# The Private Placement of Debt and Outside Equity as an Information Revelation Mechanism

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We view debt and outside equity as serving to elicit credible information from different specialists about the value of an enterprise in its various uses. The equity valuation specialist provides a price forecast for equity that reveals information about the value of the enterprise in its primary use. The debt valuation specialist provides a price forecast for debt that reveals information about the value of the enterprise in its alternative use. The prices forecast by the valuation specialists credibly reveal their private information because they are required to buy the associated claims at the forecast prices, thereby bonding their valuations.

The four decades following the seminal work of Modigliani and Miller (1958) have witnessed various explanations for corporate debt [see Harris and Raviv (1991)]. In recent years, finance scholars have sought to explain outside equity, where an entrepreneur shares ownership with investors who, as with lenders, may have little or no ongoing control over the firm's internal operations. In this article we develop a theory of the private placement of debt and outside equity based on the gains from specialized valuation and the credible revelation of the associated information.

We view an entrepreneur as someone who has incomplete information about a unique investment opportunity that requires him to act as a central contracting party in promoting a business enterprise [Alchian and Demsetz (1972)]. The entrepreneur's contracting problem is to solicit information lying

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outside of his area of expertise from parties who we characterize as the *equity* and *debt valuation specialists*. These specialists must make informational investments in valuing the enterprise in its primary (intended) and alternative use, respectively. The equity valuation specialist provides a price forecast for the firm's equity, while the debt valuation specialist provides a price forecast for the firm's debt. By requiring the valuation specialists to buy the associated claims at the forecast prices—to put their "money where their mouth is"—the entrepreneur makes them residual claimants to the accuracy of their forecasts. Their forecasts are therefore as accurate as efficient resource allocation allows, subject to the constraints imposed by asymmetric information. In our view, external corporate finance is a manifestation of Ronald Coase's (1937, p. 390) early insight that prices are costly to form and that specialists will therefore arise to perform the pricing function.

Outside equity and debt allow the entrepreneur to overcome the moral hazard problem that accompanies specialized valuation where the parties' informational investments are otherwise noncontractible. In the absence of these financial contracts, the entrepreneur would be unable to verify the informational investments or the accuracy of the resulting forecasts. He would find it necessary to gather the information himself or to do without it altogether, forgoing the gains from specialization. By overcoming the moral hazard problem, debt and outside equity allow the entrepreneur to focus on his own specialty and yet to make well-informed internal resource allocation and investment decisions. These benefits accrue even where the entrepreneur is risk neutral and faces no wealth constraint.

In most settings, entrepreneurs have unique knowledge about their firms' internal operations, such as those regarding product innovation or efficient trade-offs in the production process. But they often lack information about important external factors such as product demand. Where such demand-side information is a complement to the entrepreneur's supply-side information, he may be able to increase the value of the enterprise by contracting with those who have specialized skill in forecasting product demand. The entrepreneur could solicit expressions of interest from potential customers, who no doubt possess the relevant information but who have much to gain and little to lose by exaggerating their demand for the product and inducing the entry of a new supplier. Similarly a market research firm may have insufficient incentive to acquire the information to forecast product demand if doing so is costly and the entrepreneur is unable to verify the accuracy of the firm's forecast. As a general matter, we recognize that product supply or other real contracts may provide the entrepreneur with the necessary demand-side information, but assume for the purposes of this article that the cost of entering into such contracts is prohibitive.

Our solution is for the entrepreneur to offer an equity share to a party who has specialized skill at forecasting product demand. The price the equity valuation specialist pays credibly reveals the value of the enterprise in its primary (or intended) use and bonds both the optimality of the specialist's informational investment and the accuracy of the resulting forecast. In this way the entrepreneur avoids the investment distortion problem that would arise if he sought the information from other sources or through alternative contractual forms.

The economic organization of certain commercial real estate transactions illustrates this solution to the information problem entrepreneurs face.[1] Local commercial real estate developers have the expertise to finesse local zoning and building regulations and to contract with architects and general contractors, but they often lack knowledge about the local, regional, or national demand for office space. Among other things, real estate investment trusts (REITs) specialize in gathering this information. A local real estate developer and a REIT may therefore enter into a joint venture as equity partners in an office building project to ensure that the REIT provides a credible forecast of local office demand. The price the REIT pays for its equity share reflects its specialized expertise in estimating office demand and in valuing and operating office buildings. The REIT becomes a residual claimant to the accuracy of the forecast imbedded in its equity claim, which ensures that it makes the optimal investment in accurate valuation.

There is always some chance that an enterprise will fail altogether in its primary use and that it can profitably be redeployed to an alternative use. In that event, the equity partner's forecast of the demand for the good provided by the firm's primary use will turn out to be worthless, as will any specific investment the entrepreneur makes in reliance on the forecast [Habib and Johnsen (1999)]. This information is specific to the primary use, which will be the highest valued use of the enterprise only so long as a good state prevails. By definition, the bad states will reflect those situations in which the enterprise is better redeployed to what was initially expected to be the alternative use, but which ultimately superseded the primary use. Ex ante the entrepreneur can benefit from accurate information about the likelihood of the bad states and, indeed, about the critical enterprise value that separates the good and bad states and dictates the circumstances under which redeployment should occur.

The entrepreneur can get this information by contracting with a valuation specialist who has knowledge about the alternative use of the enterprise. Debt whose face value approximates the critical enterprise value and gives the

[1] Our solution is also a fair representation of the venture capital market in high technology industries and is largely consistent with recent work on venture capital financing by Black and Gilson (1998). Entrepreneurs with technical expertise routinely develop promising hardware and software products but in many cases lack the ability to appraise these products' commercial prospects (see, e.g., *Wall Street Journal*, "Selling a 'Killer App' is Far Tougher Job than Dreaming it Up," April 3, 1998, B1). Entrepreneurs therefore contract with venture capitalists who have the requisite expertise. The price a venture capitalist pays for its equity share reflects the efficient performance of its specialized expertise in appraising the commercial prospects of a new product and bonds the accuracy of the forecast imbedded in the claim. Being a residual claimant to the accuracy of the forecast, the venture capitalist makes the optimal investment in accurate valuation.

lender a priority claim to the enterprise in the event of default will induce him to invest optimally in gathering information about the redeployment value. This is because default, which will occur only when the value of the enterprise in its primary use falls below its redeployment value, will leave the lender to bear any deficiency between the face value of the loan and the net value of the enterprise if redeployed to its next best use [Habib and Johnsen (1999)]. The information provided by the debt valuation specialist is essential to tell the entrepreneur exactly how much he (along with the other equity owners) must vest specifically in the primary use of the enterprise. This information is a complement to the information provided by the equity valuation specialist (although it relates to substitute uses of the enterprise), and it allows the entrepreneur to increase the expected value of the enterprise by making the optimal ex ante investment.

The example of the office building helps illustrate this point. During the late 1980s to mid-1990s, worldwide downtown office occupancies declined. This trend was accompanied by a concurrent increase in the demand for downtown hotel rooms in selected markets and led to the conversion of many "failed" office building into hotels.[2] To the extent that a local real estate developer and his REIT partner recognize that such events are likely to occur, they will surely want their informational investments to be specific to the good states, that is, those in which the building will be maintained in its primary use as office space. Any information that pertains to the value of the building as office space in the bad states will be worthless precisely because in the bad states the building is best converted into a hotel. But knowledge of the good states requires identification of the bad states, which requires accurate information about the value of the building as a hotel.

Where the enterprise has a sufficiently distinct alternative use, debt provides credible information about the value of the enterprise in this next-best alternative use. It represents a claim against the enterprise specifically in that use following default, where default results from the failure of the primary use due to the occurrence of the bad state. This is surely true of secured debt, which gives the lender a property interest in the collateral on liquidation, but we believe it is also true of unsecured debt, which gives the lender contractual priority to the reorganization value of the enterprise as a going concern. Corporate debt therefore gives its holder the incentive to make the optimal investment in valuing the alternative use of the enterprise, whether in liquidation or in reorganization.

Starting with the seminal work of Ross (1977) on debt and Leland and Pyle (1977) on equity, a number of scholars have examined the use of debt and equity to communicate supply-side information from an entrepreneur (or the firm) to investors, or to induce investors to acquire information about an

[2] *Wall Street Journal*, "Old Offices Get New Lease on Life as Hotels," August 21, 1996, B1.

entrepreneur.[3] Other scholars have examined, as we do, the role of equity in communicating demand-side information from investors to an entrepreneur. Benveniste and Spindt (1989) and Benveniste and Wilhelm (1990) examine the provision of information by institutional investors in the initial public offering (IPO) book-building process. They do not discuss the use of the information obtained during the book-building process to guide the issuing firm's investment decisions. Black and Gilson (1998) note the provision of information from venture capitalists to entrepreneurs in start-up financing, and Jegadeesh, Weinstein, and Welch (1993) examine the role of post-IPO returns in providing market feedback about errors in IPO pricing. Neither article formally models the provision of information. Fishman and Hagerty (1992), Boot and Thakor (1993), Leland (1993), Dow and Rahi (1996), Dow and Gorton (1997), Habib, Johnsen, and Naik (1997), Allen and Gale (1999), Chang and Yu (1999), and Subrahmanyam and Titman (1999) examine how the information communicated by outside investors can be used to guide a firm's investment decision. These authors assume that a signal about an investment project contemplated by the firm is observed by outside investors, and examine how the quality of the signal and its communication are affected by insider trading regulations, the reliance on privately held or publicly traded equity, the design of the securities issued by the firm, and spin-offs and demergers. All these authors assume knowledge by the firm of the distribution of the returns on the investment project to which the signal pertains. Like these authors, we assume that outside investors observe a signal and communicate it to the firm. Unlike these authors, we assume that the firm does not know the mean of the distribution of the returns on the investment project. It must acquire knowledge of this mean. It does so by selling securities to outside investors, thereby inducing them to reveal their knowledge of the expected return through the size of the stake they acquire and the price they pay for it. This suggests that even firms that have issued a complete set of securities may sometimes find it optimal to issue additional securities to acquire knowledge of the expected return on new projects whose expected return may have changed over because of changed circumstances.[4] The association between the offering of securities and the need for new information about the distribution of returns may explain why such offerings are relatively infrequent.

Our analysis is closest to Maug (1996), Biais and Gollier (1997), and Garmaise (1997). Biais and Gollier (1997) examine a supplier's use of trade credit to provide information about his customers to banks. Garmaise (1997)

[3] See, for example, Harris and Raviv (1990), Chemmanur and Fulghieri (1999), and Stoughton, Wong, and Zechner (1997).

[4] It is possible that the firm can piece together such information by carefully observing how its stock price reacts through time to various incremental announcements, but this is likely to provide a murky signal. Furthermore, it does not allow the firm to alter the stake held by outside investors. It therefore denies the firm the ability to determine the investment in valuation they make.

derives debt and outside equity as optimal revelation mechanisms that allow a wealth-constrained entrepreneur to exploit his differences of opinion with investors regarding project profitability. By contrast, in our formulation, debt and outside equity provide even wealthy, risk-neutral entrepreneurs with credible information critical to their investment decisions. Maug (1996) examines how the information revealed in book building can be used to guide a firm's investment decisions. Maug's (1996) focus is on the determinants of IPO discounts, whereas ours is on the choice between inside and outside equity, and between debt and equity.

Fluck (1998) has recently proposed a theory of outside equity that extends Jensen's (1986) work on free cash flows, and related work by Bolton and Scharfstein (1996) and Hart and Moore (1995) on strategic default, from debt to outside equity. [See also Myers (1984), Myers and Majluf (1984), Aghion and Bolton (1992), Dewatripont and Tirole (1994), Burkart, Gromb, and Panunzi (1996), Biais and Casamatta (1998), Myers (1998), Chemla and Faure-Grimaud (1998), and Mahrt-Smith (1999).] We follow Fluck (1998) in examining the coexistence of debt and outside equity, but depart from her analysis by dispensing with the assumption of symmetric information between entrepreneurs or managers and investors and by assuming that cash flows are verifiable. This is because our concern is with the problem of costly information rather than the agency costs of outside equity. By encouraging specialized valuation, debt and outside equity reduce information costs.

The article proceeds as follows. Section 1 examines information revelation by an equity valuation specialist and derives comparative statics results regarding the choice between inside and outside equity. For the sake of tractability, we model only the demand-side problem of information revelation, treating the entrepreneur's supply-side information as common knowledge. In Section 2 we examine the revelation of information by a debt valuation specialist and derive comparative statics results regarding the choice between debt and equity. In Section 3 we combine the revelation of information by the equity valuation specialist and the debt valuation specialist. In Section 4 we discuss possible extensions of the model and discuss several empirical conjectures. We summarize and conclude in Section 5.

## 1. Information Revelation Through Outside Equity: The Primary Use of the Enterprise

Consider an entrepreneur who contemplates investing in a business enterprise. The entrepreneur has specialized skill in designing the firm's internal production process. This presents him with a unique investment opportunity that requires him to choose the scale, $q$, of the enterprise on realization of the state of the world $\theta$, $\theta \sim U(0, 1)$, where the enterprise has value $q\sqrt{s(\theta)}\tilde{r}_s$ and costs are given by $c(q) \equiv \frac{1}{2}cq^2$. In this formulation, $s(\cdot)$ reflects how the value of the enterprise varies with the state of the world, $\theta$, in which it is increasing. The random variable $\tilde{r}_s \sim N\left(\bar{r}_s, \frac{1}{h_s}\right)$ represents the revenue per unit of scale for a given state of the world.

