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by

Dennis W. Draper
and
James W. Hoag

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FINANCIAL INTERMEDIATION AND THE ECONOMICS OF INFORMATION

Dennis W. Draper
Assistant Professor of Decision Sciences
University of Southern California

and

James W. Hoag
Assistant Professor of Finance
University of California, Berkeley

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I. Introduction

Intermediation, and in particular financial intermediation, is a frequently cited class of activities for which the literature provides little definition. Though existent in major proportions of our economy, a precise characterization of an intermediary's function has not appeared. Rather, we refer to intermediaries by example—generally agreeing that such institutions as banks, insurance companies, etc., are intermediaries. This research addresses the issue of what an intermediary is, that is, what distinguishes the activity of intermediation from other economic activity.

If we look at these institutions called financial intermediaries, we notice that each is involved in some collection of the following three activities: (1) acquiring of information about economic entities; (2) processing of information about economic entities; and (3) packaging or repackaging the financial claims of these economic entities. Further, we notice that various subcollections of these activities exist simultaneously in the economy. Exhibit 1 details various forms of intermediaries and provides examples of the breadth of intermediation organizations.

The motivation for this analysis arises from the existence of the above organizations and noting that standard economic theory does not predict this existence. In a world of perfect and complete markets for Arrow-Debreu securities, state-information may by produced but firm or industry specific information will not. Likewise, packaging of claims will not occur, in that traders can reproduce any package by proper choice of the Arrow-Debreu securities (or other bundles of securities if a spanning set is available). This world, at best, would possess intermediaries producing
Activity
Acquire only

Acquire and Process

Acquire and Package

Acquire, Process and Package

Process only

Process and Package

Package only

Intermediary
Moody's, Standard and Poors, Value Line, Credit bureaus

Moody's, Wiesenberger, Check Guarantee Services, Econometric Models

Banks, Mutual Funds

Investment Counsels, Consultants

General Partners, Lawyers, Property Syndication

Index Funds

(and selling) state information. The real-world contrast suggests our theoretical description is inadequate; that is, some market incompletion must exist.

If we think of a security market in which a firm's financial instruments produce payouts as a function of the technology employed and the state of nature, knowledge of both would determine the aggregate production for the payoff scheme. Further, if all technological information is costlessly available, the securities will be traded and the market will permit a Pareto optimal allocation under uncertainty. Restricting the availability of technological information, however, will alter this allocation and may provide incentives for firm-specific information to be produced. Firms may have perfect information about productive opportunities but possess no method to "signal" the market (i.e., provide and verify the information). (See, for instance, Leland and Pyle (1976).)
Agents may, therefore, engage in activities which acquire and process (e.g., authenticate) this technological information. A market would arise in information produced\(^1\) and may be traded as any other good. But these information agents may have a problem similar to the firm's problem. If we presume that agents may differ in their ability to acquire and process this information and that this ability is not observable by all traders, higher ability agents' information will not be differentiated from that produced by their inferior counterpart. As above, these higher ability agents will have an incentive to "signal" this quality to the market.

The problems alluded to above have received much attention in recent years beginning with the work of Arrow (1963) and Akerlof (1970) which studied the "moral hazard" and/or adverse selection aspects of lack of observability on potential contract variables. Spence (1973) researched these issues in a labor market context in which high and low productivity individuals could not be distinguished. Presence of a "signal" more costly to low productivity people than high productivity people was sufficient for individuals to "reveal" their true quality. Ross (1977) employed a signalling concept when addressing the irrelevancy of the financing decision (a la Modigliani and Miller). He demonstrated the use of managerial incentives as a signal of firm type when firm type is unobservable. The managerial incentive package was a function of firm "values" which were effected by levels of firm debt. Levels of firm debt became "signals" of the unobservable firm type. These "signalling" papers, however, have not all produced positive

\(^1\)Assuming that appropriating and packaging this information present no problem.
results in that Riley (1975) and Rothechild and Stiglitz (1976) questioned
the existence of a stable equilibrium.

Other researchers have addressed the lack of observability of
potential contract variables leading to the moral hazard problem. Stiglitz
(1974) investigated linear contracts between an owner and a worker when
the worker's effort was not observable. He showed that even under risk
neutrality, a mixed contract of wage plus a share of the output would exist
in equilibrium, justifying the prevalence of sharecropping contracts. Spence
and Zeckhauser (1971) characterized the moral hazard condition in an insur-
ance context where reimbursements were a function of losses but neither the
state variable nor the insured's action was observable.

Potential solutions to these problems have also arisen in monitoring
contracts. Alchian and Demsetz (1972) addressed the problem of unobservable
worker's labor by augmenting the production environment with a monitor (e.g.,
supervisor). To insure proper incentives, the monitor was given the re-
sidual output. Harris and Raviv (1976) attacked the problem in a similar
manner by using conditional monitors of the agent's input. Mirrlees (1974,
1976) investigated the optimality of a dichotomous contract (with large
penalties) to approximate the full information contract when productive in-
put was unobservable.

The consistent theme of this field of research is the lack of ob-
servability of a variable upon which two parties would like to contract. As
Radner (1968) pointed out, contracts cannot be written on variables if they
are not jointly observable since both parties could not verify that all con-
ditions of the contract had been fulfilled. In each of the above paradigms,
a "nonstandard" contractual arrangement is struck or a particular organization form or activity (either a market or intermediary) arises to fill the information void.

From this point of view, we investigate the incentives which lead to formation of intermediaries and characterize the resultant contractual arrangements. In this manner, we not only justify the existence of intermediaries but also provide an implicit definition of their function.

II. Overview of the Model

We will use a state preference model in which there are three sectors of the economy—individuals, firms, and financial intermediaries. Each sector's participants will transact in a standard two-period model with decisions being made at time zero. A random state space is revealed at time one and the contract is fulfilled. With the environment specified, we proceed to specify the actors.

II.1 Individuals

An individual (denoted with subscript i∈I) is endowed solely with initial wealth $O_{Wi}$ and initial effort $O_{Ei}$ at time zero. No shares of firms or intermediaries are available as initial wealth. We think of wealth as a tradeable good—money—and of effort as an input to a productive setting. His preference function is a standard von Neumann-Morgenstern utility function $U_i(\cdot)$ over end-of-period wealth $W_i$. The individual employs his effort endowment to produce wealth. The decision consists of choosing between supplying direct labor to a productive firm and employing effort to acquire or process information or package financial claims.
\( \lambda_{ij} \): Proportion of the total direct labor of firm \( j \) which the \( i^{th} \) individual supplies at price \( p \).

