Contracting in the Self-reporting Economy[#]

Romana L. Autrey[*]
Richard Sansing[**]

October 2009

ABSTRACT

This paper examines the effect of accounting on the use of intellectual property. We analyze the licensing of intellectual property in exchange for royalties that depend on the self-report of the licensee. The self-reporting aspect of the environment gives rise to demand for auditing by the licensor or third-party attestation by the licensee. 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 find that variable royalty arrangements that depend on either audited self-reports or third-party attestation become more attractive as accounting information system costs decrease and as the benefits from outsourcing the use of intellectual property increases. We also examine how different licensing arrangements affect the relation between the variance of the returns to the intellectual property and the payoff to the owner.

JEL classification: D45; M42

Key words: Royalties; licensing; strategic auditing; contract compliance; forensic accounting.

[#] For their comments, we thank Srikant Datar, Christian Hofmann, Bob Kaplan, Brian Mittendorf and Paul Newman, and workshop participants at the University of Colorado at Boulder, the Harvard Business School supply chain reading group, the University of Iowa, the Accounting Research Workshop at the Universities of Bern and Fribourg, and the American Accounting Association annual meeting.

* Harvard Business School
** Tuck School of Business at Dartmouth and CentER, Tilburg University

Corresponding Author:
Romana L. Autrey, Harvard Business School, Morgan Hall 381, Boston, MA, 02163, rautrey@hbs.edu

1. 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] In this paper, we study self-reporting licensing agreements using a game-theoretic approach to royalty compliance. 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. 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. We also examine when it is desirable for the licensee to pay for a third party to attest to the accuracy of the reporting system.

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 or attestation. 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 or attestation by a third party as to the report's accuracy.

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 observe how extensively a licensee has used the IP. Consider an example in which an author grants a publisher the rights to publish a textbook in exchange for a percentage of the book's revenue (or a royalty per copy sold). Even in this simple example, the licensor must rely on the licensee to self-report the revenue received (or the number of copies 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.

Strategic auditing models can generate outcomes that are *ex post* inefficient in that sometimes the licensor conducts a costly audit when the licensee's self-report is correct. This outcome can be avoided if the licensee can get an independent third party to attest to the accuracy of the self-reporting system. We allow the licensee to commit to an accurate self-report by contracting with third party to attest to the licensee's reporting system.

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 prospective user of IP may not be able to bear the risk that would be associated with a fixed royalty agreement. As the profits from the use of IP are uncertain, this limited liability constraint prevents the owner

of the IP from extracting the entire 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, either through an audit of the report by the licensor or an attestation of the reporting system by an independent third party. These costs make a variable royalty arrangement less attractive.

We show that the efficient way for the owner of IP to exploit the asset depends jointly on the cost advantage of the potential licensee and the accounting, attestation and auditing costs associated with the self-reporting system. If the cost advantage of the licensee is sufficiently small, the owner will exploit the IP on its own (insource). If the cost advantage of the licensee is sufficiently large, then the owner will license the IP to a third party via a royalty arrangement. The nature of the royalty arrangement depends on the cost of the self-reporting system. If the cost is very high, the license arrangement will feature a fixed royalty that does not depend on a self-report. If it is very low, the license arrangement will feature a variable royalty generated by a system attested to by an independent third party. Intermediate costs will yield a variable royalty that depends on a self-report that is sometimes audited by the licensor.

We examine the effects of two changes in the economy on the payoffs to the principal from each of the four arrangements. First, we assume that the corporate accounting scandals and the regulatory response to them (e.g., the Sarbanes-Oxley Act of 2002) has increased the strength of internal control systems, which in turn has decreased the marginal cost of operating the system on which self-reporting is based. Second, we assume that the gains from outsourcing have increased as globalization has increased the set of potential licensees with which the owner of IP can transact. In each case, there are

three effects of these changes. First, outsourcing becomes more attractive. Second, variable royalty arrangements become more attractive and fixed royalty arrangements become less attractive. Third, the fraction of variable royalty arrangements supported by third-party attestation increases and the fraction of variable royalty arrangements based on licensor auditing decreases.

We analyze the impact of the various licensing arrangements on the relation between the variance of the project's payoff and the licensor's payoff. The fixed royalty arrangement provides the strongest incentives for low variance projects. In the variable royalty arrangement based on licensor auditing, however, the effect of variance depends on audit costs. High variance projects cause the licensor to audit a higher percentage of low reports and the licensee to install a stronger system, so there are fewer low reports. If the cost per audit is sufficiently high, the net audit costs decrease because the system generates sufficiently smaller number of low reports that even though the licensor audits a higher percentage of them. In this case, the licensor's payoff is increasing in the variance. If the cost per audit is not sufficiently high, net audit costs increase, and instead the licensor's payoff is decreasing in the variance of the project's payoff.

In section 2 we develop the model. Section 3 characterizes the equilibrium behavior of the licensor and the licensee. Section 4 describes how decreases in accounting information system costs and increases in the benefits from outsourcing have changed the way owners of IP use their property. Section 5 analyzes the effect of the variance of the project's payoff on the licensor's payoff. Section 6 concludes.

