Auditing in the Self-reporting Economy[#]

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Abstract: This paper examines the licensing of intellectual property in exchange for royalties that depend on the self-report of the licensee. The self-reporting aspect of the problem gives rise to demand for auditing by the licensor. We characterize the optimal royalty contract, accounting system choice by the licensee, and audit strategy choice by the licensor. We show when the owner prefers to license the property in exchange for a royalty and when it prefers to use the property directly. We also show that the internal control provisions of section 404 of Sarbanes-Oxley make royalty arrangements based on self-reporting more attractive.

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I. INTRODUCTION

Self-reporting pervades business relationships. This paper explores the self-reporting that occurs when one party both reports the amount it owes and pays the other party.[1] Some examples of self-reporting include a licensee's report of the royalties it owes the licensor, a general partner's report to a limited partner about the limited partner's profit, or a movie company's report to an actor who receives royalties based on the movie's profitability.

While it is difficult to quantify the entire self-reporting economy, KPMG (2004) estimated that the value of self-reported transactions was over $300 billion a year, including a wide variety of intellectual property (IP) such as copyrights, patents, trademarks, etc. In the United States alone, manufacturers of retail products paid nearly $6 billion in royalties in 2005, up 2.5% from 2003, primarily for entertainment/character/ trademark licensing (Dhar and Anand (2006)). Worldwide, patent licensees paid $100 billion in royalties in 2000, up from $15 billion in 1990 (Kulatilaka and Lin (2006)). One feature that distinguishes licensing revenue from standard sales is that license agreements often involve self-reporting; the licensor relies on the licensee to report the royalties that the licensee owes. The self-reporting aspect of these agreements creates a role for auditing. This paper characterizes the optimal way for the owner of IP to use its property in a model that features the possibility of licensing agreements based on a self-report by the licensee that is subject to audit by the licensor.

A license agreement grants a licensee the right to incorporate the licensor's IP into products/services the licensee sells in exchange for a fixed and/or variable royalty. In deciding whether to license its IP, a licensor trades off the benefits of licensing against

the costs. The benefits are the ability to leverage IP value in new markets or channels, with less investment of time, money and effort required by the licensor to reach new customers. The costs of licensing arise from the inability of the owner to capture all the benefits of the IP. By the very nature of IP and licensing, the licensor generally cannot tell how extensively a licensee has used the IP. Consider an example where a celebrity grants a calendar manufacturer the rights to use his image in a calendar in exchange for a percentage of the calendar's revenue (or a royalty per calendar sold). Even in this simple example, the licensor must rely on the licensee to self-report the revenue received (or the number of calendars sold) and the associated royalties that are owed. Many license agreements use the licensee's reported accounting information to determine the applicable royalty. As a result of this self-reporting aspect, standard license agreements permit (with certain caveats) the licensor to audit the licensee's royalty reports. KPMG (2004) describes the role of auditing in a self-reporting relationship.

A licensee's internal accounting system plays a central role in the design of licensing contracts. Royalty reports require a level of detailed accounting information that is much finer than that included in the audited financial statements. Ideally, a royalty report includes *all* of the activity relating to the licensed IP and *only* that activity. In reality, royalty reports are more prone to underreporting than to overreporting, because it is more likely for the system to miss a transaction than to fabricate a transaction (although double-counting does occasionally occur). For example, a licensee might create an updated version of a royalty-bearing product and assign it a new part number in its catalog, but neglect to update its royalty reporting system, thus causing the system to miss the royalty-bearing sales under the new part number. Should the licensor choose to

audit the licensee and detect underreporting, the licensee is liable for the amount underpayment and must improve the system to prevent future underreporting.[2]

Our paper relates to the literatures on the economics of licensing, the effect of limited liability in contracting, and strategic auditing. Tirole (1988) reviews the literature on the use of fixed and variable royalties in the context of patent licensing. Recent papers further explore the preferred contractual form of licensing an innovation under no uncertainty and complete information (e.g., Kulatilaka and Lin (2006), Lin and Kulatilaka (2006), Sen (2005a), Sen (2005b), Wang (2002), Kamien and Tauman (1986)). In general, the optimal licensing arrangement features a fixed royalty because a variable royalty distorts the incentives faced by the licensee.[3]

If the licensee is wealth constrained or is otherwise protected by a limited liability regime, a fixed royalty may not be optimal. Limited liability often means that a first-best outcome is not attainable (Laffont and Martimort (2002)). Some of the surplus goes to the agent because limited liability prevents the participation constraint from binding. In our model, the limited liability constraint can make a variable royalty arrangement preferable to a fixed royalty arrangement.

The auditing aspect of our paper relates to the strategic auditing models from the financial reporting literature (e.g., Fellingham and Newman (1985)) and the tax compliance literature (e.g. Graetz, Reinganum and Wilde (1986)). Typically, the strategic interaction between the auditee and auditor features mixed strategies on the part of both players. Our model features mixed strategies as well. The difference between our setting and either the financial auditing or tax compliance settings is that the payoffs in our

setting are in part set by the licensor and licensee via the royalty agreement. In contrast, the payoffs in the other strategic auditing settings are exogenous.

In this paper, we study self-reporting licensing agreements using a game-theoretic approach to royalty compliance. We examine the circumstances under which a potential licensor prefers to license its IP, and whether the licensor is better off with a fixed royalty or a variable royalty that is a function of the licensee's report. Further, we explore the potential effect of the section 404 internal controls provisions of the Sarbanes-Oxley Act (SOX) on the propensity to license and the preferred royalty structure.

Our setting has three features that lead to an interesting set of tradeoffs between different ways of exploiting the IP. First, an external party has lower costs of exploiting the IP than does the owner of the IP, creating the possibility of gains from entering into a licensing arrangement. For example, if the IP is the publishing rights to a book, it may be cheaper for a foreign publisher to translate the book into a different language and distribute it to a foreign market. Second, the external party has limited liability and cannot be compelled to pay a fixed fee in excess of its profits from using the IP. The limited liability constraint captures the fact that the developer of IP is often much larger than the prospective user of IP. The user often cannot bear the risk that would be associated with a fixed royalty agreement. We model this feature with a limited liability constraint. As the profits from the use of IP are uncertain, this limited liability constraint prevents the owner of the IP from extracting all of the surplus via a fixed fee arrangement. Third, it is costly to generate and audit the accounting information that is needed to support a royalty arrangement. These costs make a variable royalty arrangement less attractive.

