UNIVERSITY OF NOTTINGHAM

Discussion Papers in Economics

Discussion Paper
No. 10/09

Technology licensing with strategic tax policy

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October 2010

2010 DP 10/09

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October 2010

Abstract: Despite the important insights it has provided, technology licensing literature remains restrictive by not allowing government policies. We show that in the presence of strategic tax policies, an outside innovator and, more interestingly and in contrast to the existing works, the consumers are better off under royalty licensing compared to auction (or fixed-fee licensing) if the number of potential licensees is sufficiently large. It follows from our analysis that a combination of fixed-fee and output royalty can be preferable to the innovator compared to both royalty licensing and auction (or fixed-fee licensing).

Key Words: Licensing; Tax; Auction; Royalty
JEL Classification: L13; L24; L40; H25; D43

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Technology licensing with strategic tax policy

1. Introduction

Technology licensing is an important element of conduct in many industries and has attracted a fair amount of attention in recent years. The seminal works by Kamien and Tauman (1984, 1986) show that, if an innovator, who is not a producer,[1] licenses a technology to the final goods producers and the product market is characterized by Cournot competition, licensing with output royalty generates lower profit to the innovator compared to fixed-fee licensing and auction, regardless of the industry size and/or magnitude of the innovation.[2] In the light of this theoretical result, the wide prevalence of output royalty in licensing contracts (see, e.g., Taylor and Silberstone, 1973; Rostoker, 1984) remains a puzzle, and has drawn significant attention in explaining the superiority of royalty licensing over fixed-fee licensing or auction. The factors attributed to the presence of output royalty in a licensing contract offered by an outside innovator[3] include asymmetric information (Gallini and Wright, 1990; Beggs, 1992; Poddar and Sinha, 2002; Sen, 2005b), Bertrand competition (Muto, 1993), spatial competition (Poddar and Sinha, 2004), moral hazard (Macho-Stadler et

[1] Licensing by the Universities or independent research labs to the producers may be the examples of this scenario.

[2] See Kamien (1992) for a nice survey of this literature.

[3] Outside innovator refers to the situation were the innovator (who is the licenser) and the licensees do not compete in the product market.

al., 1996; Choi, 2001), risk aversion (Bousquet et al., 1998), incumbent innovator (Shapiro, 1985; Kamien and Tauman, 2002; Sen and Tauman, 2007), leadership structure (Kabiraj, 2004), strategic delegation (Saracho, 2002), integer constraint on the number of licenses (Sen, 2005), input market power (Mukherjee, 2010) and convex costs (Mukherjee, 2010).[4]

While the existing works focus on several important aspects, they have been restrictive by not allowing for government policies. It is well known that, in an imperfectly competitive product market, a government may use tax policies to improve welfare by reducing the distortion created by imperfectly competitive product market (see, Myles, 1996; Hamilton, 1999). Hence, a more comprehensive treatment, focusing on the interaction between technology licensing contract and strategic tax policies, deserve attention. We take up this issue in this paper.

In a simple model with $n \geq 1$ potential licensees facing zero opportunity costs, which corresponds to the case of drastic innovation in the sense of Arrow (1962), we show that, in the presence of strategic tax policy, an outside innovator prefers royalty licensing to auction if the number of potential licensees is sufficiently large. It follows

[4] There is a related literature which shows the superiority of royalty licensing and licensing with a combination of fixed-fee and royalty when the licenser and the licensees compete in the product market (see, e.g., Rockett, 1990, Wang, 1998 and 2002, Wang and Yang, 1999, Filippini, 2001, Mukherjee and Balasubramanian, 2001, Faulí-Oller and Sandonis, 2002, Fosfuri, 2004, Kabiraj, 2005, Poddar and Sinha, 2005 and Mukherjee, 2007). In this literature, the competition softening effect of output royalty may make the royalty licensing preferable than fixed-fee licensing if the licenser and the licensees compete in the product market.

from our analysis that a combination of fixed-fee and output royalty can be preferable to the innovator as compared to royalty licensing or auction.