\( L_i \): Total direct labor supplied to all firms by individual \( i \) at price \( p \).

In a similar fashion we define the following:

\( E_{i}^a \): Effort used to acquire information

\( E_{i}^p \): Effort used to process information

\( E_{i}^b \): Effort used to package financial claims

The total effort supplied to the \( k^{th} \) intermediary is:

\[
E_{ik} = E_{ik}^a + E_{ik}^p + E_{ik}^b
\]

Total effort supplied to all the above activities for all intermediaries is:

\[
E_i = \sum_{k} E_{ik}
\]

An individual is also endowed with an ability to acquire and process information and package claims.

\( \theta_{i}^a \): Endowed quality for acquiring information

\( \theta_{i}^p \): Endowed quality for processing information

\( \theta_{i}^b \): Endowed quality for packaging claims
We summarize the information production activities by an aggregate measure of quality defined as:

$$\theta_i = (\theta_i^a, \theta_i^p, \theta_i^b).$$

This quality parameter is included to represent the inherent skill or innate ability of the participant. It is an attribute and therefore unalterable in our model. (Note that since we are not concerned with provision of direct labor, we have implicitly assumed that all individuals have the same quality of direct labor. That is, direct labor is a residual undifferentiated effort possibility for the individual.) Higher quality values are "better." Given the quality level (attribute), an individual will allocate effort and direct labor (both decision variables). The individual supplies effort $E_{ik}$ to the $k^{th}$, with quality $\theta_i$, and receives a compensation package $V_{ik}$. This compensation package is described in section II.3 on Institutions.

II.2 Firms

The firm (denoted as $j \in J$) is a productive concern which employs technologies, capital and direct labor inputs and together with a random state variable produces an outcome.

- $L_j$: Total direct labor employed by firm $j$
- $K_j$: Total capital employed by firm $j$
- $T_j$: Technology of firm $j$ (possibly a discrete or continuous set)
- $s$: State variable occurring at time $t$
We define the production function to be:

\[ f: \{L\} \times \{K\} \times \{T\} \times \{S\} \rightarrow R^1 \]

Notice that the production function is not indexed, but rather the arguments are indexed. We think of a firm as a shell (that is, a production function) which employs particular levels of labor and capital and chooses a technology. Thus all shells look alike but differ in the choices they make for these variables. The output of the production function is wealth, and reasonable assumptions about scale economies in any form are implicit in the definition of \( f(\cdot) \).

The firm transacts in the market for inputs buying

\[ L_j \] total units of direct labor at a price \( p^L \) per unit.

\[ L_j = p^L L_j \] is the total promised value of all labor inputs for firm \( j \).

Additionally it issues claims on its output (both income securities and shares) where the following is defined:

\[ C_j: \text{Total promised coupon rate for income security} \ j. \]

The market to purchase a firm's securities is composed of the individual traders mentioned earlier and institutions which will be described shortly. For these two classes of investors we designate the fractions of total coupon amount held as:

\[ b_{jk}: \text{Fraction of claims to the total coupon of firm} \ j \text{ held by intermediary} \ k. \]
\[ b_{ji} \]: Fraction of claims to the total coupon of firm \( j \) held of intermediary \( i \).

\[ \sum_i b_{ji} + \sum_k b_{jk} = 1 \] \hspace{1cm} (II.2.1)

Interpretively, the individual claims are just bond payments while we can think of the institutional investment as loans. (The instruments herein are obviously identical, but with different coupon structure, we can model the loan/bond split and the whole issue of priority of claims.) In a similar fashion we can designate financial instruments with a claim on the residual as shares:

\[ a_{jk} \]: Fraction of shares of firm \( j \) held by intermediary \( k \).

\[ a_{ji} \]: Fraction of shares of firm \( j \) held by individual \( i \).

\[ \sum_i a_{ji} + \sum_k a_{jk} = 1 \] \hspace{1cm} (II.2.2)

Finally we denote the total market value of the securities issued as:

\[ \begin{align*}
\text{P}_{j}^b &: \text{Total market value of all firms } j \text{ income securities} \\
\text{P}_{j}^a &: \text{Total market value of all firms } j \text{ shares}
\end{align*} \]

The total capital employed in the productive system can now be denoted for firm \( j \) as:

\[ K_j = P_j^a + P_j^b \] \hspace{1cm} (II.2.3)

The firm's productive environment and payoff structure can now be precisely defined. If \( f_j \) is the output of firm \( j \)'s production process, where
\[ f_j = f(L_j, K_j, T_j, s) = Z_j + B_j + A_j \] (II.2.4)

Then the division of aggregate output between the classes of claimants is:

**Wageholders:** \[ Z_j = L_j - \max(0, L_j - f_j) \] (II.2.5)

**Bondholders:** \[ B_j = f_j - L_j - \max(0, L_j - f_j) \]

\[ - \max(0, f_j - C_j - L_j) \]

\[ = f_j - Z_j - A_j \]

**Stockholders:** \[ A_j = \max(0, f_j - C_j - L_j) \] (II.2.7)

This specification of the firm's market position is necessary to close the entire market structure of the model. We will not, however, detail the investment and financing decisions of the firm since our interest is in studying intermediaries. Thus we will take the values of the firm's decision variables as given.

**II.3 Institutions**

The third sector of the economy is the institution or the financial intermediary. It offers compensation packages to employees in return for effort (and quality) inputs for information activities related to productive firms. It is the form of this compensation package that we investigate and we will allow it to be a function of the individual's quality, effort, wealth invested in the intermediary, and the state of nature. The compensation package is an internal sharing contract which will assume a variety of forms.
\( \omega_{ik} \): Wealth individual \( i \) invests in intermediary \( k \in K \)

\( V_{ik} : \{E\} \times \{E\} \times \{\omega\} \times \{s\} \rightarrow \mathbb{R} \): the currently unspecified compensation package as a function of the individual's quality, effort, invested wealth, and the state outcome.

