Patent Licensing from High-Cost Firm
to Low-Cost Firm

Sougata Poddar
National University of Singapore

Uday Bhanu Sinha
Indian Statistical Institute

Abstract:
In the literature of patent licensing, most of the studies are done where new technology is transferred from a cost-efficient firm (patentee) to a less efficient firm (licensee). However, R&D intensive firms are usually based in high wage countries whereas the cost-efficient firms are based in low wage countries. As a result R&D intensive firms are not necessarily the most cost-efficient firms in the industry, although in most cases they are the patentee firms. Given this backdrop, we study a situation of patent licensing where the technology transfer takes place from an innovative firm, which is relatively inefficient in terms of cost of production to its cost-efficient rival. We look for optimal licensing arrangements in this environment. This framework also provides a platform to bridge the literature on external and internal patentees.

Keywords: licensing, fixed fee, royalty, two-part tariff, quantity competition, innovation
JEL classification: D43, D45, L13

© 2005 Sougata Poddar and Uday Bhanu Sinha. Sougata Poddar, Department of Economics, National University of Singapore, 10 Kent Ridge Crescent, Singapore 119260; E-mail: ecsp@nus.edu.sg; Fax: (65) 6775-2646. Uday Bhanu Sinha, Economic Research Unit, Indian Statistical Institute, 203, B. T. Road, Kolkata 700 108, India; E-mail: sinhauday@yahoo.com. Views expressed herein are those of the authors and do not necessarily reflect the views of the Department of Economics, National University of Singapore
1. Introduction

Patent licensing is a fairly common practice that takes place in almost all industries. It is a source of profit for the innovator (also called patentee) who earns rent from the licensee by transferring a new technology. It is generally assumed that the technologically efficient firm is also the cost efficient firm in the industry. Hence, a transfer of new technology from a technologically advanced (efficient) firm to a relatively less (or equal) technologically advanced firm is also a transfer of technology from a cost-efficient firm to relatively less (or equal) cost-efficient firm. So far the literature on patent licensing discussed widely regarding the licensing arrangements under such contexts. However, in reality, in many industries, R&D intensive innovative firms are usually based in high wage countries whereas the cost efficient firms are based in low wage countries. As a result the technologically advanced firms based in high wage countries are not necessarily the most cost efficient ones in the industry when it comes to the production of output.\(^1\) But technology transfer takes place from the technologically advanced firm to less (technologically) advanced firm. Now when this is indeed the situation in an industry, it essentially becomes a case of technology transfer from a high cost firm to a low cost firm. In this paper, we study the optimal licensing arrangements between two firms in such an environment.

In the literature of patent licensing, two types of patentees are studied closely, namely, the outsider patentee and the insider patentee. When the patentee is an independent R&D organization and not a competitor of the licensee in the product market, it is an outsider patentee; whereas when it competes with the licensee it becomes an insider patentee. So far, the studies of insider and outsider patentee are done separately in different models. The results for optimal licensing policies under a complete information framework are: if the patentee is an outsider, a fixed fee licensing is optimal to the patentee (see Kamien and Tauman (1986), Katz and Shapiro (1986), Kamien, et. al. (1992), Kamien (1992); whereas a royalty licensing is optimal to the patentee when the patentee is an insider (see Rockett (1990), Marjit (1990) and Wang (1998)). No study has been done to reconcile these two results.

\(^1\) Typically northern countries are the major producers of new technologies and they are high wage economies too. On the other hand, very little innovation takes place in southern countries, which are low wage economies. Our paper analyses the technology licensing from northern firms to southern firms when they compete in a global market place. Another way to interpret the problem is that even in a single country with same wage rate, two firms are asymmetric with respect to pre-innovation costs, due to inefficiency of the higher cost firm in some stages of its production process. However this high cost firm may bring about a cost reducing innovation in some stage of the production chain. This paper analyses the licensing contract for this technology.
Given this backdrop, the purpose of this paper is two-fold: (i) to study optimal licensing arrangements when a new technology is transferred from a firm which is relatively cost-inefficient in the pre-innovation stage compared to the recipient firm, and (ii) to provide a framework to bridge the literature on external and internal patentees.