More interestingly and in contrast to the previous works (see, e.g., Kamien and Tauman, 1986; Muto, 1993), we further show that the consumers can be better off under royalty licensing than under auction if the number of potential licensees is sufficiently large. This happens because the tax policy softens the output distortion effect of output royalty. Thus, we show that strategic government tax policies can have a significant impact on the preference for royalty licensing, both for the outside innovator and the consumers.

We have written our results in terms of auction and royalty licensing. It is worth mentioning that, because of the zero opportunity cost of the licensees, which, in other words focus on the drastic innovation, there is no difference between auction and fixed-fee licensing in our analysis. Hence, the result we report under auction is also relevant for fixed-fee licensing.

The remainder of the paper is organized as follows. We describe the model and derive the results in Section 2. Section 3 concludes.

2. The model and the results

Assume that there is an innovator, denoted by I, who has invented a new product. However, I cannot produce the good. There are $n \geq 1$ symmetric potential producers of the product, and I can license its technology to the potential producers. The innovation is assumed to be drastic, i.e., a producer cannot make profits using any pre-existing technology. A potential producer can produce at a marginal cost of c if it wins a license. To avoid analytical complexity, we ignore integer constraint and consider the number of potential producers as a continuous variable.

Assume that the outputs of the producers are perfect substitutes, and the inverse market demand function is

$$P = a - q, \tag{1}$$

where P is price of the product and q is the total output sold in the market.

We consider the following licensing contracts that are designed by I:

(i) Royalty licensing, where a fixed royalty payment r per unit of output is charged by I, and any producer who wishes to can purchase the license at this royalty rate.

(ii) Auctioning k licenses, $1 \leq k \leq n$, by I through a sealed bid English auction. The highest bidders obtain the license. The ties are resolved by I.

The innovator can also adopt a fixed-fee licensing contract, where the innovator charges a flat pre-determined license fee, F, and any producer who wishes to can purchase the license at this fixed-fee. However, it is immediate from Kamien et al. (1992) that the essential difference between auction and fixed-fee licensing stems from the difference in producers' opportunity costs of having a license. Since we are considering a situation with zero opportunity costs of the producers, it follows that auction and fixed-fee licensing provide the same solution in this situation. Therefore, we focus on auction and do not consider the case of fixed-fee licensing separately.

The implications of licensing with both fixed-fee and per-unit output royalty where the fixed-fee can be determined either by the innovator (i.e., fixed-fee plus royalty licensing) or it can be the winning bids of the licensees if the innovator auctions off licenses (i.e., auction plus royalty licensing) will follow easily from our analysis.

We consider the following games for our analysis. Under royalty licensing, at stage 1, I announces the uniform royalty rate, r. At stage 2, the producers simultaneously and independently decide whether or not to purchase a license. At stage 3, the government sets a per-unit tax, t, in order to maximize welfare of the economy. At stage 4, producers choose their outputs simultaneously. If only one producer purchases a license at stage 2, he produces like a monopolist at stage 4.

Under auction, at stage 1, I announces to auction k licenses, where $1 \le k \le n$. At stage 2, the producers simultaneously and independently decide whether or not to purchase a license, and how much to bid. At stage 3, the government sets a per-unit tax, t, in order to maximize welfare of the economy. At stage 4, the producers choose their outputs simultaneously. If I auctions only one license, the licensee produces like a monopolist at stage 4. We solve these games by backward induction.

We consider a situation where the government cannot commit to the tax policy before licensing. This is in line with Mukherjee and Pennings (2006), where the government policy is announced after technology licensing, and can be motivated by the observation that government policies are often "time inconsistent", meaning that governments have an incentive to reverse their pre-announced policies (Staiger and Tabellini, 1987). In a different context, Neary and Leahy (2000) question the ability of the governments to pre-commit to their policies.