2. 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 gross 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 personal cost of effort $k_R > 0$; low effort costs zero and ensures a low payoff. 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. The report is a function of the true payoff (x_H or x_L), the strength of the self-reporting accounting system chosen by the licensee, and whether the self-report is audited. The licensee chooses the probability p that the accounting system will function properly; this system choice might be operationalized by, for example, the degree of care provided or the ability of personnel assigned to monitor ongoing royalty-related activity. A properly functioning accounting system (i.e., a "strong" system) always reports the true payoff. A system that doesn't function properly (i.e., a "weak" system) reports the true payoff if it is audited and the low payoff if it is not audited.

The accounting system costs sp to operate, where $s>0$ is the system cost parameter. For example, 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 fails to 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 audits the self-report, the audit reveals whether the report was accurate. Audit costs of c are paid by the licensor. We assume that $c < \frac{x_H - x_L}{2}$. If this condition were violated, auditing would be so expensive that it would never be in the licensor's interest to audit a self-report. If the audit reveals underreporting, the licensee pays the correct royalty plus a transfer payment t to the licensor.[4]

The licensee can commit to an attestation process in which the licensee chooses $p = 1$ and a third party attests to this choice. The attestation process costs a, which is paid by the licensee and observable to the licensor. Because the licensee can commit to this process, the royalty payments r_H and r_L also depend on whether the licensee has

implemented an attestation process. We assume that $a < \frac{cV_E}{2V_E + 2k_E - c}$, which ensures that the attestation cost is not so high as to be never be attractive.

We impose limited liability constraints to ensure the licensee never has a pay a royalty higher than the gross payoff (x_H or x_L) from using the IP. The game tree is shown in Figure 1.

We solve for an efficient royalty arrangement by finding the (r_H, r_L, t) triplet, an audit strategy α for the licensor, and an accounting system choice p for the licensee that maximizes the licensor's utility while ensuring both that the licensee receives reservation expected utility of at least zero and that the licensee does not pay more to the licensor than the amount the licensee itself receives.

3. Equilibrium

3.1 FIXED ROYALTY AGREEMENT WITH NO AUDITING

We first characterize the actions and payoffs in a setting in which $r_H = r_L$ and $t = 0$, so the royalty paid to the licensor does not vary with the licensee's report. The payoffs in Figure 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, Figure 1 shows that the licensee has a dominant strategy of always choosing $p^* = 0$, 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 requires 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 other alternative in which the licensor's payoff does not vary with the report 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 $V_R > 0$.

3.2 Variable royalty equilibrium with licensor audit

We next characterize an equilibrium in which the royalty owed depends on the report. This equilibrium features a mixed strategy on the part of the licensor and an interior solution on the part of the licensee. In this section, we characterize the optimal royalty arrangement assuming that the licensee does not commit to the attestation process.

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, the payoffs in Figure 1 imply that the expected payoff to the

licensee is

$$\frac{x_H + x_L}{2} - k_E - sp - \frac{pr_H}{2} - \frac{(1-p)\alpha(r_H + t)}{2} - \frac{r_L[1+(1-p)(1-\alpha)]}{2}. \qquad (6)$$

The expected payoff to the licensor is

$$\frac{1}{2}\left[pr_H + (1-p)(1-\alpha)r_L + (1-p)\alpha(r_H + t - c)\right] + \frac{1}{2}\left[r_L - \alpha c\right]. \qquad (7)$$

We note that there does not exist an equilibrium in pure strategies because the audit cost *c* is sufficiently low. Equations (6) and (7) show that either the licensee or the licensor has an incentive to deviate from any pure strategy equilibrium associated with high effort. If the licensor always audits low reports (α=1), equation (6) shows that the licensee would choose a strong system (*p*=1); if the licensee chooses a strong system, equation (7) shows that the licensor prefers not to audit (α=0). If the licensor never audits low reports, equation (6) shows that the licensee would choose a weak system (*p*=0); if the licensee chooses a weak system, equation (7) shows that the licensor prefers to audit low reports as long as the cost of auditing (*c*) is sufficiently low. There is a unique mixed strategy equilibrium, however. The licensee chooses the probability of a properly functioning system, p^*, which makes the licensor indifferent between auditing and not auditing when the system provides a low signal.

$$p^* = \frac{r_H - r_L - 2c + t}{r_H - r_L - c + t} = 1 - \frac{c}{r_H - r_L - c + t} \qquad (8)$$

Similarly, the licensor chooses a probability of audit, α^*, when it receives a low royalty payment so as to make the licensee indifferent among its choices of *p* when the licensee chooses high effort.

$$\alpha^* = \frac{r_H - r_L + 2s}{r_H - r_L + t} \qquad (9)$$

Using equations (6)-(9), we can determine the expected equilibrium payoffs to the licensor and licensee, respectively.

$$E[\text{payoff to R}] = \frac{r_H + r_L}{2} - \frac{c(r_H - r_L)}{2(r_H - r_L - c + t)} \tag{10}$$

$$E[\text{payoff to E}] = \frac{x_H - r_H + x_L - r_L}{2} - k_E - s \tag{11}$$

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; the licensor audits more often, and receives more on average for doing so.

