European Journal of Business and Management www.iiste.org
ISSN 2222-1905 (Paper) ISSN 2222-2839 (Online)
Vol.7, No.22, 2015

Quality and Beliefs in the Market for University Inventions A model of bargaining with Private Information

Radu Munteanu, PhD (corresponding author)
Business&Economics Department, Saint Katherine College, 1637 Capalina Rd. San Marcos, CA 92069

Abstract[1]
The paper analyzes the efficiency implications for the licensing process of university inventions when firms can use the secrecy device. Secrecy is a confidential agreement used by the firms to learn about the quality of inventions prior to licensing. I use a bargaining model with one-side private information to analyze the extent to which the *secrecy* device improves the efficiency of the licensing process.
The decision to enter a secrecy agreement is determined by the uncertainty about the underlying quality of inventions. The bargaining model assumes that the university/inventor has private information about the value of invention and that firms use secrecies as costly device to guarantee the quality of the invention.
The main results show that the secrecy device increases the efficiency of the licensing process and that the gains in efficiency are proportional with the difference between the established firm's cost of production and the inventor's cost of production.
Keywords: bargaining, asymmetric information, private information, adverse selection, Bayesian updating

I. Introduction and short literature review

This paper analyzes the contribution of secrecy agreements to the efficiency of the licensing of university inventions by start-up and established firms. Secrecies are confidential agreements which can be used by firms to learn about the quality of the inventions. Asymmetry of information regarding the value of invention between firms and inventor plays an important role in licensing decision by start-up and established firms. The objective of the paper is to use a model of bilateral bargaining with adverse selection to analyze the extent to which the secrecy device affects the efficiency of the licensing mechanism. The main question addressed in this paper is the following: *Under what conditions does the secrecy device improve the efficiency of the licensing process and what is the gain in efficiency?* Using a bilateral bargaining model of licensing the paper analyzes the gains in the efficiency of licensing when firms use the secrecy device. My results show that the secrecy device increases the efficiency of the licensing mechanism and that the gains in efficiency are proportional with the difference in the cost of developing the invention for established and start-up firms.

Numerous empirical and theoretical studies on licensing activity at universities analyze the implications of the informational asymmetries for the efficiency of the licensing process. However, this is the first theoretical paper to describe the contribution of the secrecy device to the efficiency of the licensing process.

Samuelson (1984) argues that the presence of asymmetric information in bargaining may preclude the attainment of a mutually beneficial sale. Thus, understanding the role of the secrecy device in reducing the asymmetry of information in the licensing process is very important from a public policy perspective. Since the research activity at university is publicly funded, there is a great interest in licensing the inventions with the highest degree of efficiency.

In a survey study of licensing university inventions, Thursby & Thursby (2004) found that large proportions of the inventions disclosed at universities are at embryonic stages. These inventions require a large financial effort from the part of the licensees and thus it is important to understand the mechanism by which firms ensure the profitability of inventions. One device that firms can use to learn about the quality of inventions is the *secrecy,* which allows firms to learn about the underlying quality and decide whether to license the invention[2].

Shane (2002) argues conceptually that licensing to a start-up is a "second best solution" because start-ups lack the necessary assets to bring the inventions to the commercialization stage. Established firms enjoy a comparative advantage in commercializing the inventions due to their have the marketing skills, complementary assets and production capabilities. Lowe (2003) argues conceptually that start-ups emerge as a vehicle of developing the inventions because the asymmetry of information raises the cost of licensing for established firms.

The existing studies suggest that the asymmetry of information introduces inefficiency in the licensing process by start-up and established firms. The main contribution of my paper is to provide a formal analysis of the licensing process with a secrecy device and determine the efficiency when firms use this device. The paper also includes a quantitative description of the efficiency gains which are due to the use of secrecy device, which is not performed in other studies.

In my paper I use a model of bilateral bargaining with adverse selection similar to Samuelson and Bazerman' Acquiring a Company Game (1985). In "Acquiring a Company Game" an acquirer is considering making an offer to buy out a target firm. The target firm is more valuable under the acquirer management than under the present ownership but the acquirer does not know the target's real value.

