DISCUSSION PAPER SERIES

No. 6207

EXCLUSIVE VERSUS NON-EXCLUSIVE LICENSING STRATEGIES AND MORAL HAZARD

Patrick W. Schmitz

INDUSTRIAL ORGANIZATION

Centre for Economic Policy Research

www.cepr.org

Available online at: www.cepr.org/pubs/dps/DP6207.asp

ISSN 0265-8003

EXCLUSIVE VERSUS NON-EXCLUSIVE LICENSING STRATEGIES AND MORAL HAZARD

Patrick W. Schmitz, University of Cologne and CEPR

Discussion Paper No. 6207
March 2007

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 6207

March 2007

ABSTRACT

Exclusive versus Non-exclusive Licensing Strategies and Moral Hazard*

An upstream firm can license its innovation to downstream firms that have to exert further development effort. There are situations in which more licenses are sold if effort is a hidden action. Moral hazard may thus increase the probability that the product will be developed.

JEL Classification: D45, D82 and L12
Keywords: innovation, licences, monopoly and private information

Patrick W. Schmitz
University of Cologne
Albertus-Magnus-Platz
50923 Köln
GERMANY
Email: patrick.schmitz@uni-koeln.de.

For further Discussion Papers by this author see:
www.cepr.org/pubs/new-dps/dplist.asp?authorid=149900

* I would like to thank Andreas Roider, Stephanie Rosenkranz, and Urs Schweizer for helpful discussions.

Submitted 23 February 2007

1 Introduction

Consider an upstream monopolist who has invented a new technology. The innovator is specialized on basic research and is not able to develop a product based on the new technology. There are two firms in the downstream market that have the abilities to potentially develop the new product, provided they get a license from the upstream monopolist. The probability that a downstream firm successfully develops the product depends on its development effort, which might be a hidden action. Should the innovator sell an exclusive license to one firm or should both firms get licenses? In the latter case, both firms might be successful in developing the product, so that competition at the downstream market would lead to smaller profits.

Following Innes (1990), it is assumed that all firms are risk-neutral but subject to limited liability. It will turn out that there are circumstances under which the upstream monopolist sells licenses to *both* downstream firms when their effort decisions are hidden, while under symmetric information she would have sold an exclusive license to *one* firm only. Hence, the fact that effort is unobservable can *increase* the probability that the final product will ultimately be developed.

This finding is interesting, because usually the presence of asymmetric information tends to reduce the quantities traded.[1] A related result has been obtained in Schmitz (2002) in an adverse selection model, where a downstream firm had precontractual private information about the monopoly profit that it could make on the downstream market. In contrast, in the present paper the firms' downstream profits are verifiable, while their effort decisions may be hidden.

From a methodological perspective, the present paper illustrates the close relationship between adverse selection and moral hazard models.

[1] See e.g. Laffont and Martimort (2002, ch. 5), who point out that the rent-extraction versus incentives trade-off in the case of risk-neutrality and limited liability considered here usually leads to a reduction of the volume of trade.

Roughly speaking, adverse selection problems where an agent has private information about his costs can often be solved if one derives the optimal allocation in the case of symmetric information and then replaces the true costs by the so-called "virtual costs," which are adjusted upwards (see e.g. Laffont and Martimort, ch. 3). It is illustrated here that the concept of "virtual costs" can also be fruitfully applied in moral hazard models.

There is by now a large literature on licensing.[2] Katz and Shapiro (1986) have analyzed the profit-maximizing number of licenses issued by an innovator when there is symmetric information and the licensees do not have to exert effort in order to develop a final product. In fact, most papers in this literature do not consider development efforts subsequent to basic technology licensing. An important exception is Bhattacharya, Glazer, and Sappington (1992), where firms exert unobservable development efforts after innovative knowledge has been licensed to them. However, the questions studied there are quite different from the present analysis, which is focused on the number of licenses that maximizes the innovator's expected profit.

Finally, it should be noted that the present paper is also related to the literature on tournaments (see Lazear and Rosen, 1981).[3] When there is moral hazard, the principal may prefer a tournament between two agents exerting low effort (even if she preferred employing a single hard-working agent in the absence of moral hazard), because her agency costs would be higher in the case of an exclusive agent who must be induced to work hard.

[2] See Kamien and Tauman's (1986) and Katz and Shapiro's (1986) pioneering work and see the many extensions discussed in the surveys by Reinganum (1989) and Kamien (1992). In a more recent contribution, Aoki and Tauman (2001) show that the presence of spillovers can increase the number of licenses sold. See also Bessen (2005), who analyzes the impact of patents on the market for licenses.