In choosing the scale of the enterprise, the entrepreneur can benefit from information $\tilde{i}_s(\iota_s)$ about $\tilde{r}_s$, where $\tilde{i}_s(\iota_s) = \tilde{r}_s + \tilde{\varepsilon}_s(\iota_s)$ and $\tilde{\varepsilon}_s(\iota_s) \sim N\left(0, \frac{1}{\iota_s}\right)$. This information is valuable even to a risk-neutral entrepreneur who forms an unbiased expectation of $\tilde{r}_s$ because it allows him to choose a more appropriate scale. The value of the information is determined by the investment, $\iota_s$, the entrepreneur makes in evaluating the revenue from the enterprise prior to the realization of the state, for $\iota_s$ constitutes the precision of the noise term $\tilde{\varepsilon}_s(\iota_s)$.

On realization of the state, the entrepreneur has information $i_s(\iota_s)$ from having invested $\iota_s$ in valuing the enterprise. He solves the problem

$$\max_q q\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)] - \frac{1}{2}cq^2.$$

This requires him to choose $q$ such that

$$q = \frac{\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)]}{c}.$$

The enterprise therefore has net value equal to

$$\widetilde{V}_s(\iota_s) = \left(\frac{\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)]}{c}\right)\sqrt{s(\theta)}\tilde{r}_s - \frac{1}{2}c\left(\frac{\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)]}{c}\right)^2,$$

which has expectation conditional on receiving the information $i_s(\iota_s)$ equal to

$$\begin{aligned} E[\widetilde{V}_s(\iota_s) \mid i_s(\iota_s)] &= \left(\frac{\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)]}{c}\right)\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)] \\ &\quad - \frac{1}{2}c\left(\frac{\sqrt{s(\theta)}E[\tilde{r}_s \mid i_s(\iota_s)]}{c}\right)^2 \\ &= \frac{s(\theta)E[\tilde{r}_s \mid i_s(\iota_s)]^2}{2c} \end{aligned}$$

and unconditional expectation

$$\begin{aligned} E[\widetilde{V}_s(\iota_s)] &= \frac{s(\theta)}{2c}E[E[\tilde{r}_s \mid \tilde{i}_s(\iota_s)]^2] \\ &\equiv \frac{s(\theta)}{2c}\left(\sigma + \nu_s(\iota_s)\right), \end{aligned}$$

where $\sigma \equiv \bar{r}_s^2$ and

$$\nu_s(\iota_s) \equiv \frac{1}{h_s}\frac{\iota_s}{h_s + \iota_s}. \tag{1}$$

In this formulation, $\sigma$ indexes the intrinsic profitability of the enterprise, whereas $\nu_s(\iota_s)$ captures the increase in profitability made possible by the entrepreneur's relatively accurate estimate of $r_s$ and the more appropriate choice of scale it allows him to make. The function $\nu_s(\iota_s)$ is increasing and concave in $\iota_s$. Assuming, without loss of generality, an interest rate of zero and $c \equiv \frac{1}{2}$, the investment made by the entrepreneur in valuing the enterprise prior to the realization of the state of the world is the solution to

$$\max_{\iota_s} \int_0^1 s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta - \iota_s.$$

This represents the first-best solution, in which the entrepreneur makes the socially optimal investment in valuing the enterprise.

Suppose, however, that the entrepreneur faces a trade-off between his ability to specialize in innovating the firm's internal production processes and his ability to gather information to forecast the value of the enterprise. If he chooses to specialize, he will lack the expertise necessary to value the enterprise and will know only the distribution $H_s(\cdot)$ and the density $h_s(\cdot)$ of $\sigma$ over the range $[\underline{\sigma}, \overline{\sigma}]$.[5] His choice of scale will therefore be uninformed and his expected profits will be less than those reflected in the first-best solution. The question we address is whether and under what circumstances the entrepreneur can increase his expected profits by obtaining a credible forecast of the value of the enterprise from a party who specializes in estimating product demand. We call this party the equity valuation specialist (EVS), and examine how the purchase of an equity stake by the EVS induces him to reveal truthfully the index of profitability, $\sigma$, and to make the investment in valuation, $\iota_s$.

In our formulation, the EVS can be seen as the winner of a private-value auction in which his bid constitutes mutually binding acceptance of the entrepreneur's offer of a range of equity stakes at various prices. The EVS's bid, reflected in his willingness to buy a given stake at its associated price, credibly reveals $\sigma$ but not $i_s(\iota_s)$, which takes time for him to identify. Once having become a stakeholder, the EVS makes his valuation investment, $\iota_s$. The state of the world then unfolds, the EVS observes the information, $i_s(\iota_s)$, and he reveals it truthfully to the entrepreneur.[6] The parties then choose the optimal scale of the enterprise.

Our reliance on equity finance requires further comment. We assume, rather than derive, the optimality of equity as a financial contract. We believe this assumption can be justified by noting that equity constitutes a *linear* claim on the *net* value of the enterprise in *all* states of the world. Nonlinear contracts can be approximated through their linear counterparts [Laffont and Tirole (1993)]. Outside equity's claim on the net value of the enterprise,

[5] We assume $H_s(\cdot)$ has an increasing hazard rate.

[6] Note that an informed party who has revealed $\sigma$ truthfully and made the investments $\iota_s$ will naturally communicate the information $i_s(\iota_s)$ to the entrepreneur, for once $\iota_s$ is sunk the entrepreneur and the informed party share the same interest in choosing the optimal scale of the enterprise.

rather than on its gross value, follows naturally from our interest in financial contracts rather than real product or factor market contracts. Finally, the requirement that the EVS evaluates the enterprise and reveals the information, $i_s(\iota_s)$, truthfully in all states requires that his claim be one that applies to all states (see note 6).

Let the entrepreneur retain a fraction, $\alpha(\sigma)$, of the equity of the firm and sell the remaining fraction, $1-\alpha(\sigma)$, to the EVS at price $P_s(\sigma)$ when the EVS has declared an index of profitability $\sigma$. The combination of the fraction of the equity sold, $1-\alpha(\sigma)$, and the price at which it is sold, $P_s(\sigma)$, define two instruments that the entrepreneur can use to induce the EVS to reveal $\sigma$ truthfully and to make the investment $\iota_s$ in valuing the enterprise.

The entrepreneur solves the problem

$$\max_{0\leq\alpha(\cdot)\leq 1,\, P_s(\cdot)} \int_{\underline{\sigma}}^{\overline{\sigma}} \left[\alpha(\sigma)\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta + P_s(\sigma)\right] h_s(\sigma)d\sigma \tag{2}$$

subject to

$$\sigma = \arg\max_{\tilde{\sigma}}(1-\alpha(\tilde{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - P_s(\tilde{\sigma}) - \iota_s \quad \forall\sigma \tag{3}$$

$$\iota_s = \arg\max_{\tilde{\iota}_s}(1-\alpha(\sigma))\int_0^1 s(\theta)\big(\sigma+\nu_s(\tilde{\iota}_s)\big)d\theta - P_s(\sigma) - \tilde{\iota}_s \tag{4}$$

and

$$(1-\alpha(\sigma))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - P_s(\sigma) - \iota_s \geq 0 \quad \forall\sigma. \tag{5}$$

Equations (3) and (4) constitute the EVS's incentive compatibility constraints. They are designed to ensure his truthful revelation of $\sigma$ and to reflect his choice of $\iota_s$. Equation (5) constitutes the EVS's individual rationality constraint.

The EVS must receive an informational rent when $\sigma > \underline{\sigma}$. Such a rent is necessary to induce the EVS to reveal $\sigma$ truthfully, for he can guarantee himself a positive payoff by claiming that $\sigma$ is only $\underline{\sigma}$. To see this, note that

$$\begin{aligned}
&(1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s(\underline{\sigma},\sigma))\big)d\theta - P_s(\underline{\sigma}) - \iota_s(\sigma,\underline{\sigma})\\
&\quad= (1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s(\underline{\sigma}))\big)d\theta - P_s(\underline{\sigma}) - \iota_s(\underline{\sigma})\\
&\quad\geq (1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s(\underline{\sigma}))\big)d\theta - \iota_s(\underline{\sigma})\\
&\qquad - (1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)\big(\underline{\sigma}+\nu_s(\iota_s(\underline{\sigma}))\big)d\theta - \iota_s(\underline{\sigma})\\
&\quad= (1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)(\sigma-\underline{\sigma})d\theta > 0,
\end{aligned}$$

where

$$\iota_s(\underline{\sigma}, \sigma) = \arg\max_{\tilde{\iota}_s}(1-\alpha(\underline{\sigma}))\int_0^1 s(\theta)\big(\sigma + \nu_s(\tilde{\iota}_s)\big)d\theta - P_s(\underline{\sigma}) - \tilde{\iota}_s$$

and

$$\iota_s(\underline{\sigma}) \equiv \iota_s(\underline{\sigma}, \underline{\sigma}).$$

Here $\iota_s(\underline{\sigma}, \sigma)$ denotes the investment made by the EVS, who knows the index of profitability of the project equals $\sigma$ and yet claims it equals $\underline{\sigma}$. Accordingly the entrepreneur requires him to buy a fraction $1-\alpha(\underline{\sigma})$ of the equity of the firm at a price $P(\underline{\sigma})$. The first equality is true by noting that $\iota_s(\underline{\sigma}, \sigma) = \iota_s(\underline{\sigma})$, the first inequality by Equation (5) applied to $\underline{\sigma}$, and the second inequality by the assumption that $\sigma > \underline{\sigma}$.

Lemma 1 derives the exact amount of the informational rent and determines the price the EVS must pay for his equity stake in the enterprise.

***Lemma 1.*** *The informational rent that must be offered the EVS equals*

$$U_s(\sigma) = \int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du. \tag{6}$$

*The price paid by the EVS for his stake in the firm is*

$$P_s(\sigma) = (1-\alpha(\sigma))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - \iota_s - \int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du. \tag{7}$$

*Proof.* See the appendix.

The price the EVS pays for his stake in the enterprise equals his expected payoff from share ownership, minus his investment in valuing the enterprise, minus the informational rent necessary to induce him to reveal his information truthfully. We show that this arrangement induces the EVS to reveal his information truthfully in the proof of Lemma 2.

***Lemma 2.*** *The EVS reveals his information truthfully when asked to pay the price $P_s(\sigma)$ for a stake $1-\alpha(\sigma)$ in the enterprise when declaring an index of profitability of $\sigma$.*

*Proof.* See the appendix.

Substituting Equation (7) into the entrepreneur's payoff, the latter can be shown to become

$$\int_{\underline{\sigma}}^{\overline{\sigma}}\Bigg[\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - \iota_s - (1-\alpha(\sigma))\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta\Bigg]h_s(\sigma)d\sigma \tag{8}$$

(see the appendix).

Differentiating Equation (8) with respect to $\alpha(\sigma)$, we have

$$\begin{aligned}
&\int_0^1 s(\theta)\nu_s'(\iota_s)\frac{\partial \iota_s}{\partial \alpha(\sigma)}d\theta - \frac{\partial \iota_s}{\partial \alpha(\sigma)} \\
&\quad + \left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta + \lambda(\sigma) - \mu(\sigma) = 0 \\
&\Leftrightarrow \left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta + \left[\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta - 1\right] \\
&\quad \times \frac{\partial \iota_s}{\partial \alpha(\sigma)} + \lambda(\sigma) - \mu(\sigma) = 0 \\
&\Leftrightarrow \left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta + \alpha(\sigma)\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta \\
&\quad \times \frac{\partial \iota_s}{\partial \alpha(\sigma)} + \lambda(\sigma) - \mu(\sigma) = 0, \qquad (9)
\end{aligned}$$

where $\lambda(\sigma)$ and $\mu(\sigma)$ denote the Lagrange multipliers associated with the constraints $\alpha(\sigma) \geq 0$ and $\alpha(\sigma) \leq 1$, respectively. The second equivalence is obtained by using Equation (10) below.

To interpret Equation (9), we must determine $\frac{\partial \iota_s}{\partial \alpha(\sigma)}$ by applying the implicit function theorem to the EVS's first-order condition for $\iota_s$. Specifically

$$(1-\alpha(\sigma))\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta - 1 = 0 \qquad (10)$$

allows us to obtain

$$\frac{\partial \iota_s}{\partial \alpha(\sigma)} = \frac{\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta}{(1-\alpha(\sigma))\int_0^1 s(\theta)\nu_s''(\iota_s)d\theta} = \frac{\nu_s'(\iota_s)}{(1-\alpha(\sigma))\nu_s''(\iota_s)} < 0 \qquad (11)$$

as $\nu_s(\cdot)$ is increasing and concave. Not surprisingly, the investment made by the EVS in valuing the enterprise is increasing in his stake in the firm.

Turning to Equation (9), note that $\alpha(\sigma) < 1$ for $\sigma \in [\underline{\sigma}, \overline{\sigma}]$. Otherwise $\mu(\sigma)$ would be negative, as is apparent by substituting $\alpha(\sigma) = 1$ into Equations (9) and (11). Note also that $\alpha(\overline{\sigma}) = 0$, in which case $\lambda(\overline{\sigma}) = \mu(\overline{\sigma}) = 0$. Finally, and perhaps of most interest, $0 < \alpha(\sigma) < 1$ for $\sigma \in [\underline{\sigma}, \overline{\sigma})$. The entrepreneur's first-order condition can be interpreted as follows: he would like to minimize the fraction of the firm that he sells to the EVS, for the rent he must grant the EVS is proportional to the fraction of the firm, $1-\alpha(\sigma)$, the EVS acquires. The entrepreneur would therefore like to maximize the fraction of the firm, $\alpha(\sigma)$, that he keeps. Because $\frac{\partial \iota_s}{\partial \alpha(\sigma)} < 0$, however, the entrepreneur will be precluded from doing so by his desire to induce the EVS to accurately value the firm. Indeed, when $\sigma = \overline{\sigma}$, Equation (9) suggests that the entrepreneur will sell the entire firm to the EVS, who will then make the first-best level of investment in valuation. This will not be the case when $\sigma \in [\underline{\sigma}, \overline{\sigma})$ and $0 < \alpha(\sigma) < 1$. As is common in models of mechanism design, a distortion away from first-best arises due to the asymmetry of information between the two parties and the uninformed party's desire to minimize the informational rent that must be granted the informed party [see, e.g., Laffont and Tirole (1993)].