Given the equilibrium strategies α and p, we must find the royalty rates and transfer payment triplet (r_H, r_L, t) to associate with the pair of signals (H, L) that the accounting system could generate. The triplet maximizes the payoff to the licensor from (10) subject to several constraints. First, the limited liability constraints must be satisfied, so the licensee never has to pay the licensor more than the gross payoff. Therefore, $x_L \geq r_L$ and $x_H \geq r_H + t$. Second, the licensee must have an incentive to work hard, so the expected payoff from high effort from (11) must exceed the expected payoff from low effort. The licensee's payoff from low effort is $x_L - r_L$; note that $p^* = 0$ is the licensee's optimal choice of p given low effort and the equilibrium audit probability α from (9). Therefore, the incentive compatibility (IC) constraint requires

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

which simplifies to

$$\frac{x_H - r_H - x_L + r_L}{2} - s - k_E \geq 0. \tag{12}$$

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 (11), the participation constraint (PC) is

$$\frac{x_H - r_H + x_L - r_L}{2} - s - k_E \geq x_L - r_L. \tag{13}$$

The royalty and transfer triplet (r_H, r_L, t) must satisfy the following program.

$$\max_{r_H \geq 0,\, r_L \geq 0,\, t \geq 0} \left\{ \frac{r_H + r_L}{2} - \frac{c(r_H - r_L)}{2(r_H - r_L - c + t)} \right\}$$

$$r_H \leq x_H - t \tag{LL-hi}$$

$$r_L \leq x_L \tag{LL-lo}$$

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

$$\frac{x_H - x_L - r_H + r_L}{2} - k_E - s \geq 0 \tag{IC}$$

PROPOSITION 1: The optimal contract without attestation is

$$r_L = x_L,$$

$$r_H = x_H - 2s - 2k_E,$$

$$t = 2k_E + 2s.$$

PROOF: First, we show that the LL-hi constraint is binding. If it did not bind, t could be increased, increasing the objective function without affecting any of the other three constraints. Therefore, the LL-hi constraint is binding. Second, we show that the LL-lo constraint is binding. Suppose it did not bind, so $x_L > r_L$. In that case, the participation

constraint (PC) does not bind. But if PC does not bind, then r_H and r_L could be increased by the same amount and t decreased by the same amount. These changes would increase the objective function without violating any of the other constraints; therefore, the LL-lo constraint also binds. This in turn implies that the PC and IC constraints are identical, and simplify to $t \geq 2k_E + 2s$. Finally, this constraint also binds. If it were not binding, t could be decreased and r_H increased, increasing the objective function without violating any other constraints.

Substituting the values of r_H, r_L and t from Proposition 1 into (8) and (9) allows us to express the strategies α and p in terms of the model's exogenous parameters.

$$\alpha^* = \frac{x_H - x_L - 2k_E}{x_H - x_L} \tag{14}$$

$$p^* = \frac{x_H - x_L - 2c}{x_H - x_L - c} \tag{15}$$

Both α and p must be between zero and one in equilibrium. The fact that $V_E > 0$ ensures that $\alpha > 0$; the fact that $c < \frac{x_H - x_L}{2}$ ensures that $p > 0$.

We see from (14) that the greater the benefit from high effort ($x_H - x_L$), the higher the probability that the licensor audits a low report. The licensor must audit more aggressively to deter the licensee from choosing the corner solution of installing a weak accounting system when the intellectual property is more valuable. Similarly, (15) shows that the probability that the accounting system functions properly is increasing in the benefit from high effort, so as to keep the licensor indifferent between auditing and not auditing a low report. Similarly, p is decreasing in the audit cost c for the same reason.

The licensor's expected payoff is found by substituting the equilibrium contract from Proposition 1 into (10) to yield

$$\frac{x_H + x_L}{2} - k_E - s - \frac{c(V_E - s)}{x_H - x_L - c}. \tag{16}$$

3.3 VARIABLE ROYALTY EQUILIBRIUM WITH ATTESTATION

Next, we determine the optimal variable royalty arrangement if the licensee commits to an attestation process at cost *a* that ensures that the licensee chooses an accounting system that always reports the true payoff (*p*=1). Auditing becomes a dominated strategy for the licensor, and the optimal transfer *t* becomes irrelevant because the self-reports are always correct.

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, while not requiring the licensee to pay a royalty higher than the gross payoff.

