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ABSTRACT

In a corporate agency problem, perquisites and risk interact to produce novel, complex comparative statics. For example, even if additional debt induces risk-neutral insiders to increase risk, they never seek to increase the market value of their stock; instead, insiders decrease the present value of their subsequent, conditionally optimal perquisites. Also, the firm's optimal capital structure includes a risky bond with an agreement to remove insiders whenever the bond defaults. However, the optimal sharing rule between corporate claimants cannot be supported solely by standard securities such as bonds, stocks, options, and their hybrids.

AGENCY PROBLEMS PLAY A major part in much of modern corporate finance. Conflicts between competing corporate claimants help to explain not only the optimal mix of bonds and stock, but also the existence of many common corporate characteristics, including convertible securities, debt covenants, and public audits. In fact, much of the literature on agency in corporate finance follows from Jensen and Meckling [7].[1] Stripped to its barest elements, Jensen and Meckling's provocative argument runs roughly as follows. Insiders in firms financed with external debt optimally invest in excessively risky projects, whereas insiders in firms financed with external equity optimally consume excessive perquisites. Because outside investors anticipate these problems when purchasing corporate securities, insiders bear all agency costs in equilibrium. If insiders serve their personal interests, then they select a capital structure that compromises between the corporate agency costs of external debt and equity.

Not surprisingly, the impact on agency costs of both bonds and stock depends critically on corporate insiders' objective. Consider a firm that has just sold a bond and possibly also stock to finance its current investment. If managers maximize the market value of their personal stock, then they pick excessively risky projects but consume no perquisites. However, if managers maximize their expected personal utility from perquisites plus residual cash, then they consume excessive perquisites but pick projects of either excessive or insufficient risk. Here, this ambiguity about insiders' optimal risk follows from a surprisingly subtle relationship between perquisites and risk. With perquisites, insiders effectively have a contingent claim on corporate assets. Also, with concave utility for perquisites, this contingent claim has a nonlinear payoff. As a result, raising the firm's risk can either increase or decrease the personal value of insiders' claim, depending on the values of outsiders' bonds and stock. Moreover, the relationship

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[1] Closely related work includes that of Barnea, Haugen, and Senbet [1], Green [2], Marcus [8], Myers [11], and Townsend [14].

between perquisites, risk, and capital structure is further complicated by the contractual agreement for removing insiders, contingent possibly on corporate default.

As shown in this paper, the comparative statics for corporate risk with respect to external debt and equity can differ dramatically from familiar results. Assume, as in Jensen and Meckling [7], that insiders consume all perquisites after observing the outcome from current corporate investments. Also, assume that outsiders cannot remove insiders quickly enough to preclude all prior perquisites. In this case, additional debt induces insiders to increase risk only if outsiders hold sufficiently few of the firm's securities. However, even if insiders increase risk, they never act to decrease the market value of outsiders' bonds. Instead, insiders seek solely to reduce the present value of their subsequent, conditionally optimal perquisites. Here, this seemingly strange behavior is optimal because insiders' perquisites are excessive at the margin whenever the firm has outstanding external debt. In other cases, other complications arise.

The above analysis avoids a still more fundamental question. In a corporate agency problem, what is the optimal sharing rule between insiders and outsiders? Specifically, can this sharing rule be supported solely by standard securities, such as bonds, stocks, and options? Surprisingly, as shown in this paper, the optimal capital structure always includes a risky bond with an agreement to remove insiders whenever the bond defaults. However, the optimal contractual distribution cannot be supported solely by conventional securities, even when all investors are assumed to be risk neutral. Surprisingly, this follows solely from insiders' concave utility for perquisites. Here, strict concavity is critical; if insiders' utility is linear, then risky debt is the only optimal corporate security.[2]

Indeed, perquisites appear to be the culprit. As long as capital structure affects insiders' compensation and thereby their optimal perquisites, standard securities cannot support the optimal contractual distribution. However, if insiders' perquisites are independent of their firm's capital structure, then, under the same assumptions, standard securities are uniquely optimal.[3] This result can be interpreted as follows. For large firms in which insiders hold a negligible fraction of all corporate securities, capital structure need not affect their compensation—wages, bonuses, and options—and thereby their perquisites. In this case, capital structure is best viewed as a contract, not between insiders and outsiders, but between competing groups of external claimants.

The model is specified in Section I. Initially, insiders select the corporate sharing rule that maximizes their expected personal benefit, subject to a financial constraint and incentive-compatibility conditions. Next, insiders raise capital from outsiders and then invest privately in their firm's portfolio of projects. After one period, insiders observe their firm's final value, consume perquisites, and then report the residual to outsiders. Here, several assumptions greatly simplify

[2] In a firm with inadequate internal accounting controls—for example, a cash business—insiders can steal corporate assets. In this case, insiders' marginal rate of substitution between perquisites and cash equals one, generating a linear utility function. In a problem with a single time period, if outsiders hold any securities other than a bond, then insiders almost never report truthfully their firm's final value. Instead, they steal all corporate assets. See Townsend [14].

[3] See Williams [15].

the analysis. In a single-period agency problem, insiders act only for personal gain. Also, all investors are risk neutral, whereas insiders' utility is strictly concave in perquisites.

Sections II and III contain all results. In Section II, comparative statics are computed for insiders' optimal risk, conditional on arbitrary combinations of corporate debt and equity. Properties of the optimal capital structure are identified in Section III, discussed in Section IV, and summarized in Section V. All technical details appear in the Appendix.

I. The Model

Consider a representative firm that lasts for one period. Initially, its insiders—the senior managers and board of directors—identify potentially profitable projects, contribute all possible personal capital, K, and then raise the additional funds $I - K$ by selling securities to outside investors.[4] Next, insiders invest I in the firm's portfolio of projects, collectively characterized by the risk r. Just as in Jensen and Meckling [7], outsiders can observe the total investment I but not its allocation among projects, and thereby not the risk r. Also as in Jensen and Meckling, insiders invest all corporate capital I in the portfolio of projects and then consume any perquisites from the subsequent cash inflow.[5] Here, however, insiders' capital K and the firm's total investment I are exogenous. Because outsiders observe both K and I, endogenizing either adds no novel results and only complicates the subsequent analysis.