I extend this model by allowing the established firm to make an offer for an invention in the presence of asymmetric information (the university/inventor know the value of invention but established firm does not know the value) but adding the possibility that licensing is not always profitable for the firm. The rest of the paper is organized as follows: Section 1.1.1 provides a short description of the licensing process involving the use of secrecies, Section 1.1.2 and 1.1.3 presents the theoretical model and its implications, Section 1.1.4 includes a welfare analysis and conclusions are included in Section 1.1.5.

1.1 A Short Description of the Licensing Process

The licensing mechanism consists of three main phases:

Phase 1 - Invention's Disclosure. The invention is disclosed to the university technology transfer office in order to protect its property rights and market the invention.

Phase 2 Firms may use of confidential agreements, *secrecies,* which give firms the opportunity to learn about the quality of invention and determine whether they are interested in licensing the invention.

Phase 3 – Licensing. If firms decide to license the invention then they start a bargaining process with the university regarding the license fee.

I model licensing as a two-stage process: in the first stage the firm decides whether to enter a secrecy agreement in order to learn the profitability of the invention. In the second stage the firm makes an offer to the university in order to license the invention. If the offer is accepted by the university, the firm commits to a license agreement by paying a license fee. If the offer is not accepted, the university has the option to negotiate a license agreement with the inventor.

It is important to note the presence of the adverse selection in the licensing process. That is, a given offer will only be accepted by the university for the "low-value" inventions[3].

1.1.1. A model of bilateral bargaining

My bargaining model extends the analysis of Samuelson&Bazerman (1985) by adding the option of entering a secrecy agreement to reduce the uncertainty about the profitability of the license.

The model has two stages: 1) the firm (the *buyer*) chooses whether to enter a secrecy and 2) the buyer makes a first-and-final offer that is accepted or declined by university (*seller*). If the invention is declined by the firm then the university has the option licensing the invention to the *inventor*. The main elements of the model can be described as follows: a risk-neutral firm is deciding whether to license an invention from the university. The invention's value v is drawn uniformly from the interval $[\underline{v}, \bar{v}]$ and has a cumulative probability distribution F(v). The firm, the university and the inventor know the function F(v), but only the university and the inventor know the specific value of v .

Suppose that the firm incurs a constant and exogenous cost c_A associated with developing the invention, which is uniformly distributed over the interval $[\underline{v}, \bar{v}]$. Notice that licensing the invention is not always profitable for the firm because there is a positive probability that the value of the invention is lower than the cost c_A .

Furthermore, assume that the inventor's cost of production is c0 and is also uniformly distributed on $[\underline{v}, \bar{v}]$. The costs of production for firm and inventor are assumed to be independent and identically distributed. The costs c_0 , c_A and the function F(v) are known to all players of the model at the beginning of the bargaining process.

In the first stage of the bargaining process, the firm has the option to enter a secrecy agreement at a cost c_s to ensure the profitability of the invention.

In the second stage, a bilateral bargaining process takes place between firm and the university. The rules of the bargaining are: the firm makes a first and final offer to the university and this offer is accepted or declined. If the offer is accepted, the firm pays a price p for the use of the invention. If the offer is declined, the university has the option of negotiating a license with the inventor, who licenses the invention if $v \geq c_0$[5].

Given the rules specified above, the payoffs of the players in the second stage are determined as follows: if the firms's offer is accepted then he licenses the invention and pays a price p to the university. The payoff of the firm is then: max {0, v - c_A } – p and the payoff of the university is p. Notice that the firm's payoff incorporates the fact that, having paid the price p to the university, it learns the value of the invention v and pursues the invention only if $v \geq c_A$. If $v < c_A$, the firm does not pursues the invention and incurs a loss – p.

If the buyer's offer is rejected and $v \geq c_0$, then the inventor licenses own invention by paying a price (v - c_0). As a result, the inventor's payoff is 0 and the payoff for the university is (v - c_0). If the offer is rejected and $v < c_0$, then the invention remains unlicensed and both the university and the inventor get a payoff of 0. Overall, if the offer is rejected, the payoff to the university is: max {0, v - c_0} and the inventor's payoff is 0.