The effort which the intermediary employs is used to acquire and process information about individual firm technologies and to repackage financial claims in the market. We think of the intermediary in much the same manner as the firm, in that an intermediary is a shell which individuals can "join" by either investing or selling effort or both. The shell represents a mechanism to amalgamate the efforts of individuals in at least one of the activities noted above. With this shell concept, we have not precluded the possibility of the one-person intermediary. That is the case in which an individual produces information and chooses securities without other individuals, although this shell may also be empty. Indeed, there will be a large number of intermediaries or shells existing in our model. A vast number of these shells could be empty, and for the present, no attempt will be made to categorize the set of nonempty intermediary shells. We view this flexibility quite favorably, since it is readily observed that large numbers of intermediaries, both large and small, co-exist contemporaneously.

As noted earlier, \( a_{jk} \) and \( b_{jk} \) were fractions of firm \( j \) claims held by intermediary \( k \) after investing. This packaging process leads to issuance of securities by the intermediary denoted:
\[ q_{ki} : \text{Proportion of promised deposit coupon of financial intermediary } k \text{ owned by individual } i \]

\[ r_{ki} : \text{Proportion of shares of financial intermediary } k \text{ owned by individual } i \]

In a manner similar to the above, we denote the total market value of the securities of the \( k \)th intermediary as:

\[ p^q_k : \text{Total market value of all deposits of intermediary } k \]

\[ p^r_k : \text{Total market value of all shares of intermediary } k \]

The structure above does not preclude the financial instrument of intermediary \( k \) being held by another intermediary \( k' \). (Denoted with the appropriate change in subscripts above.) With this change, the appropriate share and deposit balance equations can be written:

\[
\sum_i q_{ki} + \sum_{k'} q_{kk'} = 1 \quad \text{(II.3.1)}
\]

\[
\sum_i r_{ki} + \sum_{k'} r_{kk'} = 1 \quad \text{(II.3.2)}
\]

The total capital invested in the \( k \)th intermediary is denoted as:

\[ K_k = \sum_i w_{ik} + p^q_k + p^r_k \quad \text{(II.3.3)} \]

Without further specifying the form of the total returns to depositors and shareholders, we define the aggregate output division variables to the claimants as:
Compensation holders: \( V_k = \Sigma V_{ik} \)

Deposit holders: \( Q_k \)

Shareholders: \( R_k \)

With this structure of claims and prices, we can summarize the market characteristics by delineating the potential flows of claims from the viewpoint of an individual.

EXHIBIT 2
An individual must choose the level of effort to devote to direct labor with productive firms and to produce information, the proportion of stock and bond investment directly with firms; and the proportion of shares and deposits with financial intermediaries. If the individual sells his effort to an intermediary, he must also negotiate the form of the compensation package (which may be nonlinear in input or output). A financial intermediary must choose the amount of effort to purchase (and negotiate the compensation package), choose what proportions of stocks and bonds of firms to hold, and what proportions of other intermediaries to hold.

II.4 Probability Assessment

To complete specification of the model, participants are endowed with probability functions over the random state of nature, a vector of firm technologies, and a quality parameter for the intermediary. This quality parameter for intermediaries is a function of the inputs, both effort and quality levels, of the individuals the intermediary hires and represents the technological uncertainty of the intermediary production much as the technology choice variable did for the firms.

$\bar{\theta}_k$: Quality parameter for intermediary $k$

With this we now designate the participant probability assessment as:

$\pi_i: \{s\} \times \{T\} \times \{\bar{\theta}\} + R^+$

$$\int \int \int \pi_i dsdtd\bar{\theta} = 1$$
The probability density function of the individual \( i \) over the random state, and the vector of firm technologies and intermediary production quality.

Intermediaries possess the same form of assessment, but in addition to the \( \overline{\theta} \) values, know the form of the \( h_k \) function which produces them.

\[
h_k: \{ \theta_k \} \times \{ E_k \} \rightarrow \overline{\theta}_k
\]

the intermediary function which takes the vectors of individual inputs of quality and effort possessed by \( k \) into intermediary \( k \) production quality.

It is this function of combining the individual \( \theta \) and \( E \) levels into an intermediary production parameter which defines the operation of the intermediary shell. Notating the probability assessment function for intermediary \( k \) is accomplished by merely changing the above "i" to "k".

\[
\pi_k(s, t, \overline{\theta})
\]

where the \( k^{th} \) intermediary knows the form of the function \( h_k(\cdot, \cdot) \) which produced \( \overline{\theta}_k \) (\( k^{th} \) element of the vector of intermediary productive quality).

III. Decisions in a Market

Sufficient definitions now exist for us to formulate the decision structure implied in Exhibit 2. As noted earlier, the thrust of this research is the form of the contract between individuals and intermediaries. In that spirit we have taken the decisions of the firms as given and will concentrate on the decisions of the individual and the intermediary.
III.1 Firm

The decision variables for the $j^{th}$ firm which are taken as given are:

Decision Variables: \( \{ C_j, T_j \} \)

The $j^{th}$ firm is given its production ($T_j$) and financing ($C_j$) decisions and has no choices in the model that we propose. Thus, the problem that Ross (1977) addresses is not present for the firm, or is, at least, implicitly assumed away. The firm's direct labor rate ($p^d$), and the value of stock ($S_j^a$) and bonds ($I_j^b$) issued are determined in the market. The firm's maximizing decisions are suppressed to highlight the other sectors.

III.2 Individual

Individual $i$ seeks to maximize his expected utility of end-of-period wealth subject to two budget constraints—one of initial wealth, another of endowed effort. As stated previously, he will choose his direct labor supply, his compensation package with an intermediary (this may include invested wealth, effort supplied, etc.), direct investment in stocks and bonds, his purchases of shares of an intermediary, and his deposits with an intermediary.

$$\max \ E[U_i(W_i | \pi_i)]$$

where

$$W_i = \sum_j (\pi_j \cdot Z_j + a_j A_j + b_j B_j) + \sum_k (V_{ik} + q_{ik} Q_k + r_{ik} R_k) \quad (III.2.1.)$$

such that
\[ \sum_{k} E_{ik} + \sum_{j} E_{ij} L_{ij} \leq 0^{E_i} \]  
(III.2.2)

\[ \sum_{j} (p_{ij}^{b} + p_{ij}^{a} a_{ij}) + \sum_{k} (\omega_{ik} + p_{ik}^{q} q_{ik} + p_{ik}^{r} r_{ik}) \leq w_{ij} \]  
(III.2.3)

