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A MODEL OF THE DEMAND FOR  
INVESTMENT BANKING ADVISEMENT  
AND DISTRIBUTION SERVICES FOR NEW ISSUES

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ABSTRACT

A model is considered in which an investment banker is better informed about the capital market than is an issuer of new securities and in which the distribution effort of the banker cannot be observed by the issuer. The paper characterizes the optimal best-efforts contract and the optimal delegation contract under which the offer price decision is delegated to the better-informed banker in order to deal with the adverse selection and moral hazard problems resulting from the informational asymmetry. The model demonstrates that there can be a positive demand for investment banking advisement and distribution services.

A Model of the Demand for Investment Banking Advisement  
and Distribution Services for New Issues\*

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1. Introduction

This paper offers a theory of the demand for investment banking advisement and distribution services based on informational differences between an issuer of new securities and an investment banker. Ultimately, an "industrial organization" theory of the organization of the financial intermediary industry is required that would predict which demanders of capital will use which type of financial intermediary for which purposes and which demanders will raise capital without engaging the services of a financial intermediary. Only a limited set of predictions are presented here for a model of a fixed-price offering under a negotiated contract in which the investment banker is better informed about the capital market than is the issuer of securities. A number of important issues are not considered here in order to simplify the analysis and to focus on the effect of this informational asymmetry. The two principal issues not addressed are competition among investment bankers and the effect of the banker's advisement and distribution decisions for the present contract on the banker's reputation and on future contracts.

An issuer who has decided to raise capital through the sale of new securities in the capital market is faced with the choice between selling the securities directly in the capital market without using an investment banker or engaging the services of an investment banker to manage the sale.<sup>1</sup> An investment banker can perform three functions that may be of value to the issuer: 1) underwriting, 2) advisement, and 3) distribution. The focus here will be on the advisement and distribution functions, and hence the demand for underwriting will be eliminated by assuming that

both the issuer and the banker are risk neutral. The advisement function may have value if the banker has better information about the capital market than does the issuer, since the issuer may be able to benefit from that information by delegating, subject to certain restrictions, the offer price decision to the banker.<sup>2</sup> Distribution by the banker may have value to the issuer to the extent that the banker can generate demand for the issue through its sales efforts. An investment banker may be able to do so either because of its ability to persuade customers to purchase the issue or because it may be able to "certify" the issue to the market by putting, for example, its reputation behind the issue. The term "delegation contract" will be used for the case in which an issuer engages the services of an investment banker under a negotiated contract to both distribute the securities and to provide advice regarding the offer price to be set.

The issuer must, of course, compensate the banker for the use of its information in setting the offer price under a delegation contract, and the issuer may find that the value of that information is not sufficient to warrant the compensation required. The second alternative to be considered is thus for the issuer to make the offer price decision itself based on its limited information and to use the investment banker only to distribute the issue. Such an arrangement will be referred to as a "best-efforts" contract, since the banker will exert effort to distribute the issue according to the incentives provided by the contract the issuer offers.<sup>3</sup>

The objective of this paper is to characterize endogenously the form of the contract to be concluded between the issuer and the banker in the context of a negotiated, fixed-price offering. In the context of an example the paper also provides predictions about which alternative various issuers would prefer. The predictions will be based in part on characteristics of the demand for the securities. For example, for a seasoned issue the effectiveness of an investment banker's distribution

effort is likely to be small because investors will be relatively well-informed about the issue. For an unseasoned common stock issue investors are likely to be less well-informed, and the distribution effort might be expected to be more effective in increasing the demand for the issue. Consequently, issuers of seasoned and unseasoned securities might be expected to make different choices among the alternative means of selling the issue. Similarly, an issuer may be more likely to prefer a delegation contract to a best-efforts contract the greater is the banker's informational advantage relative to the issuer. For example, issuers that are knowledgeable about the capital market would have less to gain from delegating the offer price decision to the banker than would less knowledgeable issuers.

In the example to be presented in Section III, the value to the issuer of delegating the offer price decision is an increasing function of the issuer's uncertainty about the information the banker possesses about the market. Furthermore, the issuer is willing to accept a lower offer price the greater is his uncertainty. For both delegation and best-efforts contracts the value to the issuer of the banker's distribution effort is an increasing function of the issuer's uncertainty, so greater uncertainty increases the demand for the advisement and distribution services of the banker.

In related models Mandelker and Raviv(1977), Baron(1979), and Baron and Holmstrom(1980) characterized the optimal contract between an issuer and an investment banker in the context of a negotiated sale. Mandelker and Raviv focused on the risk sharing features of the contract for the case in which the issuer and the banker have symmetric information at the time of contracting. Baron also assumed symmetric information at the time of contracting, but analyzed the offer price decision and the deviation from the first-best risk sharing contract necessary to deal with the incentive problem resulting from the issuer's inability to observe the distribution effort expended by the banker and the banker's incentive to price too low relative to

the first-best price in order to reduce its distribution effort. Baron and Holmstrom assumed symmetric information at the time of contracting but recognized that after contracting a banker conducts preselling activities during the registration period to gauge more accurately the demand for the issue. The information obtained by the banker during the registration period is not directly available to the issuer, so the issuer must design the contract so that the distribution effort and offer price decisions made by the banker, conditional on its private information, will serve the interests of the issuer.

The present paper does not assume that the issuer and the banker have symmetric information at the time of contracting but instead assumes that at that time the banker has better information about the market demand for the issue than does the issuer. This situation might correspond to the case in which the issuer and the banker do not finalize the contract until the end of the registration period or the case in which the contract is finalized prior to the registration period with the provision that the banker is allowed to withdraw from the contract if its compensation given its private information is unsatisfactory. The model more appropriately however may be thought of as corresponding to the case in which the banker has superior information at the time it begins its negotiations with the issuer.

Because the banker's decision of whether or not to accept the contract offered by the issuer is conditional on the banker's private information, the model in the present paper is richer for the case in which both parties are risk neutral than those papers previously cited both with respect to both the complexity of the issuer's problem and with respect to the nature of the resulting predictions. For example, in the three previous papers when the banker is risk neutral the first-best solution, a firm commitment contract under which the banker bears all the risk associated with the issue, is optimal even if there is an informational asymmetry and an observability problem. With risk

neutrality and symmetric information at the time of contracting the only prediction is that a firm commitment contract is optimal and that the pricing and distribution effort decisions are internalized by the banker. The first-best solution is not attainable, however, with risk neutrality when the banker has private information at the time of contracting. Instead, the optimal contract may involve the sharing of risk between the issuer and the banker with compensation paid to the banker for its "advice" on setting the offer price and for the distribution effort it exerts to sell the issue.

In the next section a general model of a negotiated offering incorporating the banker's informational advantage and the advisement and distribution functions is presented. The optimal delegation and best-efforts contracts are then characterized. The choice between these alternatives is analyzed in the context of an example in Section III, and conclusions are offered in the final section.

## II. The Model and the Optimal Delegation and Best-Efforts Contracts

### A. The Model

The issuer is assumed to have a specific demand for capital to be invested in a project whose value is linear in the amount of capital raised at least over the relevant range. The issuer thus has preferences that are linear in the proceeds from the security issue net of any compensation paid to the investment banker. The nature of the security issue is taken to have been determined prior to contracting, so for a bond issue, for example, the face value of the bonds, the coupon rate, maturity, etc. have been chosen. The number of securities to be issued is assumed to be fixed although in practice that number may be determined within the context of the contract. The only decisions to be made by the issuer are thus the offer price and the nature of the contract to be concluded with the banker. The proceeds  $x=x(p,e,\theta)$  from the sale of the issue are assumed to depend on the offer price  $p$ , the distribution effort  $e$  of the banker, and a state  $\theta$  which represents a vector of parameters that index the demand for the issue. The state  $\theta$  is assumed to be unobservable and to obtain after the offer price has been set and the distribution effort expended. As a function of the offer price the proceeds  $x$  may be linear in  $p$  for prices such that the issue is oversubscribed and may increase and then decrease for higher prices.<sup>4</sup> For a seasoned equity issue the proceeds function may be net of a "liquidity concession" resulting from any price depressing effects of the new issue.

Even though there will be an equilibrium price established in the aftermarket once stabilization efforts by the banker are terminated, the demands of individual investors may depend on the distribution effort of the investment banker. This dependence may reflect the ability of the banker to influence the expectations of investors through the information it provides regarding the issue or the pressure it puts on investors to

purchase the issue. For example, the banker may be able to increase demand for one issue by promising to give a customer a greater ration of another issue that is oversubscribed. The ability to ration the securities for favored customers allows a banker to generate demand for another issue that might otherwise be undersubscribed. Similarly, to the extent that the banker can provide certification of the potential returns on the securities that the firm cannot provide, the banker would have some influence over demand. There are costs to the banker, however, of influencing demand through its distribution effort including the cost of the salesman's time, any rebates granted, loss of customer goodwill, or a decrease in the effectiveness of future distribution efforts if the security is underpriced. The ability of a banker to influence demand is likely to be greater for unseasoned issues than for seasoned issues for which certification would be less important to investors. The observation that some issues are undersubscribed and that stabilization efforts occasionally fail demonstrates, however, the limits to a banker's ability to influence demand.

The banker is assumed to be better informed about  $\delta$  than is the issuer, and for the purposes of the analysis the banker will be assumed to know a parameter  $\delta$  that indexes a conditional density function  $h(\theta|\delta)$  that is common knowledge to both the issuer and the banker. The informational asymmetry arises because while the banker knows  $\delta$ , the issuer has only imperfect information represented by a differentiable density function  $f(\delta)$  defined on the interval  $[\underline{\delta}, \bar{\delta}]$  and positive on  $(\underline{\delta}, \bar{\delta})$ . The private information of the banker will be parameterized so that higher values of  $\delta$  represent less favorable information and hence smaller proceeds. The function  $f(\delta)$  may reflect the results of efforts by the issuer to obtain information about the state. Although the banker knows  $\delta$ , neither it nor the issuer knows which state  $\theta$  will occur at the time that the issue is offered for sale. The private information  $\delta$  of the banker may, for example, have been obtained during its contacts with customers made to gauge the demand for



the issue or may, as another example, represent the banker's superior knowledge of the covariance between the return on the securities and the return on the market portfolio. It is, of course, also possible that the issuer has private information about, for example, its real return opportunities, but the case considered here is that in which the issuer has revealed such information to the banker, and the banker has verified it in the context of a long-term arrangement. The issuer and the banker will be assumed to have common information about  $\theta$ , given  $\delta$ , as represented by the density function  $h(\theta|\delta)$ .