We can now establish the main comparative statics result of this section, which states that the fraction of the firm sold to the EVS should increase in the index of profitability he reveals. This is because the EVS's informational rent must be larger the higher the index of profitability and this rent is tied to the size of his stake in the firm. The price the EVS pays for his shares and the investment he makes in valuation are correspondingly higher.

***Proposition 1.*** *The entrepreneur's stake in the firm, $\alpha(\cdot)$, is decreasing in the index of profitability, $\sigma$, revealed by the EVS, and the EVS's stake, $1-\alpha(\cdot)$, is therefore increasing in $\sigma$. So are the price, $P_s(\cdot)$, at which the entrepreneur sells this outside stake, and the investment in valuation, $\iota_s$, made by the EVS.*

*Proof.* See the appendix.

We have argued in this section that an entrepreneur can offer to issue outside equity to an EVS to induce the EVS to accurately value the enterprise and to reveal truthfully the information he obtains. By taking an equity stake in the enterprise, the EVS bonds the accuracy of his valuation. Note that our formulation differs from the classical principal-agent problem by the presence of asymmetric information. This explains why the entrepreneur sells only a fraction of the enterprise to the EVS, in spite of the EVS's risk neutrality.[7] Although selling the entire enterprise to the EVS would be efficient, the entrepreneur would not maximize his payoff because of the excessive informational rent the EVS would require.

We can use the results from Proposition 1 to compare the implications of our model to those in which the entrepreneur is relatively well informed and communicates information to outside investors. In Leland and Pyle (1977), for example, the information asymmetry arises from the outside investors' inability to verify the firm's relatively high value (which is known to the entrepreneur) from among a class of otherwise identical firms. The solution they propose is for the entrepreneur to take a larger equity stake in his firm than he otherwise would take. The entrepreneur's actions "speak louder than words" and signal to outside investors the firm's true value. Contrary to Proposition 1, this leads Leland and Pyle to predict that the fraction of equity sold to outside investors will be negatively related to firm value. Work by Hertzel and Smith (1993) regarding abnormal returns to private equity placements is inconsistent with Leland and Pyle's prediction, however. Hertzel and

[7] That the EVS is risk neutral is immediately apparent from his payoff function [see Equation (5)]. Double-sided moral hazard, as in Bhattacharyya and Lafontaine (1995), would also require that ownership be shared by the entrepreneur and the EVS.

Smith report that observed announcement-day abnormal returns increase in the fraction of equity sold and reflect favorable information about firm value, which is consistent with the results of Proposition 1. We leave open the possibility that Leland and Pyle's analysis applies well in specific circumstances or that both types of information revelation sometimes occur simultaneously.

Our model predicts that private placements of equity should be made at a discount to provide outside investors with the informational rent necessary to induce them to reveal truthfully their private information. This is consistent with Hertzel and Smith (1993), who find that private placements of equity carry a discount and that the size of the discount is positively related to proxies for information asymmetry, such as book-to-market equity.[8] Of course, the existence of a private placement discount does not necessarily imply that outside equity communicates information from investors to entrepreneurs. It may simply reflect compensation due investors for incurring the costs of acquiring information about the firm that the entrepreneur is unable to convey.[9] It may also reflect a "lemons" discount [Akerlof (1970)].

## 2. Information Revelation Through Debt: The Alternative Use of the Enterprise

We now turn to the communication of information through debt. At the outset we assume that the entrepreneur knows the index of profitability of the primary use of the enterprise, $\sigma$, and can make the investment, $\iota_s$, in valuing that use. He therefore does not need to issue outside equity. We make this assumption in order to focus attention on the revelation of information through debt. In Section 3 we examine the interaction between debt and outside equity. We also assume that the enterprise can be redeployed to an alternative use that is distinctly different from the primary use, and that the costs of redeployment are zero. In this formulation, the value of the enterprise in the alternative use is $g(\theta)\big(\gamma + \nu_g(\iota_g)\big)$, where $g(\cdot)$, $\gamma$, $\nu_g(\cdot)$, and $\iota_g$ are defined similarly to $s(\cdot)$, $\sigma$, $\nu_s(\cdot)$, and $\iota_s$.

We make the following additional assumptions:

$$s(0)\big(\sigma + \nu_s(\iota_s)\big) < g(0)\big(\gamma + \nu_g(\iota_g)\big) \tag{12}$$

$$s(1)\big(\sigma + \nu_s(\iota_s)\big) < g(1)\big(\gamma + \nu_g(\iota_g)\big) \tag{13}$$

$$s'(\cdot) > 0 \tag{14}$$

$$g'(\cdot) > 0 \tag{15}$$

$$g'(\theta)(\gamma + \nu_g(\iota_g)\big) < s'(\theta)\big(\sigma + \nu_s(\iota_s)\big) \tag{16}$$

[8] This result can be obtained from our model by considering more precise information structures [see Laffont and Tirole [1993, pp. 123–124].

[9] These costs may result from due diligence by investors prior to purchase or from monitoring managers on an ongoing basis thereafter. See Wruck (1989), Hertzel and Smith (1993), and Stoughton and Zechner (1998).

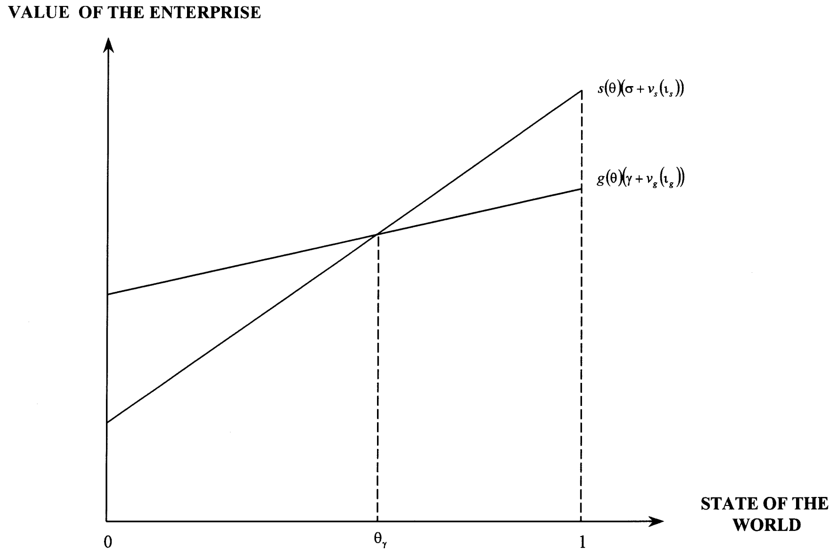


**Figure 1**
**The two uses of the enterprise**
The graph represents the value of the enterprise in its primary use ($s(\theta)(\sigma+\nu_s(\iota_s))$) and its alternative use ($g(\theta)(\gamma+\nu_g(\iota_g))$) as a function of the state of the world ($\theta$), the profitability index ($\sigma$ and $\gamma$, respectively), and the investment in valuation ($\iota_s$ and $\iota_g$, respectively). The state $\theta_\gamma$ is that in which the two uses of the enterprise have the same value.

over the relevant ranges for $\theta$, $\sigma$, $\gamma$, $\iota_s$, and $\iota_g$. Figure 1 represents these assumptions graphically. The enterprise is more valuable in its primary use in the best state of the world, $\theta = 1$, but it is more valuable in its alternative use in the worst state of the world, $\theta = 0$. The values of both uses increase in $\theta$, but the value of the primary use increases at a faster rate.

The preceding assumptions suggest that the enterprise should be devoted to its primary use over the range of states $(\theta_\gamma, 1]$ (the "good" states) but that it should be used in its alternative use over the range of states $[0, \theta_\gamma]$ (the "bad" states). Here $\theta_\gamma$ separates the good states from the bad states and identifies the critical state in which the two uses of the enterprise have the same value. The maximum value of the enterprise can be attained by solving the first-best problem

$$\max_{\theta_\gamma, \iota_s, \iota_g} \int_{\theta_\gamma}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta + \int_0^{\theta_\gamma} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (\iota_s + \iota_g),$$

where

$$\nu_g(\iota_g) \equiv \frac{1}{h_g}\frac{\iota_g}{h_g + \iota_g}, \qquad (17)$$

with $h_g$ defined similarly to $h_s$. This problem has first-order conditions

$$-s(\theta_\gamma)\big(\sigma + \nu_s(\iota_s)\big) + g(\theta_\gamma)\big(\gamma + \nu_g(\iota_g)\big) = 0 \tag{18}$$

$$\int_{\theta_\gamma}^{1} s(\theta)\nu_s'(\iota_s)d\theta - 1 = 0 \tag{19}$$

$$\int_{0}^{\theta_\gamma} g(\theta)\nu_g'(\iota_g)d\theta - 1 = 0. \tag{20}$$

Suppose the entrepreneur lacks the expertise necessary to evaluate the enterprise in its alternative use and knows only the distribution, $H_g(\cdot)$, and density, $h_g(\cdot)$, of $\gamma$ over the range $[\underline{\gamma}, \overline{\gamma}]$.[10] We investigate the circumstances under which the entrepreneur can increase his expected profits by obtaining information about the value of the enterprise in its alternative use from a party who specializes in providing that information. We call this party the debt valuation specialist (DVS), and we show that the entrepreneur can obtain the desired information by borrowing from the DVS, with secured nonrecourse debt providing the most clear-cut example.

Debt financing limits the investment in valuation made by the DVS to the next best use of the enterprise. Selling the DVS an equity claim instead of debt would require the DVS to value the enterprise in both its primary use and its alternative use, or it would require the entrepreneur to credibly signal to the DVS the value of the enterprise in its primary use. Unnecessary costs would be incurred in either case. In contrast, the fixed payment to debt frees the DVS from having to value the enterprise in those states in which debt will be repaid, because it focuses his valuation exclusively on the states in which the entrepreneur defaults. In the default states, the entrepreneur voluntarily relinquishes the enterprise, which constitutes the entire collateral for the loan. The repayment and default states can be made to coincide closely with the good and bad states, respectively, through the proper choice of contract terms.[11]

Let $D(\gamma)$ denote the face value of the loan and $P_g(\gamma)$ denote its price, which is also the amount of the loan (we consider zero-coupon bonds for simplicity).[12] Both depend on the index of profitability of the alternative use of the enterprise, $\gamma$, declared by the DVS, which they are intended to reveal. To maximize the value of the enterprise, the entrepreneur must ensure that it is deployed to its most profitable use on realization of the state. Ex ante, this requires him to focus his investment in valuation on the good states, in which the enterprise is best deployed to its primary use. This in turn requires him to structure the debt contract to induce the DVS to reveal $\gamma$ truthfully and

[10] We assume $H_g(\cdot)$ has an increasing hazard rate.

[11] Nonetheless, we assume rather than establish the optimality of debt financing.

[12] The assumption of zero-coupon bonds is without loss of generality because the determinants of the discount in the case of zero-coupon bonds are identical to those of the coupon rate in the case of coupon-paying bonds.

to make the investment, $\iota_g$, in valuing the alternative use of the enterprise. More formally, the problem solved by the entrepreneur is

$$\max_{P_g(\gamma),\, D(\gamma),\, \iota_s} \int_{\underline{\gamma}}^{\overline{\gamma}} \left[ \int_{\theta_{\gamma h}}^{1} \left[ s(\theta)\big(\sigma + \nu_s(\iota_s)\big) - D(\gamma) \right] d\theta \right.$$
$$\left. + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} \left[ g(\theta)\big(\gamma + \nu_g(\iota_g)\big) - D(\gamma) \right] d\theta - (\iota_s - P_g(\gamma)) \right] h_g(\gamma) d\gamma \tag{21}$$

subject to

$$\gamma \equiv \arg\max_{\tilde{\gamma}} D(\tilde{\gamma})(1 - \theta_{\tilde{\gamma} l}) + \int_0^{\theta_{\tilde{\gamma} l}} g(\theta)$$
$$\times \big(\gamma + \nu_g(\iota_g)\big) d\theta - (P_g(\tilde{\gamma}) + \iota_g) \quad \forall_\gamma \tag{22}$$
$$\iota_g \equiv \arg\max_{\tilde{\iota}_g} D(\gamma)(1 - \theta_{\gamma l}) + \int_0^{\theta_{\gamma l}} g(\theta)$$
$$\times \big(\gamma + \nu_g(\tilde{\iota}_g)\big) d\theta - (P_g(\gamma) + \tilde{\iota}_g) \tag{23}$$

and

$$D(\gamma)(1 - \theta_{\gamma l}) + \int_0^{\theta_{\gamma l}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big) d\theta - \big(P(\gamma) + \iota_g\big) \geq 0 \quad \forall \gamma. \tag{24}$$

Here $\theta_{\gamma h}$ denotes the state in which the value of the primary and alternative uses of the enterprise are identical, while $\theta_{\gamma l}$ denotes the state in which the value of the enterprise in its alternative use equals the face value of the debt (see Figure 2). We assume the entrepreneur has the ability to redeploy the enterprise to its next best use following realization of the state, perhaps simply by selling it. Following realization of the state but prior to the time the DVS reveals $\tilde{\iota}_g(\iota_g)$, the entrepreneur will default in the states $\theta \leq \theta_{\gamma l}$. More formally, we have

$$s(\theta_{\gamma h})\big(\sigma + \nu_s(\iota_s)\big) = g(\theta_{\gamma h})\big(\gamma + \nu_g(\iota_g)\big) \tag{25}$$

and

$$g(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big) = D(\gamma). \tag{26}$$

We shall show that $\theta_{\gamma l} < \theta_{\gamma h}$ for $\gamma \in [\underline{\gamma}, \overline{\gamma})$.