Decision Variables for each individual \( i \): \{ \ell_{ij}, v_{ik}, e_{ik}, \omega_{ik}, a_{ij}, b_{ij}, q_{ik}, r_{ik} \} \; j, \; k

III.3 Financial Intermediary

The financial intermediary has been described as a shell in that an intermediary is merely a medium for individuals to acquire and process information and to package financial instruments. Similarly, the shell does not have a preference structure, per se, but is a reflection of those who participate in it (i.e., effort suppliers and/or investors). If \( g_{k} \) designates the wealth of intermediary \( k \) at time one, then \( g_{k} \) equals the sum of the returns from stocks and bonds of firms and other intermediaries:

\[ g_{k} = \sum_{j} (a_{kj} A_{j} + b_{kj} B_{j}) + \sum_{k'} (q_{kk'} Q_{k'} + r_{kk'} R_{k'}) \]  
(III.3.1)

where \( k' \) indicates all other intermediaries except the \( k^{th} \) intermediary.

Since the intermediary is a fiction with three types of claims on its value, we also know the sum of the claims is:

\[ \sum_{i} V_{ik} + \{ \sum_{k} R_{ik} + \sum_{k'} R_{ik'} k_{k'} \} + \{ \sum_{k} Q_{ik} + \sum_{k'} Q_{ik'} k_{k'} \} = \]

\[ \sum_{i} V_{ik} + R_{ik} + Q_{ik} \]  
(III.3.2)
This merely states that all period one wealth is distributed to suppliers of effort, individual investors, or other intermediaries which have holdings in intermediary \( k \). One possible objective function may then be written as

\[
\max E\{\sum_{i} v_{ik} + r_k + q_k | \pi_k \} 
\]

(III.3.3)

such that

\[
\sum (a_{kj} p^{A}_{j} + b_{kj} p^{B}_{j}) + \sum (q_{kk}^{i} p^{q}_{k}^{i} + r_{kk}^{i} p^{r}_{k}^{i}) \leq K_k 
\]

(III.3.4)

where

\[
K_k = \sum_{i} q_{ik} + p^{q}_{k} + p^{r}_{k} 
\]

(III.3.5)

Decision Variables: \( \{v_{ik}, q_{kk}^{i}, r_{kk}^{i}, a_{kj}, b_{kj}, c_{k}\} \)

We will, in fact, not discuss the implication of signalling through the intermediary's financial structure \( c_k \). Ross (1977) discusses the implications of this decision on the firm's value.

IV.1 Financial Intermediation--A New Problem Formulation

In specification of the above problem for the intermediary, one critical decision is the compensation package \( v_{ik} \). This contractual arrangement specifies, among other things, the amounts of effective effort input and contributed wealth an individual will supply to the intermediary. For various levels of effective effort \( (\theta \cdot E) \) and contributed wealth \( (\omega) \), the intermediary adjusts proportion of shares and bonds held in firms and other intermediaries to increase the intermediary portfolio return. The
precise nature of all changes in \( a_{kj} \), \( b_{kj} \), \( c_{kk} \), \( r_{kk} \) is difficult to specify in general since it depends on how effort changes affect state or technology information or assessments. We can, however, subsume this indeterminacy by looking at the variation of the portfolio return (e.g., (III.3.1)) as a direct function of the effective effort employed. That is, the intermediary employs effective effort which, in turn, is used to select the expected portfolio return. We now redefine:

\[
\pi_k: \{g\} \times \{\theta\} \rightarrow \mathbb{R}^+
\]

where

\[
\int \pi_k dg = 1
\]

The probability density function for an intermediary is now a joint density function of return (a random variable) and the effective effort (a decision variable) used. (Note that this is given that the optimal portfolio choices are made using (III.3.3) - (III.3.5)). Further, it is assumed that the derivatives \( \frac{\partial \pi_k}{\partial \theta} \) exist. This form is used so that we can look at the way the distribution of returns changes with changes in effective effort.

The intermediary can now write its problem as one of selecting the amount of effort and/or contributed wealth to demand from individuals given that it wants to maximize the expected return on its portfolio. Also, we note that the intermediary must distribute all its wealth to the claimants as shown in equation (III.3.2). We can, therefore, write intermediary \( k \)'s problem as:
\[
\max \int (\sum_i V_{ik} + R_k + Q_k) \pi_k(g; \bar{\theta}) dg \quad \nu_i
\]  

subject to

\[
\sum_i \theta_i F_{ik} = \bar{\theta}_k^*
\]  

\[
\sum_i \omega_{ik} = \omega_k^*
\]

(Note: The asterisk values of effective effort and wealth denote the values of those two parameters used in calculating the values of \( a_{kj}, b_{kj}, r_{kk'}, q_{kk'} \) in the problem defined by (III.3.3) - (III.3.5).)

The above change in "decoupling" the intermediary's decision process also leads to some direct changes in the individual's probability function. Whereas the individual had assessments over states, firm technologies, and intermediary effective inputs, we will now redefine:

\[
\pi_i: \{s\} \times \{T\} \times \{g\} \times \{\bar{\theta}\} \rightarrow \mathbb{R}^1
\]

where

\[
\int \int \int \pi_i ds dT dg = 1
\]

As earlier, we think of the \( \bar{\theta} \) as a vector of intermediary decision variables and \( s, T, \) and \( g \) being random variables. With this change the individual problem in (III.2.1) - (III.2.3) has been altered only in definition
of the new \( \pi_k \) function and the addition that the \( V_{ik} \) (compensation), \( Q_k \) (income return), and \( R_k \) (share return) may directly depend on \( g_k \).

IV.2 Marginal Conditions on the Interior of the Solution Set for Individuals

With the specification of the decision problem in the market setting and the particular probability structure, we can now write the conditions for a maximum for the individual and the financial intermediary.