Instead of working directly with the probability distribution of the state  $\theta$ , the formulation of Holmstrom(1979) and Mirrlees(1974) will be used to express the relationship between the proceeds  $x$  and  $p$ ,  $e$ , and  $\delta$  by the density function  $g(x|p,e,\delta)$  induced on  $x$  by the probability distribution  $h(\theta|\delta)$  of the state  $\theta$ .<sup>5</sup> The function  $g$  is assumed to be twice differentiable and to be nonzero on the largest open set contained in its support. The proceeds function  $x(p,e,\theta)$  will be assumed to be strictly increasing in  $e$ , and hence the distribution function  $G(x|p,e,\delta)$  is nonincreasing in  $e$  indicating that greater effort results in a more favorable distribution of proceeds in the sense of first-degree stochastic dominance.<sup>6</sup> Similarly, the proceeds function is decreasing in  $\delta$  indicating that less favorable information results in lower proceeds, so  $G$  is nondecreasing in  $\delta$ . These conditions imply that the mean  $\bar{x}$  is nondecreasing in  $e$  and nonincreasing in  $\delta$ . Three additional assumptions on  $\bar{x}$  will be made for later analysis. First, an increase in the offer price  $p$  is assumed to increase or leave unchanged the marginal expected return from the distribution effort or  $\bar{x}_{pe} \geq 0$ . That is, the marginal proceeds from an increase in the distribution effort are greater or unchanged the higher is the offer price. Second, less favorable information (higher  $\delta$ ) is assumed to decrease the marginal expected proceeds from an increase in the offer price or  $\bar{x}_{p\delta} < 0$ . Third, to provide the needed second-order conditions, the

mean  $\bar{x}$  will be assumed to be concave in  $e$  and  $p$   
or  $\bar{x}_{ee} < 0$  and  $\bar{x}_{pp} < 0$ .

B. The Optimal Delegation Contract

Under a delegation contract the issuer's objective is to choose a compensation function  $\bar{S}$  for the banker in order to induce the banker to exert a greater sales effort than it would otherwise exert and to induce the banker to use its knowledge of the parameter  $\delta$  to set an offer price that is in the interests of the issuer. The offer price decision will be delegated to the banker by allowing the banker to choose from among a set of prices chosen by the issuer. This will be accomplished by the issuer choosing a price function  $p(\hat{\delta})$  and allowing the banker to report a value  $\hat{\delta} \in [\underline{\delta}, \bar{\delta}]$  for the parameter  $\delta$  to the issuer who will then set the offer price  $p$  according to  $p = p(\hat{\delta})$ . The compensation function  $\bar{S}$  will then be used to influence the banker's distribution effort and its choice of  $\hat{\delta}$  and hence of the offer price. The distribution effort exerted by the banker and the cost of distribution are reasonably assumed to be unobservable by the issuer, since the issuer has only a limited ability at best to determine the effort actually expended, the discounts or rebates granted, or the cost incurred by the banker. The parameter  $\delta$  and the state  $\theta$  are also assumed to be unobservable, so the compensation function  $\bar{S}(p, \hat{\delta}, x)$  can only be based on the three observable variables; the offer price  $p$ , the proceeds  $x$ , and the report  $\hat{\delta}$ .

The banker will be assumed to be risk neutral in its net income  $\bar{R}$  given by

$$\bar{R} = \bar{S}(p, \hat{\delta}, x) - C(e),$$

where  $C(e)$  is the strictly increasing and strictly convex cost of the distribution effort  $e$  with  $C(0)=0$ . The banker may behave in a risk neutral manner because of its ability to hedge its risks through positions taken in other securities or by risk sharing through syndicate formation. The distribution effort considered here is thus the effort expended in selling the issue once the decision to offer the securities has been made, and any

preselling activity conducted to learn  $\delta$  is assumed to be sunk at the time of contracting. (The banker's return to preselling is that which it can obtain as a result of the issuer's demand for a delegation contract.)

The issuer may influence the banker's decisions by choosing the functions  $\bar{S}$  and  $p$ . Given those functions, the banker will choose a response function  $\hat{\delta} = \hat{\delta}(\delta)$ , where  $\delta$  is the true value known to the banker and  $\hat{\delta}$  is the value the banker reports to the issuer. When  $\hat{\delta}$  is reported, the offer price is set as  $p(\hat{\delta})$ , and hence the compensation  $\bar{S}(p(\hat{\delta}), \hat{\delta}, x)$  can be expressed as a function  $S(\hat{\delta}, x)$  defined by  $S(\hat{\delta}, x) \equiv \bar{S}(p(\hat{\delta}), \hat{\delta}, x)$ . Given the report  $\hat{\delta}$  by the banker, the issuer may prefer to withdraw the issue if, for example, the anticipated market reception of the issue is unsatisfactory. To represent this possibility, let  $\pi(\hat{\delta})$  denote the probability that the issuer decides to sell the issue when  $\hat{\delta}$  is reported. (In the optimal solution  $\pi(\hat{\delta})$  will equal either zero or one). The banker is assumed to receive no compensation when the issue is withdrawn, so the income  $R^*(\hat{\delta}, e, x)$  to the banker is

$$R^*(\hat{\delta}, e, x) = (S(\hat{\delta}, x) - C(e))\pi(\hat{\delta}),$$

and the expected income  $R(\hat{\delta}, \delta, e)$  is

$$R(\hat{\delta}, \delta, e) = \int R^*(\hat{\delta}, e, x)g(x|p(\hat{\delta}), e, \delta)dx. \quad (1)$$

The distribution effort chosen by the banker is a function of the banker's information  $\delta$  as induced by the issuer's choice of the compensation schedule and of the price function  $p(\hat{\delta})$ . The banker's optimal distribution effort response function  $e(\hat{\delta}, \delta)$  is defined by

$$e(\hat{\delta}, \delta) = \underset{e}{\operatorname{argmax}} R(\hat{\delta}, \delta, e) = \pi(\hat{\delta}) \int (S(\hat{\delta}, x) - C(e))g(x|p(\hat{\delta}), e, \delta)dx. \quad (2)$$

If  $\pi(\hat{\delta}) > 0$ , the effort response function satisfies the first-order condition

$$\int S(\hat{\delta}, x) g_e(x | p(\hat{\delta}), e(\hat{\delta}, \delta), \delta) dx - C'(e(\hat{\delta}, \delta)) = 0, \quad (3)$$

where the subscript denotes partial derivative. The response function  $e(\hat{\delta}, \delta)$  will be assumed to be a differentiable function of  $\hat{\delta}$  and  $\delta$  for all  $\hat{\delta}$  such that  $\pi(\hat{\delta}) > 0$ .

If the issuer chooses a policy  $(p^*, S^*, \pi^*)$ , the banker will choose an effort response function  $e^*(\hat{\delta}, \delta)$  and a response function  $\delta^*(\delta)$  that gives the information it reports to the issuer. The same outcomes to the issuer and the banker can be achieved through a policy in which the banker reports its private information  $\delta$  truthfully and then the issuer uses the function  $\delta^*(\delta)$  to calculate the same report that the banker would have reported using its original response function. If the issuer then implements the policy  $(p^*(\delta^*(\delta)), S^*(\delta^*(\delta), x), \pi^*(\delta^*(\delta)))$ , the price  $p^*(\delta^*(\delta))$ , the compensation  $S^*(\delta^*(\delta), x)$  and the probability  $\pi^*(\delta^*(\delta))$  will be the same under the two policies, so the banker will choose the same effort response function under both policies. Since  $\delta^*(\delta)$  was optimal given the original policy, the banker has no incentive to report  $\delta$  untruthfully against this new policy, so a policy  $(p(\delta), S(\delta, x), \pi(\delta))$  defined by

$$(p(\delta) \equiv p^*(\delta^*(\delta)), S(\delta, x) \equiv S^*(\delta^*(\delta), x), \pi(\delta) \equiv \pi^*(\delta^*(\delta)))$$

is equivalent to the original policy. Consequently, an optimal policy will be found in the class of incentive compatible policies against which the banker has no incentive to report  $\delta$  untruthfully. This result is a consequence of the "revelation principle" developed by Gibbard(1973), Green and Laffont(1977), Myerson(1979), Harris and Townsend(1979), and Dasgupta, Hammond, and Maskin(1979). The methodology that will be used to determine the optimal incentive compatible policy is based on Holmstrom(1979), Myerson(1980), and Baron and Myerson(1979).

If the issuer decides to issue the securities, his expected net proceeds  $N(\delta)$  conditional on the reported information  $\delta$  are

$$N(\delta) = \int (x - S(\delta, x)) g(x | p(\delta), e, \delta) dx. \quad (4)$$

The issuer however may find  $N(\delta)$  to be less than his reservation level  $\bar{N}(\delta)$ , which represents the capital that can be raised from the best alternative source.<sup>7</sup> In that case the issuer will be assumed to withdraw the issue, so the net (expected) proceeds  $N^*(\delta)$  are

$$N^*(\delta) = \pi(\delta)(N(\delta) - \bar{N}(\delta)). \quad (5)$$

Since the issuer does not know  $\delta$  when he determines the contract to offer to the banker, the issuer will choose a policy to maximize its expected net proceeds  $N$  given by

$$N = \int \pi(\delta)(N(\delta) - \bar{N}(\delta)) f(\delta) d\delta.$$

The issuer's problem thus is<sup>8</sup>

$$\max_{p(\delta), S(\delta, x), \pi(\delta)} \int (\int (x - S) g(x | p(\delta), e(\delta, \delta), \delta) dx - \bar{N}(\delta)) \pi(\delta) f(\delta) d\delta \quad (6)$$

$$\text{s.t.} \quad R(\delta, \delta, e(\delta, \delta)) \geq R(\hat{\delta}, \delta, e(\hat{\delta}, \delta)) \text{ for all } \hat{\delta} \text{ and } \delta \quad (7)$$

$$e(\delta, \delta) = \arg \max_e R(\delta, \delta, e) \text{ for all } \delta \quad (8)$$

$$R(\delta, \delta, e(\delta, \delta)) \geq 0 \text{ for all } \delta \quad (9)$$

$$1 > \pi(\delta) \geq 0 \text{ for all } \delta. \quad (10)$$

The constraints in (7) define the class of incentive compatible policies and state that if the banker's information is  $\delta$  the banker prefers to report  $\delta$  truthfully rather than to report any other value  $\hat{\delta}$ .<sup>9</sup> The constraints in (8) represent the banker's optimal choice of effort. The constraints in (9) are individual rationality conditions that state that the banker will not manage the issue unless its income  $R(\delta, \delta, e(\delta, \delta))$  is at least as great as its reservation level which is taken to be zero. The constraints in (10) require  $\pi(\delta)$  to be a probability. Since the issuer does

not know  $\delta$ , the constraints must be stated for all values of  $\delta \in [\underline{\delta}, \bar{\delta}]$ .

The program in (6)-(10) yields a second-best solution to the issuer's problem, to indicate why only a second-best solution is attainable, the first-best solution will be characterized. The first-best solution is defined as the solution that could be attained if the issuer knew  $\delta$  and were able to observe  $e$ . As the following proposition demonstrates, the first-best solution is attainable if  $\delta$  is known and  $e$  is unobservable.