We show that the efficient way for the owner of IP to exploit the asset can take one of three forms. If the owner can use its IP profitably (i.e., insource), then it will do so if its potential benefits are small relative to the accounting and auditing costs associated with a variable royalty. If the potential benefits are large relative to the accounting and auditing costs, then the owner will license the IP to a third party via a variable royalty arrangement. But if the owner cannot use the IP profitably on its own, it will license the IP to a third party using a fixed royalty if the accounting and auditing costs are large relative to the potential benefits and will license the IP using a variable royalty if the costs are relatively small. Finally, we show that after SOX, the variable royalty arrangement becomes more attractive because SOX decreases the expected monitoring costs; the licensor audits less frequently even though it must audit *all* low reports.

In section 2 we develop the model. Section 3 characterizes the equilibrium behavior of the licensor and the licensee and discusses the implications of our findings. In section 4 we examine the effects of SOX on self-reporting arrangements. Section 5 concludes.

II. MODEL

A risk-neutral potential licensor (R) owns intellectual property that can be used to produce and sell a product. The sale of the product generates a payoff (exclusive of any royalty) of either x_H or x_L, $x_H > x_L$. The two payoffs occur with equal likelihood if the licensor chooses high effort at a non-monetary personal cost of effort $k_R > 0$; low effort costs zero and ensures low demand. The cost of high effort includes any costs incurred to monitor employees to ensure high effort is being provided.

We let V_R denote the net social surplus (or loss, if negative) of high effort by the licensor, so

$$V_R = \frac{x_H - x_L}{2} - k_R. \tag{1}$$

Alternatively, a risk-neutral licensee (E) can contract with the licensor to use the intellectual property to produce and sell the product. The licensee faces the same gross payoff from high effort as does the licensor, but has a lower cost of effort, k_E, so the social value of effort by the licensee is

$$V_E = \frac{x_H - x_L}{2} - k_E. \tag{2}$$

We assume that high effort by the licensee is socially efficient, so

$$\frac{x_H + x_L}{2} - k_E > x_L$$

which is equivalent to

$$k_E < \frac{x_H - x_L}{2}. \tag{3}$$

If the licensee uses the licensor's intellectual property, the licensor receives a royalty of either r_H or r_L, $r_H \geq r_L$, as a function of the *reported* payoff from sales of the product. We impose a limited liability constraint to ensure the licensee never experiences a negative monetary payoff.

The report is a function of the true payoff, the strength of the self-reporting accounting system installed by the licensee, and whether the licensor audits the report. The accounting system is either strong or weak. A strong system costs $c_S > 0$ to operate. A weak system costs zero to operate if it is not audited, but it costs $c_X > c_S$ to discover the true payoff if it is audited. Both c_X and c_S are non-monetary personal costs of effort that

are borne by the licensee. A strong accounting system always reports the true payoff. A weak system reports the true payoff if it is audited and the low payoff if it is not audited. For example, a strong system might provide a high degree of care in monitoring ongoing royalty-related activity within the licensee at a cost of c_S, while a weak system provides a low degree of care at no cost. Consider a new product launched during the period that includes the licensed IP. A strong system detects the new product and the report includes all sales regardless of the new product's volume. A weak system does not detect the new product and only includes sales of the initially established products; note that the report may be correct if the new product flops and no units are sold. If the licensor chooses to audit, the audit identifies that the strong system detected the new product and the weak system did not, and the licensee pays c_X to discover (*ex post*) the sales volume of the new product.

Audit costs of c_A are borne as follows: (i) if no underreporting is detected, the licensor bears the entire audit cost, and (ii) if underreporting is detected, then the licensee pays πc_A and the licensor pays $(1-\pi)c_A$, where $\pi \in [0,1]$.[4] We assume $c_A < c_S$, so the monetary cost of auditing is less than the non-monetary personal cost of installing a strong system. The game tree is shown in Figure 1. Possible payoffs as a function of the effort and accounting system choices of the licensee and the audit decision of the licensor are shown in Table 1.

[INSERT FIGURE 1 AND TABLE 1 ABOUT HERE]

We solve for an efficient royalty arrangement by finding the (r_H, r_L) pair, an audit strategy for the licensor, and an accounting system choice for the licensee that maximizes

the licensor's utility while ensuring that the licensee receives reservation expected utility of at least zero.

III. EQUILIBRIUM

Fixed royalty agreement with no auditing

We first characterize the actions and payoffs in a setting in which the $r_H = r_L$, so the royalty paid to the licensor does not vary with the licensee's report. The payoffs in Table 1 imply that if $r_H = r_L$, the licensor has a dominant strategy of not auditing a low report. In absence of a credible threat to audit, Table 1 shows that the licensee has a dominant strategy of always choosing $\beta = 0$, the weakest possible accounting system, regardless of the effort choice. As the weak system always reports a low payoff, the royalty is always equal to r_L. The limited liability assumption implies that $x_L \geq r_L$ and thus the fixed royalty equals the low payoff, x_L. The licensee works hard because of (3). The licensee receives an expected payoff of $\frac{x_H - x_L}{2} - k_E = V_E$, which is strictly greater than zero. Note that it is the limited liability constraint that allows the licensee to capture some of the surplus. The licensor's payoff is x_L.

The alternative is for the licensor to insource the exploitation of the intellectual property, yielding an expected payoff of

$$\frac{x_H + x_L}{2} - k_R. \tag{4}$$

Although this approach features a higher social cost because $k_R > k_E$, the licensor is able to keep all of the surplus. Comparing the licensor's payoff under the fixed royalty to (4) shows that the licensor prefers to license its intellectual property for a fixed royalty to using the property on its own if and only if

$$\frac{x_H + x_L}{2} - k_R > x_L, \tag{5}$$

which is equivalent to $V_R > 0$.