First, I describe the bargaining outcome when firms do not have the option of entering secrecies. Later in the paper I describe the bargaining outcome when firms have the option of using the secrecy device.

Assume for the rest of the paper that $c_A \leq c_0$, i.e. the firm is more efficient than the inventor in developing the invention[6].

1.1.2 Bargaining Outcome without the secrecy

Let p_b be the firm's offer for licensing the invention. An offer $p_b \geq 0$ is accepted by the university if and only if: $p_b \geq v - c_0$, or alternatively, $v \leq p_b + c_0$. Conditional on an offer p_b being accepted, firm A updates its beliefs about the value and infers that this value is in the interval $[\underline{v}, c_0 + p_b]$.

The conditional value of the invention is uniformly distributed over $[\underline{v}, c_0 + p_b]$ with probability distribution function: $g(v) = \frac{1}{c_0 + p_b - \underline{v}}$.

The probability that the invention is not profitable for the firm is: $\frac{c_A - \underline{v}}{c_0 + p_b - \underline{v}}$ and the probability that the invention is profitable for the firm is: $\frac{c_0 + p_b - c_A}{c_0 + p_b - \underline{v}}$.

The buyer's net expected profit conditional on the offer $p_b > 0$ being accepted is:

$$E_0(\Pi) = \int_{\underline{v}}^{c_0+p_b} \{\max(v - c_A, 0) - p_b\} g(v)dv = \int_{\underline{v}}^{c_A} (0 - p_b) g(v)dv + \int_{c_A}^{c_0+p_b} (v - c_A - p_b) g(v)dv \quad \text{(I)}$$

From (I), formula for the expected profit can be written as follows:

$$E_0(\Pi) = \frac{c_A - \underline{v}}{c_0 + p_b - \underline{v}}(0 - p_b) + \frac{1}{c_0 + p_b - \underline{v}}\left[\frac{(c_0 + p_b)^2}{2} - (c_A + p_b)(c_0 + p_b) - \frac{c_A^2}{2} + (c_A + p_b)c_A\right]$$

This formula takes into account that the firm, having paid p_b for the invention, learns the true value of the invention v and develops the invention if and only if $v \geq c_A$. Otherwise, the payoff to the firm is - p_b.

The buyer's objective is to maximize the expected profit and the first-order condition associated with this problem is: $-(c_A - \underline{v}) + c_0 + p_b - 2p_b - c_0 - c_A + c_A = 0$,

from which we obtain the buyer's optimal offer: $p_b^* = \underline{v} - c_A$.

Since $c_A \geq \underline{v}$ and $p_b \geq 0$, then buyer's optimal offer is $p_b^* = 0$. In equilibrium, this offer must be accepted when $v < c_0$ (the invention is worthless for the inventor) the seller makes a profit of 0.

The net expected profit for the buyer when it offers $p_b^* = 0$ and the offer is accepted becomes:

$$E_0(\Pi) = \frac{(c_0 - c_A)^2}{2(c_0 - \underline{v})}. \quad \text{(II)}$$

Notice that the value of the expected profit in this case represents the value of the integral of the profit function between c_A and c_0.

The buyer's net expected profit is proportional with the difference between the firm A's cost of production of firm A and inventor's cost of production. The more efficient is the buyer relative to the inventor, the higher is his expected profit.

The derivation for (II) takes into account that neither party pursues the invention if v is lower than his cost of production.

This analysis shows the impact of the asymmetric information on the possibility of mutual gain. Even though there are cases in which it is profitable for the firm to license the invention, a positive offer made would result in a lower net expected profit. This is due to adverse selection.

1.1.3 Bargaining outcome with secrecy agreements

I assume that, before licensing, the firm has the option of entering a secrecy by paying a cost c_s. Having entered a secrecy, the firm learns the true value of the invention v and places a bid if and only if $v \geq c_A$.

If $v < c_A$ then the firm does not places a bid and incurs the cost c_s (i.e. the cost of secrecy is sunk). The net expected payoff for the firm is then: -c_s.