Introducing the slack variables and Lagrange multipliers for the individual's maximization problem, we have:

\[ s_i^E: \] the \( i \)th individual's effort slack

\[ s_i^W: \] the \( i \)th individual's wealth slack

\[ \lambda_i: \] the \( i \)th individual's multiplier in the effort equation

\[ \psi_i: \] the \( i \)th individual's multiplier in the wealth equation

Thus the augmented objective function for this individual is:

\[
X_i = E[u_i(s_i, W_i)|\pi_i(s, T, g, \Theta)]
\]

\[
-\lambda_i \{ E \sum_i (E_{ik} + \sum_j L_j + s_i^E) \}
\]

\[
-\psi_i \{ W_i - (\sum_j (P^{b_j} + P^{a_j}) + \sum_j (P^{a_j} + P^{b_j})) \}
\]

\[
\sum_k (P^{q_{ik}} + P^{r_{ik}} + \omega_{ik}) - s_i^W \}
\]

(IV.2.1)
The wealth in period one is:

\[ W_1 = \sum_j (\varepsilon_{ij} Z_j + a_{ij} A_j + b_{ij} B_j) + \Sigma (V_{1k} + q_{1k} Q_k + r_{1k} R_k) \]  

(IV.2.2)

The expectation operator and associated integral operator for the probability measure are given as:

\[ \mathbb{E}\{U_1(W_1)|\pi_1(s, T, g; \theta)\} = \int \int \int U_1(W_1) \pi_1(s, T, g, \theta) ds \, dg \]  

(IV.2.3)

\[ I(\cdot) = \int \int \int (\cdot) ds \, dg \]  

(IV.2.4)

or

\[ \mathbb{E}\{U_1|\pi_1\} = I(U_1|\pi_1) \]  

(IV.2.5)

Finally, we define the marginal utility with respect to wealth as:

\[ \frac{\partial U_1}{\partial W_1} = U'_1 \]  

(IV.2.6)

The maximization problem can now be represented as:

\[ \max X_1 \]  

(IV.2.7)

{\ell_{ij}, a_{ij}, b_{ij}, q_{ik}, r_{ik}, \omega_{ik}, E_{ik}, V_{ik}}

Many interesting problems which depend on the effort and wealth budget conditions could be analyzed using the Kuhn-Tucker conditions for an optimum, but we analyze here only solutions on the interior of
the solution set. The conditions for an interior maximum are given below for each decision variable.

Assuming that the direct labor choice doesn't affect the value of firm \( f_j \) or its division of outputs, the optimal direct labor choice requires that:

\[
\frac{\partial X_i}{\partial l_{ij}} = I(U_i' \pi_{1j}) + \lambda_1 l_{ij} = 0 \quad \text{(IV.2.8)}
\]

The individual maximizes wealth through the firm's production by requiring that:

\[
\frac{\partial X_i}{\partial a_{ij}} = I(U_i' \pi_{1j} A_{ij}) + \psi_i p^a_j = 0 \quad \text{(IV.2.9)}
\]

\[
\frac{\partial X_i}{\partial b_{ij}} = I(U_i' \pi_{1j} B_{ij}) + \psi_i p^b_j = 0 \quad \text{(IV.2.10)}
\]

The individual also maximizes wealth from direct investment in financial intermediary shares and deposits at the margin, but it is necessary here to delineate certain impacts upon the marginal utility for wealth which are not included in these requirements:

\[
\frac{\partial X_i}{\partial r_{ik}} = I(U_i' \frac{\partial w_i}{\partial r_{ik}} \pi_{1i}) + \psi_i p^r_{ik} = 0 \quad \text{(IV.2.11)}
\]

\[
\frac{\partial X_i}{\partial q_{ik}} = I(U_i' \frac{\partial w_i}{\partial q_{ik}} \pi_{1i}) + \psi_i p^q_{ik} = 0 \quad \text{(IV.2.12)}
\]
We assume that the form of the financial intermediary compensation package has no indirect dependence on the outside ownership of shares and deposits. Later, we will discuss some necessary conditions on holdings of shares and deposits of financial intermediaries outside of the compensation package. The marginal wealth with respect to choices of shares and deposits are thusly:

\[
\frac{\partial W_i}{\partial r_{ik}} = \frac{\partial V_{ik}^x}{\partial r_{ik}} + R_k \tag{IV.2.13}
\]

\[
\frac{\partial W_i}{\partial q_{ik}} = \frac{\partial V_{ik}^x}{\partial q_{ik}} + Q_k \tag{IV.2.14}
\]

Substituting into (IV.2.11) and (IV.2.12) gives the conditions for a maximum with respect to the choices of shares and deposits:

\[
\frac{\partial X_i}{\partial r_{ik}} = I(U'_i \pi_i R_k) + \psi_i \pi_{ik} = 0 \tag{IV.2.15}
\]

\[
\frac{\partial X_i}{\partial q_{ik}} = I(U'_i \pi_i Q_k) + \psi_i q_{ik} = 0 \tag{IV.2.16}
\]

The first order condition for choosing the level of contributed wealth depends on the form of the compensation packages in a currently unspecified way:

\[
\frac{\partial X_i}{\partial \omega_{ik}} = I(U'_i \pi_i \frac{\partial V_{ik}}{\partial \omega_{ik}}) + \psi_i = 0 \tag{IV.2.17}
\]
Finally, assuming that the effort decision for the $k^{th}$ intermediary does not influence any other investment proportions, the marginal conditions for an extra unit effort are:

$$\frac{\partial X_i}{\partial E_{ik}} = I(U'_i \pi_i \frac{\partial W_i}{\partial E_{ik}} + U_i(\bar{W}_i) \frac{\partial \pi_i}{\partial E_{ik}} + \lambda_i = 0 \quad (IV.2.18)$$

Further elaborating the wealth and probability assessment changes with a change in effort gives:

$$\frac{\partial W_i}{\partial E_{ik}} = \frac{\partial V_{ik}}{\partial E_{ik}} + q_{ik} \frac{\partial Q_k}{\partial E_{ik}} + r_{ik} \frac{\partial R_k}{\partial E_{ik}} \quad (IV.2.19)$$

$$\frac{\partial \pi_i}{\partial E_{ik}} (s, \tau, g, \bar{\theta}) = \frac{\partial \pi_i}{\partial \theta_k} \frac{\partial \theta_k}{\partial E_{ik}} \quad (IV.2.20)$$

where

$$\frac{\partial \theta_k}{\partial E_{ik}} \frac{\partial h_k(\theta_k, E_k)}{\partial E_{ik}} \quad (IV.2.21)$$

Substituting, we get:

$$\frac{\partial X_i}{\partial E_{ik}} = I \left( U'_i \pi_i \left( \frac{\partial V_{ik}}{\partial E_{ik}} + q_{ik} \frac{\partial Q_k}{\partial E_{ik}} + r_{ik} \frac{\partial R_k}{\partial E_{ik}} \right) + U_i(\bar{W}_i) \frac{\partial \pi_i}{\partial E_{ik}} \frac{\partial h_k(\theta_k, E_k)}{\partial E_{ik}} \right) + \lambda_i = 0 \quad (IV.2.22)$$

In principle, it is possible to solve the problem posed above (equations IV.2, 8, 9, 10, 15, 16, 17, 22) with the payouts to wages, bonds, and deposits in the form of options on the total value of either
the firm (f_j) or the financial intermediary (g_k). In a discrete time framework, Rubenstein (1976) shows that the valuation of uncertain income streams with option-like payouts yields a typical Black-Scholes option valuation under certain conditions for returns and utility functions.