2.1. Royalty licensing

Under royalty licensing, each licensee prefers to purchase a license for $c + r + t < a$, since the licensees always have the option to produce nothing after purchasing a license, thus earning zero profit, which is the opportunity cost of having a license.

First, we determine the product market equilibrium under royalty licensing. If I licenses the technology to n producers and each of them pays a per-unit output royalty r and a per-unit output tax t, where $c+r+t<a$, the i th licensee, $i=1,2,...,n$, chooses his output to maximize the following expression:

$$\underset{q_i}{Max}(a-q-c-r-t)q_i\,. \tag{2}$$

It is straightforward to verify that the equilibrium output of the ith licensee is $q_i^{r*}=\dfrac{(a-c-r-t)}{n+1}$. The equilibrium profit of the ith licensee is $\pi_i=(q_i^{r*})^2=\left(\dfrac{a-c-r-t}{n+1}\right)^2$. Further, we have $p=a-q^{r*}=\dfrac{a+n(c+r+t)}{n+1}$ and $p(q^{r*})-t-c=\dfrac{a-c-t+nr}{n+1}$.

Now consider the decision of the government. The government determines t to maximize welfare, which is the "sum of consumer surplus, tax revenue and the total profits of the innovator and the licensees". The government chooses t to maximize the following expression:

$$\begin{aligned} W &= \underbrace{\frac{1}{2}\left(\sum_{i=1}^{n} q_i\right)^2}_{CS} + \underbrace{\sum_{i=1}^{n}[(a-\sum_{i=1}^{n} q_i)-(c+t)]q_i}_{profit} + \underbrace{\delta t \sum_{i=1}^{n} q_i}_{tax\,revenue} \\ &= \frac{1}{2}n^2\left(\frac{a-c-t-r}{n+1}\right)^2 + n\left(\frac{a-c-t+nr}{n+1}\right)\left(\frac{a-c-t-r}{n+1}\right) \\ &\quad +\delta tn\left(\frac{a-c-t-r}{n+1}\right). \end{aligned} \tag{3}$$

The term δ in (3) shows that there can be an asymmetry between social and private valuation of tax (Neary, 1994), and we assume that $\delta > 1$. Hence, δ reflects the distributional considerations of tax.

We obtain the equilibrium tax rate as

$$t^{r*} = \frac{(a-c)[(\delta-1)(n+1)-1] - r[(\delta-1)(n+1)+n]}{2(\delta-1)(n+1)+n}. \tag{4}$$

Now solve the first stage of the game, where the innovator decides the royalty rate. While choosing the royalty rate, the innovator will internalize the effect of royalty on the government tax and the output of the licensees. The innovator maximizes the following expression to determine *r*:

$$\Pi_I^r = r\sum_{i=1}^{n} q_i = \frac{rn[(a-c)\delta - r(\delta-1)]}{2(\delta-1)(n+1)+n}. \tag{5}$$

The equilibrium royalty rate is

$$r^* = \frac{(a-c)\delta}{2(\delta-1)}. \tag{6}$$

The equilibrium output of the *i*th licensee is $q_i^{r*} = \dfrac{(a-c)\delta}{2[2(\delta-1)(n+1)+n(\gamma+1)]}$, and the equilibrium payoff of I is

$$\Pi_I^{r*} = \frac{n(a-c)^2\delta^2}{4(\delta-1)[2(\delta-1)(n+1)+n(\gamma+1)]}. \tag{7}$$

2.2. Auction

Now consider the game under auction. If I auctions k licenses, where $1 \le k \le n$, the outputs of the ith licensee is $q_i^{A*} = \dfrac{(a-c-t)}{k+1}$. The profit of the ith licensee is $\dfrac{(a-c-t)^2}{(k+1)^2}$.