After one period, all uncertainty is resolved and the firm is liquidated. From its portfolio of projects, the firm realizes the risky final value x. All investors are risk neutral; all cash flows are free of taxes and transaction costs; and the probability distribution of the firm's final value is common knowledge. In this case, all investors initially value a firm's securities using the same distribution function for its risky final value x. Conditional on the corporate risk r, this distribution is denoted by $F(\cdot \mid r)$ and its associated density by $f(\cdot \mid r)$. The support of this distribution $[0, X]$ is independent of the risk r.[6] Also, to simplify the subsequent notation without substantive loss in generality, the riskless rate of interest is set equal to zero. Given these assumptions, the firm has the initial market value:

[4] In this model, all investors are risk neutral, and the capital market is perfectly competitive. In this case, investors either prefer to contribute no personal capital or have no incentive not to contribute all personal capital. Also, insiders' returns weakly dominate outsiders' returns. Therefore, if the firm finances its project partly by selling securities in the capital market, then insiders contribute all possible personal capital.

[5] In Jensen and Meckling [7], Figure 1, the production possibility frontier between the firm's market value and the market value of managers' expenditures on nonpecuniary benefits is linear with a slope of -1. This has two possible interpretations. First, managers consume all perquisites from subsequent cash inflows, as assumed in the text. Second, managers consume at least some perquisites from funds allocated to initial investment, and all projects have zero net present value. However, the latter condition is inconsistent with Jensen and Meckling's argument in Figure 2.

[6] This precludes a forcing contract, which can resolve the agency problem costlessly. Here, forcing contracts are also constrained by limited liability.

$$E(x \mid r) = \int_0^X [1 - F(x \mid r)]\, dx. \tag{1}$$

In (1), the conditional mean $E(x \mid r)$ is calculated using integration by parts.

Risk and return are related. In particular, the firm's conditional distribution F has the form:

$$F(x \mid r) = G[x \mid M(r), r], \tag{2}$$

where M represents the relationship between risk r and the measure of return $m = M(r)$. In (2), larger values of m produce first-order stochastically dominant distributions G:

$$G_m(x \mid m, r) < 0, \tag{3}$$

for all $0 < x < X$. In the statistical sense, larger values of m are good news.[7] By contrast, greater risk r produces second-order stochastically dominated distributions G:

$$\int_0^x G_r[x \mid M(r), r] \geq 0, \tag{4}$$

with an equality if and only if $x = X$. Here, larger values r represent mean-preserving spreads.[8] In addition, the risk-return relationship M is strictly concave: $M'' < 0$. Finally, to ensure that insiders' problem of controlling the corporate risk r has a unique, interior maximum, suppose that the conditional distribution F satisfies[9]

$$F_{rr} > 0, \qquad F_r(\cdot \mid 0) < 0 < F_r(\cdot \mid \infty), \tag{5}$$

for $0 < x < X$.

The contract between corporate claimants can include an allocation of cash to outsiders plus a provision for firing insiders. Only insiders see the firm's final value x. After observing x, insiders report to outsiders some feasible value y: $0 \leq y \leq X$. If insiders' report y at least equals the contractual payout p, then insiders immediately pay p to outsiders, retain their positions, and consume the perquisites $c \equiv x - y$. Next, insiders liquidate the firm, distribute to outsiders the additional cash $D(y) - p$, and then retain all residual cash $y - D(y)$. Also, this contractual distribution function D limits the liability of both insiders and outsiders: $0 \leq p \leq D(y) \leq y$. By contrast, if insiders report a terminal value y below the prior payout p, then they immediately forfeit their positions and thereby their perquisites. In this second case, outsiders acquire the firm, liquidate its assets, and realize the terminal value x. As a result, insiders neither consume

[7] See Milgrom [9].

[8] See Rothschild and Stiglitz [13].

[9] This avoids the problem studied in Mirrles [10] and Grossman and Hart [3]. To verify this, apply Mirrles' Theorem 2 to problem (22) through (25). Also, (5) holds if the conditional distribution G is weakly convex in both m and r, and the risk-return relationship M has the corner conditions: $M'(0) = \infty$ and $M'(\infty) = -\infty$. In this case, only the convexity of the conditional distribution G, the concavity of the frontier M, and the corner conditions on M can preclude $M(r) = E(x \mid r)$.

perquisites nor receive residual cash. In this manner, outsiders can control insiders without directly monitoring their perquisites.[10]

This contract between insiders and outsiders can be characterized quite simply as follows. Conditional on the corporate value x, insiders consume the perquisites c satisfying $0 \le c \le \max(x - p, 0)$. Immediately thereafter, outsiders receive their contractual share:

$$S(x, y) = \begin{cases} x & 0 \le x < p \\ D(y) & p \le x \le X. \end{cases} \tag{6}$$

Finally, insiders receive their residual share $y = S(x, y)$. In (6), the sharing rule S is determined by both the prior payout p and the contractual distribution D. Unlike previous papers on agency in corporate finance, the distribution function D need not be piecewise linear in the report y. In other words, the sharing rule S need not be supported solely by standard securities: bonds, stocks, options, and their hybrids. Instead, properties of insiders' optimal sharing rule S are identified in Section III.

Insiders consume perquisites solely for personal gain. Assuming that their firm has adequate internal accounting controls, insiders cannot steal corporate assets. Instead, to expropriate wealth they must exaggerate expenses, consume the excess internally as perquisites, and then suffer declining marginal utility. To model this phenomenon as simply as possible, represent by $U(c) + y - D(y)$ insiders' utility from consuming the perquisites c and then receiving the residual cash $y - D(y)$ under the contractual distribution D. Insiders' utility of perquisites U is increasing and strictly concave: $U' > 0 > U''$. Assuming that insiders can survive without perquisites, then their cardinal utility function U must satisfy $U(0) > -\infty$, which, when conveniently normalized, becomes $U(0) = 0$. Finally, for technical convenience the utility function U is twice differentiable on the entire real line.

As indicated, insiders' utility function is both linear in wealth and additively separable in perquisites and wealth. Here, this simple specification has several advantages. Under risk neutrality, all subsequent results follow solely from a surprisingly subtle relationship between perquisites and risk.[11] These results include not only novel comparative statics for risk and capital structure, but also surprising implications for the optimality of standard securities such as bonds, stocks, and warrants. Also, with additively separable preferences, insiders optimally consume perquisites before voluntarily distributing corporate cash. This both highlights the relationship between perquisites and risk and greatly simplifies the subsequent analysis. Here, additive separability is appropriate if and only if insiders' marginal rate of substitution between perquisites and cash is independent of cash.

Insiders always act to maximize their personal benefit, comprised of perquisites

[10] Insiders and outsiders always agree to costless monitoring. costly monitoring complicates the model somewhat but adds no new insights. Here, the simplest monitoring technology would preclude reported values y outside of some neighborhood of the true value x, with smaller neighborhoods produced by more intensive monitoring.

