $i=b$ agents who mimic receive the same expected return as investors:

$$r^*=\pi(r=g \mid i=b)\, c_g^*. \tag{7.3}$$

[6] Note that m_g^* was defined slightly differently in (6.1)–(6.3), since there, mimicking required evaluation. Here it requires only an (incorrect) statement of type.

The demand for the investment good equals the supply:

$$\chi[\pi(i=g)+m_b^*\pi(i=b)]=1-\pi(i=g)-m_b^*\pi(i=b). \tag{7.4}$$

Per capita consumption equals per capita output:

$$r^*\pi(i=b)+c_g^*\pi(i=g,r=g) \\ =\pi(i=g)\,E\{\chi r\mid i=g\}+\pi(i=b)\,m_b^*E\{\chi r\mid i=b\}. \tag{7.5}$$

This is another "mimicking" equilibrium in which some fraction m_b^* of type $i=b$ agents misrepresents type. All type $i=g$ projects are fully funded, as is fraction m_b^* of type $i=b$. Expected utility of type $i=g$ agents is maximized by having zero consumption when $r=b$ (that is, $c_b^*=0$) and maximum resource-feasible consumption when $r=g$ (that is, $c_g=c_g^*$). This minimizes the incentive to mimic. But with evaluation suppressed, this is *all* the type $i=g$ agents can do to differentiate themselves. The allocation satisfying (7.3)–(7.5) can be supported with a securities market arrangement similar to that for (6.1)–(6.3) and again, intermediary-coalitions are unneeded.

The third special case is an intermediate one in which agents are differently endowed and evaluation is possible, but observations on e provide 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

$$\pi(r\mid i,e)=\pi(r\mid i) \qquad \text{for all } (i,e,r). \tag{7.6}$$

This violates assumptions (2.1) and (2.3), but assumptions (2.2) and (2.4) are maintained. Unlike the case just considered, however, e does provide information about i, in the sense that

$$\pi(i=g\mid e=g)>\pi(i=g). \tag{7.7}$$

With these assumptions, the securities market equilibrium entails mimicking and is the same as that described by (6.1)–(6.3). The core equilibrium allocation is slightly different than in Section 4, however. In particular, (4.9) becomes

$$\chi\pi(i=g)+x_b^*\pi(i=b)=1-\pi(i=g) \tag{7.8}$$

and (4.11) becomes

$$c_{ggg}^*\pi(i=g,e=g,r=g)+c_b^*\pi(i=b) \\ =x_b^*E\{r\mid i=b\}\,\pi(i=b)+\pi(i=g)\,E\{\chi r\mid i=g\}. \tag{7.9}$$

The key change in the core equilibrium allocation is that, since r is independent of e, investment allocations are no longer conditioned upon e. However, i is not independent of the realization of e, and the decision to evaluate is, in effect, a dissipative signal of type. Thus, consumption allocations are still conditioned on (i, e, r) as they were in Section 6. And, as earlier, this allocation can be supported with competitive intermediary-coalitions.[7]

However, there are two important differences. In the present case, even in the core there is some dissipative signaling due to the evaluation of type $i = g$ projects. It is important that intermediary-coalitions can commit in advance to evaluate the projects of those agents who claim to be of type $i = g$. Only those who actually 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 commit in advance, this arrangement would not constitute an equilibrium.

The second important difference between this case and the one in Section 6 is that although intermediary-coalitions are still needed to support the core equilibrium, it is no longer necessary that the coalitions be large. Recall that, in the previous case, it was essential that each intermediary-coalition not obtain more type $i = g, e = g$ projects than it could fund at level χ. Since e is a random variable observed after contracting, this could only be achieved with certainty by committing to evaluate a large number of projects. In the present environment, though, investment decisions are not conditional upon e, and size is unimportant. An intermediary-coalition can be composed of any number n of type $i = b$ agents, as long as it evaluates n projects and contracts with $n(\chi - 1)$ depositors. It is still essential, however, that the intermediary-coalition can commit in advance to evaluate projects of those agents who claim to be of type $i = g$. Otherwise, some type $i = b$ agents would have an incentive to mimic, as they do with the securities market arrangement.

[7] A numerical example may help clarify the last case. Assume the parameters in Fig. 1 are changed so that $\pi(e = g \mid i = g) = 0.75$, $\pi(r = g \mid i = g, e = g) = \pi(r = g \mid i = g, e = b) = 0.8$. With these changes, e provides no information about r additional to that provided by i. Observation of e does give information about i, however. The core equilibrium allocation is now $x_b^* = 0.798$, $c_b^* = 1.514$, $c_{ggg}^* = 15.143$, and $u_g^* = 9.086$. The securities market equilibrium allocation is $m_b^* = 0.0771$, $r^* = 1.298$, $c_g^* = 12.984$, and $u_g^* = 7.790$. Both types of agents again prefer the core equilibrium to the securities market equilibrium. But even in the core, some type $i = g$ projects are evaluated, and this is *ex post* inefficient.

8. Summary

The intermediary-coalitions which endogenously emerge in the environment studied exhibit all five of the stylized facts listed in the introduction. And although, for brevity, we will not reiterate them here, each characteristic is necessary in supporting the equilibrium allocation. This is only true, however, in the most general case studied—the one in which we allow for *both* adverse selection and information production via evaluation. If either "source" of information is closed, intermediary-coalitions are unnecessary, in the sense that the same allocation can be supported with a (simpler) securities market arrangement. We know of no other study that has considered this class of environment or has obtained these results.

It seems logically straightforward, albeit not necessarily mathematically simple, to construct richer and more complex environments in which both intermediary-coalitions and securities markets exist side by side to support the equilibrium. (This could be done, for example, by having some, but not all, agents endowed with private information at the beginning of period one.) Similarly, it seems very likely that we could construct environments in which some intermediary-coalitions are necessarily diversified and others are not. Although we shall not pursue the matter here, it is interesting that in this general environment, when we change assumptions concerning the structure of information, endowments, and so forth, the optimal supporting arrangement also changes. In principle, one could generate testable hypotheses concerning the environmental characteristics that lead to the emergence of different intermediation arrangements. That task will be left for future research.

Some extensions of this work appear to be straightforward. For example, allowing for more than two evaluation outcomes would not be difficult. Nor would it be difficult to introduce systemic risk into the environment, in which case residual claims against intermediary-coalitions could be risky and, in that sense, more like the equity shares issued by their real-world counterparts. Diamond [2] has touched on this issue and, for present purposes, it seemed a needless complication. An extension which is not so easy, however, is to allow for more than two agent (or project) types.

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