[3] See also Bhattacharya and Guasch (1988), who study tournaments in the presence of limited liability, and Roy Chowdhury (2005) and Mukherjee (2006), who analyze effects of tournaments in the context of R&D competition with spillovers.

2 The model

Consider an innovator (principal) who can licence a patent to two downstream firms (agents). An agent who gets a licence can exert effort in order to develop a marketable final product. The development effort will lead to a success with probability p_H if the agent works hard and with probability $p_L \in (0, p_H)$ if he shirks.[4] Let an agent's disutility of exerting high effort be denoted by c. If only one agent is successful in developing the final product, his monopoly profit from selling on the downstream market is given by $M > 0$. If both agents are successful, they make zero profits due to Bertrand competition.[5] Following Innes (1990), all parties are assumed to be risk-neutral and wealth-constrained. In particular, an agent can only make a payment $t \leq M$ to the principal when he makes profit M on the downstream market.[6]

The time structure of the model is as follows. First, the principal makes take-it-or-leave-it offers to the agents, which they can accept or reject. If an agent rejects the offer, he gets his reservation utility zero. An agent who has acquired a license then decides whether or not to exert high effort. Finally, the agents' profits are realized and payments to the principal are made according to the contract.

Two scenarios will be considered. In *scenario I*, all elements of the model are assumed to be verifiable; i.e., there is symmetric information.

[4] If both agents get licenses, it is assumed that whether or not agent i is successful is independent of agent $j \neq i$.

[5] It is straightforward to generalize the model to the case in which the duopoly profits are $D < M$. Note that in accordance with Katz and Shapiro (1986), it is thus implicitly assumed that the innovator cannot soften the downstream competition, e.g. by prescribing prices for the final product or using output-based royalties.

[6] Note that fixed fees which a licensee must always pay regardless of his profit are ruled out, since a licensee cannot make a positive payment if his profit on the downstream market is zero. Note also that the principal's limited liability constraint will never be binding.

In *scenario II*, the decision of an agent whether or not to exert effort is a hidden action; i.e., there is moral hazard. In any case, the principal's goal is to maximize the expected payments that are made to her.

Assume first that the principal provides an exclusive license to one agent.[7] Let x indicate whether ($x = 1$) or not ($x = 0$) the final product is successfully developed and let e indicate whether ($e = 1$) or not ($e = 0$) the agent exerts high effort. In scenario I, the payment $t^I(x, e)$ from the agent to the principal can be conditional on x and e. The wealth constraint implies that $t^I(x, e) \leq xM$ must hold. Moreover, if the principal implements effort level e, the agent is willing to participate if

$$E[xM - t^I(x, e)|e] - ec \geq 0.$$

Obviously, if the principal wants to implement low effort, she sets $t^I(x, e) = xM$. If she wants to implement high effort, the participation constraint reads $p_H[M - t^I(1, 1)] - (1 - p_H)t^I(0, 1) \geq c$, so that she sets $t^I(0, e) = 0$, $t^I(1, 0) = M$, and $t^I(1, 1) = M - c/p_H$.

In scenario II, the payment $t^{II}(x)$ cannot be conditional on e. The wealth constraint implies $t^{II}(x) \leq xM$. If the principal wants to induce effort level e, the agent's participation constraint

$$E[xM - t^{II}(x)|e] - ec \geq 0$$

must hold. If the principal wants to implement low effort, she sets $t^{II}(x) = xM$. Otherwise, the agent's incentive compatibility constraint

$$E[xM - t^{II}(x)|e = 1] - c \geq E[xM - t^{II}(x)|e = 0]$$

must hold, which together with the wealth constraint implies participation. Incentive compatibility can be rewritten as $p_H[M - t^{II}(1)] - (1 - p_H)t^{II}(0) - c \geq p_L[M - t^{II}(1)] - (1 - p_L)t^{II}(0)$. Hence, $t^{II}(0) = 0$ and $t^{II}(1) = M - c/(p_H - p_L)$.

[7] Since the agents are identical, it does not matter whether the principal chooses agent 1 or agent 2.