The government chooses t to maximize the following expression:

$$W = \underbrace{\frac{1}{2}\left(\sum_{i=1}^{k} q_i\right)^2}_{CS} + \underbrace{\sum_{i=1}^{k}[(a-\sum_{i=1}^{k} q_i)-(c+t)]q_i}_{profit} + \underbrace{\delta t \sum_{i=1}^{k} q_i}_{tax\,revenue}$$
$$= \frac{1}{2}k^2\left(\frac{a-c-r-t}{k+1}\right)^2 + k\left(\frac{a-c-t+kr}{k+1}\right)\left(\frac{a-c-t-r}{k+1}\right) + . \qquad (8)$$
$$\delta tk\left(\frac{a-c-r-t}{k+1}\right)$$

The equilibrium tax rate is

$$t^{A*} = \frac{(a-c)[(\delta-1)(k+1)-1]}{2(\delta-1)(k+1)+k}. \qquad (9)$$

It is immediate from (4) and (9) that the equilibrium tax is lower under royalty licensing than under auction. This strategic effect of the tax will play the important role in determining the innovator's preference for a particular licensing contract. Since the output royalty distorts the output choice of the licensees, the government lowers the tax rate under royalty licensing compared to auction in order to soften the output distortion created by the royalty licensing.

Given the equilibrium tax, the output and profit of each licensee will be $\dfrac{(a-c)\delta}{2(\delta-1)(k+1)+k}$ and $\dfrac{(a-c)^2\delta^2}{[2(\delta-1)(k+1)+k]^2}$ respectively. Therefore, the Nash equilibrium bid of each potential licensee will be $\dfrac{(a-c)^2\delta^2}{[2(\delta-1)(k+1)+k]^2}$. As mentioned in Kamien et al. (1992), if $k = n$, I can guarantee this equilibrium bid by specifying a minimum bid. However, for $k < n$, the producers bid these amounts even if I does not specify the minimum bid.

If I auctions k licenses, his payoff is $\Pi_I^A = \frac{(a-c)^2\delta^2 k}{[2(\delta-1)(k+1)+k]^2}$, and the number of licenses to auction is determined by maximizing the following expression:

$$\underset{k}{Max}\frac{(a-c)^2\delta^2 k}{[2(\delta-1)(k+1)+k]^2}. \tag{10}$$

The equilibrium number of licenses is given by $k^{A*} = max\{1, \frac{2(\delta-1)}{(\delta+1)}\}$. It is easy to verify that $\frac{2(\delta-1)}{(\delta+1)} < n$ for $n \geq 2$. Hence, the innovator does not license to all the potential licensees under auction if $n \geq 2$.

The equilibrium profit of the innovator under auction is

$$\Pi_I^{A*} = \frac{(a-c)^2\delta^2(\delta+1)}{2(\delta-1)(3\delta+1)^2}. \tag{11}$$

2.3. Comparing auction with royalty licensing

We obtain from (7) and (11) that the equilibrium profit of the innovator is higher under royalty licensing than under auction if

$$n > \frac{4(\delta^2-1)}{(3\delta+1)^2 - 2(\delta+1) - 4(\delta^2-1)} \equiv n^*(\delta). \tag{12}$$

Proposition 1: *The innovator is better off under royalty licensing than under auction if $n \geq n^*(\delta)$.*

Proof: The result follows from (12). ■

As an example, consider $\delta = 2$. In this situation, it is immediate from $n^*(\delta)$ that the innovator's profit is higher under royalty licensing than under auction if $n \geq 1$.

The intuition for Proposition 1 is as follows. On the one hand, royalty licensing distorts the output decision of the licensees, which tend to reduce the profit of the innovator. On the other hand, royalty licensing (compared to auction) reduces the tax imposed by the government, thus tending to increase the output of the licensees, which, in turn, tends to increase the profit of the innovator. If the latter effect dominates the former effect, which happens in the presence of a large number of potential licensees, the innovator's profit is higher under royalty licensing than under auction.