Proposition 1: The first-best solution solves for each  $\delta \in [\underline{\delta}, \bar{\delta}]$  the program

$$\begin{aligned} & \max_{p, e, \pi, S} (\int x g dx - C(e) - \bar{N}(\delta)) \pi \\ \text{S.T.} & \int S(\delta, x) g dx - C(e) \geq 0, \end{aligned}$$

and when the issuer knows  $\delta$  is attainable through the solution  $(S^+(\delta, x), e^+(\delta), p^+(\delta), \pi^+(\delta))$  given by for all  $\delta \in [\underline{\delta}, \bar{\delta}]$

$$\begin{aligned} S(\delta, x) &= x - K(\delta), \\ \bar{x}_p(p^+(\delta), \delta, e^+(\delta)) &= 0 \\ \bar{x}_e(p^+(\delta), \delta, e^+(\delta)) - C'(e^+(\delta)) &= 0 \\ \bar{x}(p^+(\delta), \delta, e^+(\delta)) - K(\delta) - C(e^+(\delta)) &= 0 \\ \pi^+(\delta) &= \begin{cases} 1 & \text{if } K(\delta) \geq \bar{N}(\delta) \\ 0 & \text{if } K(\delta) < \bar{N}(\delta). \end{cases} \end{aligned}$$

The proof is immediate from standard agency theory for a risk neutral agent (see Harris and Raviv (1978) and Holmstrom (1979)).

If the issuer knew  $\delta$ , it would be optimal to give the banker the entire proceeds of the issue in exchange for a payment  $K(\delta)$  so that the offer price and the distribution effort decisions would be internalized with the banker. The first-best solution is not attainable when the issuer does not know  $\delta$ , however, because the issuer must choose a compensation function that provides the banker with an incentive to report its

private information truthfully, as indicated in (7), and that compensation distorts both the offer price and the distribution effort decisions away from their first-best levels as will be indicated.

To develop the second-best solution, the following interpretation is useful. The parameter  $\delta$  may be viewed as a datum, the banker's choices  $\hat{\delta}$  and  $e(\hat{\delta}, \delta)$  as dependent variables, and the functions  $S$ ,  $p$ , and  $\pi$  as the decision variables. As a first step in solving the program in (6)-(10), the dependent variable  $\hat{\delta}$  will be eliminated and an expression for  $R$  obtained that incorporates the incentive compatibility requirement in (7). To eliminate  $\hat{\delta}$  consider the banker's reporting problem in (7). In an incentive compatible policy the banker's optimal report  $\hat{\delta}$  equals  $\delta$  and satisfies the following first-order condition, given a policy  $p(\hat{\delta}), e(\hat{\delta}, \delta), \pi(\hat{\delta})$ , and  $S(\hat{\delta}, x)$  that is differentiable almost everywhere,<sup>10</sup>

$$R_{\hat{\delta}}(\hat{\delta}, \delta, e(\hat{\delta}, \delta)) \Big|_{\hat{\delta}=\delta} = \left( \int S_{\hat{\delta}}(\hat{\delta}, x) g dx + \int S(\hat{\delta}, x) g_p dx p'(\hat{\delta}) + \left( \int S(\hat{\delta}, x) g_e dx - C'(e) \right) \cdot e_{\hat{\delta}}(\hat{\delta}, \delta) \pi(\hat{\delta}) + \left( \int S(\hat{\delta}, x) g dx - C(e(\hat{\delta}, \delta)) \right) \pi'(\hat{\delta}) \right) \Big|_{\hat{\delta}=\delta} = 0. \quad (11)$$

To obtain an expression for the optimal income  $R(\delta, \delta, e(\delta, \delta))$  of the banker, totally differentiate (1) with respect to  $\delta$  to obtain

$$\begin{aligned} \frac{dR(\delta, \delta, e(\delta, \delta))}{d\delta} &= R_{\hat{\delta}}(\delta, \delta, e(\delta, \delta)) + R_{\delta}(\delta, \delta, e(\delta, \delta)) \\ &= R_{\delta}(\delta, \delta, e(\delta, \delta)) \quad (\text{from (11)}) \\ &= \pi(\delta) \int S(\delta, x) g_{\delta} dx + \pi(\delta) \left( \int S(\delta, x) g_e dx - C'(e(\delta, \delta)) \right) e_{\delta}(\delta, \delta) \\ &= \pi(\delta) \int S(\delta, x) g_{\delta} dx \quad (\text{from (3)}). \quad (12) \end{aligned}$$

The function  $S(\delta, x)$  will be assumed to be an increasing function of  $x$ , and since a decrease in  $\delta$  results in a stochastically dominated distribution of  $x$ , the derivative in (12) is strictly negative when  $\pi(\delta) > 0$  which establishes



Proposition 2: If  $S(\delta, x)$  is an increasing function of  $x$  in an optimal solution, the income  $R(\delta, \delta, e(\delta, \delta))$  is a strictly decreasing function of  $\delta$  when  $\pi(\delta) > 0$ . In an incentive compatible policy the banker thus receives greater compensation the more favorable is the information it possesses about the market.<sup>11</sup>

An expression for the income of the banker can be obtained by integrating (12) to obtain

$$\int_{\underline{\delta}}^{\bar{\delta}} \frac{dR(\delta^+, \delta^+, e(\delta^+, \delta^+))}{d\delta} d\delta^+ = R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})) - R(\delta, \delta, e(\delta, \delta))$$

for all  $\delta \in [\underline{\delta}, \bar{\delta}]$ .

Evaluating the left-side (from 12) and solving for  $R(\delta, \delta, e(\delta, \delta))$  yields

$$R(\delta, \delta, e(\delta, \delta)) = -\int_{\underline{\delta}}^{\bar{\delta}} \pi(\delta^+) \int S(\delta, x) g_{\delta} dx d\delta^+ + R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})). \quad (13)$$

The dependent variable  $\hat{\delta}$  has now been eliminated and an expression for the income of the banker that satisfies the incentive compatibility constraint has been obtained. Consequently, if the functions  $p(\delta)$ ,  $\pi(\delta)$  and  $S(\delta, x)$  are restricted to satisfy (13), the constraints in (7) can be dropped from the issuer's program. This will be accomplished below by substituting (13) into the objective function in (6).

As the next step in solving the issuer's problem, the effort constraint in (8), expressed in the form of (3), will be incorporated into the issuer's objective function using a Lagrangian multiplier  $\mu(\delta)$  which yields

$$N = \int \left[ \int (x - S(\delta, x) (1 - \mu(\delta) \frac{g_e}{g})) g dx - \mu(\delta) C'(e) - \bar{N}(\delta) \right] \pi(\delta) f(\delta) d\delta. \quad (14)$$

From (1) the payment to the banker may be expressed as

$$\pi(\delta) \int S(\delta, x) g dx = R(\delta, \delta, e) + \pi(\delta) C(e).$$

Substituting this expression into (14) yields

$$N = \int [-\pi(\delta)C(e) - R(\delta, \delta, e) + \pi(\delta) \int (x+S(\delta, x)\mu(\delta)\frac{g_e}{g})gdx - \pi(\delta)\mu(\delta)C'(e) - \pi(\delta)\bar{N}(\delta)]f(\delta)d\delta.$$

Then, substituting for  $R(\delta, \delta, e)$  from (13) yields

$$N = \int [-\pi(\delta)C(e) + \int_{\delta}^{\bar{\delta}} \pi(\delta^+) \int S(\delta, x)g_{\delta} dx d\delta + \pi(\delta) \int (x+S(\delta, x)\mu(\delta)\frac{g_e}{g})gdx - \pi(\delta)\mu(\delta)C'(e) - \pi(\delta)\bar{N}(\delta)]f(\delta)d\delta - R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})).$$

Integrating by parts yields

$$N = \int [-C(e) + \int (x+S(\delta, x)(\mu(\delta)\frac{g_e}{g} + \frac{g_{\delta}}{g} \frac{F(\delta)}{f(\delta)}))gdx - \mu(\delta)C'(e) - \bar{N}(\delta)]\pi(\delta)f(\delta)d\delta - R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})). \quad (15)$$

The issuer's problem is now<sup>12</sup>

$$\max_{p(\delta), S(\delta, x), e(\delta, \delta), \pi(\delta), R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta}))} N \quad (16)$$

$$\text{s.t. } R(\delta, \delta, e(\delta, \delta)) \geq 0 \quad \text{for all } \delta \quad (9)$$

$$1 \geq \pi(\delta) \geq 0 \quad \text{for all } \delta. \quad (11)$$

From (15) the issuer will choose  $R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta}))$  as low as possible, so from (9)  $R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})) = 0$  is optimal. Consequently, the worst information  $\delta = \bar{\delta}$  receives a payment from the issuer equal to  $C(e(\bar{\delta}, \bar{\delta}))$ . When  $S(\delta, x)$  is a nondecreasing function of  $x$ , the constraint in (9) is satisfied for all  $\delta$  and can be ignored, since from Proposition 2  $R(\delta, \delta, e(\delta, \delta))$  is nonincreasing in  $\delta$ .<sup>13</sup>

The issuer's problem then is to maximize  $N$  in (15) with respect to  $p(\delta)$ ,  $S(\delta, x)$ ,  $e(\delta, \delta)$ , and  $\pi(\delta)$  subject to (11). To simplify the compensation functions analysis will be restricted to the class of compensation functions of the form<sup>14</sup>

$$S(\delta, x) = s(\delta) + tx, t \in [0, 1]. \quad (17)$$

While this specification is restrictive, it does include the two-polar cases of a firm commitment contract ( $t=1$ ) in which the issuer receives a fixed payment independent of  $x$  for the issue and a conventional best-efforts contract ( $t=0$ ) in which the banker receives a fixed payment for its services. With this specification the terms  $\int S g_e dx$  and  $\int S g_\delta dx$  simplify to  $t\bar{x}_e$  and  $t\bar{x}_\delta$ , respectively, so  $s(\delta)$  does not appear in the expression for  $N$  in (15). The function  $s(\delta)$  can be recovered from (13) and (1). Since the specification of  $S$  in (17) is nondecreasing in  $x$ , the constraints in (9) are satisfied for all  $\delta$ .

To characterize the optimal price function, maximize (15) pointwise on  $\delta$  with respect to  $p$  which yields, for  $\pi(\delta) > 0$ ,

$$\bar{x}_p + t\mu(\delta)\bar{x}_{ep} + t(F(\delta)/f(\delta))\bar{x}_{\delta p} = 0. \quad (18)$$

This expression indicates the deviation from the first-best policy in Proposition 1 that is required to deal with the informational asymmetry. To analyze this condition, consider the third term in (18). The term  $F(\delta)/f(\delta)$  is positive and  $\bar{x}_{\delta p}$  is negative by assumption, since less favorable information decreases the marginal return from an increase in the offer price. This term reflects the deviation from the first-best price required to deal with the banker's superior information about  $\delta$  when  $e$  is fixed. This term implies that the offer price is set so that  $\bar{x}_p > 0$  which establishes

Proposition 3: If  $e$  is fixed at the first-best level, the optimal price  $p(\delta)$  satisfying (18) is lower than the first-best price characterized in Proposition 1.