Next, assume that the principal provides licenses to both agents. Let $x_i \in \{0,1\}$ indicate whether agent $i \in \{1,2\}$ successfully develops the final product and let $e_i \in \{0,1\}$ indicate whether agent i exerts high effort. In scenario I, agent i's payment to the principal is denoted by $t_i^I(x_i, x_j, e_i, e_j)$, where $j \neq i$. The wealth constraints imply that $t_i^I(x_i, x_j, e_i, e_j) \leq x_i(1 - x_j)M$ must hold and the participation constraints given that effort levels e_1 and e_2 are implemented read

$$E[x_i(1-x_j)M - t_i^I(x_i, x_j, e_i, e_j)|e_1, e_2] - e_i c \geq 0.$$

If the principal wants to induce agent i to exert low effort, it is obviously optimal to set $t_i^I(x_i, x_j, e_i, e_j) = x_i(1-x_j)M$. If the principal wants to induce agent i to exert high effort, it is optimal for her to set $t_i^I(1,0,1,e_j) = M - c/p_H(1-\pi)$, $t_i^I(0, x_j, e_i, e_j) = t_i^I(1,1,e_i,e_j) = 0$, and $t_i^I(1,0,0,e_j) = M$, where $\pi = p_L$ if $e_j = 0$ is implemented and $\pi = p_H$ if $e_j = 1$ is implemented.

In scenario II, let agent i's payment be denoted by $t_i^{II}(x_i, x_j)$, so that the wealth constraints imply $t_i^{II}(x_i, x_j) \leq x_i(1-x_j)M$ and the participation constraints are

$$E[x_i(1-x_j)M - t_i^{II}(x_i, x_j)|e_1, e_2] - e_i c \geq 0.$$

If the principal wants to implement $e_i = 0$, she sets $t_i^{II}(x_i, x_j) = x_i(1 - x_j)M$. If she wants to implement $e_i = 1$, then the incentive compatibility constraints

$$E[x_i(1-x_j)M - t_i^{II}(x_i, x_j)|e_i = 1, e_j] - c \geq E[x_i(1-x_j)M - t_i^{II}(x_i, x_j)|e_i = 0, e_j]$$

must hold, which also ensure participation. Incentive compatibility can be rewritten as $(p_H - p_L)[(1-\pi)(M - t_i^{II}(1,0) + t_i^{II}(0,0)) - \pi(t_i^{II}(1,1) - t_i^{II}(0,1))] \geq c$, where π is defined as before. Hence, it is optimal for the principal to set $t_i^{II}(1,0) = M - c/(p_H - p_L)(1-\pi)$ and $t_i^{II}(0, x_j) = t_i^{II}(1,1) = 0$.

Let $\Pi^{ex}(e)$ denote the principal's expected profit if one agent gets an exclusive license and effort level e is implemented. Analogously, let $\Pi^{non-ex}(e_1, e_2)$

denote the principal's expected profit if both agents get licenses and the effort levels e_1 and e_2 are implemented.[8] It will be very useful to introduce the following definition.

Definition 1 *Let the "virtual costs" be given by*

$$\psi(c) = \begin{cases} c & \text{if effort is verifiable,} \\ \frac{p_H}{p_H - p_L} c & \text{if effort is hidden.} \end{cases}$$

Hence, in scenario I, the virtual costs are identical to the true costs, while in scenario II, the virtual costs are adjusted upwards.

Proposition 1 *The principal's expected profits are given by*

$$\Pi^{ex}(e) = \begin{cases} p_L M & \text{if } e = 0, \\ p_H M - \psi(c) & \text{if } e = 1, \end{cases}$$

if she provides an exclusive license to one agent and by

$$\Pi^{non-ex}(e_1, e_2) = \begin{cases} 2p_L(1 - p_L)M & \text{if } e_1 = e_2 = 0, \\ [p_H(1 - p_L) + p_L(1 - p_H)]M - \psi(c) & \text{if } e_i = 0, e_j = 1, \\ 2[p_H(1 - p_H)M - \psi(c)] & \text{if } e_1 = e_2 = 1, \end{cases}$$

otherwise.

Proof. The proposition follows immediately given the optimal contracts that have been derived above. ■

Note that the principal can always extract the expected total surplus in scenario I, while an agent enjoys a rent whenever high effort is implemented in scenario II. The principal's optimal licensing strategies can now be characterized as follows.