If $v \geq c_A$ the firm's optimal offer is derived as follows: if $v < c_0$, the offer is $p_b^s = 0$. If $v \geq c_0$ then the offer is: $p_b^s = v - c_0$. As a result, if $v \geq c_A$, the firm's optimal offer can be written as: p_b^s = max {0, $v - c_0$}. Overall, the firm's net expected payoff is: max {0, $v - c_0$}- c_s.

The firm's ex-ante expected profit when entering a secrecy is:

$$E_1(\Pi) = \int_{\underline{v}}^{\bar{v}} \{\max(v - c_A, 0) - p_b^s\} f(v) dv - c_s = \int_{\underline{v}}^{c_A} 0 \cdot f(v) dv + \int_{c_A}^{c_0} (v - c_A - 0) f(v) dv + \int_{c_0}^{\bar{v}} (c_0 - c_A) f(v) dv - c_s$$

$$= \frac{1}{\bar{v} - \underline{v}} [\frac{c_0^2 - c_A^2}{2} - c_A(c_0 - c_A)] + \frac{c_0 - c_A}{\bar{v} - \underline{v}} (\bar{v} - c_0) - c_s.$$

The calculations show that:

$$E_1(\Pi) = \frac{c_0 - c_A}{(\bar{v} - \underline{v})} [\bar{v} + \frac{c_0 + c_A}{2}] - c_s. \quad \text{(III)}$$

Therefore the firm enters a secrecy if and only if $E_1(\Pi) \geq 0$, which implies that:

$$(c_0 - c_A)[\bar{v} + \frac{c_0 + c_A}{2}] \geq c_s(\bar{v} - \underline{v}). \quad \text{(IV)}$$

The effect of c_s on buyer's decision to enter a secrecy

The cost of entering a secrecy has a direct effect on the firm's decision to enter a secrecy, as shown by (IV). Notice first that, if the cost of the secrecy were 0, (IV) always holds so the firm always benefits by entering a secrecy.

If the cost of a secrecy is too high (relative to the difference in the costs between the firm and inventor) then the firm may be deterred from entering.

To analyze in more detail the effect of c_s on the secrecy choice, we can rewrite (IV) as:

$$c_s \leq \frac{1}{\bar{v} - \underline{v}} (c_0 - c_A)(\bar{v} + \frac{c_0 + c_A}{2}) \quad \text{(IV.1).}$$

In analyzing (1.1) it is useful to consider two special cases. When the costs of the firm and university are almost equal (we can make equal at the limit), then for any positive c_s the secrecy condition (1) does not hold. The buyer will not enter a secrecy because the expected profit from entering a secrecy, which is proportional to the difference in costs, is very small and offset by the cost of secrecy.

For the second special case assume that $c_A = \underline{v}$ and $c_0 = \bar{v}$ .In this case the difference in costs is at a maximum. The RHS of (IV.1) reaches the maximum value of $\frac{3\bar{v} + \underline{v}}{2}$, which implies that for values of c_s greater than $\frac{3\bar{v} + \underline{v}}{2}$ it would be unprofitable for the (most efficient) firm to enter a secrecy.

The two special cases show that the RHS of (1.1) takes values in the interval [0, $\frac{3\bar{v}+\underline{v}}{2}$] for all possible values of $c_A, c_0 \in [\underline{v}, \bar{v}]$. More specifically, if c_s is zero then all firms would enter secrecies and if c_s is greater than $\frac{3\bar{v}+\underline{v}}{2}$ then the licensing process with secrecies would be equivalent to that without secrecies.