[11] Risk-averse agents behave quite differently. For example, extra debt may induce them to reduce corporate risk.

plus residual cash. Thus, after observing their firm's final value x, insiders consume the perquisites c, which solve the problem:

$$V(x) \equiv \max_c\{U(c) + x - c - S(x, x - c): 0 \leq c \leq \max(x - p, 0)\}. \quad (7)$$

Denote by $C(x)$ the solution to the perquisite problem (7). As in Jensen and Meckling [7], insiders consume their perquisites $C(x)$ after observing their firm's true value x. This specification differs from Holmström [5], in which insiders act privately for personal gain before observing their firm's final cash inflow.[12]

After raising all initial capital, insiders pick their firm's portfolio of projects. Only the total investment I, and not the mix of projects or, equivalently, the corporate risk r, is observable by outsiders. Consequently, insiders choose the risk R, which maximizes their personal welfare:

$$R \equiv \arg\max_{r \geq 0} \int_0^X V(x) f(x \mid r)\, dx. \quad (8)$$

In (8), the right side measures insiders' present value of future perquisites plus residual cash $V(x)$, given their optimal consumption $C(x)$ in (7). In other words, when choosing their optimal risk R, insiders rationally anticipate their subsequent, optimal consumption of perquisites $C(x)$, conditional on their firm's final value x.

Outsiders also rationally anticipate insiders' subsequent actions. When contributing initial capital, they anticipate insiders' subsequent selection of both risk and perquisites. Even though outsiders can observe neither the optimal perquisites $C(x)$ from (7) nor the optimal risk R from (8), they can anticipate both, given their complete knowledge of insiders' preferences and the firm's technology, and thereby correctly value all corporate securities. In a perfectly competitive capital market, investors then contribute the initial capital $I - K$ if and only if their contractual distribution D satisfies the financial constraint:

$$I - K = \int_0^X D[x - C(x)] f(x \mid R)\, dx. \quad (9)$$

As indicated in (9), outsiders calculate the present value of their future distribution D conditional on insiders' optimal consumption function C, corporate risk R, and announced investment I.

Initially, insiders anticipate both their subsequent selection of perquisites and risk, and outsiders' rational reaction. Conditional on these correct beliefs, insiders pick the prior payout p and contractual distribution D that maximize their personal welfare. Specifically, insiders solve the agency problem:

$$\max_{p,D} \int_0^X V(x) f(x \mid R)\, dx, \quad (10)$$

subject to the limited-liability constraint $0 \leq p \leq D \leq y$, the perquisite problem (7), the optimal risk (8), and the financial constraint (9).

[12] This distinction between private action, before and after the resolution of uncertainty, is developed in Harris and Raviv [4].

II. Perquisites and Risk

The solution to the previous agency problem has some surprising properties. In part, these properties can be illustrated and the subsequent solution motivated by computing insiders' optimal perquisites and risk, for a fixed prior payout p and contractual distribution D. Moreover, to compare the conclusions with standard results in corporate finance, the contractual distribution function D must be supported by a bond and stock:

$$D(y) = \min(b, y) + a \max(y - b, 0). \tag{11}$$

In (11), outsiders realize $\min(b, y)$ from a bond with the promised payment b at maturity and $a \max(y - b, 0)$ from their fraction a of the firm's stock. Given the distribution (11), no additional generality is lost by requiring that the prior payout p not exceed principal plus interest on debt b: $p \leq b$. In other words, outsiders can fire insiders only if their firm bankrupts. This contract is consistent with Jensen and Meckling [7].

The analysis begins with perquisites. Conditional on the fraction of external equity a, promised payment on debt b, prior payout p, and realized corporate value x, insiders solve problem (7) and optimally consume the perquisites:

$$C(x) = \begin{cases} 0 & 0 \leq x < p \\ x - p & p \leq x < d^* \\ c^* & d^* \leq x \leq X. \end{cases} \tag{12}$$

With insiders' additively separable preferences in (7), their optimal consumption $C(x)$ precedes all contractual distributions other than the prior payout p. In (12), the critical consumption c^* satisfies

$$U'(c^*) = 1 - a, \tag{13}$$

with $c^* > 0$. Also, the optimal default point on debt d^* satisfies

$$U(d^* - p) = U(c^*) + (1 - a)(d^* - b - c^*), \tag{14}$$

with $d^* = b + c^*$ when $b = p$, and $d^* > b + c^*$ when $b > p$. After consuming the perquisites (12), insiders liquidate the firm, distribute to outsiders the contractual cash $D[x - C(x)]$ from (11), and then retain the residual $x - D[x - C(x)]$. For insiders, this yields in (7) the total benefit:

$$V(x) = \begin{cases} 0 & 0 \leq x < p \\ U(x - p) & p \leq x < d^* \\ U(c^*) + (1 - a)(x - c^* - b) & d^* \leq x \leq X. \end{cases} \tag{15}$$

Both external debt and equity alter insiders' consumption of perquisites. To see this, consider first the simplest case, $b = p$, in which the promised payment on debt b equals the prior payout p. With $b = p$, so that $d^* = b + c^*$ from (14), insiders consume perquisites in (12) until their marginal utility $U'(c^*)$ in (13) equals their fraction of internal equity $1 - a$. See Figure 1. Given $U'' < 0$, larger fractions of external equity a then induce insiders to consume extra perquisites, exactly as in Jensen and Meckling [7]. By contrast, additional debt forces insiders to decrease their perquisites. In particular, with $b = p$, the firm's final value to insiders effectively becomes $x - b$, so that their optimal consumption function (12) takes the form $C(a, x - b)$, with C increasing in both a and $x - b$.

This solution changes dramatically if insiders do not always lose their positions and thereby their perquisites when their firm bankrupts. If the promised payment on debt b exceeds the prior payout p, then some perquisites can precede principal plus interest on debt. In this case, if the firm sells some bonds, $b > 0$, then insiders optimally exploit their partial priority of perquisites and consume extra perquisites with additional debt—at least in some future states. As shown in Figure 2, for all final values of the firm x satisfying $c^* < x < d^*$, insiders' benefit $U(x - p)$ from consuming everything above the prior payout p, $C(x) = x - p$, exceeds their total benefit from consuming only c^*, reporting $x - c^*$, and receiving $(1 - a)(x - b - c^*)$. Only when the firm's final value x reaches d^* do insiders optimally consume c^*, report $x - c^*$, and receive their residual, contractual cash. In fact, the critical value d^* not only exceeds the optimal consumption c^*, but