We seek a royalty pair (r_H, r_L) to associate with each signal. Using the payoffs in Figure 1, the principal's problem reduces to the following program.

$$\max_{r_H \geq 0,\, r_L \geq 0} \left\{ \frac{r_H + r_L}{2} \right\}$$

subject to:

$$r_H \leq x_H \tag{LL-hi}$$

$$r_L \leq x_L \tag{LL-lo}$$

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

$$\frac{x_H - x_L - r_H + r_L}{2} - k_E \geq 0 \tag{IC}$$

PROPOSITION 2: The solution to the above problem has the form (for any $\varepsilon \in [0,1]$)

$$r_L = x_L - \varepsilon(s+a),$$

$$r_H = x_H - 2k_E - (2-\varepsilon)(s+a).$$

PROOF: First, we note that the LL-lo constraint and IC constraint are both satisfied if

$$2k_E + x_L - x_H + r_H \le r_L \le x_L.$$

This implies

$$x_H - r_H \ge 2k_E,$$

which in turn implies that the LL-hi constraint does not bind. Finally, the PC constraint implies that

$$\frac{r_H + r_L}{2} \le \frac{x_H + x_L}{2} - k_E - s - a.$$

The PC constraint must bind because otherwise r_H and r_L could be increased, which would increase the objective function without violating any other constraints. Because r_H and r_L have equal weight in the objective function and affect the PC constraint equally, there is a range of solutions that yields the same payoff to the principal and satisfies all of the constraints. The licensor's payoff for a variable royalty arrangement for any such solution is

$$\frac{x_H + x_L}{2} - k_E - s - a. \tag{17}$$

3.4 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, license its use in exchange for a variable royalty in a setting without an attestation arrangement, or license its use in exchange for a variable royalty in a setting with an attestation arrangement.

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 prefers this to prevent the licensee from capturing some of the surplus due to the limited liability constraint if $V_R > 0$.

Next, comparing the licensor's payoff from the fixed royalty arrangement (x_L) to its expected payoff from the variable royalty arrangement without attestation in (16) shows that the licensor prefers the variable royalty arrangement if and only if $s \leq V_E$. The licensor's preference can be expressed as a comparison between the net social value associated with high effort by the licensee and accounting system costs. If these costs are sufficiently low, the licensor prefers the variable royalty without attestation; higher costs cause the licensor to prefer the fixed royalty.

Next, we compare the variable royalty arrangements with and without an attestation process.[5] When the licensee uses an attestation process, the licensor's payoff is given in (17). When the licensee does not use an attestation process, the licensor's expected payoff is given in (16). Comparing (16) and (17) shows that the variable royalty without an attestation process is preferred to the variable royalty with an attestation process if and only if

$$s \geq V_E - \frac{a}{1-p^*} = V_E - \frac{a(x_H - x_L - c)}{c}.$$

Finally, we compare the variable royalty arrangements with and without attestation to the licensor using the intellectual property on its own. Comparing (4) and (17) shows that the licensor prefers to use the intellectual property on its own to a variable royalty arrangement with attestation if and only if

$$k_R \le k_E + s + a. \tag{18}$$

In this case, the licensee receives no rents, so the comparison between the two alternatives hinges entirely on the costs of effort, the cost of the strong accounting system, and the attestation cost.

Comparing (4) and (16) shows that the licensor prefers to use the intellectual property on its own to a variable royalty arrangement without attestation if and only if

$$k_R \le k_E + (1 - p^*)V_E + sp^*. \tag{19}$$

We summarize our results in Proposition 3.

PROPOSITION 3: The licensor's preferred licensing arrangement is as follows:

(a) if $V_R < 0$ and $V_E < s$, the licensor prefers to exploit its intellectual property via a fixed royalty arrangement;

(b) if $V_E - \frac{a(x_H - x_L - c)}{c} \le s \le V_E$ and $k_R \ge k_E + (1 - p^*)V_E + sp^*$, the licensor prefers to exploit its intellectual property via a variable royalty arrangement without attestation;

(c) if $s \le V_E - \frac{a(x_H - x_L - c)}{c}$ and $k_R \ge k_E + s + a$, the licensor prefers to exploit its intellectual property via a variable royalty arrangement with attestation;

(d) the licensor prefers to exploit its intellectual property on its own in all other cases.

Figure 2 illustrates these outcomes. The *x*-axis shows the cost of a perfect system, *s*, which is bounded below by *0* and is unbounded above. The *y*-axis is the cost of high effort for the licensor, k_R, which is bounded below by k_E and is unbounded above. The horizontal line $k_R = \frac{x_H - x_L}{2}$ 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). 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 the accounting system cost is high relative to the net social value of high effort ($s > V_E$), prefers a variable royalty with attestation when this cost is low $\left(s \le V_E - \frac{a(x_H - x_L - c)}{c} \right)$ and prefers a variable royalty without attestation for intermediate values of *s*. When $V_R > 0$, the owner of the IP always prefers to use the IP on its own to licensing it for a fixed royalty. Whether it prefers insourcing or one of the two variable royalty arrangements depends jointly on *s* and k_R.

[INSERT FIGURE 2 ABOUT HERE]

4. Economic Changes and the Use of Intellectual Property

In this section, we examine how the use of intellectual property changes as features of the economic environment change. We focus on the effects of a decrease in accounting system costs (*s*) and an increase in the value of outsourcing due to a decrease in the cost of licensee effort (k_E). We summarize the expected payoff to the principal under each of the four possible arrangements in Table 1.