The cost of secrecy induces a *selection effect*, i.e. for a given c_s only the more efficient buyers relative to the inventor) will find it profitable to enter secrecies.
To analyze further firm's A decision to enter a secrecy, I rewrite condition (IV) as:

$$(\bar{v}-\underline{v})c_s - c_0(\bar{v}+\frac{c_0}{2}) + c_A\bar{v} + \frac{c_A^2}{2} \le 0 \qquad \text{(V)}$$

The LHS of (2) is a quadratic function in c_A and it has 2 real solutions if the discriminant $\Delta = \bar{v}^2 - 2[(\bar{v}-\underline{v})c_s - c_0(\bar{v}+\frac{c_0}{2})]$ is positive, condition which is satisfied for large values of $\bar{v}$. The roots of the quadratic function are: $c_A^{1,2} = -\bar{v} \pm \sqrt{\Delta}$ and so condition (V) is satisfied if $c_A \in [-\bar{v}-\sqrt{\Delta}, \sqrt{\Delta}-\bar{v}]$.
However, $c_A \ge \underline{v}$ (by assumption) and thus (2) implies that $c_A \in [\underline{v}, \sqrt{\Delta}-\bar{v}]$ (VI).
The firm enters a secrecy if and only if conditions (V) and (VI) are satisfied. As a result, if the firm's cost of production is small enough then entering a secrecy is profitable.

Conversely, the firm does not enter a secrecy if: $c_A \in (\sqrt{\Delta}-\bar{v}, \bar{v}]$ (VII).
In the case when the firms do not have the opportunity to enter secrecies, due to adverse selection, the optimal bid for the firm is 0 and the net expected profit for the firm when the offer is accepted is:
$E_0(\Pi) = \frac{(c_0-c_A)^2}{2(c_0-\underline{v})}$.
When the firm has the opportunity to enter the secrecy but did not use it, condition (4) must be true. As required by a PBNE, the actions of the firm must consistent with its beliefs about the value of invention. In addition, given the firm's beliefs about the value, his actions are optimal.
Using condition (4), the buyer's expected profit when the secrecy is taken is:

$E_1(\Pi | c_A > \sqrt{\Delta}-\bar{v}) = \frac{(c_0-c_A)^2}{2(c_0-\underline{v})}\Big|_{c_A>\sqrt{\Delta}-\bar{v}}$ and the optimal offer is: $p_b^* = 0$.

As a conclusion, in a PBNE, the firm of type $c_A \in [\sqrt{\Delta}-\bar{v}, \bar{v}]$ does not enter a secrecy and its optimal bid is $p_b^* = 0$. Firm of type $c_A \in [\underline{v}, \sqrt{\Delta}-\bar{v}]$ will enter secrecies and its optimal bid is as follows: $p_b^* = 0$ if $v < c_0$ and $p_b^* = v - c_0$ if $v \ge c_0$.

1.1.4 Welfare Implications of the secrecy device

This section analyzes the welfare implications for the licensing process when firms can use the secrecy device. Collectively, a standard measure of efficiency is given by: $W = E^b(\Pi) + E^s(\Pi)$, (VIII)
where $E^{b,s}(\Pi)$ represent the ex-ante profit of the buyer and seller respectively.
The main results of the paper are:

(a) When *firms do not have the opportunity to enter secrecies and* $c_A < c_0$ *(i.e. the buyer is more efficient than the inventor) then: the buyer's offer is:* $p_b^* = 0$, *the buyer's expected profit is* $E_0(\Pi) = \frac{(c_0-c_A)^2}{2(c_0-\underline{v})}$ *and a trade takes place only if* $v \le c_0$.
The intuition is the following: in order to avoid potential losses from a positive bid due to adverse selection, the buyer bids 0.

The value of invention is known to the university and the profits for university are as follows: $\Pi^s = 0$ if $v \le c_0$

and $\Pi^s = v - c_0$ if $v > c_0$. Thus, the ex-ante expected profit for the university is: $E^s(\Pi) = \frac{(\bar{v}-c_0)^2}{2(\bar{v}-\underline{v})}$.

As a result, in case (a) the collective welfare is: $W_0 = E^b(\Pi) + E^s(\Pi) = \frac{(c_0-c_A)^2}{2(c_0-\underline{v})} + \frac{(\bar{v}-c_0)^2}{2(\bar{v}-\underline{v})}$. (IX)

(b) *When firms have the opportunity of entering secrecies, at cost c_s, the PBNE is as follows:*

(i) firm of type $c_A \in [\sqrt{\Delta} - \bar{v}, \bar{v}]$, with $\Delta = \bar{v}^2 - 2[(\bar{v}-\underline{v})c_s - c_0(\bar{v} + \frac{c_0}{2})]$, does not enter a secrecy, its optimal bid is $p_b^* = 0$ and the trade takes place if and if $v \le c_0$.