Henceforth, we assume for simplicity that wages, bonds and deposits are paid with certainty, and thus we can represent the first order conditions on the interior in a fairly simple fashion.

Since Z_j = L_j = p^L_j, we have for (IV.2.8)

$$\lambda_1 = -E[p^L \gamma']$$ (IV.2.23)

For the firm and intermediary portfolio choice equations, (IV.2.9, 10, 15, 16) this simplification implies:

$$\psi_1 = -E(G \gamma')$$ (IV.2.24)

$$\psi_2 = -E(J \gamma')$$ (IV.2.25)

$$\psi_3 = -E(K \gamma')$$ (IV.2.26)

$$\psi_4 = -E(L \gamma')$$ (IV.2.27)

Thus the system of equations (IV.2.23, 24, 25, 26, 27, 17, 22) specifies the conditions for interior solutions for each individual i{in I}. 
IV.3. Marginal Conditions for Financial Intermediaries

Next we write down the conditions for a financial intermediary $k \in K$.

Introducing the Lagrange multipliers for the intermediary's maximization problem, we have:

$\phi_{\omega}$: the $k^{th}$ intermediary's multiplier in the contributed wealth equation

$\phi_{E}$: the $k^{th}$ intermediary's multiplier in the effort equation

Then augmenting the objective function (IV.1.1) with the constraints (IV.1.2) and (IV.1.3), we get:

$$y_k = \mathbb{E}\{\sum_{i=1}^n (x_{ik} + o_k + r_k | \pi_k)\}$$

$$- \phi_{x}\{\sum_{i=1}^n (E_{ik} - E_{ik}^*)\}$$

$$- \phi_{\omega}\{\sum_{i=1}^n (\omega_{ik} - \omega_{ik}^*)\}$$

(IV.3.1)

Further, consider the specialized problem where the intermediary attempts to reward effective effort defined as $\theta E$. Then we have the following definitions:

$$\overline{\theta}_k = h_k(\theta_k, \overline{E}_{ik}) = \sum_{i=1}^n \theta_{ik} E_{ik}$$

Modifying our effort constraint and introducing a multiplier $\phi_{\overline{\theta}}$ with respect to effective effort gives:
\[ Y_k = \mathbb{E}(\Sigma V_{ik} + Q_k + R_k | \pi_k) \]

\[ - \phi \{ \Sigma \theta_i E_{ik} - \bar{\theta} \} \]

\[ - \phi \{ \Sigma \omega_i - \omega^* \} \]

\[(IV.3.2)\]

Defining the expectation and integral operators with respect to the modified intermediary density, \( \pi_k(g, \theta) \), we have:

\[ \mathbb{E}(\cdot | \pi_k(g, \theta)) = \]

\[ f(\cdot) \pi_k(g; \theta) dg \]

\[(IV.3.3)\]

\[ I(\cdot) = f(\cdot) dg \]

\[(IV.3.4)\]

The maximization problem is represented as:

\[ \max Y_k \]

\[(IV.3.5)\]

\[ \{ E_{ik}, \omega_{ik}, V_{ik} \} \]

The first order conditions for the financial intermediary's maximization problem with respect to effort and contributed wealth are:

\[ \frac{\partial Y_k}{\partial E_{ik}} = I \{ (\Sigma V_{ik} + Q_k + R_k) \frac{\partial \pi_k}{\partial \theta} \frac{\partial \theta}{\partial E_{ik}} + \frac{\partial V_{ik}}{\partial E_{ik}} \pi_k \} - \theta_{ik} \phi = 0 \]

\[(IV.3.6)\]

\[ \frac{\partial Y_k}{\partial \omega_{ik}} = I \left( \frac{\partial V_{ik}}{\partial \omega_{ik}} \pi_k \right) - \phi = 0 \]

\[(IV.3.7)\]
Since \( \frac{\partial \theta}{\partial E_{1k}} = \theta_{1k} \), we can rewrite (IV.3.6) as:

\[
E\left\{ \frac{1}{\theta_{1k}} \frac{\partial V_{1k}}{\partial E_{1k}} \right\} + I\left\{ \sum_{i=1}^{n} (z_{i} + q_{k} + r_{k}) \frac{\partial \pi_{k}}{\partial \theta} \right\} = \phi_{0} \quad \text{(IV.3.8)}
\]

and (IV.3.7) is:

\[
E\left\{ \frac{\partial V_{1k}}{\partial w_{1k}} \right\} = \phi_{w} \quad \text{(IV.3.9)}
\]

Equations (IV.3.8, 9) describe the solution for each intermediary \( k \in K \).

### IV. 4 Characteristics of Market Solution

If we look at the individual equations (IV.2.8 – IV.2.12 and IV.2.17 – IV.2.18), the intermediary equations (IV.3.8 – 9), and the share clearing equations (II.2.1 – 2 and II.3.1 – 2), we characterize the solution for markets with intermediaries as a classical economic solution. This form merely allows intermediaries to demand inputs (effort and wealth) in order to produce information about states and firms, process this information, and rebundle financial instruments which it sells on the market. The intermediary, in this formulation, takes on the role of the productive entity – producing and employing information.

From the formulation, we point out that positive \( E_{1k} \) mean that a shell (intermediary shell) is occupied. This will only happen when:

\[
\frac{\partial \pi}{\partial \theta} \neq 0
\]

That is, the formulation of the problem ensures that shells will only be occupied when information production affects the distribution of returns.
for the intermediary. Further if that is true, then the Lagrange multiplier \( \phi_\theta \) will be non-zero (in general, positive) and represents the value of an additional unit of effective effort when multiplied by \( \theta_{1k} \) of the individual supplying that effort as in equation IV.3.6.