Consequently, because of the asymmetric information the issuer is forced to lower the offer price below that which he would set in a first-best solution if the banker expended the first-best effort.

The second term in (18) reflects the deviation from the first-best solution necessary to deal with the distribution effort observability problem given the informational asymmetry. To interpret this term, the sign of the multiplier  $\mu(\delta)$  must be determined, which can be done from the adjoint equation obtained by maximizing  $N$  with respect to  $e(\delta, \delta)$ . Differentiating (15) with respect to  $e$  pointwise on  $\delta$  yields, for  $\pi(\delta) > 0$ ,

$$-C'(e) + \mu(\delta)[\bar{x}_{ee} - C''(e)] + \bar{x}_e + t(F(\delta)/f(\delta))\bar{x}_{e\delta} = 0. \quad (19)$$

Substituting for  $C'(e)$  from (3) when  $S(\delta, x) = s(\delta) + tx$  yields

$$(1-t)\bar{x}_e + \mu(\delta)[\bar{x}_{ee} - C''(e)] + t(F(\delta)/f(\delta))\bar{x}_{e\delta} = 0. \quad (20)$$

If  $t < 1$ , the first term is positive because an increase in  $e$  results in a stochastically dominant distribution of  $x$ .

If  $\bar{x}_{e\delta} > 0$ , the multiplier  $\mu(\delta)$  is positive, since  $(\bar{x}_{ee} - C''(e))$  is negative by assumption. Consequently, if the marginal proceeds from an increase in the distribution effort are greater the less favorable is the banker's information, the multiplier  $\mu(\delta)$  is positive. The multiplier has the interpretation as the increase in expected net proceeds to the issuer from an increase in the sales effort by the banker, so at the optimal solution the issuer prefers that the banker exert greater sales effort when  $\bar{x}_{e\delta} > 0$  and  $t < 1$ . If  $\bar{x}_{e\delta} < 0$ , a higher  $\delta$  results in less effort expended for a given price, and the sign of the multiplier is ambiguous. With  $\bar{x}_{e\delta}$  sufficiently negative, the issuer may prefer that the banker expend less effort in order to reduce the compensation paid to the banker to cover the cost  $C(e(\delta, \delta))$ .

This analysis is summarized as

Proposition 4: If  $t < 1$  and  $\bar{x}_{e\delta} > 0$ , then  $\mu(\delta) > 0$ .  
 If  $\bar{x}_{e\delta} < 0$ , the sign of  $\mu(\delta)$  is ambiguous in general.

Returning to the analysis of (18), if  $\mu(\delta)$  is positive, the second term is positive, since  $\bar{x}_{ep}$  is positive by assumption. Consequently, in response to his inability to observe effort, the issuer chooses a price that is higher than that which he would set were effort observable. To interpret this result, note that  $\bar{x}_{ep} > 0$  means that the marginal return effort is an increasing function of the offer price. To deal with the effort incentive problem, the issuer thus prices above the level he would otherwise prefer in order to induce the banker to exert greater effort. The sign of  $\bar{x}_p$  in (18) is thus ambiguous in this case and will be analyzed further in an example in the next section. If  $\mu(\delta)$  is negative, then  $\bar{x}_p > 0$ , so the issuer prefers to price higher than that which maximizes the expected proceeds  $\bar{x}$  given the same distribution effort.

Parameterized on  $t$ , the solution to the issuer's problem is a set of functions  $(p(\delta), e(\delta, \delta), \mu(\delta), s(\delta), \pi(\delta))$  that satisfies the following four conditions, if  $\pi(\delta) > 0$ ,

$$t\bar{x}_e - C'(e(\delta, \delta)) = 0 \quad (3)$$

$$\bar{x}_p + t\mu(\delta)\bar{x}_{ep} + t(F(\delta)/f(\delta))\bar{x}_{\delta p} = 0 \quad (18)$$

$$-C'(e(\delta, \delta)) + \mu(\delta)[t\bar{x}_{ee} - C''(e(\delta, \delta))] + \bar{x}_e + t(F(\delta)/f(\delta))\bar{x}_{e\delta} = 0 \quad (19)$$

$$\pi(\delta)(s(\delta) + t\bar{x} - C(e(\delta, \delta))) + t \int_{\delta}^{\bar{\delta}} \pi(\delta^+) \bar{x}_{\delta} d\delta^+ = 0 \quad (\text{from (13) and (1)}) \quad (21)$$

and  $\pi(\delta)$  satisfies

$$\pi(\delta) = \begin{cases} 1 & \text{if } \bar{x}(1-t) - s(\delta) \geq \bar{N}(\delta) \\ 0 & \text{if } \bar{x}(1-t) - s(\delta) < \bar{N}(\delta). \end{cases}$$

The optimal share  $t^+$  is then determined from

$$t^+ = \underset{t}{\operatorname{argmax}} \int \pi(\delta)(N(\delta) - \bar{N}(\delta))f(\delta)d\delta, \quad (22)$$

where  $N(\delta)$  is evaluated at the optimal policy.<sup>15</sup>

As one characterization of the solution consider the case in which  $\pi(\delta) = 1$  on an interval  $[\underline{\delta}, \delta^0]$  and  $\pi(\delta) = 0$  on  $(\delta^0, \bar{\delta}]$  which will be the case if  $(N(\delta) - \bar{N}(\delta))$  is decreasing in  $\delta$ , where  $N(\delta)$  is the integrand in (15). The following result then obtains

Proposition 5: If in the optimal policy

$$\pi(\delta) = \begin{cases} 1 & \text{if } \delta \in [\underline{\delta}, \delta^0] \\ 0 & \text{otherwise,} \end{cases}$$

the optimal income  $R(\delta, \delta, e(\delta, \delta))$  of the banker is continuous and satisfies

$$R(\delta, \delta, e(\delta, \delta)) \begin{cases} > 0 & \text{if } \delta \in [\underline{\delta}, \delta^0] \\ = 0 & \text{if } \delta \in [\delta^0, \bar{\delta}] \end{cases}$$

and the payment  $s(\delta^0)$  is given by

$$s(\delta^0) = C(e(\delta^0, \delta^0)) - t\bar{x}(p(\delta^0), e(\delta^0, \delta^0), \delta^0).$$

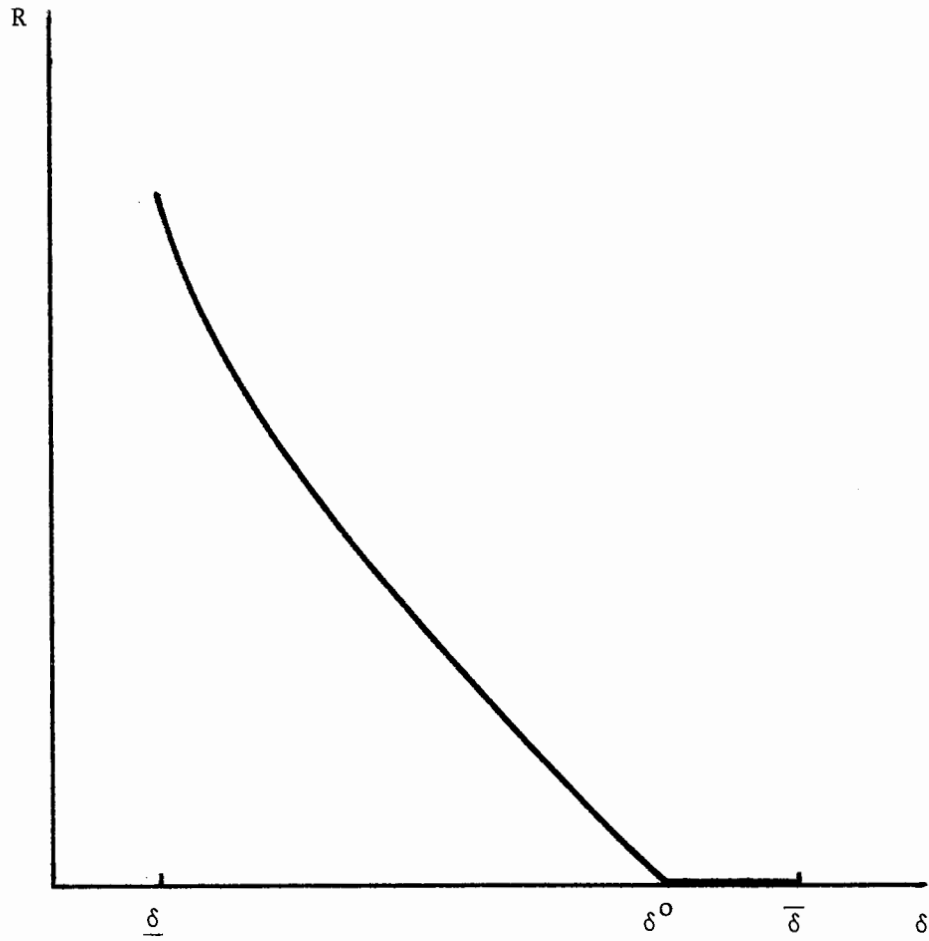
Proof: Evaluating (13) at  $\delta^0$  when  $S(\delta, x) = s(\delta) + tx, t < 1$ , yields

$$R(\delta^0, \delta^0, e(\delta^0, \delta^0)) = -\int_{\delta^0}^{\delta^0} t\bar{x}_{\delta} d\delta^+ = 0,$$

since  $\pi(\delta) = 0$  on  $(\delta^0, \bar{\delta}]$ . Continuity is immediate from (13) and from Proposition 2  $R$  is decreasing in  $\delta$  for  $\delta \in [\underline{\delta}, \delta^0)$ , which establishes the properties of  $R$ . The expression for  $s$  is immediate from (21).

The income  $R$  of the banker is illustrated in Figure 1.

Figure 1



C. A Best-Efforts Contract

An alternative to a delegation contract is to engage an investment banker solely to distribute the issue and not to use, and hence to pay for, its advisement services. In the context of the model considered here, this alternative involves the issuer determining the offer price based on his limited information, and the banker distributing the issue at that price. The issuer in this case does not ask for, and hence need not pay for, a report about  $\delta$ , so no compensation  $s(\delta)$  is made. To simplify the analysis of the optimal "best-efforts" contract, the class of linear contracts of the form

$$t(x) = tx + T, \quad (23)$$

will be considered.

Given a contract of the form of (23), the banker will choose an effort response function that depends on the offer price  $p$  chosen by the issuer, the contract, and the information  $\delta$  the banker has about the demand for the securities. The effort response function  $e(p, t, \delta)$  is defined by

$$e(p, t, \delta) = \underset{e}{\operatorname{argmax}} \bar{t\bar{x}}(p, e, \delta) + T - C(e) = \underset{e}{\operatorname{argmax}} \bar{t\bar{x}}(p, e, \delta) - C(e) \quad (24)$$

if  $\bar{t\bar{x}}(p, e(p, t, \delta), \delta) - C(e(p, t, \delta)) \geq 0$  and otherwise  $e(p, t, \delta) = 0$ , since in that case the banker will reject the contract. The response function will be assumed to be differentiable when it is nonzero.