The entrepreneur solves his maximization problem subject to the DVS's incentive compatibility and individual rationality constraints. The individual rationality constraint [Equation (24)] is quite simple. It shows that the terms of the loan made by the DVS to the entrepreneur must ensure that the DVS at least breaks even after accounting for the investment he will make in valuing the alternative use of the enterprise. The DVS has the incentive to make the

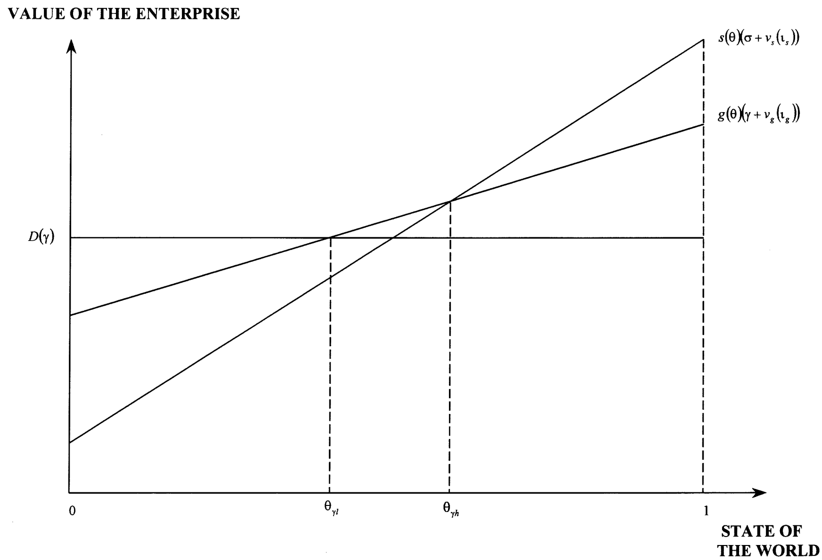


**Figure 2**
**The level of debt**
The graph represents the value of the enterprise in its primary use $(s(\theta)(\sigma + \nu_s(\iota_s)))$ and its alternative use $(g(\theta)(\gamma + \nu_g(\iota_g)))$ as a function of the state of the world $(\theta)$, the profitability index ($\sigma$ and $\gamma$, respectively), and the investment in valuation ($\iota_s$ and $\iota_g$, respectively). $D(\gamma)$ denotes the level of debt. The state $\theta_{\gamma l}$ is that in which the value of the debt equals the value of the enterprise in its alternative use. The state $\theta_{\gamma h}$ is that in which the two uses of the enterprise have the same value.

investment, for he becomes the owner of the enterprise if the entrepreneur defaults on the loan. Since the alternative use of the enterprise in the bad states generates the collateral for the loan, the DVS makes his informational investment in accurately estimating the value of this collateral.

The DVS's investment is defined by the incentive compatibility constraint [Equation (23)]. The incentive compatibility constraint [Equation (22)] states that the terms of the loan must be such that the DVS is induced truthfully to reveal $\gamma$. In this formulation, $\theta_{\tilde{\gamma}l}$ is the state at and below which the entrepreneur will default on his loan when the DVS has misrepresented the profitability index as $\tilde{\gamma}$ rather than $\gamma$.

The forthcoming analysis of the informational rent necessary to induce the DVS to reveal $\gamma$ closely follows the analysis in Section 1. As before, the entrepreneur must promise the DVS an informational rent to reveal $\gamma$ truthfully when $\gamma > \underline{\gamma}$, because the DVS could capture a rent simply by claiming that $\gamma$ is equal to $\underline{\gamma}$. In so doing, the DVS would enter into a debt contract whose terms are based on the assumption that the collateral for the loan—the value of the enterprise in its alternative use—has profitability index $\underline{\gamma}$ when the true index actually exceeds $\underline{\gamma}$. To induce the DVS to reveal the index of profitability truthfully, the debt contract must provide a net payoff that is at least as large.

The DVS solves the following problems:

$$\max_{\tilde{\gamma}} D(\tilde{\gamma})(1-\theta_{\tilde{\gamma}l}) + \int_0^{\theta_{\tilde{\gamma}l}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (P_g(\tilde{\gamma}) + \iota_g) \quad (22)$$

$$\max_{\iota_g} D(\gamma)(1-\theta_{\gamma l}) + \int_0^{\theta_{\gamma l}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (P(\gamma) + \iota_g). \quad (23)$$

These have first-order conditions

$$D'(\gamma)(1-\theta_{\gamma l}) - D(\gamma)\frac{\partial\theta_{\tilde{\gamma}l}}{\partial\tilde{\gamma}}\bigg|_{\tilde{\gamma}=\gamma} + g(\theta_{\gamma l})\big(\gamma+\nu_g(\iota_g)\big)\frac{\partial\theta_{\tilde{\gamma}l}}{\partial\tilde{\gamma}}\bigg|_{\tilde{\gamma}=\gamma} - P'_g(\gamma) = 0$$
$$\Leftrightarrow D'(\gamma)(1-\theta_{\gamma l}) - P'_g(\gamma) = 0 \quad (27)$$

and

$$-D(\gamma)\frac{\partial\theta_{\gamma l}}{\partial\iota_g} + g(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial\theta_{\gamma l}}{\partial\iota_g} + \int_0^{\theta_{\gamma l}} g(\theta)\nu'_g(\iota_g)d\theta - 1 = 0$$
$$\Leftrightarrow \int_0^{\theta_{\gamma l}} g(\theta)\nu'_g(\iota_g)d\theta - 1 = 0, \quad (28)$$

where the equivalences hold by the definition of $\theta_{\gamma l}$ in Equation (26).

Equation (28) shows that the DVS will direct his investment to the range of states, $[0, \theta_{\gamma l}]$, over which the entrepreneur will default, even though the enterprise will be put to its next best use over the range $[0, \theta_{\gamma h}]$. This is because the enterprise serves as collateral for the loan made by the DVS only over the range $[0, \theta_{\gamma l}]$. Equation (27) must hold for $\tilde{\gamma} = \gamma$ because the DVS must reveal the index of profitability truthfully in equilibrium. The face value and price of the debt must ensure that the DVS's marginal gain from misrepresenting the profitability index equals his marginal cost of doing so. This implies that

$$P_g(\gamma) = D(\gamma)(1-\theta_{\gamma l}) + \int_0^{\theta_{\gamma l}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta$$
$$- \iota_g - \int_{\underline{\gamma}}^{\gamma}\int_0^{\theta_{ul}} g(\theta)d\theta du. \quad (29)$$

The price of a loan of face value $D(\gamma)$ made by the DVS to the entrepreneur when the profitability index equals $\gamma$ consists of four terms: the first term is the expected repayment of the principal in the good states, the second term is the expected value of the collateral in the bad states, the third term is the investment made by the DVS in accurately estimating the value of the collateral in the bad states, and the fourth term is the informational rent.

We now turn to the entrepreneur's problem. Substituting $P_g(\gamma)$ from Equation (29) into the problem solved by the entrepreneur, we have the problems

$$\max_{D(\gamma)} \int_{\underline{\gamma}}^{\overline{\gamma}} \left[ \int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big) d\theta + \int_{0}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big) d\theta \right.$$
$$\left. - (\iota_s + \iota_g) - \left[ \frac{1 - H(\gamma)}{h(\gamma)} \right] \int_{0}^{\theta_{\gamma l}} g(\theta) d\theta \right] h(\gamma) d\gamma \quad (30)$$

and

$$\max_{\iota_s} \int_{\theta_{\gamma h}}^{1} \big[ s(\theta)\big(\sigma + \nu_s(\iota_s)\big) - D(\gamma) \big] d\theta$$
$$+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} \big[ g(\theta)\big(\gamma + \nu_g(\iota_g)\big) - D(\gamma) \big] d\theta - \iota_s. \quad (31)$$

Note the difference between the objective functions in Equations (30) and (31). The former represents the expected payoff to the entrepreneur from issuing debt (indeed, it is to be maximized by the choice of debt) and therefore comprises both the payoff to equity from issuing debt and the associated proceeds. The latter represents the payoff to the entrepreneur from more focused valuation of the primary use following the issuance of debt and therefore comprises only the payoff to equity, net of the investment made in evaluating the primary use of the enterprise. Clearly the entrepreneur makes his investment in evaluating the primary use following the issuance of the debt, as one purpose of issuing debt is to guide the entrepreneur's choice of $\iota_s$.

Equations (30) and (31) have first-order conditions

$$\left[ \int_{0}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g) d\theta - 1 \right] \frac{\partial \iota_g}{\partial D(\gamma)} - g(\theta_{\gamma l}) \left[ \frac{1 - H(\gamma)}{h(\gamma)} \right] \frac{\partial \theta_{\gamma l}}{\partial D(\gamma)} = 0 \quad (32)$$

and

$$\int_{\theta_{\gamma h}}^{1} s(\theta)\nu_s'(\iota_s) d\theta - 1 = 0. \quad (33)$$

From Equation (28), we have

$$\frac{\partial \iota_g}{\partial D(\gamma)} = \frac{\partial \iota_g}{\partial \theta_{\gamma l}} \frac{\partial \theta_{\gamma l}}{\partial D(\gamma)},$$

where

$$\frac{\partial \iota_g}{\partial \theta_{\gamma l}} = \frac{-g(\theta_{\gamma l})\nu_g'(\iota_g)}{\int_0^{\theta_{\gamma l}} g(\theta)\nu_g''(\iota_g) d\theta} > 0. \quad (34)$$

Equation (32) can therefore be rewritten as

$$\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta \frac{\partial \iota_g}{\partial \theta_{\gamma l}} - g(\theta_{\gamma l})\left[\frac{1-H_g(\gamma)}{h_g(\gamma)}\right] = 0. \tag{35}$$

Equation (35) shows that $\theta_{\gamma h} > \theta_{\gamma l}$ for the existence of an interior solution. This in turn implies that the asymmetry of information between the entrepreneur and the DVS precludes the first-best solution for $\gamma \in [\underline{\gamma}, \overline{\gamma})$. Even if $\theta_{\gamma h}$ were to equal $\theta_\gamma$, and the entrepreneur were to make the first-best investment in evaluating the primary use of the enterprise by Equations (19) and (33), the DVS would fall short by Equation (28) and the inequality $\theta_{\gamma h} > \theta_{\gamma l}$.

Equation (35) can be explained as follows. In choosing $D(\gamma)$, the entrepreneur essentially chooses the range of states over which he will default and the enterprise will be transferred to its next best use. The entrepreneur thereby balances two opposing effects: (1) the increased investment the DVS makes due to an increase in the range of states over which he expects to take possession of the enterprise, and (2) the increased informational rent the DVS must be promised to reveal the true index of profitability. The second effect is a consequence of the DVS's ability to claim a lower collateral value than is actually the case. The greater the face value of the debt, the greater the range of states over which he expects to take possession of the enterprise, and thus the greater his gain from misrepresenting his knowledge.

We now prove two comparative statics results based on how the debt-equity ratio of the enterprise varies with the indices of profitability, $\sigma$ and $\gamma$. The optimal levels of debt and equity have value

$$D = g(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big) \tag{36}$$

and

$$E = \int_{\theta_{\gamma h}}^{1} s(\theta)(\sigma + \nu_s(\iota_s))d\theta + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (1-\theta_{\gamma l})D. \tag{37}$$

Equation (36) is nothing but Equation (26). Equation (37) reflects the fact that equity represents a claim on the value of the enterprise, net of debt, with limited liability. $\iota_s$, $\iota_g$, $\theta_{\gamma l}$, and $\theta_{\gamma h}$ are the solutions to the system of equations defined by Equations (25), (28), (33), and (35).

***Lemma 3.*** *The state, $\theta_{\gamma l}$, in which the value of the enterprise in its alternative use equals the face value of the debt; the state, $\theta_{\gamma h}$, in which the value of the enterprise in its alternative use equals the value of its use in its primary use; and the investment, $\iota_g$, made by the DVS decrease in the profitability of the primary use of the enterprise and increase in the profitability of the alternative use. The investment, $\iota_s$, made by the entrepreneur increases in the profitability of the primary use of the enterprise and decreases in the profitability of the alternative use.*

*Proof.* See the appendix.

The intuition of the preceding result is immediate. Consider an increase in the profitability of the alternative use of the enterprise. This increases the range of states over which the enterprise should be redeployed to its alternative use, $[0, \theta_{\gamma h}]$. It in turn decreases the investment, $\iota_s$, made by the entrepreneur in evaluating the primary use of the enterprise, because the enterprise will be used in its primary use over a smaller range of states $(\theta_{\gamma h}, 1]$. The increased profitability of the alternative use of the enterprise also increases the informational rent that must be offered the DVS for him to reveal such increased profitability. This is achieved by increasing the range of states, $[0, \theta_{\gamma l}]$, over which the DVS receives the enterprise, in turn prompting the DVS to increase the investment, $\iota_g$, he makes in valuing the enterprise in its alternative use.

Now consider an increase in the profitability of the primary use of the enterprise. This increases the range of states over which the enterprise should remain in its primary use, $(\theta_{\gamma h}, 1]$. It in turn increases the investment, $\iota_s$, made by the entrepreneur in evaluating that use. The lower range of states over which the enterprise is to be redeployed to its alternative use implies a lower investment, $\iota_g$, in the valuation of that use by the DVS. This is achieved by decreasing the range of states, $[0, \theta_{\gamma l}]$, over which the DVS expects to receive the enterprise.