The ex-ante profits of the firm and university are respectively: $E_1^b(\Pi) = \frac{(c_0-c_A)^2}{2(c_0-\underline{v})}$, $E^s(\Pi) = \frac{(\bar{v}-c_0)^2}{2(\bar{v}-\underline{v})}$. The collective welfare equals W_0, as in case (a).

(ii) firm of type $c_A \in [\underline{v}, \sqrt{\Delta} - \bar{v}]$ will enter secrecies and their optimal bid is: $p_b^* = 0$ if $v < c_0$ and $p_b^* = v - c_0$ if $v \ge c_0$ and the trade takes place in both cases. The ex-ante profits for the firm and university are respectively: $E_1^b(\Pi) = \frac{(c_0-c_A)(2\bar{v}+c_0+c_A)}{2(\bar{v}-\underline{v})}$, $E^s(\Pi) = \frac{(\bar{v}-c_0)^2}{2(\bar{v}-\underline{v})}$.

In this case the collective welfare is:

$$W_1 = E^b(\Pi) + E^s(\Pi) = \frac{(c_0-c_A)(2\bar{v}+c_0+c_A)}{2(\bar{v}-\underline{v})} + \frac{(\bar{v}-c_0)^2}{2(\bar{v}-\underline{v})}. \quad \text{(X)}$$

Notice that in case b (ii), the efficiency is enhanced because the more efficient player (i.e. low-cost firm) licenses the invention.

The use of secrecies (at a cost) eliminates the asymmetry of information and the adverse selection. Thus, the two parties involved in the bargaining can trade efficiently by allowing the more efficient player to license the invention. If the firm is a low-cost type, then the parties enjoy gains in welfare since $W_1 > W_0$. The gain in welfare gain is:

$$\Delta W = \frac{(c_0-c_A)(\bar{v}-c_0)(c_0+c_A-2\underline{v})}{2(\bar{v}-\underline{v})(c_0-\underline{v})}. \quad \text{(XI)}$$

The increase in welfare is proportional with the difference in the two unit costs. The higher is the difference in the costs, the higher are the welfare gains due to use of secrecy device.

As a conclusion, the collective welfare increase weakly when the licensing process incorporates a secrecy device for firms.

1.1.5 Conclusions

The paper uses a bargaining model with adverse selection to analyze the efficiency of the licensing process when firms have the option of using the secrecy device. Firms face an adverse selection issue in the absence of the secrecy device and the optimal bid for the inventions is zero. This bid is accepted by the university only for lower quality inventions. Inefficiency occurs because there some of the higher quality inventions are not licensed by the most efficient player. If the licensing process has the option of the secrecy device, then firms use these secrecies to ensure the profitability of invention and eliminate the asymmetry of information regarding the value of invention. In this case, the low-cost firm enters secrecies and bid successfully on the invention. This leads to a net gain in the collective welfare of the players. Another main result is that the gain in welfare is proportional to the difference in the costs of production between the firm and the inventor.

As a main conclusion, the theoretical model presented in this paper predicts that the secrecy device enhances the efficiency of the licensing mechanism by eliminating the adverse selection and asymmetry of information.

The results have direct public policy implications, suggesting ways of designing and implementing a more efficient licensing process.

This model can be extended to analyze the welfare implications if multiple licensees are allowed for the same invention. Another direction of research is analyzing the welfare implications of the licensing process with the secrecy device in the presence of liquidity constraints faced by the inventor.

References

Farrell Joseph and Gibbons Robert (1989), "Cheap Talk Can Matter in Bargaining", Journal of Economic Theory, Vol. 48.

Samuelson William F. (1980), "First-Order Bargains", Management Science, Vol.26

Samuelson William F. (1984), "Bargaining under Asymmetric Information", Econometrica, Vol. 52, No.4

Samuelson William F.; and Bazerman, Max H.(1985). "The winner's curse in Bilateral Negotiations." In Research in Experimental Economics, vol. 3, Vernon L. Smith, ed., Greenwich, CT: JAI Press 1985.