We assume that, in the pre-innovation stage, the patentee is less cost-efficient than the licensee in terms of production of output. When they are equally efficient (or the patentee is more efficient), we are back to the literature of patent licensing with internal patentee. Now, as the patentee becomes less efficient, it is as if it becomes “less internal” because it has less profits to defend. In the limit when it is very inefficient compared to licensee, it becomes, de facto, an external patentee. Under this backdrop, in this paper, we would like to focus in the change in optimal licensing schemes offered by the patentee as one moves from (almost) symmetric pre-innovation costs of production to very asymmetric costs of production between the patentee and licensee.

Our results show that the initial costs asymmetry in the pre-innovation stage play a crucial role in determining the licensing policy of the patentee. If the patentee has a significant higher marginal cost of production in the pre-innovation stage compared to its rival, then under certain parametric configuration, fixed fee licensing is always superior to royalty or no licensing irrespective of the size of innovation i.e. drastic or non-drastic. Note that when the patentee is less efficient it is as if it becomes “less internal” because it has less profits to defend on its own account and it can go for more licensing revenue through fixed fee as royalty distorts the effective marginal cost for the licensee. In the limit when it is very inefficient, it becomes, de facto, an external patentee. We know from the literature that fixed fee licensing is optimal when the patentee is an outsider in a complete information framework. Thus, our result is consistent with the optimal licensing policy when the patentee is actually an outsider under complete information. Whereas when the pre-innovation cost asymmetry is not too great i.e. the patentee is marginally less cost-efficient than the licensee, royalty turns out to be better than fixed fee or no licensing for the patentee under both drastic and non-drastic innovation. This is also consistent with the results in the literature with insider patentee. Interestingly, when the degree of cost asymmetry is moderate, in the case of non-drastic innovation, a two-part tariff policy is shown to be optimal for the patentee. However, under drastic innovation, a two-part tariff is always shown to be optimal irrespective of the degree of initial costs asymmetry. This result is interesting as we are able to prove the optimality of a two-part tariff licensing even under a complete information framework. So far, the theoretical studies which try to explain the prevalence of a two-part
A tariff licensing contract can be found in models with incomplete (asymmetric) information or uncertainty (see Gallini and Wright (1990), Macho-Stadler et al. (1991), Bousquet et al. (1998))². In general, the existence of two part tariff pricing is not at all surprising in the framework of asymmetric information or uncertainty as it is also prevalent in various other contexts in economics. However, in this particular context, we provide the rational for a two-part tariff pricing using only the feature of pre-innovation asymmetric costs conditions of the competing firms.

The literature on patent licensing under complete information framework (see Kamien and Tauman (1986), Katz and Shapiro (1986), Rockett (1990), Kamien (1992), Wang (1998), Kamien and Tauman (2002) among others) has mainly established the dominance of either fixed fee or per unit royalty scheme when a patentee licenses out its patented innovation. However, empirical facts say otherwise⁴, e.g. Rostoker (1983) in a firms survey finds out royalty plus fixed fee (i.e. a two-part tariff) licensing accounts for 46 percent of the licensing arrangements, royalty alone 39 percent and fixed fee alone 13 percent. Similar studies by Taylor and Silberston (1973) find that arrangements with royalties or a mixture of fixed fee and royalty are far more common than a simple fee. In the literature cited above generally either fixed fee, or pure royalty (or in some cases no licensing) is shown to be optimal, hence the issue of two-part tariff licensing did not arise. In this paper, we show apart from fixed fee and royalty, a two-part tariff licensing can be optimal when competing firms have certain initial cost configurations. To this end, we also provide a theoretical rationale for the commonly observed licensing practices in reality.

The rest of the paper is organized as follows. In section 2, we lay down the basic framework and describe competing firms’ payoff under no licensing agreement. Main analysis on optimal licensing is done in section 3 and section 4. Section 3 deals with case of non-drastic innovation and section 4 with drastic innovation. Finally, section 5 concludes.

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² Recently, Choi (2001) considered a moral hazard problem in a licensing relationship where as previously Beggs (1992) examined a signaling game.

³ Interestingly, Rockett (1990) showed that in a model with complete information if the patentee firm is actually the efficient one (in contrast to our case considered here), then under the possibility of imitation by the licensee, the optimal licensing contract can be of two-part tariff. In our case, we obtain the optimal two-part tariff licensing without any possibility of imitation by the licensee. In Rockett’s case with no possibility of imitation, the optimal contract is pure royalty.