While the issuer can be certain that the banker will agree to the contract by choosing  $t$  and  $T$  such that

$$\min_{\delta \in [\underline{\delta}, \bar{\delta}]} (\bar{t\bar{x}}(p, e(p, t, \delta), \delta) + T) \geq 0,$$

it is, however, not necessarily optimal for the issuer to choose a contract that the banker is certain to accept. Instead, the



issuer may prefer to learn something about  $\delta$  from the banker's decision to accept or reject the contract. For example, the issuer may prefer not to issue the securities if  $\delta$  is unfavorable (high) and may be able to accomplish this by offering the banker a contract that it will reject when  $\delta$  is unfavorable and accept when  $\delta$  is favorable. If, for example,  $\bar{x}(p, e(p, t, \delta), \delta)$  is everywhere decreasing in  $\delta$ , the issuer can choose  $T$  such that the banker will accept the contract for  $\delta$  in an interval  $[\underline{\delta}, \delta^*]$  and reject it on  $(\delta^*, \bar{\delta}]$ , where  $\delta^* = \delta^*(t, T, \delta)$  is defined as the  $\delta$  such that the income  $R^*(\delta)$  equals zero or

$$R^*(\delta^*) = tx(p, e(p, t, \delta^*), \delta^*) + T - C(e(p, t, \delta^*)) \equiv 0. \quad (25)$$

The variation in  $R^*(\delta)$  when the banker accepts the contract is

$$\frac{dR^*(\delta)}{d\delta} = t\bar{x}_\delta + (t\bar{x}_e - C'(e))e_\delta = t\bar{x}_\delta,$$

which is negative since  $\bar{x}_\delta < 0$ . Consequently, if  $t$  and  $T$  are set so that the banker will accept the contract at  $\delta = \underline{\delta}$  and reject it at  $\delta = \bar{\delta}$ , the optimal solution will have nonempty acceptance and rejection regions  $[\underline{\delta}, \delta^*]$  and  $(\delta^*, \bar{\delta}]$ , respectively.

The issuer's problem can thus be stated as

$$\max_{p, t, T} N^* \equiv \int_{\underline{\delta}}^{\delta^*} ((1-t)\bar{x}(\delta) - T - \bar{N}(\delta))f(\delta)d\delta + \int_{\delta^*}^{\bar{\delta}} \bar{N}(\delta)f(\delta)d\delta.$$

The decision of whether or not to issue the securities thus rests with the banker, and to influence the banker's decision, the issuer chooses  $p$ ,  $t$ , and  $T$  to satisfy the following three first-order conditions:

$$\int_{\underline{\delta}}^{\delta^*} ((1-t)(\bar{x}_p + \bar{x}_e e_p)) f(\delta) d\delta + ((1-t)\bar{x}^* - T) f(\delta^*) \frac{\partial \delta^*}{\partial p} = 0 \quad (26)$$

$$\int_{\underline{\delta}}^{\delta^*} (-\bar{x} + (1-t)\bar{x}_e e_t) f(\delta) d\delta + ((1-t)\bar{x}^* - T) f(\delta^*) \frac{\partial \delta^*}{\partial t} = 0 \quad (27)$$

$$-\int_{\underline{\delta}}^{\delta^*} f(\delta) d\delta + ((1-t)\bar{x}^* - T) f(\delta^*) \frac{\partial \delta^*}{\partial T} = 0,$$

where  $\bar{x}^* = \bar{x}(p, e(p, t, \delta^*), \delta^*)$ .

The first result that can be obtained is that a firm commitment contract ( $t=1$ ) is not optimal and that when the issuer finds it optimal to engage the services of the banker, both the issuer and the banker bear a portion of the risks. If  $t \geq 1$ , then the first term in (27) is negative, since  $\bar{x}_e e_t > 0$ . To evaluate the second-term in (27), differentiate (25) holding  $T$  and  $p$  fixed to obtain

$$\left. \frac{\partial \delta^*}{\partial t} \right|_{\delta=\delta^*} = -\bar{x} / (t(\bar{x}_e e_\delta + \bar{x}_\delta) - C' e_\delta) \Big|_{\delta=\delta^*} = -\bar{x} / (t\bar{x}_\delta) \Big|_{\delta=\delta^*}$$

which is positive. The term  $((1-t)\bar{x}^* - T)$  can be expressed from (25) as

$$(1-t)\bar{x}^* - T = \bar{x}^* - C(e(p, t, \delta^*)),$$

so if the expected proceeds are at least as great as the cost of the distribution effort when  $\delta=\delta^*$  and the effort is given by  $e(p, t, \delta^*)$ , the term  $(1-t)\bar{x}^* - T$  is positive. In this case (27) can be satisfied only if  $T < 0$ , but if  $t \geq 1$ , the net proceeds of the issuer are negative and the issuer is then better off by not selling the issue. The optimal share  $t$  thus is less than one and a firm commitment contract is not optimal.

A conventional best-efforts arrangement involves a contract

of the form  $(t=0, T>0)$  in which the banker receives only a fixed payment. If  $t \leq 0$ , the distribution effort expended is zero in the context of the model considered here, so the issuer will choose  $T=0$ . This corresponds to a direct sale by the issuer. These results are summarized as

Proposition 6: In a best-efforts contract in which the issuer chooses the offer price based on his limited information and engages a banker for its distribution services, a firm commitment contract is not optimal nor is a contract in which the banker receives only a lump-sum payment. In an optimal best-efforts contract both the issuer and the banker bear a portion of the risk associated with the issue.

Since a best-efforts contract is a special case of a delegation contract in which  $p(\delta)$  is constant in  $\delta$  and in which the issue is withdrawn ( $\pi(\delta)=0$ ) on some interval  $(\delta^*, \bar{\delta}]$ , an issuer weakly prefers a delegation contract to a best-efforts contract. This does not imply strict preference, however, although strict preference is indicated in the example presented in the next section.

### III. An Example

The example is based on the following specifications:

$$C(e) = \frac{1}{2}be^2, \quad b > 0$$

$$\bar{x}(p, e, \delta) = a(\bar{\delta} - \delta)e + d(\bar{\delta} - \delta)p + dp^0 - \frac{1}{2}m(p - p^0)^2, \quad a > 0, d > 0, m > 0, p^0 > 0 \quad (28)$$

$$f(\delta) = \begin{cases} 1/\bar{\delta} & \text{if } \delta \in [0, \bar{\delta}] \\ 0 & \text{otherwise.} \end{cases}$$

The parameter  $p^0$  may be thought of as an offer price at which the issue is expected to be fully subscribed. An offer price  $p > p^0$  can result in greater net proceeds depending on the market parameter  $\delta$  and the parameters  $d$  and  $m$ . To provide a needed

second-order condition, it will be assumed that  $2a^2m - bd^2 > 0$ .

A. The Optimal Delegation Contract

From (3) the effort response function given  $t(x) = tx$  is

$$e(\delta, \delta) = ta(\bar{\delta} - \delta)/b, \quad (29)$$

which is decreasing in  $\delta$  and is independent of  $p$ . From (18) the offer price function  $p(\delta)$  is

$$p(\delta) = p^0 + d(\bar{\delta} - \delta(1+t))/m, \quad (30)$$

which is decreasing in  $\delta$ . Solving (19) for  $\mu(\delta)$  yields

$$\mu(\delta) = a(\bar{\delta}(1-t) - \delta)/b. \quad (31)$$

The expected proceeds  $\bar{x}(\delta)$  are

$$\bar{x}(\delta) = a^2(\bar{\delta} - \delta)^2 t/b + \frac{d^2((\bar{\delta} - \delta)^2 - t^2\delta^2)}{2m} + p^0 d(1 + \bar{\delta} - \delta). \quad (32)$$

From (23) the income  $R(\delta, \delta, e(\delta, \delta))$  of the banker is

$$R(\delta, \delta, e(\delta, \delta)) = \frac{a^2 t^2 (\bar{\delta} - \delta)^2}{2b} + \frac{d^2 t ((\bar{\delta} - \delta)^2 - t(\bar{\delta}^2 - \delta^2))}{2m} + p^0 dt(\bar{\delta} - \delta), \quad (33)$$

which is strictly decreasing in  $\delta$  if  $p(\delta) > 0$ , is strictly convex in  $\delta$ , and satisfies  $R(\bar{\delta}, \bar{\delta}, e(\bar{\delta}, \bar{\delta})) = 0$ . The payment  $s(\delta)$  is given by

$$s(\delta) = \frac{d^2 t^2}{2m} (\delta^2(1+t) - \bar{\delta}^2) - tp^0 d, \quad (34)$$

which is strictly increasing and strictly convex in  $\delta$ .

The optimal policy of the issuer may be interpreted as a self-selection mechanism in which for a fixed  $t$  the issuer offers the banker a set of contracts  $\{s(\hat{\delta}), p(\hat{\delta}); \hat{\delta} \in [\underline{\delta}, \bar{\delta}]\}$ , and the banker

chooses among those contracts given its private information  $\delta$ . The optimal set of contracts in the  $(p,s)$ -plane in Figure 1 is the convex function  $s^*(p)$  which is obtained from (30) and (34) and is given by<sup>16</sup>

$$s^*(p) = -tp^0d + \frac{d^2t^2}{2m} \left( \frac{(\bar{\delta} - (p-p^0)\frac{m}{d})^2}{1+t} - \bar{\delta}^2 \right).$$

The slope of the banker's indifference curve in the  $(s,p)$ -plane is given by totally differentiating

$$R = s + t\bar{x} - C(e)$$

to obtain<sup>17</sup>

$$\frac{ds}{dp} = -t\bar{x}_p = tm(p-p^0) - td(\bar{\delta} - \delta).$$

Indifference curves are shown in Figure 2 for the cases of high and low  $\delta$ . If the banker knows that the market reception will be favorable ( $\delta$  low), the banker will choose a contract with a high offer price and a low payment  $s(\delta)$ , while if  $\delta$  is high, the banker will choose a low offer price and a high  $s(\delta)$ . The payment  $s(\delta)$  is greater for high  $\delta$  than for low  $\delta$  because 1) the banker has a greater incentive to misrepresent its information when  $\delta$  is high than when it is low and 2) when  $\delta$  is high the compensation  $t\bar{x}$  is low. Since the expected compensation of the banker is greater the more favorable is its information, when  $\delta$  is low the banker receives more of its compensation in the form of its share  $t\bar{x}$  of the expected proceeds and less in the form of the payment  $s(\delta)$ .