Variable royalty equilibrium with strategic auditing

We next characterize an equilibrium in which the royalty varies depending on the report. This equilibrium features mixed strategies on the part of both the licensor and licensee. In the next section we consider the implications of the Sarbanes-Oxley Act in which the legal environment compels the licensor and/or the licensee to audit more or install stronger internal controls, both of which involve more costs than the shareholders would prefer absent such regulation.

We restrict our attention to a royalty arrangement that induces the licensee to choose high effort. Low effort yields a maximum payoff of x_L, which the licensor can obtain without incurring any audit costs using a fixed royalty arrangement. Given high effort from the licensee, there does not exist a pure strategy equilibrium as long as the audit cost c_A is sufficiently low. Table 1 shows that either the licensee or the licensor has an incentive to deviate from any pure strategy equilibrium associated with high effort. Intuitively, if the licensor always audits, the licensee would install a strong system, but if the licensee installs a strong system, the licensor prefers not to audit; if the licensor never audits, the licensee would install a weak system, but if the licensee installs a weak system, the licensor prefers to audit. There is a unique mixed strategy equilibrium, however. The licensee chooses the probability of installing a strong system, β, which makes the licensor indifferent between auditing and not auditing when the system provides a low signal.

$$\beta = \frac{r_H - r_L - c_A(2-\pi)}{r_H - r_L - c_A(1-\pi)} \tag{6}$$

Similarly, the licensor chooses a probability of audit, α, when it receives a low royalty payment so as to make the licensee indifferent between choosing a strong or weak accounting system when the licensee chooses high effort.

$$\alpha = \frac{r_H - r_L + 2c_S}{r_H - r_L + \pi c_A + 2c_X} \tag{7}$$

Using (6), (7), and the payoffs in Table 1, we can determine the expected equilibrium payoffs to the licensor and licensee, respectively.

$$E[Payoff \text{ to R}] = \frac{r_H + r_L}{2} - \frac{c_A(r_H - r_L)}{2(r_H - r_L - (1-\pi)c_A)} \tag{8}$$

$$E[Payoff\ to\ E] = \frac{x_H - r_H + x_L - r_L}{2} - k_E - c_S \tag{9}$$

We note that an increase in the expected royalty payment, $\frac{r_H + r_L}{2}$, increases the payoff to the licensor and decreases the payoff to the licensee. An increase in the difference between the two royalty payments, $r_H - r_L$, has no effect on the expected payoff to the licensee, but increases the payoff to the licensor via its effect on the net proceeds of auditing; R audits more often, but receives more on average for doing so.

Given the equilibrium strategies α and β, we must find a pair of royalty payments (r_H, r_L) to associate with the pair of signals that the accounting system could generate. The pair maximizes the payoff to the licensor from (8) subject to several constraints. First, the limited liability constraints must be satisfied, so the licensee never suffers a negative monetary payoff. Therefore, $r_L \le x_L$ and $r_H \le x_H - \pi c_A$. Second, the licensee must have an incentive to work hard, so the expected payoff from high effort from (9)

must exceed the expected payoff from low effort. If the licensee chooses low effort, it should also choose a strong accounting system, given the licensor's audit strategy. A licensee choosing low effort would prefer a strong system because the licensee's payoff from {low effort, weak system} equals $x_L - r_L - \alpha c_X$ and the payoff from {low effort, strong system} equals $x_L - r_L - c_S$. Using the equilibrium audit probability α from (7), the licensee's payoff from {low effort, strong system} is strictly higher than its payoff from {low effort, weak system}. Therefore, the incentive compatibility (IC) constraint requires

$$\frac{x_H - r_H + x_L - r_L}{2} - c_S - k_E \geq x_L - r_L - c_S,$$

which simplifies to

$$r_H - r_L \leq x_H - x_L - 2k_E. \tag{10}$$

Third, the licensee must have a high enough expected payoff to participate in the deal, so it must have an expected payoff of at least zero. Using (9), the participation constraint (PC) is

$$x_H + x_L - r_H - r_L - 2k_E - 2c_S \geq 0. \tag{11}$$

So the royalty pair (r_H, r_L) must satisfy the following program.

$$\max_{r_H, r_L} \left\{ \frac{r_H + r_L}{2} - \frac{c_A(r_H - r_L)}{2(r_H - r_L - c_A(1-\pi))} \right\}$$

subject to:

$$r_H \leq x_H - \pi c_A$$

$$r_L \leq x_L$$

$$r_H - r_L \leq x_H - x_L - 2k_E \tag{IC}$$

$$x_H + x_L - r_H - r_L - 2k_E - 2c_S \geq 0 \tag{PC}$$

The solution is

$$r_L = x_L - c_S \tag{12}$$

$$r_H = x_H - c_S - 2k_E \tag{13}$$

because both the incentive compatibility constraints and participation constraints are binding. The IC constraint binds because the higher the difference between the high and low royalties, the lower the licensor's expected audit costs. The participation constraint binds because the only reason to pay the licensee more than the reservation utility is if one of the limited liability constraints are binding, which they are not given the royalties in (12) and (13) and the fact that $c_A < c_S$.

The licensor's expected profit strictly increases in the degree of audit cost sharing, π. If the licensor had the ability to set $\pi = 1$, it would clearly do so. However, as numerous license agreements observed in practice do not contain this provision, unmodeled forces may prevent the licensor from specifying π or otherwise contracting on c_A *ex ante*. For example, the audit cost may not be observable for contracting purposes. For now, we leave the variable π as an exogenous parameter and consider the special cases of $\pi = 0$ and $\pi = 1$ later.

Substituting the values of r_H and r_L from (12) and (13) into (6) and (7) allows us to express the strategies α and β in terms of the model's exogenous parameters.

$$\alpha = \frac{2V_E + 2c_S}{2V_E + 2c_X + c_A\pi} \tag{14}$$

$$\beta = \frac{2V_E - c_A(2-\pi)}{2V_E - c_A(1-\pi)} \tag{15}$$

Both α and β must be between zero and one in equilibrium. The fact that $c_X > c_S$ ensures that $\alpha < 1$; for $\beta > 0$, we require $c_A < \frac{2V_E}{2-\pi}$. If c_A exceeds this value, an equilibrium with variable royalties cannot be sustained because the licensor would be unwilling to audit even if it knew the licensee had installed a weak accounting system.