⁴ See also Caves et al. (1983), Macho-Stadler et al. (1996), Jensen and Thursby (2001) among others.
2. The Basic Framework

Consider a Cournot duopoly model with firms producing a homogenous product. The inverse demand function is given by \( p = a - Q \), where \( p \) denotes price and \( Q \) represents aggregate industry output. Initially firms are asymmetric; firm 1, the innovative firm, has marginal cost of production \( c_1 \) and firm 2 has \( c_2 \). Without loss of generality, we assume \( c_1 > c_2 \), so that the innovative firm is the inefficient firm in terms of cost of production. We assume in the pre-innovation stage (i.e. when \( c_1 > c_2 \)), even if firm 1 is inefficient compared to firm 2, yet both firms are active and producing positive quantities, this implies \( (a - 2c_1 + c_2) > 0 \). We also assume that firm 1 is the R&D intensive firm and comes up with a successful cost reducing innovation. After innovation its marginal cost becomes \( c_1 - \varepsilon \), where \( \varepsilon (>0) \) is the amount of cost reduction. \( c_1 - \varepsilon \) can be greater than or less than \( c_2 \) depending on the size of innovation i.e. \( \varepsilon \). In this paper, we do not explicitly model the R&D part of the innovative firm; we begin our analysis after the innovation takes place. Now whether the innovation is drastic or non-drastic that depends on the actual size of \( \varepsilon \). In our analysis, we will consider both cases. Following the usual definition of drastic and non-drastic innovation, we say that the innovation is drastic if the rival firm is unable to compete profitably after the innovation if not licensed and stops production; while the innovation is non-drastic if the rival still remains in business, and produces positive output without being licensed. To capture these two situations formally, we need to look at the ensuing competition after innovation when the innovator does not license the innovation to its rival.

2.1 No Licensing

When firm 1 and firm 2 compete in quantities after innovation with costs \( c_1 - \varepsilon \) and \( c_2 \) respectively, then Nash equilibrium quantities are:

\[
q_1 = \frac{a - 2c_1 + c_2 + 2\varepsilon}{3} \quad \text{and} \quad q_2 = \frac{a - 2c_2 + c_1 - \varepsilon}{3}
\]

The innovation is drastic when \( q_2 = 0 \), and the innovating firm 1 remains as a monopoly, i.e. when \( \varepsilon \geq a - 2c_2 + c_1 \); otherwise, the innovation is non-drastic.

Profits under drastic innovation are: \( \pi_1^{NL} = \frac{(a - c_1 + \varepsilon)^2}{4} \) and \( \pi_2^{NL} = 0 \) (1)

Profits of firms under non-drastic innovation are:
\[ \pi_1^{NL} = \frac{(a - 2c_1 + c_2 + 2\varepsilon)^2}{9} \quad \text{and} \quad \pi_2^{NL} = \frac{(a - 2c_2 + c_1 - \varepsilon)^2}{9} \]  

(2)

For the purpose of comparison with the existing literature, in the following analysis we are going to consider three licensing policies offered by firm 1, namely (i) (per unit) royalty; (ii) (lump-sum) fixed fee and (iii) a two part tariff, i.e., a fixed fee plus royalty.

We consider the following three stage licensing game. In the first stage, the patent holding firm 1 decides whether to license out the technology. Licensing reduces the marginal cost of the rival by \( \varepsilon. \) In case it offers to license out the technology, it charges a payment from the licensee (a fixed licensing fee or a royalty rate or a combination of both royalty and fixed fee). In the second stage, the firm 2 decides whether to accept or reject the offer made by firm 1. Firm 2 accepts any offer if it receives weakly greater payoff from acceptance than rejection. In the last stage, both firms compete as Cournot duopolists with quantities as the choice variables.

First, we will consider the case of non-drastic innovation.

3. Non-Drastic Innovation \((0 < \varepsilon < a - 2c_2 + c_1)\)

To discuss a meaningful story of licensing by firm 1, we also need to assume that the size of innovation is such that \( c_2 - \varepsilon > 0 \) for the rest of the analysis.