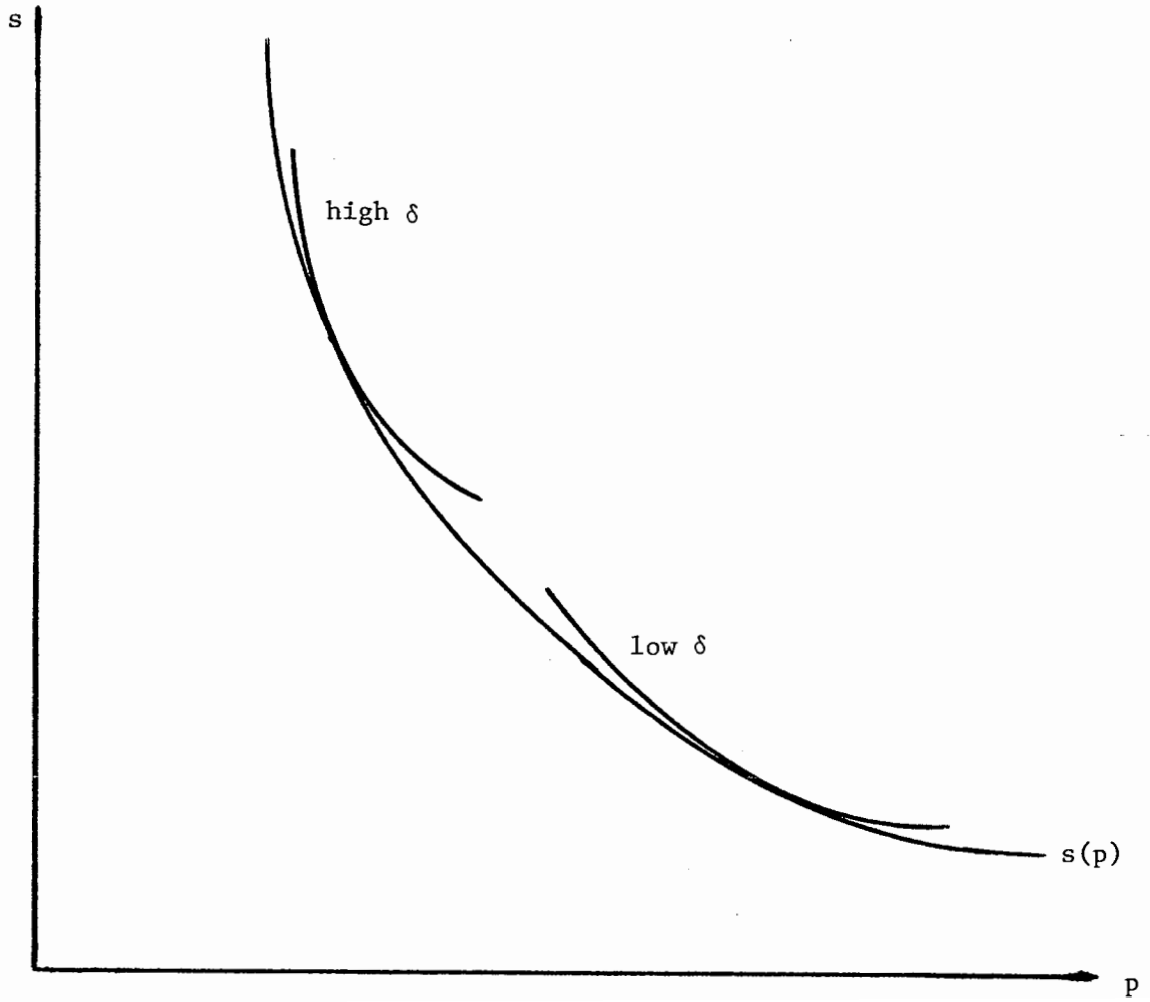
To verify that the optimal policy is incentive compatible, consider an interval in  $[0, \bar{\delta}]$  such that  $\pi(\delta)=1$  for all  $\delta$  in that interval. The revenue  $R(\hat{\delta}, \delta, e(\hat{\delta}, \delta))$  is

$$R(\hat{\delta}, \delta, e(\hat{\delta}, \delta)) = s(\hat{\delta}) + t\bar{x}(p(\hat{\delta}), \delta, e(\hat{\delta}, \delta)) - C(e(\hat{\delta}, \delta))$$

and maximizing with respect to  $\hat{\delta}$  yields the first-order condition

Figure 2

Self-Selection Based on  $\delta$



$$R_{\hat{\delta}}(\hat{\delta}, \delta, e(\hat{\delta}, \delta)) = \frac{d^2 t}{m} (1+t)(\delta - \hat{\delta}) = 0.$$

The second-order condition is satisfied for all  $\hat{\delta}$ , so it is globally optimal for the banker to report  $\hat{\delta} = \delta$  and the optimal policy is strongly incentive compatible.

The first-best solution  $(p^+(\delta), e^+(\delta), s^+(\delta))$  maximizes  $\bar{x} - C(e)$  pointwise on  $\delta$  and is

$$e^+(\delta) = a(\bar{\delta} - \delta)/b$$

$$p^+(\delta) = p^0 + \frac{d}{m}(\bar{\delta} - \delta)$$

$$s^+(\delta) = C(e^+(\delta)) = \frac{a^2(\bar{\delta} - \delta)^2}{2b}$$

$$\bar{x}^+(\delta) = \frac{a^2(\bar{\delta} - \delta)^2}{b} + \frac{d^2(\bar{\delta} - \delta)^2}{2m} + p^0 d.$$

Compared to the second-best solution with  $t \in [0, 1)$ , the first-best solution involves greater effort and for  $t \in (0, 1]$  a lower offer price. Furthermore, the income of the banker in the first-best solution is identically zero, while in the second-best solution the banker's utility is strictly positive for  $\delta < \bar{\delta}$ . The issuer is thus strictly worse-off and the banker strictly better off in the second-best solution for  $\delta < \bar{\delta}$  than in the first-best solution. This results because of the asymmetry of information about  $\delta$  and not because of the issuer's inability to observe the distribution effort.

The net expected proceeds  $N(\delta)$  to the issuer in the second-best solution are

$$N(\delta) = \frac{a^2 t (\bar{\delta} - \delta)^2}{b} (1-t) + p^0 d (1 + (1-t)(\bar{\delta} - \delta)) + \frac{d^2}{2m} ((\bar{\delta} - \delta)^2 (1-t) + t^2 (\bar{\delta}^2 - 2\delta^2)). \quad (35)$$

The reservation level  $\bar{N}(\delta)$  will be assumed to be such that  $N(\delta) > \bar{N}(\delta)$  for all  $\delta \in [0, \bar{\delta}]$  at the optimal  $t$ . Taking the expectation of  $N(\delta)$  in (35) with respect to  $\delta$  yields

$$N^+ = \frac{a^2 t(1-t)\bar{\delta}^2}{3b} + p^0 d(1+(1-t)\bar{\delta}/2) + \frac{d^2 \bar{\delta}^2}{6m}(1-t+t^2). \quad (36)$$

The optimal share  $t^+$  is obtained by maximizing  $N^+$  which yields

$$t^+ = \begin{cases} \max\{0, 1/2 - \frac{3p^0 mbd}{2y\bar{\delta}}\} & \text{if } y > 0 \\ 0 & \text{otherwise.} \end{cases} \quad (37)$$

where  $y \equiv 2a^2 m - d^2 b$ .

If the parameter  $a$ , which indexes the marginal productivity of the distribution effort, is sufficiently large that  $y > 0$ , the optimal share is bounded above by  $1/2$ , so the issuer never gives the banker more than one half of the proceeds. In this case the share  $t^+$  is an increasing function of  $a$  indicating that the greater is the marginal effectiveness of the distribution effort the greater is the share of the proceeds given to the banker. The greater share reduces the offer price  $p(\delta)$  from (30), so the issuer responds to a more effective sales effort by reducing the offer price and inducing a greater effort by giving the banker a greater share of the proceeds. Similarly, as  $m$  increases, the marginal expected proceeds from an increase in the offer price are reduced, so the issuer increases the share allocated to the banker in order to increase its effort. An increase in the marginal cost of effort or the marginal return (higher  $d$ ) to a greater offer price decreases the share given to the banker.

If  $a$  is such that  $y \leq 0$ ,  $N^+$  is a strictly convex function of  $t$  with a maximum at  $t=0$ . Then, from (21)  $s(\delta)=0$  for all  $\delta$ . This indicates that the issuer asks the banker for its information and pays the banker nothing. The banker is as well off if it does or does not provide the information, so the banker is not opposed to providing it. Clearly, this will not occur in practice. The implication of this result is that in this example the issuer



cannot induce the banker to tell him its information when the banker cannot affect demand through its distribution effort as well. For example, if the issuer offered a payment  $s(\hat{\delta}) \neq 0$  for all  $\hat{\delta}$ , the banker will just report the  $\hat{\delta}$  that maximizes  $s(\hat{\delta})$ . The issuer has no way to prevent the banker from misreporting, so the issuer is left with the other alternatives of a direct sale or a best-efforts contract.<sup>18</sup>

From (31)  $y > 0$ , the multiplier  $\mu(\delta)$  is positive for  $\delta$  such that

$$\delta < \bar{\delta}/2 + 3p^0 mbd / (2(2a^2 m - d^2 b)).$$

Consequently, at least for favorable information ( $\delta$  low), the issuer prefers that the banker exert greater distribution effort.

For the case in which  $y > 0$  the expected net proceeds  $N^+$  after substituting for  $t^+$  are<sup>19</sup>

$$N^+ = p^0 d + \frac{d^2 \bar{\delta}^2}{6m} + \frac{(\bar{\delta}y + 3p^0 mbd)^2}{24mby}. \quad (38)$$

The objective is to compare  $N^+$  in this case with the expected proceeds from the other two alternatives available to the issuer: 1) to sell the securities directly in the market without using the investment banker and 2) using the banker under a best-efforts arrangement in which the banker is engaged to distribute the issue but the offer price decision is not delegated to the banker. Before considering these two alternatives the effect of the issuer's uncertainty about the private information  $\delta$  of the banker will be analyzed.

#### B. The Effect of the Issuer's Uncertainty About $\delta$ on the Demand for Delegation

In a delegation contract the issuer benefits from both the distribution effort and the private information of the banker.

If the issuer knew  $\delta$ , there would obviously be no benefit from delegation, and one might conjecture that the more uncertain the issuer is about  $\delta$  the greater would be the value of delegation. To examine this issue in the context of the example, consider the case in which the issuer's density function  $f(\delta)$  is given by

$$f(\delta) = \begin{cases} \frac{1}{\bar{\delta} + \Delta - (\underline{\delta} - \Delta)} & \text{if } \underline{\delta} - \Delta \leq \delta \leq \bar{\delta} + \Delta \\ 0 & \text{otherwise.} \end{cases}$$

The mean of  $\delta$  is independent of  $\Delta$ , so an increase in  $\Delta$  may be interpreted as representing greater uncertainty on the part of the issuer. In order that the marginal return be independent of  $\Delta$ , the expected proceeds in (28) will be rewritten with  $\bar{\delta}$  replaced by  $\bar{\delta} + Z$  where  $Z$  is a positive constant such that  $Z > \Delta$ .