This characterization was derived with an expected value formulation for the intermediary in order to simplify the characterization. We note, however, that the intermediary objective function might well be the sum of linearly weighted individual expected utilities for all individuals who have claims on the intermediary. In the spirit, we could easily have defined a general function:

\[ h_k: \{g_k\} \rightarrow \mathbb{R}^1 \]

The \( h(.) \) function may be the linear form postulated in III.3.3 or a strictly concave function representing the sum of the weighted utilities of all claim-holders of the intermediary. Though the notation changes, the substance of the discussion remains unaltered. (We will employ this general form at various points, interpreting its form in context.)

The characterization above describes a market solution when the only unobservable variables are the state variable and the firm technologies. Individuals transact for effort (at particular quality levels) as they would any other commodity. One interesting question, however, is what form will the compensation contracts take if either an individual's effort level or quality level is unobservable to the intermediary.

V. Individual's Effort Level in Unobservable

In the earlier discussion effort and quality were observable and were transacted upon; if the individual's effort level, however, is not observable, the intermediary and the individual cannot contract directly
for a given level of $E_{ik}$. The problem then becomes one of choosing 
a compensation package such that the individual is induced to supply the 
level of effort he would have supplied in the earlier section. The 
intermediary will choose a compensation package $V_{ik}$ such that the individual 
will accept the contract and knowing that the individual will choose to 
optimize his own preference function with respect to effort for any 
compensation package chosen.

We use $H_k(.)$ as a function representing the concave preference 
function of the intermediary to investigate the contractual arrangement 
($V_{ik}$) between individual $i$ and intermediary $k$. Since $g_k$ is the return to 
intermediary $k$ and $V_{ik}$ is the compensation paid to individual $i$, the 
argument of the intermediary's preference function is $g_k - V_{ik}$ (i.e. 
$H(g_k - V_{ik})$ is the preference formulation). The problem of the inter-
mediary $k$ in contracting with individual $i$ is:

$$\max_{\{V_{ik}\}} \int H_k(g_k - V_{ik}(g_k)) \, \pi_k(g; \theta) \, dg_k$$

such that  
$$\int U_k(W_i) \, \pi_i(s, T, g; \theta) \, ds \, dt \geq U_i^*$$

and  
$$\int (U_i'(W_i) \frac{\partial W_i}{\partial E_{ik}} + U_i(W_i) \frac{\partial \pi_i}{\partial \theta}) \, ds \, dt \pi_i + \lambda_i = 0$$

The objective function of intermediary suggests that since $E_{ik}$ is not a 
decision variable, it cannot be contracted on -- only the compensation 
package can be chosen as a function of $g_k$, and implicitly of the individual's 
$\theta_i$ since it is still observable. The first constraint reflects the com-
petitive market assumption that to get individual's to supply effort, a 
minimum expected utility level must be obtained. Finally, the second
constraint states that for any compensation package chosen individual "i" will maximize his expected utility with respect to effort supplied.

Forming the Lagrangian (using \( \delta \) and \( \mu \)), isolating the first order condition, and integrating over all variables except \( g_k \), we have the following:

\[
H'_k (-1) \pi _k + \delta U'_i \Pi^S_k + \mu U'_i \frac{\partial \Pi^S_k}{\partial E_{1k}} = 0
\]

where \( \pi _k = \Pi^S_k \)

(Note: If \( \Pi \) is the distribution function, then \( \Pi^S_k \) is the marginal density over \( g_k \). The above equivalence states that the intermediary and the individual share equivalent assessments over the intermediaries return distribution.)

Rearranging the terms above, we obtain the following characterization:

\[
\frac{H'_k}{U'_i} = \delta + \mu \frac{\partial \Pi^S_k}{\partial E_{1k}} \pi _k
\]  

(V.1.1)

The result is similar to that of Mirrlees (1974, 1976) and more recently Holmstrom (1977). If we look at equation V.1.1, we see that for \( \mu = 0 \), the solution reduces to the ratio of marginal utilities equals a constant. This result is consistent with optimal risk-sharing (see Wilson (1968)). When \( \mu \neq 0 \), the incentive problem forces us away from an optimal risk sharing result — reflecting the moral hazard problem (referred to in such works as Spence and Zeckhauser (1970)).

In a similar characterization, Mirrlees (1976) points out that for
some values of $g_k$, the right-hand side may go negative
\[
\exists \eta_k \exists \frac{\partial g_k}{\partial E_k} \rightarrow -\infty
\]
(that is, as $g_k \rightarrow -\infty$, $\frac{\partial E_k}{\partial \eta_k} \rightarrow -\infty$) while the left-hand side will always remain positive. It leads him to suggest that the optimal compensation package (in Mirrlees (1976) it is a sharing function) must not exist in the class of unbounded function. Holmstrom (1977), for one, has suggested that a solution can be found in a class of bounded functions. Further, researchers (Mirrlees (1974, 1976), Homstrom (1977), Draper (1978) in various settings) have approximated the first best solutions by employing a dichotomous contract. The contract is a compensation package which observes only the outcome $g_k$ and uses large penalties for outcomes which would be very unlikely when the optimal effort is supplied. In other words, the threat of a large penalty is used as a deterrent to the individual's supplying other than the "first best" amount of effort. If we denote $v_{ik}^*(\cdot)$ and $e_{ik}^*$ as the optimal compensation package and effort levels from the first section, then we can arbitrarily closely approximate this with a dichotomous contract of the form:
\[
v_{ik}(g_k) = \begin{cases} 
v_{ik}^*(E_{ik}^*, g_k) & g_k \geq \eta \\
\overline{v}_{ik}(g_k, \eta) & g_k < \eta \end{cases}
\]

The derivation is construction in the spirit of Mirrlees (1974) and Holmstrom (1977). To achieve the approximation we need to set the $\overline{v}_{ik}(\cdot, \cdot)$, representing the penalty portion of the contract, such that the utility loss to the individual is only a function of the "cutoff" $\eta$. 
Define $\bar{W}_i^* = 1_{i} W_i - V_{ik}^*$

That is, $1_{i} W_i^*$ is the total wealth of individual $i$ at time $t$ not including the compensation from intermediary $k$. Then the individual's utility difference between the earlier sharing rule $V_{ik}^*$ and the $V_{ik}$ in this section is:

$$U_i(1_{i} W_i + \bar{V}_{ik}(g_k, \eta)) - U_i(1_{i} W_i^* + V_{ik}^*(E_{ik}, g_k)) = \Delta(\eta)$$  \hspace{1cm} (V.1.2)\nonumber

for $g_k < \eta$.