Shane Scott (2002). "Selling University Technology: Patterns fromMIT", Management Science, Vol. 48.

Vincent P. Crawford and Nagore Irriberi (2005), "Level-k Auctions: Can a Non-Equilibrium Model of Strategic Thinking Explain the Winner's Curse and Overbidding in Private-Value Auctions?", UCSD.

Thursby J. and Thursby M (2004), "Are faculty critical? Their role in university-industry licensing", Contemporary Economic Policy, Vol. 22.

Notes

Note 1. This paper benefited greatly from the generous discussions with Prof. Crawford and Prof. Noel

Note 2.The analysis could be extended by allowing secrecies to be are correlated with the quality of the invention. Potential licensees could thus use the information contained in past secrecies to update their beliefs about the quality; so secrecies could play an important signaling function in the licensing process.

Note 3. In practice, the adverse selection is mitigated by the financing constraints faced by the inventor. Without borrowing constraints the inventors could secure the necessary financing for developing the high quality inventions. But due to lack of collateral and uncertainty about the quality of inventions inventors may not be able to raise the necessary financial resources necessary for the development of the inventions. The presence of imperfect in the capital markets reduces the adverse selection problem for the established firms.

Note 4. Multiple licenses are possible for the same invention. For simplicity I assume that firms cannot sublicense the invention and that the profitability of the license to firm A does not depend on the number of other potential licensees.

Note 5. Multiple licenses are possible for the same invention. For simplicity I assume that firms cannot sublicense the invention and that the profitability of the license to firm A does not depend on the number of other potential licensees.

Note 6. In the case when c0<cA the analysis is as follows: if the licensing process does not include the use of secrecies then any positive offer by the buyer and accepted by the university will result in negative profits for the firm since the offer is accepted if and only if v-c0> v-cA. If the buyer bids 0, then the offer is accepted if and only if v < c0 and since c0<cA then v < cA which again leads to negative profits; the firm will not develop the invention in this case. As result, when c0<cA , the buyer is indifferent between bidding 0 or placing no bid and it makes 0 profit. The invention is licensed by the inventor only if v>c0 , in which case seller's expected profit is , otherwise the invention remains unlicensed. If the buyer has the option of using secrecy agreements then, using a similar reasoning as above, the optimal strategy for the firm is not to enter a secrecy and being indifferent between bidding 0 or not bidding for the invention.

Note 7. A given offer is accepted by the university only for lower value inventions.

Note 8. The calculation takes into account that the buyer, having paid the cost of a secrecy cs, learns the true value of the invention v and then places a bid if and only if v>ca. Otherwise, the invention remains undeveloped and the payoff to the licensee is -cs

Note 9. The gains in expected profit based on the difference between the firm's cost and inventor's cost could be offset by the high cost of secrecy.

Note 10. In the second special case, if $c_s > \frac{3\bar{v}+\underline{v}}{2}$ then the buyer's offer is 0 and trade takes place.

Note 11.Given a pair of values for c_0 and c_A , condition (1.1) determines an interval for c_s such that it is profitable for firm A to enter a secrecy. Furthermore, within this interval, the expected profit from entering a secrecy is greater than the expected profit from not entering a secrecy if $c_s \in [0, c_s^*]$, where $c_s^* = \frac{\bar{v}+c_A}{2(\bar{v}-\underline{v})} + \frac{c_0(c_A+c_0)}{2(\bar{v}-\underline{v})(c_0-\underline{v})}$. The intuition is that if c_s is less than c_s^* then entering a secrecy enhances the expected profit by reducing the asymmetry of information and adverse selection issue.

Note 12. Trade here refers to a licensing agreement between the buyer and university and not a licensing agreement between university and inventor.

Note 13. One assumption is that the profitability of the invention decreases with the number of licensees. More specifically, the value of invention can be written as $v(n)$, where n is the number of licensees and dv/dn <0.