Proposition 2 *(a) If $p_H \leq 1/2$, then the principal always provides licenses to both agents. Both agents exert high effort if $\psi(c) \leq (p_H - p_L)(1 - 2p_H)M$,*

[8] Note that, obviously, $\Pi^{non-ex}(0, 1) = \Pi^{non-ex}(1, 0)$.

both agents exert low effort if $\psi(c) > (p_H - p_L)(1-2p_L)M$, while one agent exerts low effort and the other agent exerts high effort otherwise.
(b) If $p_L \geq 1/2$, then one agent gets an exclusive license. High effort is exerted whenever $\psi(c) \leq (p_H - p_L)M$, and low effort otherwise.
(c) If $p_L < 1/2 < p_H$, then one agent gets an exclusive license and exerts high effort if $\psi(c) \leq [p_H - 2p_L(1-p_L)]M$, while both firms get licenses and exert low effort otherwise.

Proof. The proposition follows from a comparison of the expected profits that have been stated in Proposition 1.

(a) If $p_L < p_H \leq 1/2$, then $\Pi^{non-ex}(0,0) > \Pi^{ex}(0)$ and $\Pi^{non-ex}(0,1) \geq \Pi^{ex}(1)$, so that it is always optimal to provide two licenses. Moreover, $\Pi^{non-ex}(1,1) \geq \Pi^{non-ex}(0,1)$ whenever $\psi(c) \leq (p_H - p_L)(1-2p_H)M$ and $\Pi^{non-ex}(0,0) > \Pi^{non-ex}(0,1)$ whenever $\psi(c) > (p_H - p_L)(1-2p_L)M$.

(b) If $1/2 \leq p_L < p_H$, then $\Pi^{ex}(0) \geq \Pi^{non-ex}(0,0)$, $\Pi^{ex}(1) > \Pi^{non-ex}(1,1)$, and $\Pi^{ex}(1) > \Pi^{non-ex}(0,1)$. Hence, it is always optimal to provide an exclusive license. Furthermore, $\Pi^{ex}(1) \geq \Pi^{ex}(0)$ whenever $\psi(c) \leq (p_H - p_L)M$.

(c) If $p_L < 1/2 < p_H$, then $\Pi^{non-ex}(0,0) > \Pi^{ex}(0)$, $\Pi^{ex}(1) > \Pi^{non-ex}(1,1)$, and $\Pi^{ex}(1) > \Pi^{non-ex}(0,1)$. Moreover, $\Pi^{ex}(1) \geq \Pi^{non-ex}(0,0)$ whenever $\psi(c) \leq [p_H - 2p_L(1-p_L)]M$. ■

Intuitively, if even high effort leads to a relatively small success probability (case a), it is always in the principal's interest to provide licences to both agents, in order to increase the probability that the final product is developed. If even low effort leads to a success with a relatively large probability (case b), it is always optimal to provide an exclusive license to one agent. Otherwise (case c), when the effort costs are small it is optimal to provide an exclusive license and implement high effort, while two licenses are provided and low effort is implemented when the effort costs are large.

3 The effect of moral hazard

It is now instructive to compare scenarios I and II. In the cases (a) and (b) of Proposition 2, the only effect of introducing moral hazard is that for a given effort cost c, it may happen that low instead of high effort is implemented.[9] This result follows from the fact that in scenario II, inducing high effort is more costly since the principal must leave a rent to the agent, which is well in line with standard models. However, an interesting new effect arises in case (c).

Corollary 1 *Consider the case $p_L < 1/2 < p_H$. If*

$$\frac{p_H - p_L}{p_H}[p_H - 2p_L(1-p_L)]M < c < [p_H - 2p_L(1-p_L)]M,$$

then one agent gets an exclusive license under symmetric information (scenario I), while both agents get licenses if there is moral hazard (scenario II).

Thus, there are situations in which *more* licences are sold due to moral hazard. Even though in this case in scenario II the two agents will only exert low effort, while the one agent in scenario I would exert high effort, it may well be true that in scenario II the final product is developed with a *higher* probability.

Corollary 2 *Under the conditions of Corollary 1, the probability that the final product will be developed under symmetric information (scenario I) can be smaller than the probability that the final product will be developed when there is moral hazard (scenario II).*

The probability that the innovation is made in scenario I is given by p_H, while it is given by $1-(1-p_L)^2$ in scenario II. The latter term may well be

[9] In order to see this, note that the relevant threshold levels of c below which high effort is implemented are always smaller in scenario II, since then $\psi(c) > c$.

larger than p_H in the case under consideration (where $p_L < 1/2 < p_H$). For example,[10] let $p_L = 2/5$ and $p_H = 3/5$. Then $1 - (1 - p_L)^2 = 16/25 > p_H$.

