Economics Bulletin

Volume 36, Issue 3

Environmental policy on the fixed-fee licensing of eco-technology under foreign penetration

Seung-leul Kim
Chonnam National University

Sang-ho Lee
Chonnam National University

Abstract

This study investigates environmental policy on the fixed-fee licensing strategy of clean eco-technology by an innovator having foreign ownership. We show that near-zero emission taxes accompanied by non-exclusive licensing regulation can improve social welfare when the cost gap is small or foreign penetration is high. However, when foreign ownership is not high, exclusive licensing regulations with an appropriate emission tax policy may improve social welfare.

I would greatly appreciate it if you could consider it for publication in your journal. Best regards, Sang-Ho Lee
Citation: Seung-leul Kim and Sang-ho Lee, (2016) "Environmental policy on the fixed-fee licensing of eco-technology under foreign penetration", *Economics Bulletin*, Volume 36, Issue 3, pages A134
Contact: Seung-leul Kim - slkim@jnu.ac.kr, Sang-ho Lee - sangho@jnu.ac.kr.
Submitted: May 18, 2016. **Published:** July 14, 2016.

Economics Bulletin

Submission Number: EB-16-00396

Environmental policy on the fixed-fee licensing of eco-technology under foreign penetration

Seung-leul Kim
Chonnam National University

Sang-ho Lee
Chonnam National University

Abstract

This study investigates environmental policy on the fixed-fee licensing strategy of clean eco-technology by an innovator having foreign ownership. We show that near-zero emission taxes accompanied by non-exclusive licensing regulation can improve social welfare when the cost gap is small or foreign penetration is high. However, when foreign ownership is not high, exclusive licensing regulations with an appropriate emission tax policy may improve social welfare.

I would greatly appreciate it if you could consider it for publication in your journal. Best regards, Sang-Ho Lee

Submitted: May 18, 2016.

1. Introduction

Recent policy concerns on climate change and stricter environmental laws have contributed to the development of clean eco-technologies, which are likely to be patented. Given the exclusiveness of eco-patents, it is contemporary and critical to examine how the licensing strategy of clean eco-technology affects the environmental policy. In fact, many governments play a strong role in developing and distributing clean eco-technologies, for example, CleanTECH San Diego in USA, LAKES (Lahti Regional Development Company) in Finland, Solar Valley Mitteldeutschland in Germany, and Water Cluster in Israel.

Most research on the R&D activities of cost-reducing innovation has analyzed the relationship between market structure and general licensing strategies such as royalty, fixed-fees, and/or auctioning. Previous literature has shown that "outside innovator"[1] prefers fixed-fee licensing to royalty licensing in perfect competition (Kamien and Tauman, 1984) and homogenous oligopoly (Kamien and Tauman, 1986; Kamien et al., 1992), and a fixed-fee is superior to auctioning in an asymmetric duopoly (Stamatopoulos and Tauman, 2009) and sub-licensing model (Miao, 2013).

Recent studies also observe that the strategic choice of a fixed-fee contract depends on government policies such as import tariff (Kabiraj and Marjit, 2003; Mukherjee and Pennings, 2006), output tax (Mukherjee and Tsai, 2013), and emission tax (Kim and Lee, 2014, 2016a, 2016b). Hence, an examination of government policies and their effects on technology licensing would enhance our understanding of private licensing strategies.

This study investigates environmental policy on the fixed-fee licensing strategy of clean eco-technology by an innovator with foreign penetration. We show that the optimal licensing strategy depends not only on the cost efficiency gap but also on emission tax. We also take foreign penetration into account and show that near-zero emission taxes accompanied by non-exclusive licensing regulation can improve social welfare when the cost gap is small or foreign penetration is high. However, when foreign ownership is not high, exclusive licensing should be allowed under an appropriate emission tax policy.

2. Model

Consider a Cournot duopoly where two firms with homogeneous products that emit pollutants compete against each other. The inverse demand function is $P(Q) = A - Q$, where $Q = q_1 + q_2$ is the market output and q_i (*i=1,2*) is firm i's output. We assume that both firms have a constant marginal cost c_i; however, firm 1 can be more efficient than firm 2. We normalize c_1 to 0 and c_2 represents the cost efficiency gap, where we assume $\frac{A}{2} > c_2 \geq c_1 = 0$.

Now, consider an outside eco-innovator, which licenses environmentally clean eco-technologies to either one or two firms under fixed-fee licensing. This licensed technology enables firms to reduce pollution and consequently expenditure on emission tax. We assume a zero-pollution clean technology that produces no emission.[2] However, non-licensed firms will continue to emit pollution and their emission function is defined as $e_i = q_i$. We denote

[1] Outside innovator refers to the situation where the innovator is not a product-market competitor of the licensees.