***Proposition 2.*** *The debt-equity ratio of the firm decreases in the profitability of the primary use of the enterprise and increases in the profitability of the alternative use.*

*Proof.* See the appendix.

Equity should be the prime beneficiary of the increase in the value of the firm that results from an increase in the profitability of the primary use of the enterprise. This explains why the debt-equity ratio decreases in $\sigma$. The increase in firm value need not be shared with the DVS in such a case because the DVS has no private information about $\sigma$ that he must be induced to reveal. In contrast, an increase in firm value that results from an increase in the profitability of the alternative use of the enterprise must be shared with the DVS to induce him truthfully to reveal the increased profitability. The increased informational rent the DVS must receive implies a higher face value of debt, as noted in our discussion of Equation (35). This explains why the debt-equity ratio increases in $\gamma$. The result is similar to Proposition 1, in which we noted the increase in outside equity as $\sigma$ increases. In both cases the valuation specialists must be induced to reveal their information truthfully by receiving a claim to the value of the enterprise in the appropriate use. The amount of this claim is proportionate to the profitability they declare.

Under the simplifying assumption that the next best alternative use of the enterprise involves liquidation of its tangible assets, our prediction that the debt-equity ratio increases in the profitability of the alternative use of the enterprise is consistent with the well-documented observation that firms with more tangible assets have higher debt-equity ratios [see the review article by Harris and Raviv (1991)].[13] Our prediction that the debt-equity ratio decreases in the profitability of the primary use of the enterprise is also well supported by existing evidence, which has extensively documented lower leverage in more profitable firms [Harris and Raviv (1991)].

Jensen's (1986) theory of free-cash flow and related work on strategic default by Bolton and Scharfstein (1990, 1996) and Hart and Moore (1995) also predict lower leverage for more profitable firms. These explanations have an important limitation, however, because their predictions hold only for firms that have more profitable growth opportunities. For firms that have more profitable assets in place, and hence higher free cash flows, they predict higher leverage [Stulz (1990)]. This does not appear to hold true, at least when using a firm's return on assets as a proxy for the profitability of the firm's assets in place. This is because return on assets has been shown to be negatively related to leverage [Harris and Raviv (1991)]. In contrast, holding the next best use of the enterprise constant, we predict that firm leverage should decline with the going concern profitability of both assets in place and future growth opportunities. This is because, in our view, it is uses rather than assets that determine financing choices.

## 3. Information Revelation Through Debt and Outside Equity: The Two Uses of the Enterprise

In our discussion of debt finance in Section 2, we assumed the entrepreneur need not raise outside equity because he knows the index of profitability of the primary use of the enterprise, $\sigma$, and can make the investment, $\iota_s$, in valuing that use on his own. To show how debt and outside equity are jointly determined, we now examine the case where the entrepreneur must obtain information from both the EVS and the DVS. The combination of debt and outside equity involves multidimensional screening, with the two dimensions being the primary use and the alternative use of the enterprise. In general with multidimensional screening, full revelation rarely occurs [Rochet and Choné (1998)]. But two considerations make our problem dramatically simpler than the general problem.[14] Because our formulation is based on the gains from specialized valuation, the EVS and the DVS can realistically be treated as different parties for whom the costs of cooperation are prohibitive. Furthermore, as already noted, the DVS need not concern himself with the primary use of the asset. The problem of inducing the DVS to reveal his information truthfully therefore remains unchanged given that the EVS has done so.

[13] The higher debt-equity ratio of firms that have more tangible assets is also consistent with the belief that such firms have lower bankruptcy costs.

[14] We thank Jean-Charles Rochet for that essential insight.

As a result, the entrepreneur can induce the EVS to reveal his information conditional on the index of profitability, $\gamma$, the DVS will declare.[15] The stake offered the EVS who has declared an index of profitability, $\sigma$, is then $1-\alpha(\sigma,\gamma)$. It is offered at a price $P_s(\sigma,\gamma)$. These can be derived in a manner analogous to the analysis in Section 1. The analogue to Equation (9) is

$$\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_{\theta_{\gamma h}}^{1} s(\theta)d\theta + \alpha(\sigma,\gamma)\int_{\theta_{\gamma h}}^{1} s(\theta)v_s'(\iota_s)d\theta\frac{\partial\iota_s}{\partial\alpha(\sigma,\gamma)}$$
$$+(1-\alpha(\sigma,\gamma))s\big(\theta_{\gamma h}\big)\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\frac{\partial\theta_{\gamma h}}{\partial\iota_s}\frac{\partial\iota_s}{\partial\alpha(\sigma,\gamma)}=0. \tag{38}$$

This differs from Equation (9) because the stake sold to the EVS now constitutes a claim on the levered equity of an enterprise that can be redeployed to an alternative use, rather than the unlevered equity of an enterprise that has a single use, as in Section 1. This explains the change in the lower bound on the states from zero to $\theta_{\gamma h}$, where $\theta_{\gamma h}$ is as defined in Equation (25). It also explains the presence of the third term, which shows that a change in the stake sold to the EVS now affects both the informational rent that must be granted to the EVS in every state and also the range of states over which he receives the rent.

The joint revelation of the two indices of profitability proceeds as follows. The entrepreneur induces the EVS to reveal his information by offering him a combination of equity stakes and prices that are conditional on the index of profitability that the DVS will reveal. The entrepreneur then induces the DVS to reveal his information by offering to issue the appropriate amount of debt. Finally, the entrepreneur issues the debt and the outside equity stake.[16] The complete solution is characterized by the system of Equations (25), (26), (28), (29), (32), (38), and

$$(1-\alpha(\sigma,\gamma))\int_{\theta_{\gamma h}}^{1} s(\theta)v_s'(\iota_s)d\theta - 1 = 0. \tag{39}$$

Equation (39) differs from Equation (33) because the party who makes the investment, $\iota_s$, in valuing the primary use of the enterprise has a claim on a fraction, $1-\alpha(\sigma,\gamma)$, of the equity rather than on the entire equity of the firm. Equation (39) recalls Equation (10), from which it differs because the fraction of the equity sold to the EVS now depends both on the index

[15] Equivalently, the conditioning can be of the level of debt to be issued, $D(\gamma)$, for there is a one-to-one relation between $\gamma$ and $D(\gamma)$.

[16] As we do not establish the optimality of the joint use of debt and equity, it is certainly possible that other mechanisms dominate. One possible mechanism is convertible debt. However, as convertible debt constitutes a conditional claim on both the next best use of the enterprise and, in case of conversion, its primary use, convertible debt is likely to suffer from the previously noted problem of multidimensional screening [Rochet and Choné (1998)]. An alternative rationale for the use of convertible debt is in the context of sequential screening [Courty and Li (1997)].

of profitability of the primary use of the enterprise, and also on the index of profitability of the alternative use of the enterprise. This is because the profitability of the alternative use of the enterprise affects the state, $\theta_{\gamma h}$, below which the enterprise is redeployed to its alternative use. Naturally the range of states toward which the EVS directs his investment in valuing the primary use is now $(\theta_{\gamma h}, 1]$, rather than $[0, 1]$.

The comparative statics of the joint determination of debt and outside equity requires imposing further constraints on our model. This is because some entries in the Hessian of the problem cannot otherwise be signed.[17] One natural constraint is imposed by the difference between good states and bad states. We have thus far assumed that there was a continuous progression from the bad states to the good states, and that the state $\theta_{\gamma h}$ which separates good states from bad states was endogenously determined as the solution to Equation (25). However, a point may be made that there is a structural difference between good states and bad states, that is between what may be viewed as economy-wide expansions and recessions; and that a structural break occurs at the now exogenous $\theta_{\gamma h}$ (see Figure 3). We assume that $\theta_{\gamma h}$ is decreasing in $\sigma$ and increasing in $\gamma$ (as was shown endogenously in the simpler setting of Section 2), but that it is unaffected by $\iota_g$ and $\iota_s$; the exogenously determined probability of a good state or a bad state depends on the profitability of the good and bad states, but not on the investments made in valuation. These are valued conditionally on the occurrence of the states to which they pertain. The assumption that $\theta_{\gamma h}$ is exogenous allows us to examine the joint comparative statics of debt and outside equity.

***Proposition 3.*** *The debt-equity ratio of the firm decreases in the profitability of the primary use of the enterprise and increases in the profitability of the alternative use of the enterprise. The ratio of outside to inside equity may be increasing, decreasing, or constant in the profitability of the primary use of the enterprise. It increases in the profitability of the alternative use of the enterprise. The ratio of debt to inside equity increases in the profitability of the alternative use of the enterprise. It decreases in the profitability of the primary use of the enterprise if the ratio of outside to inside equity decreases in that profitability. The ratio of debt to outside equity decreases in the profitability of the primary use of the enterprise if the ratio of outside to inside equity increases in that profitability.*

*Proof.* See the appendix.

The comparative statics of the firm's debt to total equity ratio remain the same as in Section 2 because, as noted earlier, the problem of inducing the DVS to reveal his information truthfully remains unchanged. Our new results focus on the fraction of the equity sold to the EVS. This fraction increases

[17] This is the case of the derivatives of Equation (38) with respect to $\theta_{\gamma h}$ and $\iota_s$.

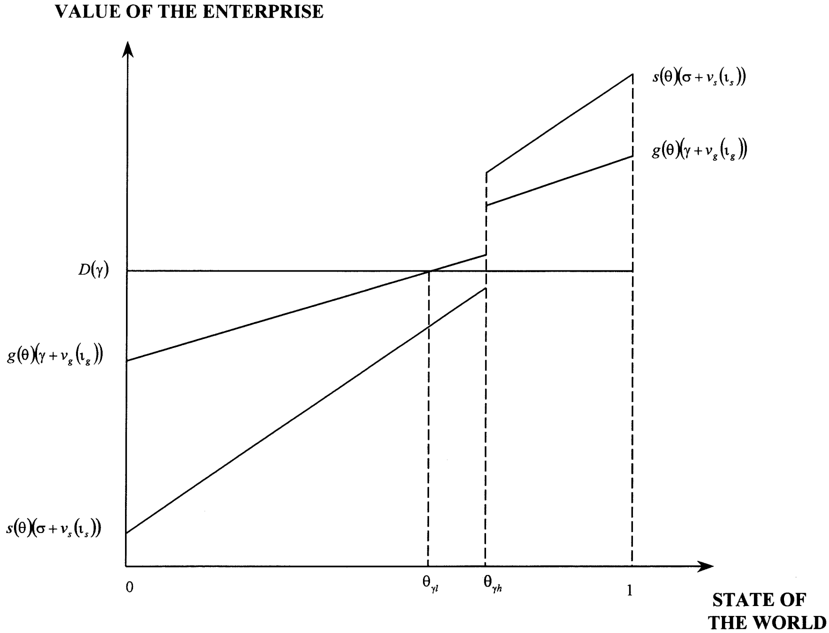


**Figure 3**
**The case of a structural break**
The graph represents the value of the enterprise in its primary use ($s(\theta)(\sigma + \nu_s(\iota_s))$) and its alternative use ($g(\theta)(\gamma + \nu_g(\iota_g))$) as a function of the state of the world ($\theta$), the profitability index ($\sigma$ and $\gamma$, respectively), and the investment in valuation ($\iota_s$ and $\iota_g$, respectively). $D(\gamma)$ denotes the level of debt. The state $\theta_{\gamma l}$ is that in which the value of the debt equals the value of the enterprise in its alternative use. A structural break occurs at $\theta_{\gamma h}$: the primary use dominates the alternative use for $\theta > \theta_{\gamma h}$, whereas the opposite is true for $\theta < \theta_{\gamma h}$.

in the profitability of the alternative use of the enterprise. With the sale of debt, the decrease in the range of states over which the enterprise remains in its primary use implies that the EVS makes a lower investment in valuation for any given fraction of the equity he acquires. The entrepreneur reacts to this decreased investment by increasing the fraction of the equity he sells to the EVS. As in Section 1, the fraction of the equity sold to the EVS should increase in the profitability of the primary use of the enterprise to induce the EVS to reveal his information truthfully. Unlike in Section 1, however, there is now an offsetting effect. Specifically, the increase in the range of states over which the enterprise remains in its primary use increases the investment made by the EVS in valuing that use. An increase in the profitability of the primary use of the enterprise thus presents an opportunity for the entrepreneur to decrease the share of equity sold to the EVS, thereby decreasing the EVS's informational rent, without necessarily decreasing his investment in valuation. The net effect is undetermined. The fraction of the equity sold to the EVS could increase, decrease, or remain constant in the profitability of the primary use of the enterprise.[18]

The final results, regarding the ratio of debt to inside and outside equity simply combine the earlier results. The lower fraction of equity retained by the entrepreneur for a more profitable alternative use of the enterprise combines with the higher debt-equity ratio to imply a higher debt-inside equity ratio. A higher fraction of the equity retained by the entrepreneur for a more profitable primary use of the enterprise combines with the lower debt-equity ratio to imply a lower debt-inside equity ratio. Finally, a lower fraction of the equity retained by the entrepreneur for a more profitable primary use of the enterprise combines with the lower debt-equity ratio to imply a lower debt-outside equity ratio.