4 A generalization

In analogy to the preceding analysis, it is possible to generalize the model to the case of $N > 2$ agents. If the principal sells $n \leq N$ licenses and induces $m \leq n$ agents to exert high effort, then her expected profit can be written as $[(n-m)p_L(1-p_H)^m(1-p_L)^{n-m-1} + mp_H(1-p_H)^{m-1}(1-p_L)^{n-m}]M - m\psi(c)$.

Let n^- be the largest number $n \in \{1, ..., N\}$ such that $p_H \leq 1/n$. Then the number of licenses n^* that maximizes the principal's expected profit satisfies $n^* \geq n^-$.[11] Moreover, if $p_L < 1/(N+1)$, let $n^+ = N$. Otherwise, let n^+ be the smallest number $n \in \{1, ..., N\}$ such that $p_L \geq 1/(n+1)$. Then the optimal number of licenses n^* satisfies $n^* \leq n^+$.[12] If $n^- = n^+$, the number of licenses sold does not depend on the effort costs (this generalizes cases (a) and (b) of Proposition 2). If $n^- < n^+$, then the optimal number of licenses n^* depends on the effort costs. In the latter case, depending on the parameter constellation it can again be optimal to sell more licenses in scenario II than in scenario I.

[10] In order to satisfy all conditions of Corollary 1, assume e.g. that $M = 1$ and $c = 1/25$.

[11] To see this, it can be checked that if $p_H \leq 1/n$, then the expected profit with n licenses and $m \in \{0, ..., n-1\}$ agents that exert high effort is larger than the expected profit with $n-1$ licenses and m agents that exert high effort.

[12] It can be verified that if $p_L \geq 1/(n+1)$, then the expected profit with n licenses and $m \in \{0, ..., n\}$ agents that exert high effort is larger than the expected profit with $n+1$ licenses and m agents that exert high effort. Moreover, the expected profit with n licenses and n agents that exert high effort is also larger than the expected profit with $n+1$ licenses and $n+1$ agents that exert high effort.

5 Conclusion

A profit-maximizing licensor may sell more licenses in the presence of moral hazard with regard to development effort than under symmetric information. This result is noteworthy, because usually the presence of moral hazard reduces the quantity traded in models with risk-neutrality and limited liability. Moreover, it has been illustrated that the concept of "virtual costs," that is prominent in the literature on adverse selection, can also be useful in models with moral hazard.

References

Aoki, R. and Tauman, Y., 2001. Patent licensing with spillovers. Economics Letters 73, 125–130.

Bessen, J., 2005. Patents and the diffusion of technological information. Economics Letters 86, 121–128.

Bhattacharya, S., Glazer, J., and Sappington, D.E.M., 1992. Licensing and the sharing of knowledge in research joint ventures. Journal of Economic Theory 56, 43–69.

Bhattacharya, S. and Guasch, J.L., 1988. Heterogeneity, tournaments, and hierarchies. Journal of Political Economy 96, 867–881.

Innes, R.D., 1990. Limited liability and incentive contracting with ex-ante action choices. Journal of Economic Theory 52, 45–67.

Kamien, M.I., 1992. Patent licensing. In: Aumann, R.J. and Hart, S., eds., Handbook of Game Theory, Elsevier, Amsterdam, 331–355.

Kamien, M.I. and Tauman, Y., 1986. Fees versus royalties and the private value of a patent. Quarterly Journal of Economics 101, 471–479.

Katz, M.L. and Shapiro, C., 1986. How to license intangible property. Quarterly Journal of Economics 101, 567–589.

Laffont, J.-J. and Martimort, D., 2002. The Theory of Incentives: The Principal-Agent Model. Princeton, N.J.

Lazear E.P. and Rosen, S., 1981. Rank-order tournaments as optimum labor contracts. Journal of Political Economy 89, 841–864.

Mukherjee, A., 2006. Patents and R&D with imitation and licensing. Economics Letters 93, 196–201.

Reinganum, J.F., 1989. The timing of innovation: Research, development and diffusion. In: Willig, R. and Schmalensee, R., eds., Handbook of Industrial Organization, Vol. I. Amsterdam, North-Holland, 849–908.

Roy Chowdhury, P., 2005. Patents and R&D: The tournament effect. Economics Letters 89, 120–126.

Schmitz, P.W., 2002. On monopolistic licensing strategies under asymmetric information. Journal of Economic Theory 106, 177–189.