[2] Note that even though the assumption of zero-pollution eco-technology is relaxed, the qualitative implications of licensing strategies by an eco-innovator are not directly relevant to this form of abatement technology.

total emission level as $E = e_1 + e_2$ and environmental damage as $D(E) = dE$, which is constant to the total emission level. The government will tax this emission at the rate of t. We assume that $0 < t \le \bar{t} \equiv \frac{A - 2c_2}{2}$ to assure the interior solutions in the analysis.

We analyze fixed-fee licensing contracts, in which the innovator controls licensee profit by restricting the number of licenses, and examine how an exclusive contract affects equilibrium and welfare. The game runs as follows: In the first stage, for a given emission tax, an eco-innovator announces *k* number of licenses for a fixed-fee, *f.* In the second stage, two polluting firms simultaneously decide whether or not to purchase a license after observing the licensing contract. In the third stage, they choose their outputs in the Cournot fashion. Subsequently, the sub-game perfect Nash equilibrium is derived through backward induction.

3. Analysis

Let us consider a fixed-fee licensing contract in which the innovator announces *k (= 1,2)* number of licensees and charges the same fixed-fee, *f(k).* Subsequently, the profit functions of a licensed firm and a non-licensed firm are determined with the fixed-fee and the number of licensed firms as follows:

$$H_i(k) = P(Q)q_i^L - c_i q_i^L - f(k) \quad \text{and} \quad h_i(k) = P(Q)q_i^N - c_i q_i^N - te_i^N,$$

where q_i^L and q_i^N are the firm's output levels as a licensee and a non-licensee, respectively.

Consider *k=2*. We obtain the maximum willingness to pay a fixed-fee of each firm from $H_i(2) - h_i(1) = 0$. In the third stage, using the first-order conditions, we have $q_1^L = \frac{A + c_2}{3}$, $q_2^L = \frac{A - 2c_2}{3}$, and $P = \frac{A + c_2}{3}$ at equilibrium. Therefore, each firm's maximum willingness to pay a fixed-fee is $f_1(2) = \frac{4t(A + c_2 - t)}{9}$ and $f_2(2) = \frac{4t(A - 2c_2 - t)}{9}$, respectively. The innovator determines the fixed-fee at $f_2(2) = \min\,[f_1(2), f_2(2)]$, which is in fact the maximum willingness to pay of an inefficient firm. The profits of both licensed firms are $H_1(2) = \left(\frac{A + c_2}{3}\right)^2 - f_2(2)$ and $H_2(2) = \left(\frac{A - 2c_2}{3}\right)^2 - f_2(2)$. Therefore, the following innovator's profit is increasing in t:

$$\pi^M(2) = \frac{8t(A - 2c_2 - t)}{9}. \tag{1}$$

Consider *k=1*. The fixed fee should be equal to the maximum profit difference of each licensee between accepting and rejecting the licensing offer, given that the other firm rejects it. That is, $f_i(1)$ should satisfy such that $H_i(1) - h_i(0) = 0$. In the third stage, using the first-order conditions, we have $q_1^L = \frac{A + c_2 + t}{3}$, $q_2^N = \frac{A - 2(c_2 + t)}{3}$, and $P = \frac{A + c_2 + t}{3}$ at equilibrium. Then, each firm's maximum willingness to pay a fixed-fee is $f_1(1) = \frac{4t(A + c_2)}{9}$ and $f_2(1) = \frac{4t(A - 2c_2)}{9}$, respectively. The innovator will determine the fixed-fee at $f_1(1) = \max\,[f_1(1), f_2(1)]$. This gives us $H_1(1) = \left(\frac{A + c_2 + t}{3}\right)^2 - f_1(1)$ and $h_2(1) = \left(\frac{A - 2(c_2 + t)}{3}\right)^2$. Therefore, the following innovator's profit is also increasing in t:

$$\pi^M(1) = \frac{4t(A + c_2)}{9}. \tag{2}$$

Let us define $c^M = \frac{(A-2t)}{5}$, which satisfies $\pi^M(1) = \pi^M(2)$ in (1) and (2).

Proposition 1.

(i) When $\frac{A}{5} < c_2$, the innovator chooses an exclusive fixed-fee licensing for all $t < \bar{t}$.

(ii) When $0 \le c_2 < \frac{A}{5}$, the innovator chooses a non-exclusive (exclusive) fixed-fee licensing if $c_2 > (<)\, c^M$.