3.1 Royalty Licensing

Suppose the firm 1 decides to license out the innovation to firm 2 by charging a per unit royalty \( r. \) Note that firm 2 would not accept the licensing contract if \( r > \varepsilon. \) Thus, a feasible royalty contract must involve \( r \leq \varepsilon. \) Under this royalty licensing the firm 1’s payoff is

\[ \pi_i' = \frac{(a - 2c_1 + c_2 + \varepsilon + r)^2}{9} + r \left( \frac{a - 2c_2 + \varepsilon - 2r + c_j}{3} \right) \]

The optimal royalty calculated as an unconstrained problem (i.e. by ignoring the constraint \( r \leq \varepsilon \)) yields

\[ r = \frac{5a - c_1 - 4c_2 + 5\varepsilon}{10} > 0 \quad \text{(given } a > c_j > c_2 \text{ and } \varepsilon > 0) \]

\(^5\) As an example, think of a situation where two firms use two different types of technologies but they use one common device, which can be improved upon using the innovation; or in the case where firms use the same technology, consider they are at the different stages of technological frontier and a common invention can improve both. Under such circumstances, it is always possible for the innovator to reduce the costs of production of both the firms equally, using the new innovation.
Now for lower \( \varepsilon \), the above \( r \) is always greater than \( \varepsilon \). Hence, the optimal \( r \) (with the constraint \( r \leq \varepsilon \)) is \( \varepsilon \).

Now when \( \varepsilon > \frac{5a-c_1-4c_2}{5} = 0 \) (say), then \( r = \frac{5a-c_1-4c_2+5\varepsilon}{10} \).

Note that \( \frac{5a-c_1-4c_2}{5} < a-2c_2+c_1 \) (since \( a > c_1 > c_2 \)). Thus, the optimal royalty scheme under non-drastic innovation is given as

\[
r^* = \begin{cases} 
\varepsilon & \text{if } \varepsilon \leq \theta \\
\frac{a+\varepsilon-c_1+4c_2}{2} & \text{if } \varepsilon > \theta 
\end{cases}
\]

Thus the total income of firm 1 under royalty is given by

\[
\pi_r^* = \pi_1^* + r^* q_2^* = \begin{cases} 
\left(\frac{a-2c_1+c_2+2\varepsilon}{9}\right) + \varepsilon \left(\frac{a-2c_2+c_1-\varepsilon}{3}\right) & \text{if } \varepsilon \leq \theta \\
\left(\frac{a-c_1+\varepsilon}{4}\right) + \left(\frac{c_1-c_2}{5}\right) & \text{if } \varepsilon > \theta 
\end{cases}
\]

**Lemma 1**

*Under non-drastic innovation, royalty licensing is better than no licensing for the patentee.*

**Proof:** First by comparing (2) and (3a), it is immediate that the payoff of the firm 1 from royalty licensing is greater than what it gets by choosing not to license the technology. Also by comparing (2) and (3b), we find that the payoff of the firm 1 from royalty is greater than no licensing (using \( \varepsilon < a-2c_2+c_1 \)).

The above lemma establishes that licensing through royalty is always better than no licensing. In order to find out the optimal licensing policy we need to compare the payoffs from the fixed fee licensing and the two-part tariff contract. First, we turn to the fixed fee licensing policy.

### 3.2 Fixed fee Licensing

Note that firm 2 would accept the licensing contract under fixed fee provided the amount of fixed fee does not exceed the incremental payoff received by firm 2 in the third stage of the game due to licensing of the technology. Thus, firm 1 would charge optimally the
incremental payoff as the fixed fee and this offer would be accepted by firm 2. In this case, 
the optimal fixed fee is \( F^* = \frac{(a-2(c_2-\varepsilon)+c_1-\varepsilon)^2}{9} - \frac{(a-2c_2+c_1-\varepsilon)^2}{9} \)

Thus, \( F^* = \frac{4\varepsilon}{9}(a-2c_2+c_1) \) (after simplification).

Note that \( F^* > 0 \) since \( a > c_1 > c_2 \).

Thus, total income of firm 1 under fixed fee licensing is given by

\[
\pi^F = \pi_1 + F^* = \frac{(a-2c_1+c_2+\varepsilon)^2}{9} + \frac{4\varepsilon}{9}(a-2c_2+c_1) \tag{4}
\]

### 3.3 Comparison between Royalty and Fixed Fee

By making a comparison between fixed fee and royalty licensing we get the following.