[INSERT TABLE 1 HERE]

We first consider the possibility that the corporate accounting scandals led to both regulatory changes (e.g., Sarbanes-Oxley) and a change in attitudes towards good

governance within the corporate sector. If either or both of these changes have led to improved systems of internal controls, then the variable cost of operating a more accurate system of self-reporting should have decreased. Table 1 shows that a decrease in *s* increases the payoffs to both variable royalty arrangements and has no effect on the payoffs from either insourcing or a fixed royalty arrangement. Furthermore, the increase in the principal's payoff due to a decrease in *s* is larger under the attestation arrangement than under the auditing arrangement. Therefore, we predict that a decrease in the variable cost of an information system will have three effects. First, it will increase the extent to which owners of IP enter into licensing arrangements with third parties instead of using the property on their own. Second, it will increase the use of variable royalty arrangements and decrease the use of fixed royalty arrangements. Third, it will increase the fraction of variable royalty arrangements that rely on third-party attestation and decrease the fraction of variable royalty arrangements that rely on licensor auditing.

Next, we consider how a decrease in the cost of licensee effort changes the way in which IP is used. Table 1 shows that a decrease in k_E has the same effects as a decrease in *s*. Therefore, as gains from outsourcing increase, we expect to see an increase in outsourcing, an increase in the use of variable royalty arrangements and a decrease in fixed royalty arrangements, and an increase in the fraction of variable royalty arrangements than rely on third-party attestation and decrease in the fraction of variable royalty arrangements that rely on licensor auditing. Finally, we note that in each case, the net effect on the use of variable royalty arrangements supported by licensor auditing is ambiguous; these arrangements become more attractive relative to insourcing and fixed

royalty arrangements, but less attractive relative to variable royalty arrangements supported by third-party attestation. We summarize both effects in Table 2.

[INSERT TABLE 2 HERE]

5. Effect of Project Variance on the Licensor

In this section, we investigate how an increase in the variance of the project's payoffs changes the licensor's payoff under each licensing arrangement. In the existing model, high effort increases both the mean and variance of returns. To disentangle these forces, we define

$$\begin{aligned} x_H &= \mu + \delta \\ x_L &= \mu - \delta, \text{ where } \delta \geq 0. \end{aligned} \tag{20}$$

Using these definitions, $x_H + x_L = 2\mu$, $x_H - x_L = 2\delta$ and $V_E = \delta - k_E$. We begin by observing that an increase in μ affects all the payoffs in Table 1 in exactly the same way, so the form of the licensing arrangement does not affect the relation between the project's mean payoff and the licensor's payoff. In contrast, differentiating the payoffs in Table 1 with respect to δ reveals differences across licensing arrangements with respect to the how the variance of the project's payoff affects the licensor's payoff.

The payoff in the fixed royalty decreases one-for-one with a unit increase in δ, whereas the there is no impact on the expected payoffs in the insourcing and attestation regimes. The impact of δ in the variable licensing arrangement with licensor auditing is more subtle. The IP owner's payoff in this contract is

$$\mu - k_E - s - \frac{c(\delta - k_E - s)}{2\delta - c} = \mu - \delta + (\delta - k_E - s)\left[\frac{2\delta - 2c}{2\delta - c}\right]. \tag{21}$$

If auditing were free (c=0), the payoff would be $\mu - k_E - s$, and thus the variance of outcomes would have no effect on the licensor's payoff. Even if auditing were not free, the IP owner could achieve this same expected payoff if the licensee could commit to a perfect system (p=1) and the IP owner could commit not to audit ($\alpha = 0$). The inability to commit means that the players choose their equilibrium strategies for α and p in (14) and (15), or

$$\alpha^* = \frac{2\delta - 2k_E}{2\delta},\ p^* = \frac{2\delta - 2c}{2\delta - c}. \tag{22}$$

The inability to commit has two countervailing effects. The payoff increases by a lower system cost (the equilibrium system strength versus a perfect system), but it decreases by the expected audit cost (versus not auditing).

First, the lower system cost increases the IP owner's payoff by $s(1-p) = \frac{sc}{2\delta - c}$. Taking the derivative of this expression with respect to δ yields

$$-\frac{2cs}{(2\delta - c)^2}. \tag{23}$$

Thus, the system cost component strengthens the IP owner's incentives to pursue R&D projects with *low* payoff variance. Intuitively, the weaker the system, the more underreporting; the more underreporting, the lower the net payoffs – all of which is exacerbated as variance increases.