## 4. Conjectures, Extensions, Concluding Remarks

We have shown that as a general matter debt and outside equity can be used to elicit accurate information from outside investors about the value of an enterprise in alternative uses. The equity valuation specialist reveals information about the current or primary use of the enterprise. The debt valuation specialist reveals information about a distinct alternative use. The specialized valuation that arises from these financial claims narrows the range and character of the information with which each class of investors must be concerned and thereby reduces the sum of informational rents paid by the entrepreneur. The mechanism that ultimately ensures truthful revelation by the valuation specialists is the residual that derives from their state-contingent ownership claims. Any pricing errors will be borne by the class of investors that holds itself out, ex ante, as having a comparative advantage in estimating the highest valued use of the enterprise in the relevant states of the world. No single class of investors can be viewed strictly as *the* residual claimants to firm value; shareholders bear the good-state residual accruing to accurate valuation of the primary use, while debtholders bear the bad-state residual accruing to accurate valuation of the alternative use.

The comparative statics implications of our theory are that the share of firm equity held by outside equity investors will increase in the profitability of the enterprise and that the debt-equity ratio will decrease in the profitability of the primary use and increase in the profitability of the alternative use. As long as the debt and equity valuation specialists are precluded from cooperating, the joint determination of capital structure is straight forward.[19]

[18] Note that the necessary condition for a maximum is no longer $\frac{\partial\alpha}{\partial\sigma} \leq 0$ in this case. It can be shown to become $-\frac{\partial\alpha}{\partial\sigma}\int_{\theta_{\gamma h}}^{1} s(\theta)d\theta - (1-\alpha)s(\theta_{\gamma h})\frac{\partial\theta_{\gamma h}}{\partial\tilde{\sigma}}\big|_{\tilde{\sigma}=\sigma} \geq 0$. This condition can be shown to be true by substituting the value of $\frac{\partial\alpha}{\partial\sigma}$ obtained in Proposition 3.

[19] So-called strip financing, in which a single investor buys both the equity and the debt of a single firm and parent-firm holdings of both the equity and debt of a subsidiary call for further investigation, but as cases that are likely to involve multidimensional screening they are beyond the scope of this article.

Implicit in our model is the assumption that the firm can contract for price information in both financial markets and real (factor and product) markets. When the price terms of an agreement are contractually (or otherwise) enforceable the price becomes a bond that, in anticipation, will prompt the parties to make specialized informational investments. Mayers and Smith (1982) have identified the role of insurance contracts in providing the corporation with bonded information specifically about bad-state casualty or liability losses, for example.

It is important to clarify our assertion above that levering a "distinct" alternative use of the enterprise can generate gains from specialized valuation. Identifying which among many alternative uses is sufficiently distinct to warrant the issuance of debt is implicitly the outcome of equilibrium financial contracting. Conceptually there are many alternative uses of the enterprise whose expected values may differ only trivially from one another.[20] Think of these as $U_1 \cdots U_n$, where $U_1$ is expected to be the highest valued and most specialized use of the enterprise and $U_n$ represents the expected value of the enterprise if redeployed to the most general of all possible alternative uses. Given the benefits of specialized valuation, why not "lever to the hilt," with an equity value of only epsilon? Our answer is that levering a relatively high-order alternative use, say, $U_2$, provides little benefit from specialized valuation because $U_1$ and $U_2$ will be closely correlated across states of the world. If contracting to clearly delineated ownership to $U_1$ and $U_2$ is costless, however, it nevertheless pays to lever up to $U_2$. With costly contracting, as we move down the hierarchy of alternative uses, say, to $U_i$, the benefits of contracting increase because there are a larger number of states that differentially affect the value of $U_1$ and $U_i$. At the same time, the contracting costs of clearly delineating ownership and residual claimancy to $U_1$ and $U_i$ will decline. The benefits from levering a sufficiently low-order alternative use might eventually exceed the associated contracting costs and the entrepreneur will gain from issuing debt backed by $U_i$, with this particular use being what we described at the outset as a distinct alternative use of the enterprise. This suggests that some firms have no debt because the costs of contracting exceed the benefits from specialized valuation of any alternative use.[21]

One clearly distinct category of alternative uses is piecemeal liquidation of the firm's tangible assets, for which contracting costs are sufficiently low that the assets can serve as collateral for secured debt. But unsecured corporate debt, though not explicitly secured, is implicitly secured by an alternative use of the corporate enterprise as a going concern that, although intangible,

[20] In this extreme setting, firing a single clerical worker could be asserted to constitute the redeployment of the enterprise to an alternative use.

[21] These firms may consist of tangible assets that are actively traded in factor markets and whose redeployment value is therefore known, plus an intangible asset that is entirely specialized to the current use.

is sufficiently distinct to generate net benefits from specialized valuation.[22] In this framework, corporate equity communicates information about the value of the current going concern use of the enterprise, unsecured debt communicates information about the value of an alternative going concern use of the enterprise, and secured debt communicates information about the value of the firm's tangible assets in piecemeal liquidation. Accordingly we view equity as a specific quasi-rent reflecting the value of the most specialized use of the enterprise above what it could earn in its next best use. Unsecured debt is a specific quasi-rent reflecting the value of a less specialized use of the enterprise above what it could earn in its most generalized use in piecemeal liquidation. Corporate financial structure identifies what might be called the specialized quasi-rent structure of enterprise [Johnsen (1995)]. Each layer of quasi-rents represents a real, if intangible, asset whose limits have been defined by the associated financial claims and whose value reflects the resources that each class of claimant truly vests in the enterprise.

By establishing residual claimancy to these otherwise amorphous value flows across various states of the world, corporate financial claims unbundle them from a composite whole and allocate ownership over the repackaged assets to different classes of investors.[23] That these value flows sometimes fail to materialize as expected is perhaps less surprising than that they are routinely treated as financial assets to which many of the normal incidents of property ownership attach and over which the assignment of residual claimancy effectively occurs. Several examples come to mind. The first involves the wave of leveraged buyouts (LBOs) that occurred during the 1980s with Michael Milken's creation of high-yield bonds and an active market in which they could be traded. The second involves the process of bankruptcy reorganization resulting from the stochastic nature of the firm's primary and alternative uses conditional on the state.

Milken's pioneering work with junk debt constitutes a discrete reduction in the costs of financial contracting to lever higher-order intangible uses of the corporate enterprise. That Milken was in the business of using junk debt to unbundle intangible assets is evident from the following passage recently quoting him in the *Milken Institute Review* on the all-time high in market-to-book values: "[T]he book value shown on balance sheets doesn't reflect

[22] Many secured lenders have recognizable skill in redeploying tangible collateral, and their ex ante commitment to redeploy in the bad states necessarily includes specialized valuation of the collateral in secondary markets. Examples include aircraft finance firms, auto finance firms, and many other firms that finance equipment. But the vast majority of lenders have no obvious skill in redeployment. In fact, many are reluctant to take possession of the collateral on default. These lenders appear to provide specialized valuation only, with the redeployment function vertically disintegrated to specialized intermediaries or performed by auction markets. Historically the advent of specialized valuation separate from "collateral administration" appears to have developed with the rise of sophisticated financial analysis and reporting in the early 20th century [Scott (1986)], which, in turn, led to the widespread use of unsecured debt. It is our belief that sophisticated financial analysis is an indirect but effective way of identifying an intangible going concern use of the enterprise that is sufficiently distinct to warrant specialized valuation through the creation of separate financial claims.

[23] The unbundling process can be said to *reify* or *hypostatize* an entirely new asset.

intangible assets such as human capital, management information systems, software and digital distribution systems that are increasingly important in an knowledge-based economy. . . . [W]hat is the right tool for measuring value and risk in the next three decades? I believe the answer will be found by those who develop the best understanding of what defines income-producing assets in a digital world."[24]

Bankruptcy reorganization attempts to discover the next best going concern use of the enterprise and to reassign residual claimancy to the appropriate valuation specialists where the initial assignment has failed. Where the value of the primary and alternative uses of the enterprise have stochastic elements, the disparity of outcomes in bankruptcy become easier to understand. The conventional "absolute priority rule" suggests that equity should never participate in reorganization unless all senior claimants have been paid in full. While this rule applies in many reorganizations, there are many in which the absolute priority rule is violated, with equity holders retaining control and sharing in the reorganization value even though unsecured creditors receive less than full value [Franks and Torous (1989, 1994)]. In our view, bankruptcy courts tend to adhere to the absolute priority rule where the value of the primary use of the enterprise has fallen below the value of the alternative use, while they deviate from the rule where both the primary and the alternative uses of the enterprise have fallen in value, with the primary use remaining the best use of the enterprise even though cash flows are insufficient to avoid default. Anticipating such situations, the bankruptcy process—including the automatic stay and rules regarding debtors in possession—apparently holds out the prospect that equity will be able to retain control of the enterprise following default. This efficiently recognizes equity's specialized ability to value the primary use and feeds into the parties' incentive to make ongoing informational investments. Contingent allocation of property rights improves the parties' willingness to truthfully reveal their information by reducing the distortion due to ex post bargaining over any associated quasi-rents in achieving the optimal allocation of ownership.[25]

Consider the response to Federated Department Stores' January 2, 1994, announcement that it had acquired part of R.H. Macy's secured debt. Macy's was then under Chapter 11 protection, and the purchase was intended to make it possible for Federated to press in bankruptcy court its plan for a merger of the two retailing chains. Macy's bonds rose in response to the announcement, while its equity remained essentially unchanged at around $40 per share.

[24] Notable and Quotable, *Wall Street Journal*, February 23, 1999, p. A22.

[25] Contracting always occurs within a broader institutional and legal framework. For secured debt contracts, the lender's claim is regarded in law as a property interest protected by the takings clause of the U.S. Constitution. This is the source of adherence to the "absolute priority rule" for secured creditors in bankruptcy, although this adherence is qualified. It can exclude forgone interest and applies only to secured creditors whose collateral is worth as much or more than the principal value of their debt claim. Unsecured creditors receive no such Constitutional protection for their claims, and the undersecured portion of a secured creditors claim is treated as an unsecured claim subject to pro rata sharing.

The information contained in the announcement could not have pertained to the primary use of the enterprise, specifically the continued operation of Macy's as an independent firm, because equity, which we argue communicates information about the primary use of the enterprise, was unaffected by the announcement. Instead, the information pertained to an alternative use of Macy's collection of assets under Federated management. It is worth noting that the differing responses of Macy's debt and equity prices cannot be explained solely by an increase in bondholders' bargaining power, because that would have caused the value of the equity to decrease. If there had been only a single use for the Macy's enterprise, the value of both debt and equity would have changed.

A fully developed formulation of our theory would examine how financial contracting affects the extent, or degree, of asset specificity. Returning to the office-to-hotel conversion example from the introduction, the type of office buildings best suited to conversion are those with rectangular, rather than square, floor plans, which minimize interior space away from exterior walls and ensure that hotel guests will have ample natural light from outside windows. But for given square area (scale), a building with a rectangular floor plan is more costly to construct because it requires more linear feet of exterior walls per floor. An entrepreneur considering what floor plan to choose for an office building of given scale faces a trade-off between the building's suitability for use specifically as office space (a square floor plan) and its suitability for redeployment as a hotel (a rectangular floor plan) in the event of a bad state. The more specialized the building is to use as an office, the less a knowledgeable DVS will offer to lend against its bad-state value. The amount of debt financing and associated cost of capital for buildings with different floor plans will provide the entrepreneur with critical information in choosing the amount he should vest specifically in the asset or enterprise when arriving at its initial design.

Our theory suggests that the quasi-rent structure of the corporate enterprise provides a market-based proxy for asset specificity that could dramatically improve the testability of that notion and contribute substantially to the overall theory of economic and financial organization. Future work will include empirical analyses of voluntary and bankruptcy reorganizations as well as careful analysis of the factors affecting the direction of information revelation, whether from investors to the entrepreneur, from the entrepreneur to investors, or from both directions at once.

## Appendix

*Proof of Lemma 1.* Differentiate the payoff of the EVS as represented by the objective function in Equation (3) with respect to $\sigma$, using the envelope theorem to neglect the derivatives with respect to $\tilde{\sigma}$ and $\iota_s$ to obtain

$$(1-\alpha(\sigma))\int_0^1 s(\theta)d\theta.$$

Now integrating with respect to $\sigma$, we define the payoff of an EVS that knows $\sigma$ to be

$$U_s(\sigma) \equiv \int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du + U_s(\underline{\sigma}). \tag{6}$$

$U(\sigma)$ constitutes the informational rent of an EVS that knows $\sigma$, which the EVS is offered as an inducement to reveal the index of profitability, $\sigma$, truthfully. As the EVS receives no informational rent in case the index of profitability is $\underline{\sigma}$, for it is the ability to claim that the index of profitability is $\underline{\sigma}$ when it is $\sigma > \underline{\sigma}$ that makes such a rent possible, we have $U(\underline{\sigma}) = 0$.

From the two formulations of the payoff of the EVS in Equation (5) and in Equation (6), we can write

$$\begin{aligned} P_s(\sigma) = \big(1-\alpha(\sigma)\big)\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - \iota_s \\ - \int_{\underline{\sigma}}^{\sigma}\big(1-\alpha(u)\big)\int_0^1 s(\theta)d\theta du. \end{aligned} \tag{7}$$

Q.E.D.