We have considered that the innovator does not use royalty and fixed-fee together. It follows from the above analysis that the net profits of the licensees are positive under royalty licensing. Hence, it is trivial that the innovator prefers to use fixed-fee along with royalty to extract the entire profits of the licensees. While royalty provides the beneficial tax effect, auction helps to extract the entire surplus from the licensees. *It is then intuitive that the innovator prefers auction plus royalty licensing over royalty licensing or auction*. Under auction plus royalty, the innovator determines the number of licenses to auction and the uniform royalty, *r*. Since the dominance of the auction plus royalty licensing is straightforward from the above analysis, we skip the mathematical details for this result.

2.4. The effect on the consumers

Now we are in position to see the effects of different licensing contracts on consumer surplus, which is $\frac{q^2}{2}$. We obtain that, in equilibrium, consumer surplus is $CS^{r*} = \frac{n^2(a-c)^2\delta^2}{[4(\delta-1)(n+1)+2n]^2}$ under royalty licensing, and $CS^{A*} = \frac{(a-c)^2\delta^2}{(3\delta+1)^2}$ under auction.

Proposition 2: *Consumer surplus is higher under royalty licensing than under auction if* $n > \frac{4(\delta-1)}{(3-\delta)}$.

Proof: A straightforward comparison of CS^{r*} and CS^{A*} proves the result. ■

As an example, consider that $\delta = 2$. In this situation, it follows from the condition shown in Proposition 2 that consumer surplus is higher under royalty licensing than under auction if *n > 4*.

Since the tax rate is lower under royalty licensing than under auction, the tax policy tends to offset the negative output-distortion effect of the royalty licensing.

Hence, if the number of potential licensees is sufficiently large, royalty licensing can create higher total output compared to auction, thus making the consumers better off under royalty licensing compared to auction.

Proposition 2 shows an important result that is in contrast to the common wisdom, viz., consumers are worse off under royalty licensing than auction or fixed-fee licensing (Kamien and Tauman, 1986 and Muto, 1993).

2.5. The implications of $\delta = 1$

It is important to note that the above analysis is valid for $\delta > 1$. However, the results will be affected significantly when $\delta = 1$, i.e., if the social and private valuation of tax is the same. In this situation, the government can perfectly compensate the effect of the royalty rate and the number of licenses from the welfare point of view. If $\delta = 1$, we get that $t^{r*} + r = \frac{-(a-c)}{n}$ and $t^{A*} = -(a-c)$, since there is single license under auction. Therefore, under the royalty licensing, tax rate will adjust following the royalty rate to make the sum of tax and royalty equal to $\frac{-(a-c)}{n}$. Further, we find that the total outputs of the firms are the same under auction and under royalty licensing and it is given by $\overline{q} = (a-c)$. Therefore, the product price is the same under royalty licensing and under auction if $\delta = 1$. Even if the total output of the firms are the same under both licensing contracts, more licenses under royalty licensing compared to auction reduces the per-unit profit of the firms under the former licensing contract compared to the latter.

If $\delta = 1$, under auction, the total profit of the licensee, which is also the profit of the innovator, is $\overline{\Pi}^{A^*} = (a - \overline{q} - c)\overline{q} - t^{A^*}\overline{q}$.

If $\delta = 1$ and there is royalty licensing, the royalty rate will be as high as possible, since the royalty rate will be determined by maximizing $r\overline{q}$. Hence, the innovator will charge the royalty rate which satisfies $r\overline{q} = (a - \overline{q} - c)\overline{q} - (t^{r^*} + r)\overline{q}$.[5] Since $t^{r^*} + r = \frac{-(a-c)}{n} > t^{A^*} = -(a-c)$ for *n* > *1*, it is then immediate that the equilibrium profit of the innovator is higher under auction than under royalty licensing.