Second, the IP owner's expected payoff decreases by the incremental audit costs. Recall that a low report is observed with probability $\left(\frac{2-p}{2}\right)$, and the IP owner chooses

to audit with probability α. Thus, the IP owner's expected payoff decreases by $-c\alpha\left(\frac{2-p}{2}\right) = -\frac{c(\delta - k_E)}{(2\delta - c)}$. The derivative of this expression with respect to δ is

$$\frac{c(c-2k_E)}{(2\delta - c)^2}. \tag{24}$$

The incremental audit cost component strengthens the IP owner's incentives to pursue R&D projects with *high* payoff variance if audit costs are sufficiently high (i.e., $c > 2k_E$). As the payoff variance increases, there are fewer low reports (because the licensee chooses a stronger system) and the IP owner audits low reports more often.[6] When $c > 2k_E$, an increase in δ reduces the number of audits performed; although the IP owner audits a higher percentage of low reports, there are fewer low reports received, so the net effect is a lower audit cost. Taken together, the net impact of increasing payoff variance on the audit and system cost components of the IP owner's expected payoff is

$$\frac{c(c-2k_E-2s)}{(2\delta - c)^2}. \tag{25}$$

Thus, when $c > 2(k_E + s)$, an increase in payoff variance creates more benefit from the audit cost component than loss due to the system cost component. To summarize, in the variable royalty licensing arrangements with licensor auditing, the IP owner's payoff can be either increasing or decreasing in the variance of the project's payoffs. The licensor's payoff is increasing in variance if the audit costs are high relative to system costs and is decreasing in variance otherwise. The IP owner's payoff is decreasing in variance in the fixed royalty arrangement, and is unaffected by variance when a variable royalty with attestation arrangement is used.

6. Conclusions

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 either auditing of the report by the licensor or third-party attestation of the reporting system. 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 information system, audit and attestation 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 find that if information system costs and the licensee cost of effort have decreased over time, the ways in which the owner of intellectual property will use that property will change in three ways. First, we expect outsourcing to increase. Second, we expect variable royalty arrangements will become more common and fixed royalty arrangements will become less common over time. Third, we expect that of the variable royalty arrangements, a higher fraction will be supported by third-party attestation and a lower fraction will be supported by a licensor auditing over time.

Finally, we show that the effect of an increase in the variance of the project's payoffs on the licensor's payoff depends on the licensing arrangement. In the fixed royalty arrangement, the owner prefers low project variance because this increases the payoff from the low outcome, which is also the owner's payoff. In the variable royalty arrangement with auditing, the owner prefers high variance projects if and only if auditing costs are sufficiently high.

References

Arya, A. and B. Mittendorf. 2006. Enhancing vertical efficiency through horizontal licensing. *Journal of Regulatory Economics* 29: 333-342.

Dhar, R. and B. N. Anand. 2006. Licensing Industry Survey 2006. The International Licensing Industry Merchandisers' Association (LIMA): New York, NY.

Fellingham, J. and D. P. Newman. 1985. Strategic considerations in auditing. *The Accounting Review* 60(4 (October)): 634-650.

Graetz, M. J., J. F. Reinganum and L. L. Wilde. 1986. The Tax Compliance Game: Toward an Interactive Theory of Law Enforcement. *Journal of Law, Economics and Organization* 2(1): 1-32.

Hughes, S. 2007. Sarbanes-Oxley is eased.

Kamien, M. I. and Y. Tauman. 1986. Fees versus royalties and the private value of a patent. *The Quarterly Journal of Economics* 101: 471-491.

KPMG. 2004. The self-reporting economy: A matter of transparency and trust. KPMG International: United Kingdom.

Kulatilaka, N. and L. Lin. 2006. Impact of licensing on investment and financing of technology development. *Management Science* 52(12 (December)): 1824-1837.

Laffont, J.-J. and D. Martimort. 2002. *The theory of incentives: The principal-agent model*. Princeton University Press: Princeton, NJ.

Lin, L. and N. Kulatilaka. 2006. Network effects and technology licensing with fixed fee, royalty and hybrid contracts. *Journal of Management Information Systems* 23(2 (Fall)): 91-118.

Sen, D. 2005a. Fee versus royalty reconsidered. *Games and Economic Behavior* 53: 141-147.

Sen, D. 2005b. On the coexistence of different licensing schemes. *International Review of Economics and Finance* 14: 393-413.

Tirole, J. 1988. *The Theory of Industrial Organization*. The MIT Press: Cambridge, Massachusetts.

Wang, X. H. 2002. Fee versus royalty licensing in a differentiated Cournot duopoly. *Journal of Economics & Business* 54: 253-266.