Differentiating (14) shows that the higher the social value of the licensee's action (V_E), the higher the probability that the licensor audits a low report. The licensor must audit more aggressively to deter the licensee from installing a weak accounting system when the intellectual property is more valuable. The audit probability is increasing in the cost c_S of operating a strong system, and decreasing in both the cost c_X of rectifying a weak system that is audited and the percentage π of the audit costs paid by the licensor in the event underreporting is detected. In each case, the licensor adjusts the audit probability to keep the licensee indifferent between installing a strong or weak accounting system. Similarly, differentiating (15) shows that the probability that the licensee installs a strong accounting system is increasing in V_E and π, so as to keep the licensor indifferent between auditing and not auditing a low report. Similarly, β is decreasing in the audit cost c_A for the same reason.

Finally, we consider the total audit and system costs associated with the variable royalty arrangement. Audit and system costs in this setting are

$$\alpha\beta\left[c_S + \frac{c_A}{2}\right] + \alpha(1-\beta)[c_X + c_A] + (1-\alpha)\beta c_S. \tag{16}$$

Substituting in the equilibrium values of α and β from (14) and (15) yield total costs of

$$c_S + \frac{c_A}{2} + \frac{c_A^2(1-\pi)}{2[2V_E - c_A(1-\pi)]}. \tag{17}$$

Note that total audit and system costs are decreasing in π, and are $c_S + \frac{c_A}{2}$ when $\pi = 1$.

Preferred arrangement

Next, we ask whether the owner of the IP prefers to insource the use of the IP, license its use in exchange for a fixed royalty with no auditing, or license its use in exchange for a variable royalty that involves costly auditing. Comparing the licensor's payoff from using its intellectual property on its own from (4) or licensing it to the licensee in exchange for a fixed royalty of x_L shows that the licensor prefers to license the property if and only if $V_R \leq 0$. Because the licensor only receives a payoff of x_L from the licensing arrangement, its payoff is the same as it would have been if it used the property itself and chose low effort. Therefore, if effort by the licensor is socially valuable, it prefers to use the property on its own to the fixed royalty arrangement. This course of action involves a social cost because $k_E < k_R$; but the licensor may prefer this to prevent the licensee from capturing some of the surplus due to the limited liability constraint.

Next, we compare the fixed royalty and variable royalty arrangements. In the former, the licensor's expected payoff is x_L. In the latter, the expected payoff is found by substituting the equilibrium royalties from (12) and (13) into (8) to yield

$$\frac{x_H + x_L}{2} - k_E - c_S - \frac{c_A V_E}{2V_E - c_A(1-\pi)}. \tag{18}$$

The fact that $k_E < \frac{x_H - x_L}{2}$ implies that the expected payoff to the licensor from the variable royalty arrangement exceeds that from the fixed royalty arrangement as long as the costs of implementing (c_S) and auditing (c_A) a strong system are sufficiently low. Note

that because the variable royalty arrangement can only be sustained when $c_A < \frac{2V_E}{2-\pi}$, the last term in (18) is positive.

Comparing the licensor's payoff from the fixed royalty arrangement (x_L) to its expected payoff from the variable royalty arrangement in (18) shows that the licensor prefers the variable royalty arrangement if and only if

$$V_E > \frac{2c_S + c_A(2-\pi) + \sqrt{(2c_S + \pi c_A)^2 + 4c_A^2(1-\pi)}}{4}. \tag{19}$$

The licensor's preference can be expressed as a comparison between the net social value associated with high effort by E and the audit and accounting system costs. If these costs are sufficiently low, the licensor prefers the variable royalty; higher costs cause the licensor to prefer the fixed royalty.

Finally, we compare the variable royalty arrangement with the licensor using the intellectual property on its own. Comparing (4) and (18) shows that the licensor prefers the variable royalty arrangement if and only if

$$k_R > k_E + c_S + \frac{c_A V_E}{2V_E - c_A(1-\pi)}. \tag{20}$$

We summarize our results in Proposition 1.

Proposition 1 The licensor's preferred licensing arrangement is as follows:

(a) if $V_R < 0$ and $V_E < \frac{2c_S + c_A(2-\pi) + \sqrt{(2c_S + c_A\pi)^2 + 4c_A^2(1-\pi)}}{4}$, the licensor prefers to exploit its intellectual property via a fixed royalty arrangement;

(b) if $V_R > 0,$ and $k_R < k_E + c_S + \frac{c_A V_E}{2V_E - c_A(1-\pi)},$ the licensor prefers to exploit its intellectual property on its own;

(c) if $V_R < 0$ and $V_E > \frac{2c_S + c_A(2-\pi) + \sqrt{(2c_S + c_A\pi)^2 + 4c_A^2(1-\pi)}}{4}$, or if $V_R > 0$ and $k_R > k_E + c_S + \frac{c_A V_E}{2V_E - c_A(1-\pi)}$, the licensor prefers to exploit its intellectual property via a variable royalty arrangement.

Figure 2 illustrates these outcomes. The *x*-axis is the gross social value of high effort, $\frac{x_H - x_L}{2}$, which is bounded below by k_E (from (3)) and is unbounded above. The *y*-axis is the cost of high effort for the licensor (k_R), which is also bounded below by k_E and is unbounded above. The 45 degree line in Figure 2 divides the region into the area for which $V_R < 0$ (above the line) and $V_R > 0$ (below the line). When $V_R < 0$, the owner of the IP cannot use it profitably on its own and therefore always licenses it. It prefers a fixed royalty when accounting system and audit costs are high relative to the net social value of high effort and prefers a variable royalty when these costs are relatively low. When $V_R > 0$, the owner of the IP prefers to use the IP on its own to licensing it for a fixed royalty when accounting system and audit costs are sufficiently high and prefers to license the IP in exchange for a variable royalty when these costs are relatively low.