3. Conclusion

While technology licensing literature has considered several important aspects of today's world, it has been restrictive by not allowing government policies. In this

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[5] It may worth noting that even if the innovator wants only one firm to purchase the license under royalty licensing and charges the royalty in anticipation of getting the royalty income as $r\overline{q} = (a - \overline{q} - c)\overline{q} - t^{A^*}\overline{q}$, this royalty rate will encourage more than one licensee to purchase the license since, given the symmetry of the licensees and in the absence of any fixed cost associated with licensing, if a licensing contract is profitable to one licensee, it is also profitable to other licensees. Hence, under royalty licensing, we will obtain $t^{r^*} + r = \frac{-(a-c)}{n}$, and the innovator will not be able to replicate the income earned under auction through the royalty contract. In order to replicate the income earned under auction through royalty licensing, the innovator also needs to specify the number of licenses under royalty licensing.

paper, we have shown that strategic government tax policies can have a significant impact on the preference for royalty licensing, both for the outside innovator and the consumers. More specifically, we show that, in the presence of strategic tax policies, an outside innovator and, more interestingly, the consumers are better off under royalty licensing compared to auction (or fixed-fee licensing) if the number of potential licensees is sufficiently large. It is immediate from our analysis that a combination of fixed-fee and output royalty can be preferable to the innovator compared to royalty licensing or auction (or fixed-fee licensing).

References

Arrow, K., 1962, ‘Economic welfare and the allocation of resources for invention’, in R. Nelson (Ed.), *The Rate and direction of inventive activity*, Princeton University Press, Princeton.

Beggs, A. W., 1992, ‘The licensing of patents under asymmetric information’, *International Journal of Industrial Organization*, 10: 171-91.

Bousquet, A., H. Cremer, M. Ivaldi and M. Wolkowicz, 1998, ‘Risk sharing in licensing’, *International Journal of Industrial Organization*, 16: 535-54.

Choi, J. P., 2001, ‘Technology transfer with moral hazard’, *International Journal of Industrial Organization*, 19: 249-66.

Faulí-Oller, R. and J. Sandonis, 2002, ‘Welfare reducing licensing’, *Games and Economic Behavior*, 41: 192-205.

Filippini, L., 2001, ‘Process innovation and licensing’, *Mimeo*, Università Cattolica.

Fosfuri, A., 2004, ‘Optimal licensing strategy: Royalty or fixed fee?’, *International Journal of Business and Economics*, 3: 13-19.

Gallini, N. T. and B. D. Wright, 1990, ‘Technology transfer under asymmetric information’, *Rand Journal of Economics*, 21: 147-60.

Hamilton, S.F., 1999, ‘Tax incidence under oligopoly: A comparison of policy approaches’, *Journal of Public Economics* 71, 233-45.

Kabiraj, T., 2004, ‘Patent licensing in a leadership structure’, *The Manchester School*, 72: 188-205.

Kabiraj, T., 2005, ‘Technology transfer in a Stackelberg structure: Licensing contracts and welfare’, *The Manchester School*, 73: 1-28.

Kamien, M. I., 1992, ‘Patent licensing’, in R. J. Aumann and S. Hart (Eds.), *Handbook of game theory*, Elsevier, Amsterdam: 331-55.

Kamien, M. I. and Y. Tauman, 1984, ‘The private value of a patent: A game theoretic analysis’, *Journal of Economics (Zeitschrift für Nationalökonomie)*, 4 (Supplement): 93 -118.

Kamien, M. I. and Y. Tauman, 1986, ‘Fees versus royalties and the private value of a patent’, *The Quarterly Journal of Economics*, 101: 471-79.

Kamien, M. I. and Y. Tauman, 2002, ‘Patent licensing: the inside story’, *The Manchester School*, 70: 7-15.

Kamien, M. I., S. S. Oren and Y. Tauman, 1992, ‘Optimal licensing of cost-reducing innovation’, *Journal of Mathematical Economics*, 21: 483-508.