That is on the region when the intermediary value $g_k$ drops below the "cutoff" ($\eta$), the individual suffers a utility loss of $\Delta(\eta)$. By making this loss (on an expected utility basis) arbitrarily small, we can arbitrarily closely approximate the original solution. Multiplying by $\frac{\partial \Pi_k}{\partial E_{ik}}$ and integrating over values of $g$ from $-\infty$ to $\eta$ we get:

$$\int_{-\infty}^{\eta} U_i(1_{i} W_i^* + \bar{V}_{ik}(g_k, \eta)) - U_i(1_{i} W_i^* + V_{ik}^*(E_{ik}, g_k)) \frac{\partial \Pi_k(g_k, \bar{\theta})}{\partial E_{ik}} = \Delta(\eta) \frac{\partial \Pi_k(\eta; \bar{\theta})}{\partial E_{ik}}$$

$$= \Sigma$$  \hspace{1cm} (V.1.3)\nonumber

($\Pi_k$ is the distribution function over $g_k$)  \hspace{1cm} (constant)

Having chosen $\bar{V}_{ik}$ such that the expected utility loss as a function of $\eta$ and with respect to changes in $E_{ik}$ is a constant, we note that the intermediary is better off since under some circumstances it pays out less in compensation. The actual expected utility loss of the individual is $\Delta(\eta) \Pi_k(\eta, \bar{\theta})$. From this and V.1.3 we can now write:

$$\Delta(\eta) \Pi_k(\eta, \bar{\theta}) = \Sigma \frac{\Pi_k(\eta, \bar{\theta})}{\frac{\partial \Pi_k(\eta, \bar{\theta})}{\partial E_{ik}}}$$  \hspace{1cm} (V.1.4)
With the left-hand side being the expected utility loss of the individual, it becomes arbitrarily small if \( \frac{\partial \Pi_k}{\partial E_{ik}} \rightarrow 0 \). This can be shown by recalling that if for some values of \( g_k \) \( \frac{\partial E_{ik}}{\partial E_{ik}} \rightarrow -\infty \), then for some value of the cutoff \( (\eta) \) we have \( \frac{\partial \Phi_k}{\pi_k} < 0 \). Choosing a value \( \beta \) such that \( \frac{\partial \Phi_k}{\pi_k} \leq \beta < 0 \)

and integrating \( \frac{\partial \Phi_k}{\partial E_{ik}} \leq \pi_k \beta \) over \( g \), we obtain:

\[
\frac{\partial \Phi_k}{\partial E_{ik}} \leq \pi_k \beta.
\]

Thus as \( \eta \rightarrow -\infty \), \( \frac{\partial \Phi_k}{\partial E_{ik}} \rightarrow 0 \) which means that \( V.1.4 \) can be made arbitrarily small by the proper choice of \( \eta \).

By the kind of construction we can design a dichotomous contract in outcome \( g_k \) that will induce the same effort level as would be contracted for in the earlier scenario. Note that this construction does not insure that an individual will not be penalized even when the proper action is taken for there is still a non-zero chance of outcomes below \( \eta \).

Interpreting the compensation package \( V_{ik} \), it suggests that the individual will receive some fee and share in the outcome \( g_k \) if both the individual and the intermediary preference functions are strictly concave. If the intermediary preference function were linear in \( g_k \), the optimal compensation package would have the individual trade his portion of the \( V_{ik} \) above \( \eta \) for a fixed salary and the intermediary would bear the risk.
The penalty portion of the compensation package, however, would remain to provide proper incentives for the optimal effort to be provided.

Researchers (e.g. Holmstrom (1977)) have asked whether bonuses will work as well as penalties. The problem that arises is in the concavity of the preference function. With concave objective functions, a sufficient bonus may not exist. As the preferences become more risk neutral (linear preferences), the bonus or penalty problem is quite symmetric.

If we note the period one wealth \(W_1\), we find a constraint on the ability of the penalty scheme to induce proper effort. The penalty scheme implicitly assumes everything else is constant. Included in the period one wealth is the return to the individual from stocks and bonds of firms and stocks and deposits of intermediaries. If all else were not constant from our first scenario, the penalty scheme may not be sufficient to induce proper action in that the individual may supply less effort and short the financial instruments of the intermediary. As suggested in Ross (1977) in another context, this is a rationale for prohibiting trading in instruments of one's company or at a minimum for the existence of disclosure rules.

V.1.2 Contracting When Individual's Quality Level is Unobservable

The scenario differs in that effort (decision variable) is observable but an individual's quality (attribute or endowed characteristic) or ability to produce and process information is not. As with the Akerlof (1970) and Spence (1973) research, the market prices all individuals as averages. If we have two quality individuals (high and low), the high quality
individual will have an incentive to "signal" themselves out. Spence's (1973) work used incentives packages as signals. Though we have not produced a characterization as yet, preliminary analysis suggests that high quality producers will exchange their "average quality" price per unit effort for a claim on the residual. Low quality individuals will not accept this package presuming each individual knows his quality. The form of this exchange needs to be isolated.

VI. Remarks

This research was aimed at addressing why intermediaries arise in an economy. The formulation was structured as a shell which will be occupied when there is "value" in producing and processing information and rebundling firm securities. Value is defined as conditions on the distribution of intermediary payoffs.

The investigation looked at the problem of an intermediary contracting with an employee when the amount of effort supplied is unobservable. A penalty form contract was shown to reproduce the effort supplied when effort was observable by both parties. We then speculated that if effort was observable and quality unobservable, a "signalling" equilibrium may result from a high quality processor trading a wage for a residual.

Much work needs to be done in this area to understand the existence of intermediaries and the kinds of contracts they strike with employees. Another promising area is an investigation of the forms of contracts which investors or depositors will strike with intermediaries. Investors may possess incomplete information about the intermediary's ability to process information and rebundle securities. Under this incompleteness, what
contractual forms will arise. Lastly, we noted at the beginning that many forms of intermediaries arise. As yet, we have little to say about conditions for each of the various forms, per se, to arise.
REFERENCES