[INSERT FIGURE 2 ABOUT HERE]

Special Cases for State-contingent Audit Cost Sharing

In this subsection, we consider the special cases regarding which party bears the cost of the royalty audit in the event underreporting is detected. From (18), the licensor's expected payoff strictly increases in π. Thus, if circumstances permit the licensor to specify any sharing of the audit cost c_A, it chooses π = 1; i.e. if underreporting is detected the licensee bears the full audit cost, and if no underreporting is detected the licensor

bears the full audit cost. If the licensor cannot specify audit cost sharing, then π = 0, and the licensor bears the entire audit cost even if underreporting is detected. Note, however, that irrespective of audit cost sharing, the licensee always pays c_X to determine the true payoff when the accounting system is weak.

Consider first the impact of state-contingent audit cost sharing on the optimal strategies:

$$\alpha\big|_{\pi=0} = \frac{2V_E + 2c_S}{2V_E + 2c_X} > \frac{2V_E + 2c_S}{2V_E + 2c_X + c_A\pi} > \frac{2V_E + 2c_S}{2V_E + 2c_X + c_A} = \alpha\big|_{\pi=1}$$

$$\beta\big|_{\pi=0} = \frac{2V_E - 2c_A}{2V_E - c_A} < \frac{2V_E - c_A(2-\pi)}{2V_E - c_A(1-\pi)} < 1 - \frac{c_A}{2V_E} = \beta\big|_{\pi=1}$$

As noted above, both α and β are between zero and one in equilibrium given $c_X > c_S$ and $c_A < \frac{2V_E}{2-\pi}$. An increase in π from zero to one increases the probability that the licensee installs a strong accounting system and decreases the probability that the licensor audits a low report. These two effects reduce the sum of expected accounting system costs and expected audit costs, as was shown in (17). This in turn increases the licensor's expected payoff from (18).

Figure 3 illustrates the effect of state-contingent audit cost sharing compared to the outcomes in Figure 2. Notice that variable royalty regions under audit cost sharing are strictly larger than the corresponding regions in Figure 2. Because audit-cost sharing increases the licensor's expected payoff associated with variable royalty arrangements, these arrangements become more attractive relative to both fixed royalty arrangements and insourcing.

[INSERT FIGURE 3 ABOUT HERE]

IV. REGULATION

In this section, we consider the implications of changes to the legal environment such that the licensor and/or the licensee are compelled to audit more frequently or to install stronger internal controls, respectively, thereby incurring more costs than the firms would choose absent such regulation. One example of such regulation is Section 404 of the Sarbanes-Oxley Act of 2002 (SOX), which increased the responsibility of management of companies with listings on US stock exchanges to have in place controls to safeguard assets so as to prevent materially misstated financial statements.

Effect of SOX requirements

In the context of our model, we interpret the application of Section 404 to the licensor as requiring an audit of any low report by the licensee (i.e., $\alpha = 1$). The internal controls over the integrity of the licensor's revenue stream are located at the licensee; any SOX-required comprehensive audit of the licensor's controls requires an audit of the licensee's controls.[5] In essence, the internal controls are outsourced along with the IP itself.

We interpret the application of Section 404 to the licensee as requiring the implementation of a strong system (i.e., $\beta = 1$). This interpretation is consistent with SOX requiring the licensee to ensure it has no unrecorded liabilities.

As before, the licensor and licensee choose a royalty arrangement that induces the licensee to choose high effort and yields the licensee an expected payoff of at least zero. The expected payoff to the licensee from high effort and a strong system is the same as in the previous section, as shown in (9), even though the players choose pure strategies here and mixed strategies in the earlier section. This occurs because the licensor's equilibrium

strategy made the licensee indifferent between choosing a strong system and a weak system, so the licensee's expected payoff is the same when it has a pure strategy of choosing a strong accounting system.

We must find a pair of royalty payments (r_H, r_L) to associate with each signal. The pair maximizes the payoff to the same incentive compatibility constraint and participation constraints from the earlier analysis, so the constraints are

$$r_H - r_L \leq x_H - x_L - 2k_E \qquad \text{(IC)}$$

$$x_H + x_L - r_H - r_L - 2k_E - 2c_S \geq 0. \qquad \text{(PC)}$$

If both constraints bind, the solution is:

$$r_H = x_H - 2k_E - c_S,\ r_L = x_L - c_S.$$

Note that the limited liability conditions are satisfied for both outcomes.

The licensor's expected payoff given this royalty arrangement is

$$\frac{x_H + x_L}{2} - k_E - c_S - \frac{c_A}{2}. \qquad (21)$$

Note that for $\pi < 1$, (21) is strictly greater than (18). If the licensor cannot specify π, then one consequence of SOX is that the regulation makes variable royalty arrangements as appealing as under state-contingent audit cost sharing. If the licensor can specify π, then it sets $\pi = 1$, and SOX has no impact on the licensor's expected payoff under variable royalties.

Under SOX, the licensor is better off with a pure strategy of auditing all low reports and detecting no underreporting than playing a mixed strategy of auditing only some of the time and detecting underreporting some of the time. The intuition is that because the licensor must audit all low reports under SOX, the licensee has a dominant strategy of always installing a strong accounting system.[6] This means fewer low reports

will be made, which drives down expected audit costs. At the same time, there is no change in the licensee's expected accounting system costs because the non-SOX licensee is indifferent between installing a strong or a weak system. Intuitively, SOX provides the licensor a credible way to commit to always audit low reports. When the licensee always installs a strong system and the licensor audits all low reports, the total audit and system costs are $c_S + \frac{c_A}{2}$. Comparing this level of costs to the expected level of costs in the absence of SOX from (17) shows that the costs under SOX are the same as the minimum level of costs without SOX, which occurred when $\pi = 1$.

Comparing (4), (21), and x_L yields the licensor's preferred arrangement, which we summarize in Proposition 2.

Proposition 2

> When the licensor is subject to the SOX regulatory environment, the expected payoffs and preferred royalty arrangements are identical to those in which the licensee bears the audit cost when underreporting is detected ($\pi = 1$).