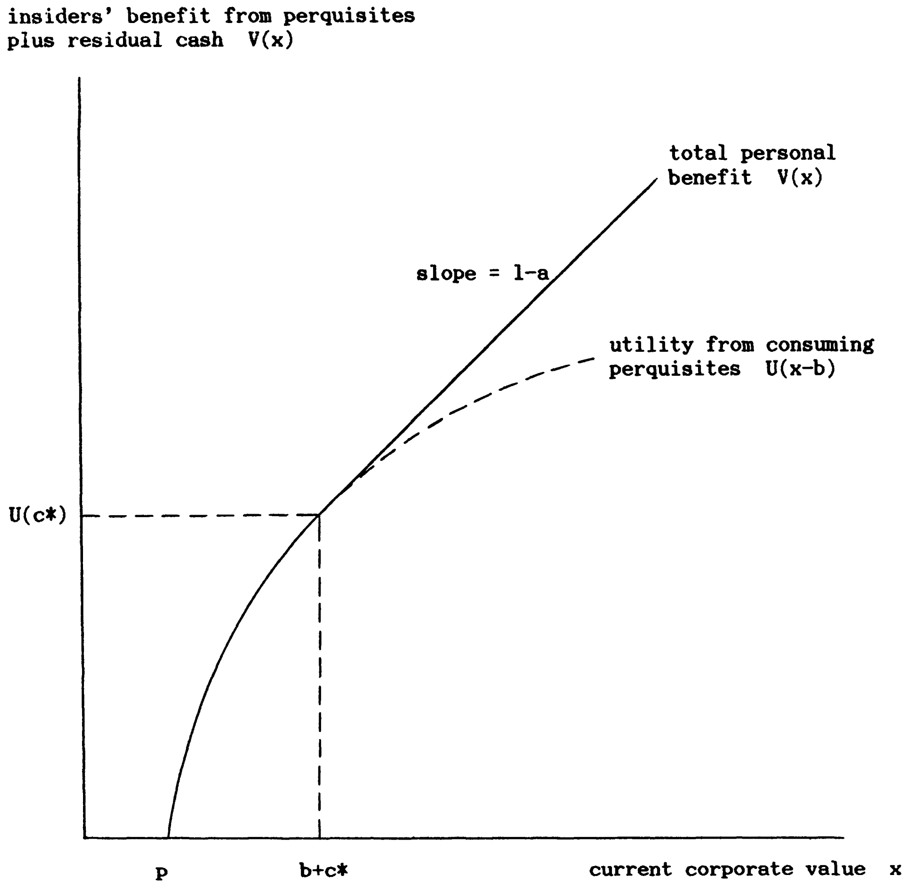

Figure 1. Insiders' benefit from optimally consuming perquisites and realizing residual cash when $p = b$. Conditional on the fraction of external equity a, promised payment on debt b, prior payout p, and current corporate value x, insiders optimally consume the perquisites $C(x)$ and thereby realize the personal benefits $V(x)$ from both perquisites and residual cash along the solid line in the figure.

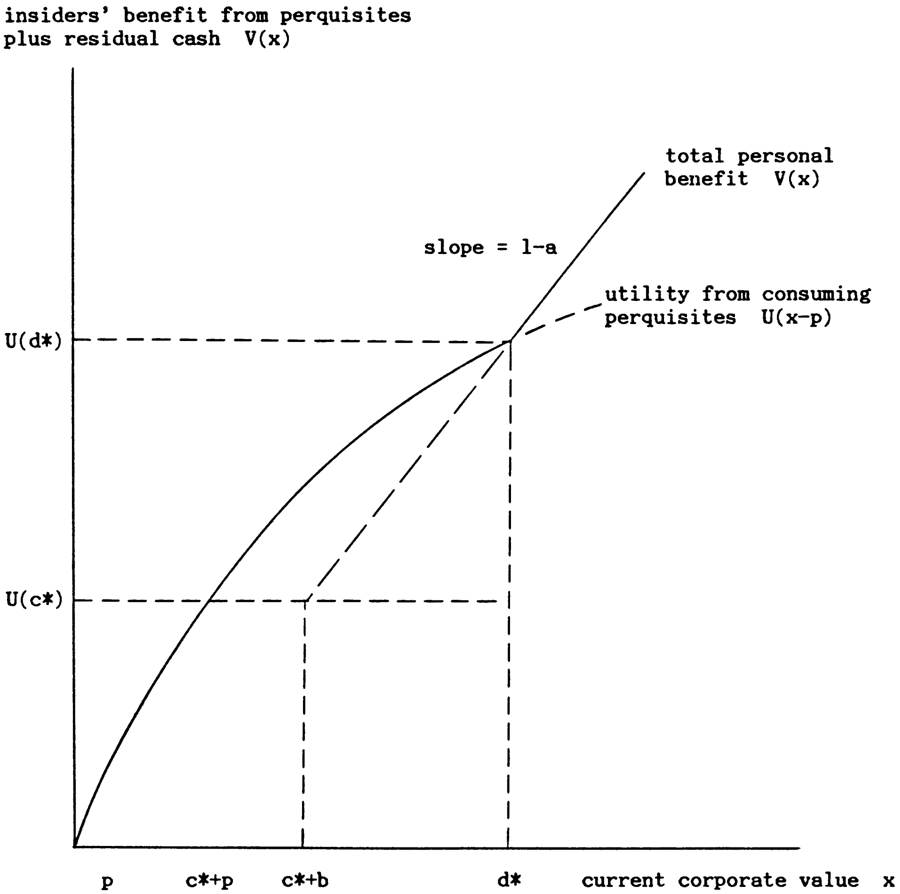

Figure 2. Insiders' benefit from optimally consuming perquisites and realizing residual cash when $0 \leq p < b$. Conditional on the fraction of external equity a, promised payment on b, prior payout p, and current corporate value x, insiders optimally consume the perquisites $C(x)$ and thereby realize the personal benefits $V(x)$ from both perquisites and residual cash along the solid line in the figure.

also increases with both larger fractions of external equity a and larger promised payments b.

Conditional on the contract with outsiders, insiders pick their firm's portfolio of projects and thereby its corporate risk. To compute this risk, insert (15) into (8), integrate by parts, and apply (14). This produces the problem:

$$R(a, b, p) \equiv \operatorname{argmax}_{r \geq 0} \left\{ \int_p^{d^*} U'(x - p)[1 - F(x \mid r)]\, dx \right.$$

$$\left. + (1 - a) \int_{d^*}^{X} [1 - F(x \mid r)]\, dx \right\}. \quad (16)$$

Given the fraction of external equity a, the promised payment on debt b, and the prior payout p, insiders' problem (16) has a unique solution, the conditionally optimal risk $R(a, b, p)$. In general, this risk differs from the risk R^*, which uniquely maximizes the firm's market value $E(x \mid r)$ in (1).