With this specification the solution is given by:

$$e_{\Delta}(\delta, \delta) = \frac{at(\bar{\delta} + Z - \delta)}{b} \quad (29a)$$

$$p_{\Delta}(\delta) = p^0 + \frac{d}{m}(\bar{\delta} + Z - \delta - t(\delta - (\underline{\delta} - \Delta))) \quad (30a)$$

$$\bar{x}_{\Delta}(\delta) = \frac{a^2 t (\bar{\delta} + Z - \delta)^2}{b} + p^0 d (1 + \bar{\delta} + Z - \delta) + \frac{d^2}{2m} ((\bar{\delta} + Z - \delta)^2 - t^2 (\delta - (\underline{\delta} - \Delta))^2) \quad (32a)$$

$$R_{\Delta}(\delta, \delta, e(\delta, \delta)) = \frac{a^2 t^2 ((\bar{\delta} + Z - \delta)^2 - (Z - \Delta)^2)}{2b} + p^0 dt (\bar{\delta} + \Delta - \delta) + \frac{d^2 t}{2m} ((\bar{\delta} + Z - \delta)^2 - t((\bar{\delta} + \Delta - (\underline{\delta} - \Delta))^2 - (\delta - (\underline{\delta} - \Delta))^2)) \quad (33a)$$

$$N_{\Delta}(\delta) = \frac{a^2 t(1-t)(\bar{\delta} + Z - \delta)^2}{b} + p^0 d(1 + (1-t)(\bar{\delta} + Z - \delta) + t(Z - \Delta)) + \frac{d^2}{2m} ((1-t)(\bar{\delta} + Z - \delta)^2 + t^2 ((\bar{\delta} + \Delta - (\underline{\delta} - \Delta))^2 - 2(\delta - (\underline{\delta} - \Delta))^2)) + \frac{a^2 t^2}{2b} (Z - \Delta)^2 + \frac{d^2 t}{2m} (Z - \Delta)^2 \quad (35a)$$

$$\begin{aligned}
 N_{\Delta}^{+} = & \frac{a^2 t(1-t)(\bar{\delta}+\Delta-(\underline{\delta}-\Delta))^2}{3b} + p^0 d(1+(1-t)(\bar{\delta}-\underline{\delta})/2+\Delta)+(Z-\Delta)) \\
 & + \frac{d^2}{6m}(\bar{\delta}+\Delta-(\underline{\delta}-\Delta))^2(1-t+t^2) + \frac{a^2 t}{b}((Z-\Delta)^2 + (Z-\Delta)(\bar{\delta}+\Delta-(\underline{\delta}-\Delta))) \\
 & - \frac{a^2 t^2}{b}(Z-\Delta)(\bar{\delta}+\Delta-(\underline{\delta}-\Delta)) - \frac{a^2 t^2}{2b}(Z-\Delta)^2 \\
 & + \frac{d^2}{2m}((Z-\Delta)^2 + (Z-\Delta)(\bar{\delta}+\Delta-(\underline{\delta}-\Delta)) - t(Z-\Delta)(\bar{\delta}+\Delta-\underline{\delta}-\Delta)) \quad 36(a)
 \end{aligned}$$

$$N_{\Delta}^{+} = \max \left\{ 0, \frac{1}{2} - \frac{3(p^0 d b m L - a^2 m (Z-\Delta)^2 + d^2 b (Z-\Delta)L)}{2a^2 m (2L^2 + 3(Z-\Delta)^2 + 6(Z-\Delta)L) - 2bd L^2} \right\} \quad \text{if } a^2 m (2L^2 - 3(Z-\Delta)^2 + 6(Z-\Delta)L) - bd L^2 > 0 \quad (37a)$$

otherwise.

where  $L = (\bar{\delta}+\Delta-(\underline{\delta}-\Delta))$ .

For a given  $t$  the offer price function is decreasing in  $\Delta$  indicating that as the uncertainty of the issuer increases he is willing to accept a lower offer price. If an issuer of unseasoned securities may be taken to be more uncertain about the market reception for its securities than is an issuer of seasoned securities, the issuer of unseasoned securities will accept a relatively lower offer price and hence underpricing, as indicated in the study by Ibbotson (1975), would be expected.

The expected proceeds  $\bar{x}_{\Delta}(\delta)$  are strictly decreasing in  $\Delta$  for a given  $t$ , so the issuer views the offering as less "valuable" the greater is his uncertainty about the parameter  $\delta$ . The effect of  $\Delta$  on the income of the banker and the net proceeds of the issuer is ambiguous in general, however, but as will be demonstrated in Section III.D., the gain to the issuer from a delegation contract relative to a best-efforts contract is increasing in the issuer's uncertainty.

### C. The Direct Sale Alternative

If the issuer sells the issue directly, the optimal offer

price  $p^*$  maximizes the expected proceeds  $E\bar{x} = \int \bar{x}f(\delta)d\delta$  and is given by

$$p^* = p^0 + \frac{d\bar{\delta}}{2m}.$$

The optimal expected proceeds  $E\bar{x}$  are

$$E\bar{x} = dp^0 + \frac{d^2\bar{\delta}^2}{8m}.$$

The expected proceeds  $E(\bar{x}(\delta))$  from a delegation contract are greater than  $E\bar{x}$ , since

$$E(\bar{x}(\delta)) - E\bar{x} = \frac{a^2 t \bar{\delta}^2}{3b} + \frac{d^2 \bar{\delta}^2}{6m} (1/4 - t^2) + p^0 d > 0,$$

which is positive, since  $t$  is bounded above by  $1/2$ . The issuer must compensate the banker for its distribution effort and for its information, so greater expected proceeds do not imply that the issuer prefers a delegation contract to a direct sale. To determine the preference of the issuer, subtract  $E\bar{x}$  from  $N^+$  in (36) to obtain

$$N^+ - E\bar{x} = \frac{d^2 \bar{\delta}^2}{24m} + \frac{(\bar{\delta}y + 3p^0 mbd)^2}{24mby} > 0.$$

The issuer thus prefers a delegation contract over a direct sale, indicating a positive demand for the advisement and distribution services of the investment banker.

A delegation contract has two advantages over a direct sale. First, the issuer benefits from the distribution effort of the banker not only because effort increases the net proceeds to the issuer but also because the effort response function results in a return represented by the first term in (37) that is strictly convex in  $\delta$ . Second, the issuer benefits from being able to price responsively based on the banker's information, which also results in a strictly convex net proceeds function  $N(\delta)$  for the issuer. Because of the strict convexity the expectation  $N^+$  of  $N(\delta)$  is greater than  $N(E(\delta))$  by Jensen's inequality, so the issuer benefits from the banker's response to

its information. Since the offer price in a direct sale is not a function of  $\delta$ , the proceeds are linear in  $\delta$ , and hence the issuer cannot benefit from adjusting the offer price to market conditions.

D. A Best-Efforts Contract

The third alternative available to the issuer is to engage the banker only for its distribution effort under a best-efforts contract. To be able to compare a best-efforts contract with a delegation contract,  $a$  will be assumed to satisfy  $2a^2m-d^2b > 0$ , so that the distribution services will be demanded in both cases. The issuer in this case knows that for a linear payment function the banker will choose the response function  $e(\delta, \delta) = ta(\bar{\delta}-\delta)/b$ . Recognizing this, the issuer will choose the offer price  $p$  and the share  $t$  based on his own information about  $\delta$  represented by  $f(\delta)$ , since the issuer will have no way of learning  $\delta$  when effort is not observable. The reservation level  $\bar{N}(\delta)$  will be assumed to be such that the issuer prefers to sell the issue for all  $\delta$ . In order to ensure that the banker will handle the issue, however, the income  $R^*(\delta)$  of the banker, given by

$$R^*(\delta) = t\left(\frac{a^2(\bar{\delta}-\delta)^2t}{b} + dp(\bar{\delta}-\delta) + p^0d - \frac{1}{2}m(p-p^0)^2\right) + T - \frac{a^2(\bar{\delta}-\delta)^2t^2}{2b},$$

must be nonnegative. This implies that

$$T(p, t) = \frac{t}{2}m(p-p^0)^2 - tp^0d.$$

The expected net proceeds  $N^*$  to the issuer then are

$$\begin{aligned} N^* &= \int((1-t)\bar{x}-T)f(\delta)d\delta \\ &= (1-t)\left(\frac{a^2t\bar{\delta}^2}{3b} + \frac{d\bar{\delta}}{2}p + p^0d - \frac{1}{2}m(p-p^0)^2\right) - \frac{t}{2}m(p-p^0)^2 + tp^0d \\ &= (1-t)\left(\frac{a^2t\bar{\delta}^2}{3b} + \frac{d\bar{\delta}}{2}p\right) - \frac{1}{2}m(p-p^0)^2 + p^0d. \end{aligned} \quad (39)$$

Maximizing with respect to  $p$  yields the optimal offer

price  $p^*$  given by

$$p^* = p^0 + \frac{d\bar{\delta}(1-t)}{2m},$$

which is the expectation of the second-best price response function  $p(\delta)$  in (30). Substituting  $p^*$  into  $N^*$  and maximizing with respect to  $t$  yields

$$t^* = \begin{cases} \max\left\{0, \frac{1}{2} - \frac{3d^2b + 12dp^0bm/\bar{\delta}}{2(8a^2m - 3d^2b)}\right\} & \text{if } 8a^2m - 3d^2b > 0 \\ 0 & \text{otherwise,} \end{cases}$$

which is bounded above by  $1/2$ . Comparing  $t^*$  with  $t^+$  in (37) yields

$$t^+ - t^* = \frac{3d^2b}{2(8a^2m - 3d^2b)} \left[ 1 + \frac{3p^0mbd/\bar{\delta}}{2a^2m - d^2b} \right],$$

so the issuer gives the banker a smaller share of the proceeds in a best-efforts contract than in a delegation contract. The intuition behind this result is unclear, but it may simply be that the issuer uses the greater share in a delegation contract as a portion of the payment for the banker's information about  $\delta$ .

The delegation of the offer price decision allows the issuer to take advantage of the banker's information about  $\delta$ , and the expected proceeds  $E(\bar{x}(\delta))$  from a delegation contract using (32) are given by

$$E(\bar{x}(\delta)) = \frac{a^2t\bar{\delta}^2}{3b} + \frac{d^2\bar{\delta}^2}{6m}(1-t^2) + p^0d(1+\bar{\delta}/2).$$

The expected proceeds  $E(\bar{x}^*(\delta))$  from a best-efforts contract is

$$E(\bar{x}^*(\delta)) = \frac{a^2t\bar{\delta}^2}{3b} + \frac{d^2\bar{\delta}^2}{8m}(1-t^2) + p^0d(1+\bar{\delta}/2),$$

which is strictly less for all  $t < 1/2$  than for a delegation contract, since

$$E(\bar{x}(\delta)) - E(\bar{x}^*(\delta)) = \frac{d^2 \bar{\delta}^2 (1-t^2)}{24m} > 0 \text{ if } t < 1.$$

Consequently, the total proceeds to be shared among the issuer and the banker are greater in a delegation contract for all  $t < 1$ , and since the effort expended in the two cases is the same, the total proceeds available to the issuer and the banker are greater under price delegation. This does not imply, however, that the issuer is better off with price delegation, since the banker must be compensated for its information about  $\delta$  in a delegation contract.