Kamien, M. I., Y. Tauman and I. Zang, 1988, ‘Optimal license fees for a new product’, *Mathematical Social Sciences*, 16: 77-106.

Neary, J.P. and D. Leahy, 2000, ‘Strategic trade and industrial policy towards dynamic oligopolies’, *Economic Journal*, 110: 484-508.

Macho-Stadler, I., X. Martinez-Giralt and J. D. Pérez-Castrillo, 1996, ‘The role of information in licensing contract design’, *Research Policy*, 25: 25-41.

Mukherjee, A. and N. Balasubramanian, 2001, ‘Technology transfer in horizontally differentiated product market’, *Research in Economics*, 55: 257-74.

Mukherjee, A., 2007, ‘Optimal licensing contract in an open economy’, *Economics Bulletin*, 12 (3): 1-6.

Mukherjee, A., 2010, ‘Licensing a new product: fee vs. royalty licensing with unionized labor market’, *Labour Economics*, 17: 735-42.

Mukherjee, A., 2010, ‘Technology licensing under convex cost”, *Discussion Paper, 10/05*, School of Economics, University of Nottingham.

Mukherjee, A. And E. Pennings, 2006, ‘Tariffs, licensing and market structure’, *European Economic Review*, 50: 1699-1707.

Muto, S., 1993, ‘On licensing policies in Bertrand competition’, *Games and Economic Behavior*, 5: 257-67.

Myles, G.D., 1996, ‘Imperfect competition and the optimal combination of *ad valorem* and specific taxation’, *International Tax and Public Finance* 3, 29-44.

Neary, J.P., 1994, ‘Cost asymmetries in international subsidy games: should governments help winners or losers?’, *Journal of International Economics*, 37: 197-218.

Poddar, S. and U. B. Sinha, 2002, ‘The role of fixed fee and royalty in patent licensing’, *Working Paper, No. 0211*, Department of Economics, National University of Singapore.

Poddar, S. and U. B. Sinha, 2004, ‘On patent licensing and spatial competition’, *Economic Record*, 80: 208-18.

Poddar, S. and U. B. Sinha, 2005, ‘Patent licensing from high-cost to low-cost firm’, *Working Paper, 05/03*, Department of Economics, National University of Singapore.

Rockett, K., 1990, ‘The quality of licensed technology, *International Journal of Industrial Organization*, 8: 559-74.

Rostoker, M., 1984, ‘A survey of corporate licensing’, *IDEA: The Journal of Law and Technology*, 24: 59-92.

Saracho, A. I., 2002, ‘Patent licensing under strategic delegation’, *Journal of Economics and Management Strategy*, 11: 225-51.

Sen, D., 2002, ‘Monopoly profit in a Cournot oligopoly’, *Economics Bulletin*, 4: 1-6.

Sen, D., 2005a, ‘Fee versus royalty reconsidered’, *Games and Economic Behavior*, 53: 141-47.

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

Sen, D. and Y. Tauman, 2007, ‘General licensing scheme for a cost-reducing innovation’, *Games and Economic Behavior*, 59: 163-86.

Shapiro, C., 1985, ‘Patent licensing and R&D rivalry’, *American Economic Review, Papers and Proceedings*, 75: 25-30.

Staiger, R. and G. Tabellini, 1987, ‘Discretionary trade policy and excessive protection’, *American Economic Review*, 77: 823-37.

Taylor, C. and Z. Silberstone, 1973, *The economic impact of the patent system*, Cambridge University Press, Cambridge.

Wang, X. H., 1998, ‘Fee versus royalty licensing in a Cournot duopoly model’, *Economics Letters*, 60: 55-62.

Wang, X. H., 2002, ‘Fee versus royalty licensing in a differentiated Cournot duopoly’, *Journal of Economics and Business*, 54: 253-66.

Wang, X. H. and B. Yang, 1999, ‘On licensing under Bertrand competition’, *Australian Economic Papers*, 38: 106-19.