In this problem with both perquisites and risk, insiders do not always pick excessively risky projects. Most notably, the value-maximizing risk R^* can exceed the conditionally optimal risk $R(a, b, p)$, in part because the risk R^* exceeds, as shown in the Appendix, the Pareto-optimal risk $R(0, 0, 0)$ from (16). This latter risk maximizes the present value of insiders' perquisites plus residual cash in (16), given no external financing. Without external financing, perquisites always produce greater marginal utility than terminal cash, so that insiders optimally consume all perquisites before distributing any cash. Anticipating this, insiders initially reduce risk, $R(0, 0, 0) < R^*$, and thereby protect their more valuable, prior perquisites.

The interaction between perquisites and risk is surprisingly subtle. To see this, compute the comparative statics from the first-order conditions associated with (16):

$$R_a = \frac{1}{H}\left[(d^* - b - c^*)F_r(x^* \mid R) + \int_{d^*}^{X} F_r\,dx\right], \tag{17}$$

$$R_b = \frac{1}{H}(1 - a)F_r(d^* \mid R), \tag{18}$$

and

$$R_p = \frac{1}{H}\left[U'(0)F(p \mid R) - U'(d^* - p)F_r(x^* \mid R) + \int_{p}^{d^*} U'' F_r\,dx\right], \tag{19}$$

with

$$H \equiv \int_{p}^{d^*} U' F_{rr}\,dx + (1 - a)\int_{d^*}^{X} F_{rr}\,dx > 0 \tag{20}$$

from (7).

To interpret these complex comparative statics, focus first on the effects of external equity. In (17), there are two terms: the impact of extra external equity a on insiders' conditionally optimal risk $R(a, b, p)$ through the optimal default point d^* in the first term and insiders' equity relative to their perquisites plus equity in the second term. In general, either term can have either sign. Only in special cases is the sign of (17) unambiguous. For example, if the prior payment p equals the promised payment on debt b and the firm then has sufficiently little debt outstanding, then, as verified in the Appendix, insiders optimally reduce risk with extra external equity: $R_a < 0$. As shown subsequently, none of these properties appears in the more familiar model without perquisites.

Next, consider the comparative statics for outside debt. In (18), the conditionally optimal risk $R(a, b, p)$ can either increase or decrease in the promised payment b—again unlike the more familiar model without perquisites. To see this, imagine initially that outsiders cannot remove insiders quickly enough to preclude all prior perquisites, so that the prior and promised payments satisfy p

$< b$. In this case, insiders reduce risk with additional debt, $R_b < 0$, whenever the firm has outstanding sufficient securities so that insiders' optimal default point d^* from (14) exceeds the firm's initial value (1). Moreover, even if insiders increase risk, they never seek to decrease the market value of outsiders' debt. Instead, they act solely to decrease the present value of their subsequent, conditionally optimal perquisites. In (12), insiders optimally consume all their perquisites before voluntarily reporting any residual cash. Thus, whenever $F_r(d^* \mid R) > 0$, additional risk reduces insiders' prior consumption of perquisites. In this case, insiders optimally increase risk with additional debt and subsequently consume less perquisites. Here, this seemingly strange behavior is optimal because insiders' conditionally optimal perquisites are excessive at the margin, as previously illustrated in Figure 2.

The comparative statics for debt become even more complicated if bondholders can remove insiders sufficiently quickly to preclude all prior perquisites. In this case, the prior payment p equals the promised payment on debt b. With $b = p$ for all promised payments on debt b, the comparative statics for debt become $R_b + R_p$. As indicated in (18) and (19), this sum is a complex expression with a sign that can be either positive or negative.

These comparative statics differ dramatically from the more familiar properties without perquisites. To see this, temporarily ignore perquisites and compute the risk that maximizes the market value of insiders' stock. This conditionally optimal risk $R^1(b)$ solves the problem:

$$\max_{r \geq 0} \left\{(1 - a) \int_b^X [1 - F(x \mid r)]\, dx\right\}, \tag{21}$$

again using integration by parts. Clearly, the risk $R^1(b)$ does not depend on either the fraction of external equity a or the prior payout p. Also, from the first-order conditions associated with (21), this risk increases almost everywhere in the promised payment on debt b.[13] These comparative statics differ from (17) through (19) because previously, perquisites and risk interacted to affect the implications of agency costs for different capital structures.

The previous results also differ from a model in which insiders consume their perquisites from the firm's initial investment rather than its subsequent cash inflows. In this case, the state-price distribution function F depends on both insiders' actual investment $I - c$ and the corporate risk r. Also, the prior payout p cannot constrain insiders' perquisites c, so that their actions can depend only on the fraction of external equity a and promised payment on debt b. Consequently, insiders consume the perquisites $C^2(a, b)$ and choose the corporate risk $R^2(a, b)$ that solve the problem:

$$\max_{c,r} \left\{U(c) + (1 - a) \int_b^X [1 - F(x \mid I - c, r]\, dx\right\}. \tag{22}$$

Depending on the sign of the partial derivative $\partial^2 F/\partial(I - c)\partial r$, the comparative statics for the conditionally optimal consumption $C^2(a, b)$ and risk $R^2(a, b)$ can

[13] With a non-negative interest rate, the promised payment on the bond b must satisfy $b \leq E(x \mid r)$. Thus, (22) is positive everywhere except at $b = E(x \mid r)$.

either replicate or not replicate the previous results. In particular, if this derivative is zero, then insiders consumption C^2 is increasing in both the external equity a and the promised payment b, while the firm's risk R^2 is independent of a but increasing in b. Alternatively, if the derivative is nonzero, then the comparative statics are more complicated. For example, the optimal consumption C^2 is increasing in the fraction a if the derivative is positive but decreasing if the derivative is negative.

How can these results be interpreted? Given that ex ante and ex post perquisites interact differently with debt and equity, which type of consumption affects observed capital structures? In practice, probably both do. Even if perquisites are financed completely from funds allocated to current investment, optimal perquisites are influenced by cash inflows from previous investments. That is, in a multiperiod problem, ex ante perquisites financed from current investment are ex post from the perspective of previous periods. Here, this holds not only for managerial compensation, such as luxury offices and company cars, but also for potentially more costly perquisites, such as suboptimal organizational structures and production functions. For example, managers may expand their personal power by excessively extending their span of control. Alternatively, managers may enhance their personal reputations by producing a prestigious line of products or investing excessively in, say, product safety and pollution control. Clearly, managers make these decisions conditional on both the returns realized from past investments and the possible returns from current investments.