TABLE 1: Payoff to principal under each arrangement

Arrangement	**Expected payoff to principal**
Insource	$\frac{x_H + x_L}{2} - k_R$
Fixed royalty	x_L
Variable royalty, licensor audit	$\frac{x_H + x_L}{2} - k_E - s - \frac{c(V_E - s)}{x_H - x_L - c}$
Variable royalty, third-party attestation	$\frac{x_H + x_L}{2} - k_E - s - a$

TABLE 2: Attractiveness of each arrangement as s and k_E decrease

Arrangement	$\boldsymbol{s}$	$\boldsymbol{k_E}$
Insource	decreases	decreases
Fixed royalty	decreases	decreases
Variable royalty, licensor audit	indeterminate	Indeterminate
Variable royalty, third-party attestation	increases	increases

Figure 1: Game tree

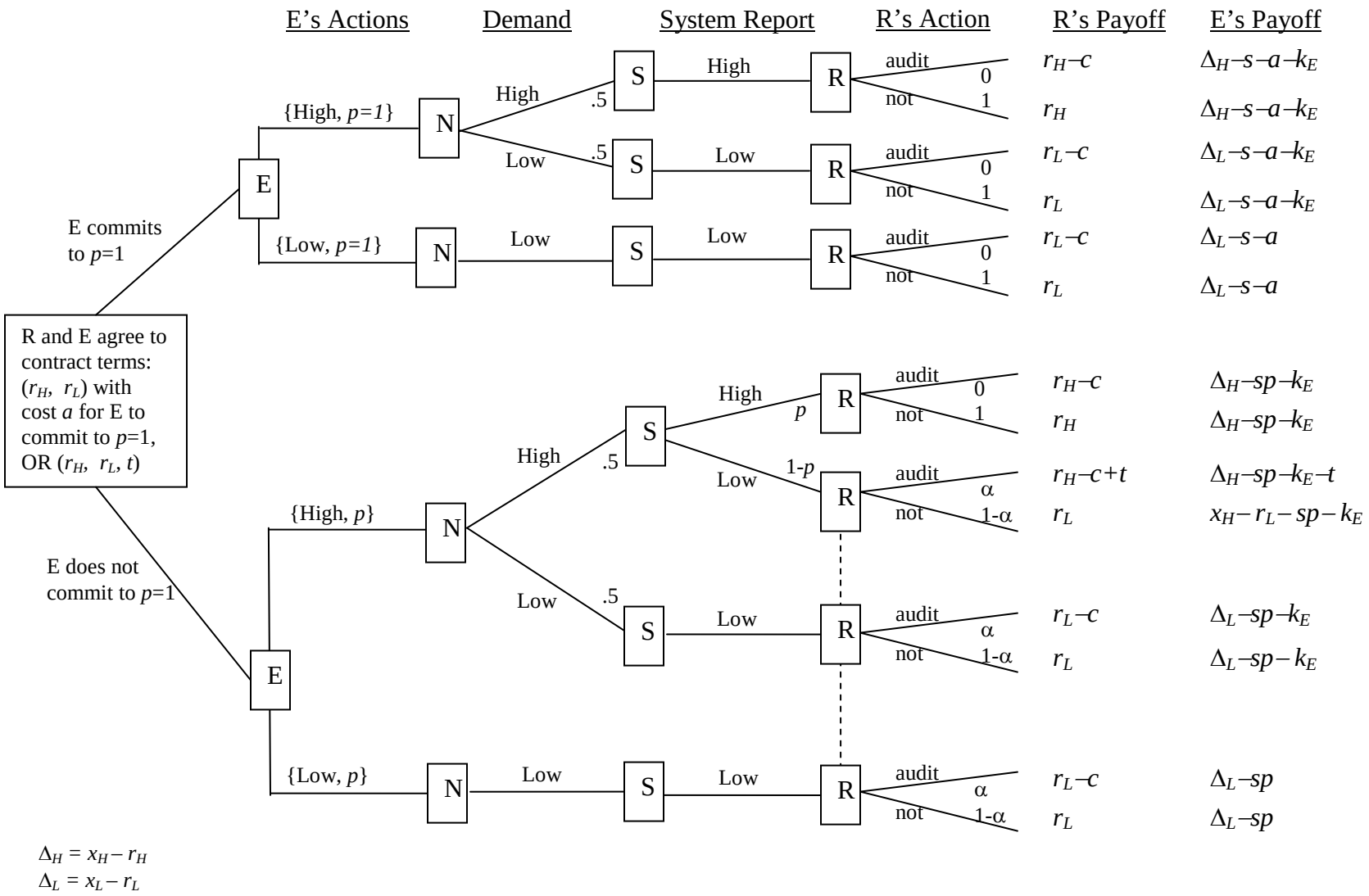
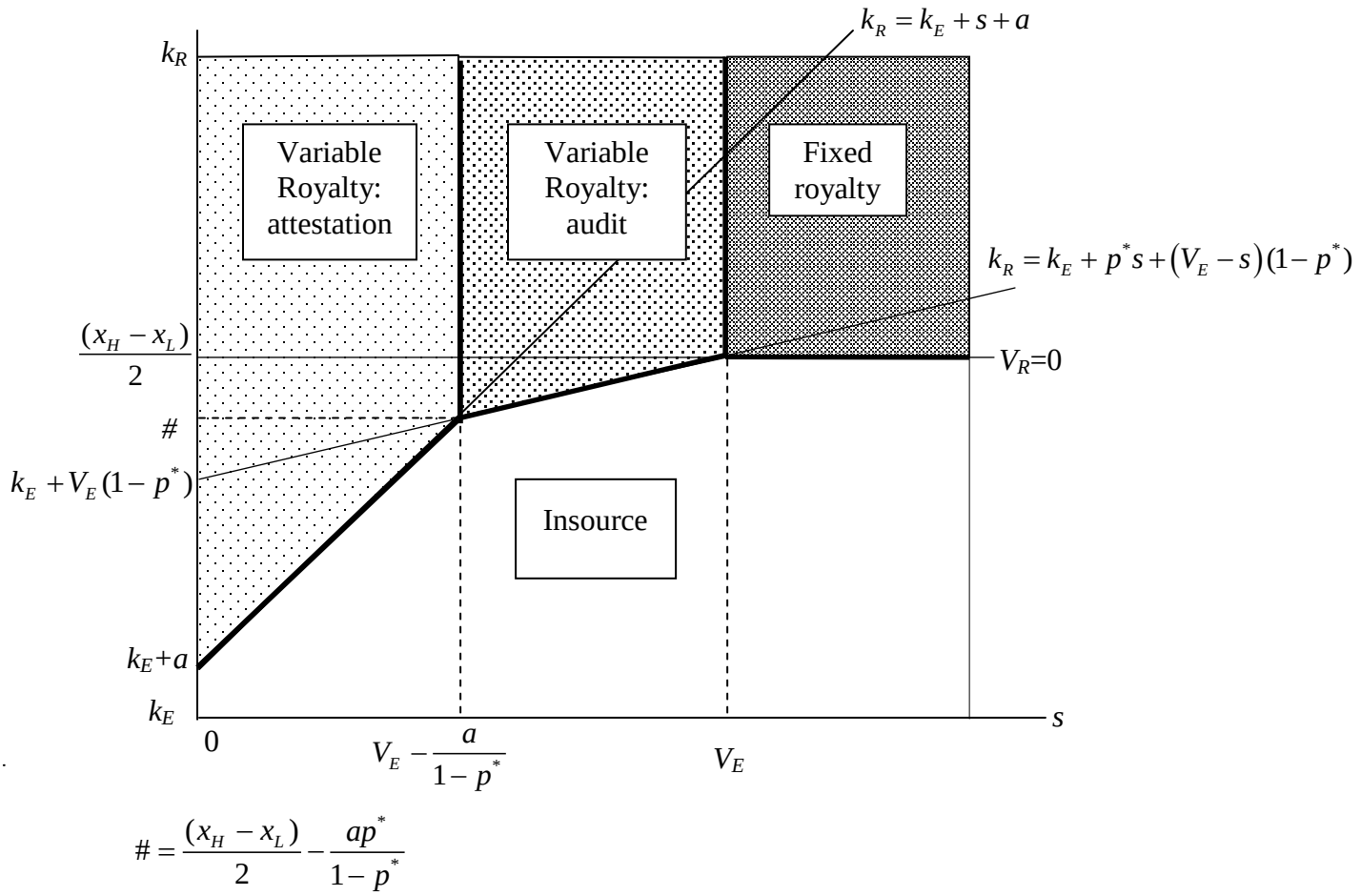