To determine if the issuer prefers a best-efforts contract to a contract in which the offer price decision is delegated to the banker, subtract  $N^*$  in (39) from  $N^+$  in (36) to obtain

$$N^+ - N^* = \frac{d^2 \bar{\delta}^2}{24m} (1+t)^2 > 0.$$

The issuer thus strictly prefers a delegation contract to a best-efforts contract for all  $t$ , and hence, there is a positive demand for the advisement function of the banker.

To determine the effect of greater uncertainty on the part of the issuer on the value of a delegation contract relative to a best efforts contract, consider the example of Section III.B. The difference  $N_{\Delta}^+ - N_{\Delta}^*$  in the net proceeds of the issuer under the two contracts is

$$\begin{aligned} N_{\Delta}^+ - N_{\Delta}^* &= \frac{d^2}{24m} (\bar{\delta} + \Delta - (\underline{\delta} - \Delta))^2 (1-t)^2 \\ &\quad + \frac{d^2 t}{2m} (Z - \Delta) ((\bar{\delta} + \Delta - (\underline{\delta} - \Delta))(1-t) + (Z - \Delta)(2-t)), \end{aligned}$$

which is strictly increasing in  $\Delta$ . Greater uncertainty on the part of the issuer increases the advantage of a delegation contract over a best-efforts contract because the issuer benefits

from the responsive pricing of the banker over a wider range of values of  $\delta$ . Similarly, the value to the issuer of the distribution effort is increasing in  $\Delta$ , so greater uncertainty on the part of the issuer increases the value of the distribution function for both delegation and best-efforts contracts.

To determine the issuer's preference for a best-efforts contract versus a direct sale, note that a direct sale is a special case of a best-efforts contract for  $t=0$ . Consequently, if the issuer finds it optimal to share the proceeds with the banker, a best-efforts contract is preferred to a direct sale. Since the optimal share  $t^*$  is increasing in  $a$  and decreasing in  $b$ , the greater is the marginal return or the smaller is the marginal cost of effort, the stronger is the preference for a best-efforts contract over a direct sale.

#### IV. Conclusions

In this model an issuer's opportunity to benefit from the advisement and distribution functions performed by an investment banker results from private information about the capital market that the banker may use in setting the offer price and from the banker's ability, if any, to affect the demand for the issue through its distribution effort. The issuer's ability to benefit from the distribution services of the banker is limited, however, by the issuer's inability to observe the distribution effort expended by the banker. The issuer can benefit from the services of the banker in spite of this limitation by hiring the banker to distribute the issue under a best-efforts arrangement with the offer price determined by the issuer based on his limited information. The example presented in Section III indicates that there can be a positive demand for best-efforts contracts compared to a direct sale by the issuer even though the distribution effort cannot be observed. The demand results because the effect of the distribution effort on the net proceeds to the issuer is greater than the compensation that must be paid to the banker, and the value to the issuer of a best-efforts



contract compared to a direct sale is greater the more responsive is the banker's distribution effort to its private information.

The issuer may be able to improve on a best-efforts contract by delegating the offer price decision to the banker, since the banker will choose the offer price conditionally on its private information, and this response function results in a proceeds function that is convex in the information parameter. For the example, the expected net proceeds to the issuer are greater with a delegation contract than with a best-effort contract, so there is a demand for the advisement services of an investment banker.

These results establish a demand for investment banking services but are not specific enough to predict which issuers would prefer each of the three alternative sales arrangements considered here. If issuers could be identified in terms of the information they possess about the capital market, at least in the context of the example considered in Section III the less informed issuer would have a stronger preference for a delegation contract compared to the other two alternatives than would a more informed issuer. If issuers of unseasoned securities are less informed about the capital market than are issuers of seasoned securities, the former would have a greater demand for the advisement function of an investment banker. Furthermore, the issuers of unseasoned issues would be willing to accept a lower price the greater is their uncertainty about market demand.

The demand for investment banking services should also be a function of the securities themselves. For example, the effectiveness of the banker's distribution effort would be expected to be greater for an unseasoned issue than for a seasoned issue, and hence, the demand for the banker's distribution effort would be greater for the issuers of unseasoned issues than for the issuers of seasoned issues.

Footnotes

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1. Other alternatives such as a rights offering, a private placement, bank borrowing, and an action of the securities will not be considered here.

2. The analysis presented here takes as given the institutional practice of setting a fixed offer price and attempting to sell the issue at that price until the issue is fully-subscribed or until no further sales can be made at that price at which time stabilization is assumed to be terminated.

3. This type of contract differs from the conventional best-efforts contract under which the issuer bears all the risk involved with the sale and the banker received a lump-sum payment.

4. Investment banking practice involves "rebates" in the form of overtrading and soft-dollar designations, so the proceeds may nowhere be linear in  $p$  (see SEC(1979)).

5. The support of the distribution of  $x$  is assumed to be independent of  $e$  and  $\delta$ . If this is not the case it may be possible to impose penalties and improve the solution as indicated in Mirrlees(1974) and Holmstrom(1979).

6. The proceeds function is constant in  $e$  and  $\delta$  if the issue is oversubscribed at a fixed offer price, since a greater sales effort or a more favorable market valuation will not increase the

proceeds. If however the offering involves give-ups, soft-dollar designation, or swaps, the proceeds need not be linearly related to  $e$ .

7. The function  $\bar{N}(\delta)$  is assumed to be exogenously determined and not be used strategically by the issuer to influence the banker.

8. The program in (6)-(10) is a game with perfect information in which the issuer moves first in choosing his strategy ( $p(\cdot)$ ,  $S(\cdot)$ ,  $\pi(\cdot)$ ) and the banker moves second in choosing response functions  $\hat{\delta}(\delta)$  and  $e(\hat{\delta}, \delta)$ . While the issuer does not know  $\delta$  when he chooses his strategy, he does know perfectly the response functions the banker will choose as a result of his strategy.

9. The constraints in (7) correspond to weak incentive compatibility. For the example in Section III the optimal policy will be shown to have the property of strong incentive compatibility.

10. In the second-best solution  $\pi(\delta)$  will equal zero or one and at points of discontinuity the derivative does not exist. When  $\pi(\delta)=0$ ,  $R$  is zero under an incentive-compatible policy, and hence the functions  $p(\delta)$ ,  $e(\delta, \delta)$ , and  $S(\delta, x)$  are irrelevant.

11. If  $R$  is not a nonincreasing function of  $\delta$ , the banker may have an incentive to report its information untruthfully. Baron and Myerson (1979) and Maskin and Riley (1980) provide methods for guaranteeing that  $R$  is a nonincreasing function.

12. Maximization with respect to  $e(\delta, \delta)$  yields the adjoint equation that gives the multiplier  $\mu(\delta)$ .

13. If  $t(x)$  is not a nondecreasing function, the individual rationality constraint in (10) must be directly incorporated into the optimization. Restricting  $t(x)$  to be nondecreasing seems to be plausible in light of investment banking practice.

14. This assumption is not meant to imply that a separable and linear compensation function is optimal.

15. If the number  $n$  of securities to be sold is to be determined endogenously, that decision can be delegated to the banker by the issuer choosing a function  $n(\delta)$  that enters the proceeds function  $x(p, e, \theta, n)$  and the reservation level  $\bar{N}(\delta, n)$ . An expression analogous to (18) is then added to the conditions characterizing the solution.

16. The preferences of the banker for  $p$  and  $s$  in this example are independent of effort because of the separability of the expected proceeds function  $\bar{x}$ ,

17. Substituting  $p(\delta)$  from (30) indicates that the indifference curve is negatively sloped. The curvature (as measured by the second derivative) of the indifference curve is greater than the curvature of the contract function, as illustrated in Figure 2.

18. This results because there is no cost to the banker of making a false signal or report.

19. The optimal contract with  $t^+$  given in (37) is superior to a firm commitment contract ( $t=1$ ) by the amount represented by the last term in (38).

References

- Baron, D. P., "The Incentive Problem and the Design of Investment Banking Contracts," Journal of Banking and Finance, 3 (1979), 157-175.
- Baron, D. P. and Holmstrom, B., "The Investment Banking Contract For New Issues Under Asymmetric Information: Delegation and the Incentive Problem," Journal of Finance forthcoming(1980).
- Baron, D. P. and Myerson, R. B., "Regulating a Monopolist with Unknown Costs," Working paper No. 412, Center for Mathematical Studies in Economics and Management Science, Northwestern University, December 1979.
- Dasgupta, P. S., Hammond, P. J., and Maskin, E. S., "Implementation of Social Choice Rules: Some Results on Incentive Compatibility," Review of Economic Studies 46 (1979), 185-216.
- Gibbard, A. "Manipulation of Voting Schemes" A General Result," Econometrica, 41 (1973), 587-602.
- Green, J. and Laffont, J. J. "Characterization of Satisfactory Mechanisms for the Revelation of Preferences for Public Goods," Econometrica, 45, 427-438.
- Harris, M. and Raviv, A. "Some Results on Incentive Contracts with Applications to Education and Employment, Health Insurance, and Law Enforcement," American Economic Review, 68 (March, 1978), 20-30.
- Harris, M. and Townsend, R. M. "Resources Allocation with Asymmetric Information," Working Paper #43-77-78, Graduate School of Industrial Administration, Carnegie-Mellon University, July 1979.

- Holmstrom, B. "Moral Hazard and Observability," Bell Journal of Economics, 10(Spring 1979), 74-91.
- Ibbotson, R. G. "Price Performance of Common Stock New Issues," Journal of Financial Economics, 2 (September 1975), 235-272.
- Mandelker, G. and Raviv, A. "Investment Banking: An Economic Analysis of Optimal Underwriting Contracts," Journal of Finance, 32 (June 1977), 683-694.
- Maskin, E. and Riley, J. "Auctioning an Indivisible Object," "Discussion Paper 87D, Kennedy School of Government, Harvard University, Cambridge, Mass., April 1980.
- Mirrlees, J. "Notes on Welfare Economics, Information, and Uncertainty," in Balch, McFadden, and Wu, eds., Essays on Economic Behavior Under Uncertainty, Amsterdam: North Holland, 1974.
- Myerson, R.B. (1979) "Incentive Compatibility and the Bargaining Problem," Econometrica, 47, (January 1979), 61-74.
- Myerson, R. B. (1980) "Optimal Auction Design," Mathematics of Operations Research (forthcoming).
- Securities and Exchange Commission. "Practices in Fixed Price Offerings; Request for Comments and Announcement of Public Hearings," Federal Register Vol. 44, No.95, May 15, 1979, pp. 28574-28586.