III. Optimal Capital Structure

As shown in the previous section, the interaction between perquisites and risk produces novel comparative statics for the insiders' optimal risk. However, these results reveal nothing about a firm's optimal capital structure. Most importantly, the optimal capital structure may not consist solely of the securities on which the previous comparative statics depend. In fact, the optimality of standard securities—bonds, stocks, options, and their hybrids—has largely been ignored in the expanding literature on corporate agency problems.[14]

Accordingly, the problem posed in Section I is now analyzed. The analysis has two steps. First, the original agency problem of maximizing (10), subject to (7), (8), and (9), is shown to be equivalent to a second, simpler problem without the perquisite problem (7).[15] Next, properties of the solution to this second problem are identified using standard methods of optimal control. In this latter problem, insiders initially select a prior payout p and a consumption function C or, equivalently, a reporting rule Y, with $Y(x) \equiv x - C(x)$, to maximize the present value of their perquisites plus wealth in (10), subject to all constraints but (7). Also, insiders support this selection with a distribution function D that solves the perquisite problem (7).

The equivalent agency problem is derived in the Appendix. In this second,

[14] Exceptions include Townsend [14] and Williams [15].

[15] This solution technique is familiar from the literature on bargaining with asymmetric information—for example, Myerson and Satterthwaite [12] and the references cited therein.

simpler problem, insiders pick the prior payout p and reporting rule Y that solve

$$\max_{p,Y} \int_p^X U'(1 - F)\, dx, \tag{23}$$

subject to

$$I - K \leq pF(p \mid R) - \int_0^p F\, dx + \int_p^X [(U + Y)f - U'(1 - F)]\, dx, \tag{24}$$

$$0 = \int_p^X U'F_r\, dx. \tag{25}$$

Also, the reporting function Y must be nondecreasing in the true value x, with the corner conditions: $Y(p) = p \geq 0$ and $Y(X) \leq X$. In sequence, (23) through (25) follow from the previous maximand (10), the financial constraint (9), and the first-order condition for insiders' optimal risk (8). In other words, insiders initially act to maximize their expected gain, subject to a financial constraint and incentive-compatibility conditions. To support this solution, insiders must then choose a contractual distribution D such that the resulting report $Y(x)$ solves the perquisite problem (7). Here, the monotonicity of the reporting rule Y holds if and only if there exists a distribution function D satisfying the second-order condition for (7).

As previously indicated, the solution to this second problem is easily characterized using standard methods of optimal control. In turn, this characterization produced two propositions containing the economically significant properties of the solution. The proofs of both propositions appear in the Appendix.

PROPOSITION 1: *The optimal solution to the agency problem* (23) *through* (25) *yields less utility for insiders than the Pareto-optimal solution whenever* $K < I$. *The latter solution is characterized by the corporate risk* $R = R(0, 0, 0)$ *and consumption of perquisites*:

$$C(x) = \begin{cases} x & 0 \leq x < x^* \\ x^* & x^* \leq x \leq X, \end{cases} \tag{26}$$

with $U'(x^*) = 1$.

As indicated in Proposition 1, no sharing rule between corporate claimants can induce insiders to pick the Pareto-optimal perquisites and risk whenever the firm sells securities to new investors.[16] The intuition behind this result is simple. Because the corporate cash inflows can equal zero and all feasible securities must satisfy limited liability, the firm cannot issue riskless debt. Consequently, any sharing rule S that supports the Pareto-optimal risk $R(0, 0, 0)$ from (16) and the corresponding consumption function C from (26) also violates the financial constraint (24) whenever $K < I$. In fact, as verified in the Appendix, any sharing rule that supports the first-best consumption violates the financial constraint.

[16] This contrasts with the conclusion in Barnea, Haugen, and Senbet [1], in part because their insiders consume all perquisites ex ante from funds allocated to corporate investment.

What are some properties of the second-best sharing rule? Does this sharing rule include a prior payout p? Also, is the optimal distribution function D continuous and piecewise linear in the report y, like (11)? In other words, do agency costs induce insiders to sell only conventional securities, such as bonds, stocks, options, and their hybrids? These questions are answered in the second proposition.

PROPOSITION 2: *The optimal prior payout p is positive. Also, for almost all conditional distributions F, the optimal distribution function D is not continuous and piecewise linear in the report y.*

Given an agency problem, the optimal contract is supported partly by a risky bond, combined with a rule for removing insiders. On this bond with a promised payment equal to the prior payout p, outsiders realize $\min(p, x)$. Also, insiders lose their positions and thereby their perquisites whenever they declare the bond in default: $0 \leq y < p$. Here, the prior, promised payment $p > 0$ is optimal for the following reason. When outsiders buy risky securities, $K < I$, insiders bear all agency costs. Also, extra external securities impose on insiders additional agency costs. Hence, if outsiders buy risky securities and some security has no marginal agency costs, then insiders optimally sell more of that security. Because the firm's final value x has a lower bound at 0, independent of its risk r, increasing the prior payment p around $p = 0$ adds no agency cost. Therefore, the optimal prior payout p must be positive whenever the first-best solution is infeasible: $K < I$.

As indicated in Proposition 2, the optimal sharing rule between insiders and outsiders is not continuous and piecewise linear in the reported corporate value. Hence, it cannot be supported solely by standard securities, such as bonds, stocks, options, and their hybrids. Here, this essentially negative result holds despite the assumed risk neutrality of all investors; instead, it follows from insiders' concave utility of perquisites. With concave utility, insiders' optimal consumption function C is generally not piecewise linear in their firm's true value x. Consequently, this consumption function C cannot generally be supported in the perquisite problem (7) by a piecewise-linear distribution function D. Here, strict concavity is critical. With linear utility, outsiders buy only a corporate bond, because any other security induces insiders to steal corporate cash.

IV. Discussion

Because conventional securities support continuous and piecewise-linear sharing rules, this simple model of pure agency cannot explain observed capital structures. True, piecewise-linear payoffs can approximate nonlinear allocations; however, more accurate approximations require more kinks and therefore more contingent claims. More importantly, an argument based on approximations avoids a more fundamental problem: What conditions make piecewise-linear payoffs optimal as either exact or approximate solutions to the problem of optimal capital structure? Moreover, models that are inconsistent with observed corporate securities are unlikely to produce empirically accurate predictions about the optimal mix of those securities. In short, a theory of optimal corporate securities logically precedes a theory of optimal capital structure.

Perhaps piecewise-linear payoffs, as relatively simple sharing rules, economize on inside information. In practice, the prevalence of these simple sharing rules might reflect outsiders' inability to verify independently insiders' reports about their firm's true state. In fact, this argument appears in the closely related paper of Williams [15]. There, in an agency game with communication, piecewise-linear payoffs are shown to be uniquely optimal. Moreover, these sharing rules are supported by extremely simple capital structures, consisting solely of bonds and stock. Surprisingly, only two critical differences distinguish that model from this. There, insiders possess private information about their firm's current value, so that any credible report of this information, like announced earnings, must serve insiders' interests. Also, with the firm's current value computed net of insiders' perquisites, wages, bonuses, and other incentive compensation, capital structure becomes a contract between competing groups of external claimants, rather than a sharing rule between insiders and outsiders.