Proposition 1 implies that the innovator's licensing strategies depend not only on the level of emission tax but also on the cost gap[3]. The innovator prefers a non-exclusive licensing only with a lower cost gap. This is because higher total output and also smaller difference in willingness to pay of the license. Thus, licensing to both firms is a more profitable strategy to the innovator. When both the cost gap and emission tax are low, purchasing clean eco-technology is more attractive to an inefficient firm. However, when the cost gap or emission tax is high, reducing emissions is more advantageous to an efficient firm since its output is larger and willingness to pay for each unit is higher. Thus, an innovator prefers an exclusive licensing contract with an efficient firm because the difference in profits increases with clean eco-technology.

4. Environmental Policy with Foreign Penetration

We assume that the innovator is a private multinational firm that is owned by private investors, both domestic and foreign. Let us denote α $(0 \le \alpha \le 1)$ as the fraction of foreign ownership, that is, foreign penetration. The social welfare function can be defined by $W(k) = CS + \pi_1 + \pi_2 + (1-\alpha)\pi^M + tE - dE = \int_0^Q P(u)du - c_2 q_2 - \alpha\pi^M - dE$.

Therefore, the resulting welfare from a licensing strategy with *k =1, 2* is given as follows, respectively:

$$W(1) = \frac{1}{18}\{8A(A-c_2) + 11c_2^2 - t^2 + 2(5c_2 - A)t - 8\alpha t(A+c_2) - 6d(A - 2c_2 - 2t)\} \quad (3)$$

$$W(2) = \frac{1}{18}\{8A(A-c_2) + 11c_2^2 + 16\alpha t(2c_2 + t - A)\} \quad (4)$$

Let us define $c^W = \frac{t(2A+t) + 2(A-2t)(3d - 4\alpha t)}{2\{5t(1-4\alpha) + 6d\}}$, which satisfies $W(1) = W(2)$ in (3) and (4).

Proposition 2. Non-exclusive (exclusive) licensing improves welfare when $c_2 < (>)\, c^W$.

Proposition 2 implies that the comparison of welfare between exclusive and non-exclusive contracts depends on the level of emission tax and foreign penetration. Note that there is a trade-off between net consumer surplus (defined as consumer surplus minus environmental damage) and producer surplus plus government revenue. When *k=2*, environmental damage is eliminated and net consumer surplus is larger because of low price. However, producer surplus and government revenue are larger when *k=1* because higher cost gap increases innovator's profit. Therefore, non-exclusive licensing improves welfare only when the cost gap is low.

---

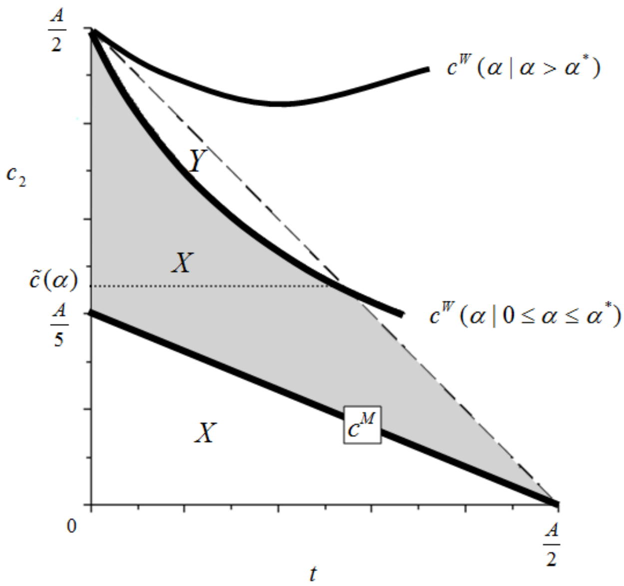
[3] Stamatopoulos and Tauman (2009) showed that the revenue from selling the license of a cost-reducing innovation depends on the cost efficiency gap.

Let us define two sets that pertain to the welfare effect of licensing strategy with *k* under foreign penetration as follows:

$X(t,c_2):=\{0<t<\bar{t}\mid W(2)>W(1)\}=\{0<t<\bar{t}\mid c_2<c^W\}$ and $Y(t,c_2):=R^2/X$

Fig.1 shows that X is socially desirable under non-exclusive licensing while Y is desirable under exclusive licensing. Thus, X contains the welfare loss(shaded area) caused by an innovator's strategic choice of exclusive licensing. Note that as foreign penetration increases, c^W moves upward and welfare loss expands[4]. Note also that if $\alpha>\alpha^*=\dfrac{22c_2-5A}{48c_2}$, c^W lies outside feasible region ($0<t<\bar{t}$) and thus Y is null.