Figure 2: Licensor's preferred arrangement with strategic auditing



$$\# = \frac{(x_H - x_L)}{2} - \frac{ap^*}{1 - p^*}$$

Origin at (0, k_E). The x-axis shows the cost of a perfect system, s, which is bounded below by 0 and unbounded above. The y-axis is the cost of high effort for the licensor, k_R, which is bounded below by k_E and is unbounded above. The horizontal line V_R=0 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 vertical line s=V_E divides the region into the area for which the net social surplus of high effort by the licensee with a perfect system, $V_E - s$, is positive (left of the line) and negative (right of the line).

The steeper diagonal line $k_R = k_E + s + \frac{c}{2}$ divides the region into the area where the licensor prefers a variable royalty arrangement with licensee attestation and a perfect system to insourcing (above the line) and vice versa (below the line). The flatter diagonal line $k_R = k_E + p^* s + (V_E - s)(1 - p^*)$ divides the region into the area where the licensor prefers variable royalty without attestation (that is, licensor-initiated auditing), and a less-than-perfect system to insourcing. The vertical line $V_E - \frac{a}{1 - p}$ divides the region into the area for which the licensor prefers a variable royalty arrangement with licensee attestation (left of the line) versus without attestation (right of the line).

[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 (e.g., 10%) is detected, the licensee bears the entire audit cost (i.e., $t=c$). 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., $t=0$); however, the licensee still must pay the incremental royalties detected by the audit ($r_H - r_L$).

[5]These two arrangements have been referred to by practitioners as *offensive* – where the licensor initiates the audit – and *defensive* – where the licensee attests to a strong system, and hires a third party to opine on its attestation. We thank Ron Safran of KPMG LLP for this terminology.

[6] In particular, $\frac{\partial}{\partial \delta}\alpha^* = \frac{k_E}{\delta^2} > 0, \frac{\partial}{\partial \delta} p^* = \frac{2c}{(2\delta - c)^2} > 0$.