Surprisingly, this emphasis on competing groups of external claimants, in which perquisites are not linked to capital structures, is critical in corporate agency games with communication. To see this, modify the model in this paper as follows. Suppose that insiders do not liquidate their firm at time 1 immediately after observing its true value x, consuming the perquisites c, and reporting the residual $y = x - c$. Instead, imagine that insiders report some value z, possibly different from the true residual value y, distribute to outsiders the assets $D(y, z)$, and then continue to operate their firm for at least a short period of time. In general, the report z must be within some feasible neighborhood of the true residual value y. Also, as in Williams [15], the distribution $D(y, z)$ can come in the form of cash, securities, or other corporate assets and therefore can depend on both the true residual value y and insiders' contemporaneous report z through any contract that outsiders can enforce. As argued by Williams, these enforceable contracts must have the following form: $D(y, z) = A(z)y + B(y)$, where A and B are unspecified functions.

Despite these modifications, the results of Section III again apply. As verified in the Appendix, insiders' original agency problem is again equivalent to the second, simpler problem (23) through (25). In turn, this second problem again produces the previous results. In particular, the optimality of nonlinear contractual allocations follows, as before, from the strict concavity of insiders' utility for perquisites. Again, this concavity is critical; with linear preferences, the only optimal corporate security is a risky bond. In short, agency problems with perquisites appear not to explain the existence of standard corporate securities.

In corporate finance, agency games with communication or, equivalently, agency-signalling models have an additional advantage over pure agency models. Only models with communication can explain the announcement effects documented in so many event studies. In pure agency models, outsiders cannot observe insiders' private actions but can anticipate those actions given their complete knowledge of insiders' preferences and the firm's technology. When selling corporate securities, insiders anticipate outsiders' reaction, which insiders recognize in return, and so on. In short, insiders' optimal private actions are common knowledge. In pure agency models, this property permits outsiders to price all corporate securities but virtually precludes any announcement effects.[17] By contrast, announcement effects arise naturally as characteristics of separating equilibria in models with communication.

V. Summary

This paper has two separate sets of conclusions. First, for capital structures consisting solely of bonds and stock, the comparative statics for insiders' optimal corporate risk reflect a surprisingly subtle interaction between perquisites and risk. Also, the comparative statics depend critically on contractual agreements for removing insiders, contingent possibly on corporate default. Second, the optimal sharing rule is supported partly by a risky bond with an agreement to remove insiders if and only if the firm is bankrupt. However, the optimal contractual distribution is not continuous and piecewise linear; hence, it cannot be supported solely by conventional securities such as bonds, stocks, options, and their hybrids.

This paper leaves unanswered an interesting question. Given an agency problem with perquisites, under what conditions do standard securities support optimal sharing rules between competing groups of corporate claimants? Here, several approaches are promising. Perhaps, under some conditions, perquisites can be controlled through salaries and bonuses paid to insiders. In this case, the perquisite problem could be separated from the problem of controlling corporate assets, valued net of insiders' compensation plus perquisites. Alternatively, with additional private actions or multiple time periods, the optimal sharing rule might simplify significantly. In such cases, insiders' optimal incentive compensation might even be linear in their firm's current value, much as in Holmström and Milgrom [6].

Appendix

Verification of the Properties Cited in Section II

The Pareto-optimal risk $R(0, 0, 0)$ and the value-maximizing risk R^* have the relationship: $R(0, 0, 0) < R^*$. To show this, first note from (2) through (5) that the risk R^*, which maximizes the firm's market value (1), uniquely satisfies

$$0 = \int_0^X F_r \, dx \quad \text{and} \quad 0 = M'(R^*). \tag{A1}$$

By contrast, the Pareto-optimal risk $R(0, 0, 0)$ from (16) uniquely satisfies

$$0 = \int_0^{x^*} (U' - 1)F_r \, dx + \int_0^X F_r \, dx, \tag{A2}$$

[17] Possibly, announcement effects can reflect the resolution of uncertainty during the trading day on an actively traded stock. However, insiders and outsiders must be informed simultaneously. Also, insiders must act on their information immediately.

since $d^* = x^*$ with $U'(x^*) = 1$ from (13) and (14). Also, with $C(x) = x$ on $0 \le x \le c^*$ from (12) and (13), as well as $G_r(0 \mid r) = 0$, integration by parts yields

$$\int_0^{x^*} (U' - 1)F_r\, dx = M' \int_0^{x^*} (U' - 1)G_m\, dx - \int_0^{x^*} U'' \int_0^{x} G_r\, dz\, dx$$

$$> M' \int_0^{x^*} (U' - 1)G_m\, dx, \tag{A3}$$

where the inequality follows from (5) and $U'' < 0$. If $R(0, 0, 0) \ge R^*$, then (A1) and $M'' < 0$ require that $M'(R) \le 0$, so that (12), (13), and $U'' < 0$ ensure that $U' \ge 1$ on $0 \le x \le x^*$. In this case, (3) and (A3) force the first term in (A2) to be positive. However, if $R(0, 0, 0) \ge R^*$, then (5) and (A1) also require the second term in (A2) to be positive, forcing the first term in (A2) to be negative. This contradiction completes the proof.

Also, insiders' optimal risk $R(a, b, p)$ decreases in the fraction of external equity a whenever $b = p$ and $b \approx 0$. To show this, note that if $r < R^*$ and $d^* < X$, then (3) through (6) and (A1) imply that

$$\int_{d^*}^{X} F_r\, dx < M' \int_{d^*}^{X} G_m\, dx < 0.$$

Because $d^* = b + c^*$ from (14) when $b = p$, then $R(a, p, p) < R^*$ ensures that $R_a(a, p, p) < 0$ in (17). Given $R(0, 0, 0) < R^*$ from above, (17) must be negative if $b = p$ and $0 \le p < \epsilon$ with some $\epsilon > 0$.