Section 404 of SOX was widely criticized as too costly, and ultimately the requirements of this section were eased (Hughes (2007)). Proposition 2 suggests a positive byproduct of the stricter 404 rules; namely, when the parties are subject to SOX, and audit-cost-sharing cannot be contractually specified, SOX enables more profitable variable royalty arrangements, albeit in pure strategies instead of in mixed strategies. Furthermore, this result arises even though we have assumed that SOX is implemented in a very inefficient manner, because given the licensee always installs a strong system, auditing all low reports increases costs by $\frac{c_A}{2}$ without creating a corresponding benefit to

any other player. If the regulatory regime required $\beta = 1$ and $\alpha < 1$, the system and audit costs would only be $c_S + \frac{\alpha c_A}{2}$ under SOX.[7]

Empirical Implications

The model suggests several empirically testable predictions. After the implementation of Sarbanes-Oxley, the model predicts cross-sectional variation in the attractiveness of variable royalty arrangements across licensor-licensee pairs that differ by geographic region (US/non-US) or by public/private ownership. Further, the model predicts that stronger accounting systems for tracking royalties owed will become more prevalent in all areas if a licensing partner is subject to SOX. Finally, licensor audits will detect less royalty underreporting due to these stronger accounting systems.

V. CONCLUSION

Intellectual property can be used by its owner directly, licensed to a third party for a fixed royalty, or licensed to a third party for a variable royalty. The variable royalty arrangement depends on self-reporting by the licensee, which in turn induces demand for auditing by the licensor. The setting we explore features a production cost advantage on the part of an outside party that creates gains from licensing, a limited liability constraint that prevents the owner of the intellectual property from capturing all of the economics surplus via a fixed royalty agreement, and accounting and auditing costs that reduce the benefits of a variable royalty agreement.

We show that the owner of intellectual property will enter into a variable royalty agreement with an outside party if and only if the accounting and auditing costs are sufficiently low. With higher cost levels, the owner will use the property directly if it can

do so profitably and license the property in exchange for a fixed royalty otherwise. We characterize the equilibrium accounting system and auditing choices by the licensor and licensee in such a setting and derive the optimal variable royalty agreement. We show that expected aggregate accounting system and audit costs are minimized when the licensor can compel the licensee to bear the audit costs in case underreporting is detected. Finally, we show that the internal control provisions of section 404 of the Sarbanes-Oxley Act make variable royalty arrangements based on self-reporting and auditing relatively more attractive than both fixed royalty arrangements and having the owner use the IP directly. This occurs because, although the licensor audits *all* low reports, a strong accounting system reduces the frequency with which low reports occur, so the licensor audits the licensee less often.

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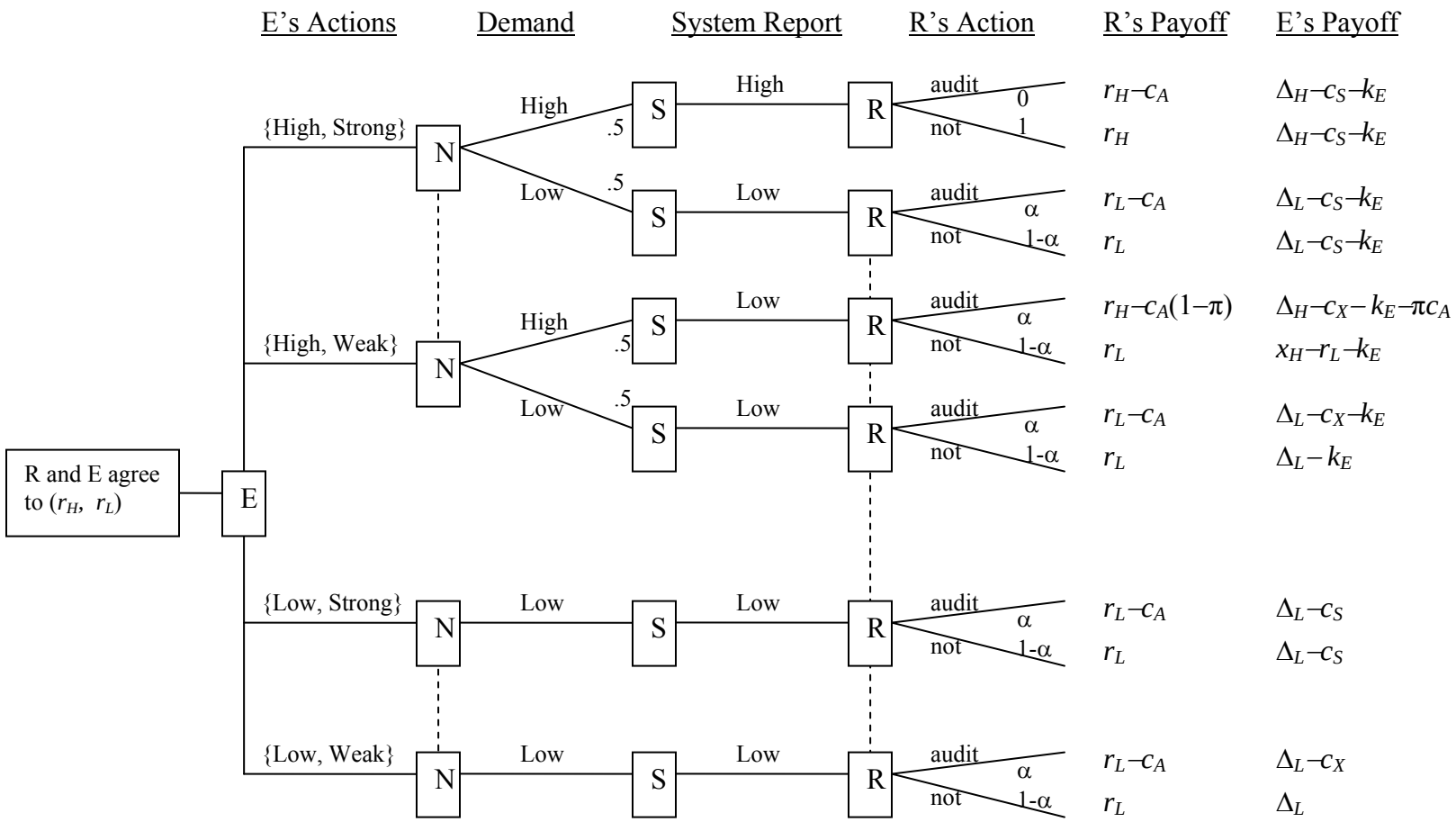
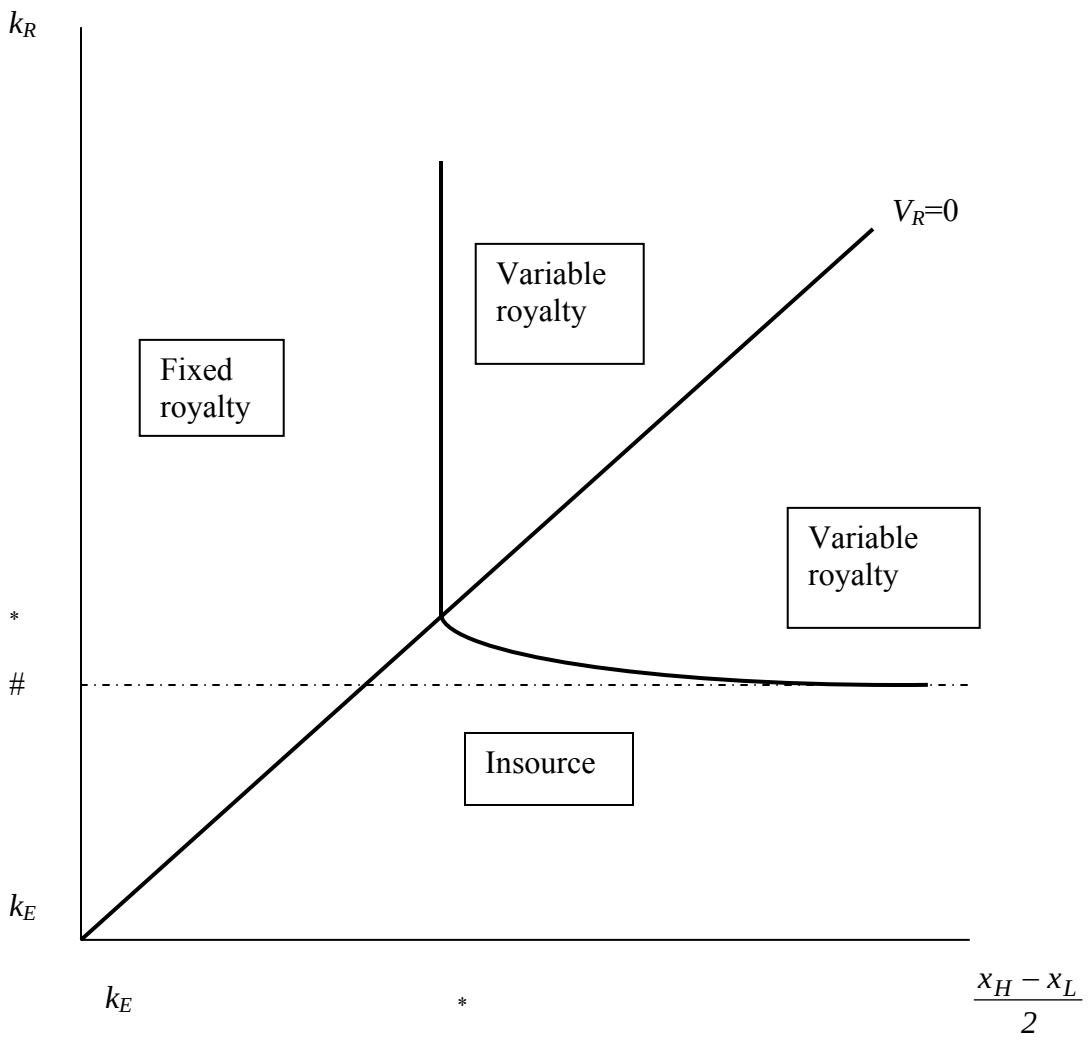
Figure 1: Game tree