*Proof of Lemma 2.* Substitute $P_s(\tilde{\sigma})$ from Equation (7) into Equation (3) to obtain the problem

$$\begin{aligned} &\max_{\tilde{\sigma}}(1-\alpha(\tilde{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s(\tilde{\sigma},\sigma))\big)d\theta - \iota_s(\tilde{\sigma},\sigma) \\ &- (1-\alpha(\tilde{\sigma}))\int_0^1 s(\theta)\big(\tilde{\sigma}+\nu_s(\iota_s(\tilde{\sigma}))\big)d\theta + \iota_s(\tilde{\sigma}) \\ &+ \int_{\underline{\sigma}}^{\tilde{\sigma}}(1-\alpha(u))\int_0^1 s(\theta)d\theta du, \end{aligned}$$

where $\iota_s(\tilde{\sigma},\sigma)$ and $\iota_s(\tilde{\sigma})$ are defined analogously to $\iota_s(\underline{\sigma},\sigma)$ and $\iota_s(\underline{\sigma})$, specifically

$$\iota_s(\tilde{\sigma},\sigma) = \arg\max_{\tilde{\iota}_s}(1-\alpha(\tilde{\sigma}))\int_0^1 s(\theta)\big(\sigma+\nu_s(\tilde{\iota}_s)\big)d\theta - P_s(\tilde{\sigma}) - \tilde{\iota}_s$$

and

$$\iota_s(\tilde{\sigma}) \equiv \iota_s(\tilde{\sigma},\tilde{\sigma}).$$

Differentiating with respect to $\tilde{\sigma}$, using the envelope theorem to neglect differentiation with respect to $\iota_s(\tilde{\sigma},\sigma)$ and $\iota_s(\tilde{\sigma})$, and noting that $\iota_s(\tilde{\sigma},\sigma) = \iota_s(\tilde{\sigma})$, we have

$$-\alpha'(\tilde{\sigma})\int_0^1 s(\theta)[\sigma-\tilde{\sigma}]d\theta$$

The preceding expression equals zero at $\tilde{\sigma} = \sigma$.

We now turn to the second-order condition. We note that the first-order condition of Equation (3) is

$$F(\tilde{\sigma},\sigma)|_{\tilde{\sigma}=\sigma} \equiv -\alpha'(\tilde{\sigma})\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - P_s'(\tilde{\sigma})\Big|_{\tilde{\sigma}=\sigma} = 0.$$

As the preceding equation holds true as an identity, we must have

$$\frac{\partial F}{\partial \tilde{\sigma}}\bigg|_{\tilde{\sigma}=\sigma} + \frac{\partial F}{\partial \sigma}\bigg|_{\tilde{\sigma}=\sigma} = 0.$$

The necessary condition for a maximum, $\frac{\partial F}{\partial \tilde{\sigma}}\big|_{\tilde{\sigma}=\sigma} \leq 0$, is therefore equivalent to $\frac{\partial F}{\partial \sigma}\big|_{\tilde{\sigma}=\sigma} \geq 0$. It is in turn equivalent to $\alpha'(\sigma) \leq 0$. This necessary condition for a maximum can be shown to be sufficient as well [see, e.g., Laffont and Tirole (1993, p. 121)]. We show it to be true in Proposition 1. Q.E.D.

***Derivation of Equation (8).*** *Substituting the expression for $P_s(\sigma)$ into the entrepreneur's payoff, the latter becomes*

$$\begin{aligned}
&\int_{\underline{\sigma}}^{\overline{\sigma}} \bigg[\alpha(\sigma)\int_0^1 s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta + (1-\alpha(\sigma))\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta \\
&\quad - \iota_s - \int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du\bigg]h_s(\sigma)d\sigma \\
&= \int_{\underline{\sigma}}^{\overline{\sigma}}\bigg[\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - \iota_s \\
&\quad - \int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du\bigg]h_s(\sigma)d\sigma \\
&= \int_{\underline{\sigma}}^{\overline{\sigma}}\bigg[\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta - \iota_s \\
&\quad - (1-\alpha(\sigma))\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta\bigg]h_s(\sigma)d\sigma,
\end{aligned}$$

*where the last equality is true by noting that, integrating by parts,*

$$\begin{aligned}
&\int_{\underline{\sigma}}^{\overline{\sigma}}\bigg[\int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du\bigg]h_s(\sigma)d\sigma \\
&\quad = -\int_{\underline{\sigma}}^{\sigma}(1-\alpha(u))\int_0^1 s(\theta)d\theta du(1-H_s(\sigma))\big|_{\underline{\sigma}}^{\overline{\sigma}} \\
&\quad\quad + \int_{\underline{\sigma}}^{\overline{\sigma}}(1-H_s(\sigma))(1-\alpha(\sigma))\int_0^1 s(\theta)d\theta d\sigma
\end{aligned}$$

*and that the first term on the right-hand side of the above equation is zero as $H_s(\overline{\sigma}) = 1$ and $U(\underline{\sigma}) = 0$.*

*Proof of Proposition 1.* $\alpha(\sigma)$ and $\iota_s$ are the solutions to

$$\begin{aligned}
&\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right]\int_0^1 s(\theta)d\theta + \alpha(\sigma)\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta\frac{\partial \iota_s}{\partial \alpha(\sigma)} = 0 \\
&\Leftrightarrow \left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right] - \frac{\alpha(\sigma)}{2(1-\alpha(\sigma))}\frac{1}{h_s+\iota_s} = 0,
\end{aligned}$$

where we have made use of Equations (1) and (11), and

$$(1-\alpha(\sigma))\int_0^1 s(\theta)\nu_s'(\iota_s)d\theta - 1 = 0.$$

Totally differentiating with respect to $\sigma$, we have

$$\begin{pmatrix} -\frac{1}{2(1-\alpha(\sigma))^2}\frac{1}{h_s+\iota_s} & \frac{\alpha(\sigma)}{2(1-\alpha(\sigma))}\frac{1}{(h_s+\iota_s)^2} \\ -\nu_s'(\iota_s) & (1-\alpha(\sigma))\nu_s''(\iota_s) \end{pmatrix} \begin{pmatrix} \frac{\partial\alpha}{\partial\sigma} \\ \frac{\partial\iota_s}{\partial\sigma} \end{pmatrix} = \begin{pmatrix} -\frac{\partial}{\partial\sigma}\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right] \\ 0 \end{pmatrix}.$$

Solving by Cramer's rule, and recalling that

$$\frac{\partial}{\partial\sigma}\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right] < 0$$

by the assumption of increasing hazard rate, we can show that $\frac{\partial\alpha}{\partial\sigma} < 0$ and $\frac{\partial\iota_s}{\partial\sigma} > 0$.

Now differentiating $P_s(\sigma)$ from Equation (7) with respect to $\sigma$ and using the envelope theorem to neglect differentiation with respect to $\iota_s$, we have

$$\begin{aligned} P_s'(\sigma) &= -\alpha'(\sigma)\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta \\ &\quad + (1-\alpha(\sigma))\int_0^1 s(\theta)d\theta - (1-\alpha(\sigma))\int_0^1 s(\theta)d\theta \\ &= -\alpha'(\sigma)\int_0^1 s(\theta)\big(\sigma+\nu_s(\iota_s)\big)d\theta > 0. \end{aligned}$$

Q.E.D.

*Proof of Lemma 3.* $\iota_g$, $\theta_{\gamma h}$, $\theta_{\gamma l}$, and $\iota_s$ are the solutions to

$$\int_0^{\theta_{\gamma l}} g(\theta)\nu_g'(\iota_g)d\theta - 1 = 0$$

$$s(\theta_{\gamma h})\big(\sigma+\nu_s(\iota_s)\big) - g(\theta_{\gamma h})\big(\gamma+\nu_g(\iota_g)\big) = 0$$

$$\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\,\frac{\partial\iota_g}{\partial\theta_{\gamma l}} - g(\theta_{\gamma l})\left[\frac{1-H_g(\gamma)}{h_g(\gamma)}\right] = 0$$

$$\Leftrightarrow \frac{1}{2(h_g+\iota_g)}\frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} - \left[\frac{1-H_g(\gamma)}{h_g(\gamma)}\right] = 0$$

and

$$\int_{\theta_{\gamma h}}^1 s(\theta)\nu_s'(\iota_s)d\theta - 1 = 0,$$

where the equivalence is obtained by using Equations (17) and (34). Totally differentiating with respect to $\gamma$, we have

$$\begin{pmatrix} \int_0^{\theta_{\gamma l}} g(\theta)\nu_g''d\theta & g(\theta_{\gamma l})\nu_g' & 0 & 0 \\ -g(\theta_{\gamma h})\nu_g' & 0 & s'(\theta_{\gamma h})(\sigma+\nu_s) - g'(\theta_{\gamma h})(\gamma+\nu_g) & s(\theta_{\gamma h})\nu_s' \\ -\frac{1}{2(h_g+\iota_g)^2}\frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} & -\frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma l})\int_0^{\theta_{\gamma h}} g(\theta)d\theta}{\left(\int_0^{\theta_{\gamma l}} g(\theta)d\theta\right)^2} & \frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma h})}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} & 0 \\ 0 & 0 & -s(\theta_{\gamma h})\nu_s' & \int_{\theta_{\gamma h}}^1 s(\theta)\nu_s''d\theta \end{pmatrix}$$

$$\times \begin{pmatrix} \frac{\partial\iota_g}{\partial\gamma} \\ \frac{\partial\theta_{\gamma l}}{\partial\gamma} \\ \frac{\partial\theta_{\gamma h}}{\partial\gamma} \\ \frac{\partial\iota_s}{\partial\gamma} \end{pmatrix} = \begin{pmatrix} 0 \\ g(\theta_{\gamma h}) \\ \frac{\partial}{\partial\gamma}\left[\frac{1-H_g(\gamma)}{h_g(\gamma)}\right] \\ 0 \end{pmatrix}.$$

Note that the condition for a maximum requires the determinant of the preceding system of equations to be positive. Using Cramer's rule, it is easy but tedious to show that $\frac{\partial \iota_s}{\partial \gamma} < 0$. The fourth equation then implies that $\frac{\partial \theta_{\gamma h}}{\partial \gamma} > 0$. As the first equation implies that $\frac{\partial \iota_g}{\partial \gamma}$ and $\frac{\partial \theta_{\gamma l}}{\partial \gamma}$ have the same sign, we can use the third equation and the result that $\frac{\partial \theta_{\gamma h}}{\partial \gamma} > 0$ to conclude that $\frac{\partial \iota_g}{\partial \gamma} > 0$ and $\frac{\partial \theta_{\gamma l}}{\partial \gamma} > 0$.

Now totally differentiating with respect to $\sigma$, we have

$$\begin{pmatrix} \int_0^{\theta_{\gamma l}} g(\theta)\nu_g'' d\theta & g(\theta_{\gamma l})\nu_g' & 0 & 0 \\ -g(\theta_{\gamma h})\nu_g' & 0 & s'(\theta_{\gamma h})(\sigma+\nu_s) - g'(\theta_{\gamma h})(\gamma+\nu_g) & s(\theta_{\gamma h})\nu_s' \\ -\frac{1}{2(h_g+\iota_g)^2}\frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} & -\frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma l})\int_0^{\theta_{\gamma h}} g(\theta)d\theta}{\left(\int_0^{\theta_{\gamma l}} g(\theta)d\theta\right)^2} & \frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma h})}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} & 0 \\ 0 & 0 & -s(\theta_{\gamma h})\nu_s' & \int_{\theta_{\gamma h}}^1 s(\theta)\nu_s'' d\theta \end{pmatrix}$$

$$\times \begin{pmatrix} \frac{\partial \iota_g}{\partial \sigma} \\ \frac{\partial \theta_{\gamma l}}{\partial \sigma} \\ \frac{\partial \theta_{\gamma h}}{\partial \sigma} \\ \frac{\partial \iota_s}{\partial \sigma} \end{pmatrix} = \begin{pmatrix} 0 \\ s(\theta_{\gamma h}) \\ 0 \\ 0 \end{pmatrix}.$$

The desired results can be shown by direct application of Cramer's rule. Q.E.D.

*Proof of Proposition 2.* Differentiating $D$ with respect to $\sigma$, we have

$$\frac{\partial D}{\partial \sigma} = g'(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial \theta_{\gamma l}}{\partial \sigma} + g(\theta_{\gamma l})\nu_g'(\iota_g)\frac{\partial \iota_g}{\partial \sigma} < 0, \tag{A1}$$

where the inequality is true by recalling that $\frac{\partial \theta_{\gamma l}}{\partial \sigma} < 0$ and $\frac{\partial \iota_g}{\partial \sigma} < 0$ from Lemma 3.

Now differentiating $D$ with respect to $\gamma$, we have

$$\frac{\partial D}{\partial \gamma} = g(\theta_{\gamma l}) + g'(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial \theta_{\gamma l}}{\partial \gamma} + g(\theta_{\gamma l})\nu_g'(\iota_g)\frac{\partial \iota_g}{\partial \gamma} > 0, \tag{A2}$$

where the inequality is true by recalling that $\frac{\partial \theta_{\gamma l}}{\partial \gamma} > 0$ and $\frac{\partial \iota_g}{\partial \gamma} > 0$ from Lemma 3.