Derivation of Problem (23) through (25)

First, for notational convenience, rewrite the perquisite problem (7) as follows:

$$V(x) = \max_y\{U(x - y) + y - D(y) \colon p \le y \le x\}, \tag{A4}$$

for all $p \le x \le X$. Denote the solution to (A4) by the optimal report: $y_i = Y(x_i)$, with $Y(x) \equiv x - C(x)$, $0 \le x \le X$. For all $p \le y_i \le X$, (A4) requires that

$$\begin{aligned} V(x_1) &= U(x_1 - y_1) + y_1 - D(y_1) \\ &\ge U(x_1 - y_2) + y_2 - D(y_2), \\ V(x_2) &= U(x_2 - y_2) + y_2 - D(y_2) \\ &\ge U(x_2 - y_1) + y_1 - D(y_1). \end{aligned}$$

Together, these inequalities imply that

$$U(x_2 - y_1) - U(x_1 - y_1) \le V(x_2) - V(x_1) \le U(x_2 - y_2) - U(x_1 - y_2). \tag{A5}$$

Choosing $x_1 < x_2 < x_1 + \epsilon$ for some small $\epsilon > 0$ gives

$$U'(x_1 - y_1)(x_2 - x_1) \le V(x_2) - V(x_1) \le U'(x_1 - y_2)(x_2 - x_1). \tag{A6}$$

In turn, (A6) has two implications. With $U'' < 0$, the optimal reports y_1 and

y_2 must then satisfy $y_1 \le y_2$. Because this must be true for all feasible x_1,

$$Y \quad \text{is nondecreasing} \tag{A7}$$

on $p \le x \le X$. Also, the solution to (7) requires that $Y(x) = x$ and $V(x) = 0$ on $0 \le x \le X$. Letting $\epsilon \to 0$ in (A6) then yields

$$V(x) = \int_p^x U'[z - Y(z)]\, dz \tag{A8}$$

on $p \le x \le X$, with integrability ensured by (A7).

To derive the maximand in (23), integrate (10) by parts and apply (A8). Similarly, for the financial constraint (24), insert $D(Y) = U(x - Y) + Y - V$ from (7) into (9), integrate by parts, and again apply (A8). Finally, for the incentive-compatibility condition (25), integrate the maximand in (8) by parts, apply (A8), and compute the first-order condition. Given (5) and $U' > 0$, the first-order condition (25) uniquely characterizes the solution to (8).

Conversely, given problem (23) through (25) and the resulting reporting rule Y, the distribution function D need only solve the perquisite problem (7). For all $0 \le x_1 \le x_2 \le X$, the monotonicity condition (A7) and $U'' < 0$ ensure that

$$\int_{x_1}^{x_2} U'(z - y_1)\, dz \le \int_{x_1}^{x_2} U'[z - Y(z)]\, dz \le \int_{x_1}^{x_2} U'(z - y_2)\, dx.$$

When combined with the envelope condition (A8), these inequalities imply (A5). In turn, (A5) implies (A4):

$$\begin{aligned} V(x_1) &- [U(x_1 - y_2) + y_2 - D(y_2)] \\ &= [V(x_1) - V(x_2)] + [U(x_2 - y_2) - U(x_1 - y_2)] \\ &\ge [U(x_2 - y_2) - U(x_1 - y_2)] + [U(x_2 - y_2) - U(x_1 - y_2)] \\ &= 0. \end{aligned}$$

Proof of Proposition 1

If the first-best solution is feasible, then the optimal consumption function C is (26), as verified from (12) and (13) with $a = b = p = 0$. In this case, the envelope condition (A8) simplifies to

$$V(x) = U(x^*) + x - x^*,$$

for all $x^* \le x \le X$. To support this solution, the distribution function D and the optimal consumption function C must satisfy (A4):

$$V(x) = U(x^*) + x - x^* - D(x - x^*),$$

for all $x^* \le x \le X$. However, this requires that $D(y) = 0$ for all $0 \le y \le X - x^*$. Thus, the first-best solution violates the financial constraint (24) whenever $K < I$.

Proof of Proposition 2

Add to problem (23) through (25) the control variable k, with the constraint $0 \le k \le K$. This problem has the Lagrangian:

$$L \equiv \int_p^X U'(1-F)\,dx - k + \lambda\{pF(p\mid R) - \int_0^p F\,dx +$$

$$\int_p^X [(U+Y)f - U'(1-F)]\,dx - (I-k)\} + \mu \int_p^X U'F_r\,dx, \qquad \text{(A9)}$$

with the constants λ and μ. Given (5), maximizing (A9) is equivalent to solving (23) through (25), subject to (A7) and $0 \le Y(x) \le x$.

As assumed in the text, insiders optimally contribute all possible personal capital K. Here, this requires that $0 < L_k = \lambda - 1$. Because $F_r(0\mid R) = 0$, $U(0) = 0$, and $Y(0) = 0$, the Lagrangian (A9) then has at $p = 0$ the partial derivative:

$$L_p = U'(0)(\lambda - 1)[1 - F(p\mid R)] > 0.$$

In this case, the optimal solution must satisfy $p > 0$.

To complete the proof, suppose that the optimal distribution function D is piecewise linear. In this case, the solution to (A4) satisfies either $Y(x) \in \{0, X\}$ everywhere or $Y(x) = x - \eta$ on some interval. Consider first any interval on which $Y(x) = x - \eta$. Here, the solution satisfies both the monotonicity condition (A7) and the first-order condition $0 = L_Y$ from (A9). Fix the utility function U, define the constant $\nu \equiv \lambda[1 - U'(c^*)]/U''(c^*)$, and write the first-order condition $0 = L_Y$ as follows:

$$0 = (\lambda - 1)(1 - F) - \mu F_r + \nu f. \qquad \text{(A10)}$$

Next, replace the distribution function F by the distribution function $F_n \equiv T_n(F)$ with the Frechet differentiable, increasing transformation T_n satisfying $T_n(0) = 0$ and $T_n(1) = 1$. With any nonlinear transformation T_n, the distribution F_n cannot satisfy (A10) for any constants λ, μ, and ν. Also, given a suitable norm, the space of distribution functions containing F_n is both complete and separable. Consequently, the desired result is verified by constructing a sequence of such distributions $\{F_n\}$ converging to F. Alternatively, this result can be verified by solving explicitly the first-order, linear-partial differential equation (A10) and noting that the family of solutions has measure zero in the space of functions F defined over the interval on which (A10) holds. Also, if $Y(x) \in \{0, X\}$ everywhere, consistent with the monotonicity condition (A7), then similar arguments hold with $L_y \le 0$ and $L_y \ge 0$. This completes the proof.

Derivation of Problem (23) through (25) for the Agency Model with Communication

Under the assumptions in Section III, the argument in the Appendix, second part, is altered as follows. For $p \le x \le X$, replace the perquisite problem (7) with the following pair of problems:

$$W(x, y) \equiv \max_z\{U(x - y) + A(z)y - B(z){:}\ Z_1(y) \le z \le Z_2(y)\},$$

with $p \leq Z_1(y) < y < Z_2(y) \leq X$, and

$$V(x) \equiv \max_y\{W(x, y): \min(p, x) \leq y \leq x\}.$$

Replicating the previous argument yields for the above two incentive-compatibility conditions the following necessary and sufficient conditions: (A3) and (A4), with A nondecreasing on $0 \leq z \leq X$. Repeating the argument after (A8) then produces the desired result: problem (23) through (25).

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