R = Licensor
E = Licensee
N = Nature
S = Licensee's accounting system

$\Delta_H = x_H - r_H$
$\Delta_L = x_L - r_L$

Figure 2: Licensor's preferred arrangement with strategic auditing

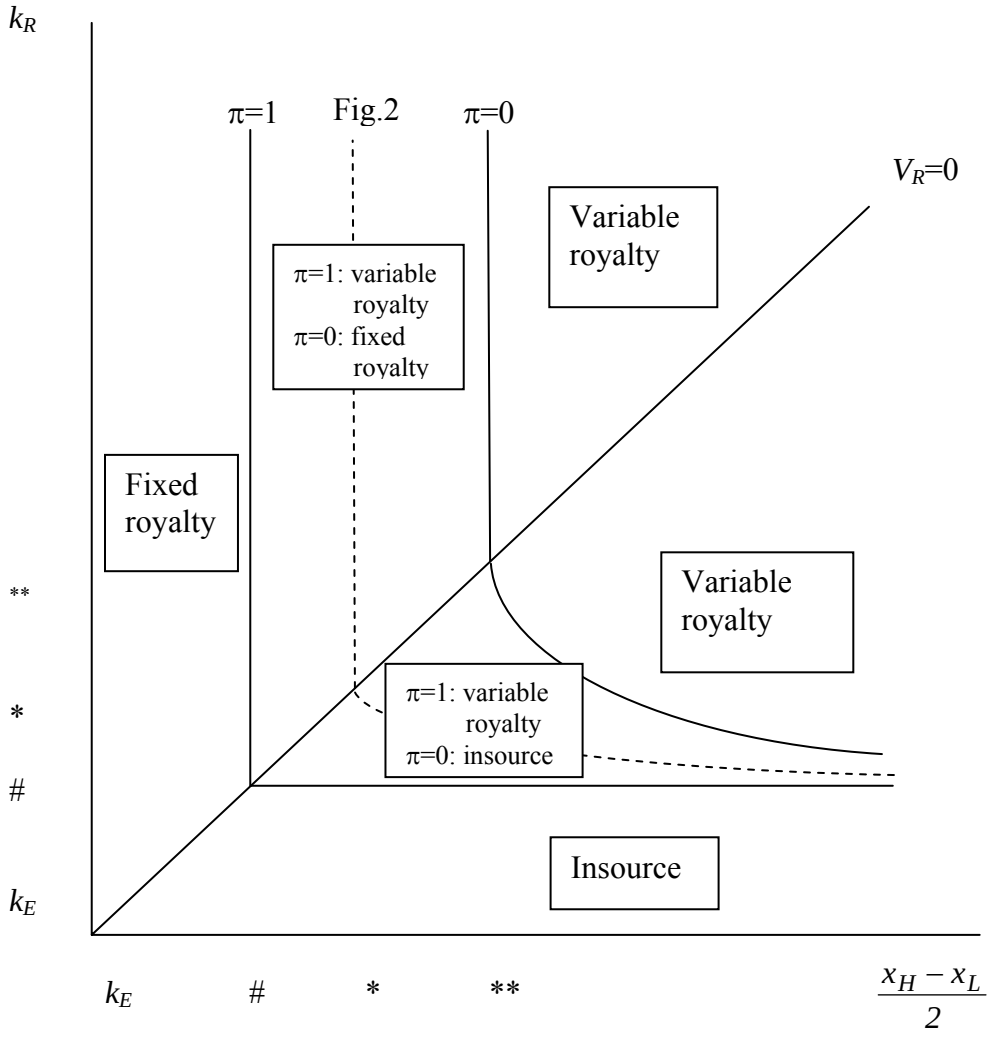


$$* = \frac{c_A + c_S}{2} + \frac{\sqrt{(2c_S + \pi c_A)^2 + 4c_A^2(1-\pi)} - \pi c_A}{4} + k_E$$

$$\# = c_S + \frac{c_A}{2} + k_E$$

Origin at (k_E, k_E). The *x*-axis shows the gross social value of high effort, $\frac{x_H - x_L}{2}$, which is bounded below by k_E and unbounded above. The *y*-axis is the cost of high effort for the licensor, k_R, which is also bounded below by k_E and is unbounded above. The 45 degree line divides the region into the area for which the net social surplus of high effort by the licensor, V_R , is positive (below the line) and negative (above the line). The curved boundary line below the 45 degree line asymptotically approaches the dotted line at #.

Figure 3: Licensor's preferred arrangement with and without state-contingent audit cost sharing



$$\# = c_S + \frac{c_A}{2} + k_E$$

$$* = \frac{c_A + c_S}{2} + \frac{\sqrt{(2c_S + \pi c_A)^2 + 4c_A^2(1-\pi)} - \pi c_A}{4} + k_E$$

$$** = \frac{c_A + c_S + \sqrt{c_A^2 + c_S^2}}{2} + k_E$$

Origin at (k_E, k_E). The variable royalty regions are strictly larger the greater the percentage π of audit cost the licensee bears when underreporting is detected.

Table 1: Payoff Matrix

This matrix contains the possible payoffs as a function of the effort and accounting system choices of the licensee, and the audit choice of the licensor. In each cell, the licensor's payoff is the first line and the licensee's payoff is the second line.

Licensee's choice of {Effort, Accounting System}

	{High, Strong}	{High, Weak}	{Low, Strong}	{Low, Weak}
Licensor audits low report	$(r_H+r_L-c_A)/2$ $(x_H+x_L-r_H-r_L)/2-c_S-k_E$	$(r_H+r_L)/2-c_A+\pi c_A/2$ $(x_H+x_L-r_H-r_L)/2-c_X-k_E-\pi c_A/2$	r_L-c_A $x_L-r_L-c_S$	r_L-c_A $x_L-r_L-c_X$
Licensor does not audit low report	$(r_H+r_L)/2$ $(x_H+x_L-r_H-r_L)/2-c_S-k_E$	r_L $(x_H+x_L-2r_L)/2-k_E$	r_L $x_L-r_L-c_S$	r_L x_L-r_L

c_A: cost to licensor to audit licensee's royalty report
c_S: cost to licensee to operate a strong accounting system
c_X: cost to licensee to discover the true payoff when audit detects weakness
k_E: cost to licensee for high effort
r_i: royalty owed by licensee for report of i (i=L,H)
x_i: gross proceeds to licensee for realized demand of i (i=L,H)

[1] The other main type of self-reporting occurs when one party both reports the amount it is owed and receives the check from another party (for example, an insurance claim). Another type of self-reporting is reported compliance with policies that could have future financial repercussions, such as environmental compliance, where divisions report to corporate headquarters their compliance with environmental standards, especially when the corporate standard exceeds the local regulatory standards. These self-reporting relationships have similar issues to those analyzed in this paper; the party receiving the report must decide whether to accept the amount reported and the resulting cash impact, or whether to audit the report to ascertain the appropriateness of the claim.

[2] One of the most common reasons for errors detected by audits of self-reported royalties is a system weakness that hinders contractual compliance (KPMG (2004)).

[3] Other papers focus on the effect of licensing rather than the preferred contractual form of licensing. Arya and Mittendorf (2006) find that in a setting with no uncertainty, a licensor may be better off giving up monopoly rights by licensing its innovation to a competitor because the licensing fee exceeds the monopoly rents.

[4] In practice, license agreements sometimes stipulate that if underreporting in excess of a given threshold (typical thresholds are 10-20%) is detected, the licensee bears the entire audit cost (i.e., $\pi = 1$). Otherwise, the licensor pays for the audit. Although this audit-cost-sharing feature is somewhat common, many license agreements do not include this clause, so the licensor bears the entire cost of the audit even if underreporting is detected (i.e., $\pi = 0$); however, the licensee still must incur the cost to discover the true payoff (c_X) and pay the incremental royalties detected by the audit ($r_H - r_L$).

[5] Anecdotally, practitioners we spoke with observed that licensors increased their audit frequency post-SOX.

[6] Note that the licensee's best response to the licensor choosing to audit all low reports is to install a strong system. Thus, so long as the licensor is required to choose $\alpha = 1$, then the licensee installs a strong system even if it is not required to do so (e.g., if the licensee were not subject to SOX).

[7] If the licensee were subject to SOX but the licensor were not (e.g., if the licensor were a private or non-US-listed company), in the context of our model, the licensee would install a strong system ($\beta = 1$) and the licensor would never audit ($\alpha=0$).