Turning to $E$, we have

$$\begin{aligned} \frac{\partial E}{\partial \sigma} = {} & \int_{\theta_{\gamma h}}^1 s(\theta)d\theta + \int_{\theta_{\gamma h}}^1 s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \sigma}\right) \\ & + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\left(\frac{\partial \iota_g}{\partial \sigma}\right) - (1-\theta_{\gamma l})\frac{\partial D}{\partial \sigma} \end{aligned} \tag{A3}$$

and

$$\begin{aligned} \frac{\partial E}{\partial \gamma} = {} & \int_{\theta_{\gamma h}}^1 s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \gamma}\right) + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta \\ & + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\left(\frac{\partial \iota_g}{\partial \gamma}\right) - (1-\theta_{\gamma l})\frac{\partial D}{\partial \gamma}. \end{aligned} \tag{A4}$$

We need to show $\frac{\partial D}{\partial \sigma}E - D\frac{\partial E}{\partial \sigma} < 0$ and $\frac{\partial D}{\partial \gamma}E - D\frac{\partial E}{\partial \gamma} > 0$. To see this, note that we can use Equations (36), (37), (A1), and (A3) to write

$$
\begin{aligned}
\frac{\partial D}{\partial \sigma}E - \frac{\partial E}{\partial \sigma}D = \frac{\partial D}{\partial \sigma}\bigg(&\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta \\
&+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (1-\theta_{\gamma l})D\bigg) \\
&- \bigg(\int_{\theta_{\gamma h}}^{1} s(\theta)d\theta + \int_{\theta_{\gamma h}}^{1} s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \sigma}\right) \\
&+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\left(\frac{\partial \iota_g}{\partial \sigma}\right) - (1-\theta_{\gamma l})\frac{\partial D}{\partial \sigma}\bigg)D \\
= &\left(g'(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial \theta_{\gamma l}}{\partial \sigma} + g(\theta_{\gamma l})\nu_g'(\iota_g)\frac{\partial \iota_g}{\partial \sigma}\right) \\
&\times \left(\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta\right) \\
&- \bigg(\int_{\theta_{\gamma h}}^{1} s(\theta)d\theta + \int_{\theta_{\gamma h}}^{1} s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \sigma}\right) \\
&+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\left(\frac{\partial \iota_g}{\partial \sigma}\right)\bigg) \times g(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big) \\
= &\, g'(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial \theta_{\gamma l}}{\partial \sigma} \\
&\times \left(\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta\right) \\
&+ g(\theta_{\gamma l})\nu_g'(\iota_g)\frac{\partial \iota_g}{\partial \sigma}\left(\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta\right) \\
&- \left(\int_{\theta_{\gamma h}}^{1} s(\theta)d\theta + \int_{\theta_{\gamma h}}^{1} s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \sigma}\right)\right) \\
&\times g(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big) < 0,
\end{aligned}
$$

where the inequality is true by $\frac{\partial \theta_{\gamma l}}{\partial \sigma} < 0$, $\frac{\partial \iota_g}{\partial \sigma} < 0$, and $\frac{\partial \iota_s}{\partial \sigma} > 0$ from Lemma 3.

Similarly, we use Equations (36), (37), (A2), and (A4) to write

$$
\begin{aligned}
\frac{\partial D}{\partial \gamma}E - \frac{\partial E}{\partial \gamma}D = \frac{\partial D}{\partial \gamma}\bigg(&\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta \\
&+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta - (1-\theta_{\gamma l})D\bigg) \\
&- \bigg(\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta + \int_{\theta_{\gamma h}}^{1} s(\theta)\nu_s'(\iota_s)d\theta\left(\frac{\partial \iota_s}{\partial \gamma}\right) \\
&+ \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\nu_g'(\iota_g)d\theta\left(\frac{\partial \iota_g}{\partial \gamma}\right) - (1-\theta_{\gamma l})\frac{\partial D}{\partial \gamma}\bigg)D \\
= &\left(g(\theta_{\gamma l}) + g'(\theta_{\gamma l})\big(\gamma + \nu_g(\iota_g)\big)\frac{\partial \theta_{\gamma l}}{\partial \gamma} + g(\theta_{\gamma l})\nu_g'(\iota_g)\frac{\partial \iota_g}{\partial \gamma}\right) \\
&\times \left(\int_{\theta_{\gamma h}}^{1} s(\theta)\big(\sigma + \nu_s(\iota_s)\big)d\theta + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)\big(\gamma + \nu_g(\iota_g)\big)d\theta\right)
\end{aligned}
$$

$$
\begin{aligned}
&- \left( \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta) d\theta + \int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s'(\iota_s) d\theta \left( \frac{\partial \iota_s}{\partial \gamma} \right) \right. \\
&\qquad \left. + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta) \nu_g'(\iota_g) d\theta \left( \frac{\partial \iota_g}{\partial \gamma} \right) \right) \times g(\theta_{\gamma l}) \big( \gamma + \nu_g(\iota_g) \big) \\
= &\left( g(\theta_{\gamma l}) + g(\theta_{\gamma l}) \nu_g'(\iota_g) \frac{\partial \iota_g}{\partial \gamma} \right) \times \left( \int_{\theta_{\gamma h}}^{1} s(\theta) \big( \sigma + \nu_s(\iota_s) \big) d\theta \right) \\
&+ \left( g'(\theta_{\gamma l}) \big( \gamma + \nu_g(\iota_g) \big) \frac{\partial \theta_{\gamma l}}{\partial \gamma} \right) \\
&\times \left( \int_{\theta_{\gamma h}}^{1} s(\theta) \big( \sigma + \nu_s(\iota_s) \big) d\theta + \int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta) \big( \gamma + \nu_g(\iota_g) \big) d\theta \right) \\
&- \left( \int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s'(\iota_s) d\theta \left( \frac{\partial \iota_s}{\partial \gamma} \right) \right) \times g(\theta_{\gamma l}) \big( \gamma + \nu_g(\iota_g) \big) > 0,
\end{aligned}
$$

where the inequality is true by $\frac{\partial \theta_{\gamma l}}{\partial \gamma} > 0$, $\frac{\partial \iota_g}{\partial \gamma} > 0$, and $\frac{\partial \iota_s}{\partial \gamma} < 0$ from Lemma 3. Q.E.D.

*Proof of Proposition 3.* Under the assumption that $\theta_{\gamma h}$ is exogenous, the endogenous variables $\iota_g$, $\theta_{\gamma l}$, $\iota_s$, and $\alpha$ are the solutions to

$$
\int_{0}^{\theta_{\gamma l}} g(\theta) \nu_g'(\iota_g) d\theta - 1 = 0
$$

$$
\frac{1}{2(h_g + \iota_g)} \frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta) d\theta}{\int_0^{\theta_{\gamma l}} g(\theta) d\theta} - \left[ \frac{1 - H_g(\gamma)}{h_g(\gamma)} \right] = 0
$$

$$
(1 - \alpha) \int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s'(\iota_s) d\theta - 1 = 0
$$

and

$$
\left[ \frac{1 - H_s(\sigma)}{h_s(\sigma)} \right] \int_{\theta_{\gamma h}}^{1} s(\theta) d\theta + \alpha \int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s'(\iota_s) d\theta \frac{\partial \iota_s}{\partial \alpha} = 0 \tag{A5}
$$

$$
\Leftrightarrow \left[ \frac{1 - H_s(\sigma)}{h_s(\sigma)} \right] - \frac{\alpha}{2(1 - \alpha)} \frac{1}{h_s + \iota_s} = 0. \tag{A5$'$}
$$

Equation (A5) differs from Equation (38) in that $\theta_{\gamma h}$ no longer depends on $\iota_s$. Equation (A5′) is obtained by using Equations (1) and (39). Totally differentiating with respect to $\gamma$, we have

$$
\begin{pmatrix}
\int_0^{\theta_{\gamma l}} g(\theta) \nu_g'' d\theta & g(\theta_{\gamma l}) \nu_g' & 0 & 0 \\
-\frac{1}{2(h_g + \iota_g)^2} \frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta) d\theta}{\int_0^{\theta_{\gamma l}} g(\theta) d\theta} & -\frac{1}{2(h_g + \iota_g)} \frac{g(\theta_{\gamma l}) \int_0^{\theta_{\gamma h}} g(\theta) d\theta}{\left( \int_0^{\theta_{\gamma l}} g(\theta) d\theta \right)^2} & 0 & 0 \\
0 & 0 & (1 - \alpha) \int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s'' d\theta & -\int_{\theta_{\gamma h}}^{1} s(\theta) \nu_s' d\theta \\
0 & 0 & \frac{\alpha}{2(1-\alpha)} \frac{1}{(h_s + \iota_s)^2} & -\frac{1}{2(1-\alpha)^2} \frac{1}{h_s + \iota_s}
\end{pmatrix}
$$

$$
\times \begin{pmatrix}
\frac{\partial \iota_g}{\partial \gamma} \\
\frac{\partial \theta_{\gamma l}}{\partial \gamma} \\
\frac{\partial \iota_s}{\partial \gamma} \\
\frac{\partial \alpha}{\partial \gamma}
\end{pmatrix}
=
\begin{pmatrix}
0 \\
\frac{\partial}{\partial \gamma} \left[ \frac{1 - H_g(\gamma)}{h_g(\gamma)} \right] - \frac{1}{2(h_g + \iota_g)} \frac{g(\theta_{\gamma h})}{\int_0^{\theta_{\gamma l}} g(\theta) d\theta} \frac{\partial \theta_{\gamma h}}{\partial \gamma} \\
(1 - \alpha) s(\theta_{\gamma h}) \nu_s' \frac{\partial \theta_{\gamma h}}{\partial \gamma} \\
0
\end{pmatrix}.
$$

By direct application of Cramer's rule, we have $\frac{\partial \iota_g}{\partial \gamma} > 0$, $\frac{\partial \theta_{\gamma l}}{\partial \gamma} > 0$, $\frac{\partial \iota_s}{\partial \gamma} < 0$, and $\frac{\partial \alpha}{\partial \gamma} < 0$. We then have $\frac{\partial}{\partial \gamma}\left(\frac{(1-\alpha)E}{\alpha E}\right) = -\frac{1}{\alpha^2}\frac{\partial \alpha}{\partial \gamma} > 0$. In a manner analogous to that in the proof of Proposition 2, we can show that $\frac{\partial}{\partial \gamma}\left(\frac{D}{E}\right) > 0$. Combining $\frac{\partial}{\partial \gamma}\left(\frac{D}{E}\right) > 0$ and $\frac{\partial \alpha}{\partial \gamma} < 0$ we obtain $\frac{\partial}{\partial \gamma}\left(\frac{D}{\alpha E}\right) > 0$. We note that $\frac{\partial}{\partial \gamma}\left(\frac{D}{(1-\alpha)E}\right)$ cannot be signed.

Now totally differentiating with respect to $\sigma$, we have

$$\begin{pmatrix} \int_0^{\theta_{\gamma l}} g(\theta)v_g'' d\theta & g(\theta_{\gamma l})v_g' & 0 & 0 \\ -\frac{1}{2(h_g+\iota_g)^2}\frac{\int_{\theta_{\gamma l}}^{\theta_{\gamma h}} g(\theta)d\theta}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta} & -\frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma l})\int_0^{\theta_{\gamma h}} g(\theta)d\theta}{\left(\int_0^{\theta_{\gamma l}} g(\theta)d\theta\right)^2} & 0 & 0 \\ 0 & 0 & (1-\alpha)\int_{\theta_{\gamma h}}^1 s(\theta)v_s'' d\theta & -\int_{\theta_{\gamma h}}^1 s(\theta)v_s' d\theta \\ 0 & 0 & \frac{\alpha}{2(1-\alpha)}\frac{1}{(h_s+\iota_s)^2} & -\frac{1}{2(1-\alpha)^2}\frac{1}{h_s+\iota_s} \end{pmatrix}$$

$$\times \begin{pmatrix} \frac{\partial \iota_g}{\partial \sigma} \\ \frac{\partial \theta_{\gamma l}}{\partial \sigma} \\ \frac{\partial \iota_s}{\partial \sigma} \\ \frac{\partial \alpha}{\partial \sigma} \end{pmatrix} = \begin{pmatrix} 0 \\ -\frac{1}{2(h_g+\iota_g)}\frac{g(\theta_{\gamma h})}{\int_0^{\theta_{\gamma l}} g(\theta)d\theta}\frac{\partial \theta_{\gamma h}}{\partial \sigma} \\ (1-\alpha)s(\theta_{\gamma h})v_s'\frac{\partial \theta_{\gamma h}}{\partial \sigma} \\ -\frac{\partial}{\partial \sigma}\left[\frac{1-H_g(\sigma)}{h_g(\sigma)}\right] \end{pmatrix}.$$

By direct application of Cramer's rule, we have $\frac{\partial \iota_g}{\partial \sigma} < 0$, $\frac{\partial \theta_{\gamma l}}{\partial \sigma} < 0$, and $\frac{\partial \iota_s}{\partial \sigma} > 0$. As regards $\frac{\partial \alpha}{\partial \sigma}$, we have

$$sign\left(\frac{\partial \alpha}{\partial \sigma}\right) = sign\left(-\frac{\partial}{\partial \sigma}\left[\frac{1-H_s(\sigma)}{h_s(\sigma)}\right](1-\alpha)\int_{\theta_{\gamma h}}^1 s(\theta)v_s'' d\theta - \frac{\alpha}{2(h_s+\iota_s)^2}s(\theta_{\gamma h})v_s'\frac{\partial \theta_{\gamma h}}{\partial \sigma}\right).$$

The expression in parentheses cannot be signed. It could conceivably be positive, negative, or zero. The same is therefore true of $\frac{\partial}{\partial \sigma}\left(\frac{(1-\alpha)E}{\alpha E}\right) = -\frac{1}{\alpha^2}\frac{\partial \alpha}{\partial \sigma}$. In a manner analogous to that in the proof of Proposition 2, we can show that $\frac{\partial}{\partial \sigma}\left(\frac{D}{E}\right) < 0$. However, our inability to sign $\frac{\partial \alpha}{\partial \sigma}$ implies the inability to sign $\frac{\partial}{\partial \sigma}\left(\frac{D}{\alpha E}\right)$ and $\frac{\partial}{\partial \sigma}\left(\frac{D}{(1-\alpha)E}\right)$. Nonetheless, we can conclude that $\frac{\partial}{\partial \sigma}\left(\frac{D}{\alpha E}\right) < 0$ when $\frac{\partial \alpha}{\partial \sigma} \geq 0$ and $\frac{\partial}{\partial \sigma}\left(\frac{D}{(1-\alpha)E}\right) < 0$ when $\frac{\partial \alpha}{\partial \sigma} \leq 0$. Q.E.D.

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