Fig.1 Innovator's optimal choice and welfare



Let us also define $t^*(k):=\arg\max_t W(k)$ and $W^*(k):=W(t^*(k))$.

Proposition 3.

(i) Suppose $\alpha>\alpha^*$. Prohibiting exclusive licensing with near-zero emission tax can improve social welfare for all c_2.

(ii) Suppose $0\le\alpha<\alpha^*$. If $c_2\in X$, prohibiting exclusive licensing with near-zero emission tax can improve social welfare. However, if $c_2\in Y$, allowing exclusive licensing under optimal emission tax $t^*(1)$, can improve social welfare.

Proof. (i) Suppose $\alpha>\alpha^*$. Then, Y is null. Welfare in (4) is decreasing in *t*, which implies that a near-zero emission tax is optimal when *k* = *2*. (ii) Suppose $0\le\alpha<\alpha^*$. Then, Y is not null. If $W^*(1)<W^*(2)$, the same results in (1) are still applicable. However, if $W^*(1)>W^*(2)$, the optimal tax is at $t^*(1)$. ■

Proposition 3 implies that the optimal policy decision depends not only on the cost gap

---

[4] It is easily shown that $\dfrac{\partial c^W}{\partial\alpha}=\dfrac{2t\{18d(A-2t)+25t^2\}}{\{5t(1-4\alpha)+6d\}^2}>0$.

but also foreign penetration. When foreign penetration is sufficiently high, the net consumer surplus becomes more important from the welfare perspective; therefore, prohibiting exclusive licensing with sufficiently low emission taxes will reduce the rent-extraction effect of the foreign innovator. However, when foreign penetration is low, the optimal policy decision depends on the cost gap, which, if low, still requires near-zero emission tax and non-exclusion regulations. However, if the cost gap is high, it is beneficial to allow exclusive licensing with an optimal emission tax. Therefore, as foreign penetration increases, non-exclusion regulation on licensing contracts should be adopted.

5. Conclusion

Recent concerns on climate change policy and environmental regulation have exerted the research on the licensing strategy of clean eco-technology and its effects on the environmental policy. We have demonstrated that near-zero emission taxes accompanied with non-exclusive licensing regulations can improve social welfare when the cost gap is small or foreign penetration is high. However, when foreign ownership is not high, exclusive licensing regulations with an appropriate emission tax policy may improve social welfare. As a future research, the analysis on the relation between market structure and general licensing strategies are necessary.

References

Kabiraj, T. and S. Marjit (2003) “Protecting Consumers through Protection: The Role of Tariff-Induced Technology Transfer” *European Economic Review* **47**, 113-124.

Kamien, M. and Y. Tauman (1984) “The Private Value of A Patent: A Game Theoretic Analysis” *Journal of Economics* **4**, 93-118.

Kamien, M. and Y. Tauman (1986) “Fees Versus Royalties and the Private Value of A Patent” *Quarterly Journal of Economics* **101**, 471-491.

Kamien, M., S. Oren and Y. Tauman (1992) “Optimal Licensing of Cost-Reducing Innovation” *Journal of Mathematical Economics* **21**, 483-508.

Kim, S.L. and S.H. Lee (2014) “Eco-Technology Licensing under Emission Tax: Royalty vs. Fixed-Fee” *Korean Economic Review* **30**, 273-300.

Kim, S.L. and S.H. Lee (2016a) “Optimal Two-Part Tariff Licensing Strategies of Eco-technology” *Firms' Strategic Decisions: Theoretical and Empirical Findings vol. 2*, 217-238.

Kim, S.L. and S.H. Lee (2016b) “The Licensing of Eco-Technology under Emission Taxation: Fixed Fee vs. Auction” *International Review of Economics and Finance*, doi: 10.1016/j.iref.2016.07.004.

Miao, C.H. (2013) “On the superiority of fixed fee over auction in technology licensing” *Manchester School* **81**, 324-331.

Mukherjee, A. and E. Pennings (2006) “Tariffs, Licensing and Market Structure” *European Economic Review* **50**, 1699-1707.

Mukherjee, A. and Y. Tsai (2013) "Technology Licensing under Optimal Tax Policy" *Journal of Economics* **108**, 231-247.

Stamatopoulos, G. and T. Tauman (2009) "On the Superiority of Fixed Fee over Auction in Asymmetric Markets" *Games and Economic Behavior* **67**, 331-333.