**Proposition 1**

*Under non-drastic innovation*

(a) for \( \varepsilon \leq \theta \), fixed fee licensing is better than royalty licensing i.e. \( \pi^F > \pi^R \), when

\[c_1 > \frac{1}{5}(a+4c_2)\]

and vice versa.

(b) for \( \varepsilon > \theta \), fixed fee licensing is better than royalty licensing when

\[c_1 > 5a-4c_2+45\varepsilon-4\sqrt{5\varepsilon(6a-6c_2+25\varepsilon)}\]

*Otherwise, the reverse happens.*

**Proof:** In Appendix.

Alternatively, we can characterize the optimal licensing policy of the firm 1 with the help of
the following diagram.

![Diagram showing comparison between fixed fee and royalty licensing](image)

**Figure 1**
The intuition of the above result is as follows. First note that when a fixed fee license is offered, the relative strategic positions of the firms remain unchanged. In the pre-innovation stage $c_1 > c_2$, and in the post innovation stage $c_1 - \varepsilon > c_2 - \varepsilon$. Now, even if the relative strategic positions remain unchanged, there is an overall increase in the efficiency level in the industry due to innovation, and this leads to an overall increase in the aggregate profit of the industry as well as individual profit of the firms. Thus, a relatively big fixed fee can be extracted by the patentee. Now this is not possible when a royalty license is offered, although there is some gain in efficiency due to innovation, yet firm 2 effectively operates at higher marginal cost than the fixed fee licensing case. So, when the initial cost difference is large, relatively less royalty revenue can be extracted in this case from firm 2 as compared to fixed fee licensing. On the other hand, when the initial cost difference is not large, other things being equal, royalty is better than fixed fee as firm 1 does better by keeping the cost advantage for any degree of innovation. Simply put, when $c_1$ is high fixed fee licensing dominates royalty and when $c_1$ is low royalty dominates fixed fee licensing. This is consistent with the earlier results on insider and outsider patentee. When $c_1$ is high, firm 1 is more of an outsider than an insider as a result fixed fee licensing dominates royalty licensing. However, the reverse happens for the lower values of $c_1$.

3.4 Analysis of Two-Part Tariff Licensing Scheme

So far we have analyzed the licensing policy of the firm 1 when it charges only fixed fee or royalty. Let us now consider the general licensing scheme involving both fixed fee and royalty together (i.e., as two part tariff). Suppose the firm 1 decides to license the innovation by offering a contract $(f, r)$, where $f$ is fixed fee charged upfront and $r$ is royalty rate per unit of output produced by the licensee. Both $f, r \geq 0$ and $r \leq \varepsilon$.

Suppose the firm 2 accepts the licensing contract $(f, r)$. The firm 2’s profit would be

$$
\frac{(a - 2c_2 + c_1 + \varepsilon - 2r)^2}{9} - f.
$$

In case the firm 2 does not accept the licensing contract, it receives a payoff

$$
\frac{(a - 2c_2 + c_1 - \varepsilon)^2}{9}.
$$
Thus, for a given \( r \), the firm 2 would accept the licensing contract if the fixed fee is not greater than 
\[
\frac{(a-2c_2+c_j+\varepsilon-2r)^2}{9} - \frac{(a-2c_2+c_j-\varepsilon)^2}{9}.
\]
So the firm 1 can at the most charge this \( f \) as fixed fee.

The firm 1’s payoff under this licensing contract would be its own profit in the product market due to competition plus the fixed fee it charges and the royalty revenue it receives.

Thus, the firm 1’s total payoff is
\[
\pi_i^{f,r} = \frac{(a-2c_2+c_j+\varepsilon+r)^2}{9} + \frac{(a-2c_2+c_j+\varepsilon-2r)^2}{9} - \frac{(a-2c_2+c_j-\varepsilon)^2}{9} + r\left(\frac{(a-2c_2+c_j-2r+c_j)}{3}\right)
\]

The unconstrained maximization with respect to \( r \) of the above payoff function yields
\[
r = \frac{(a-5c_1+4c_2+\varepsilon)}{2}.
\]

Now depending on the parameter configuration we have the following three distinct possibilities.

**Case (i):** \( c_j \geq \frac{a+4c_2+\varepsilon}{5} \).

Then, we get \( r \leq 0 \) from the above expression. Now given the natural restriction on \( r \geq 0 \), we argue that the optimal \( r^* = 0 \) and the patentee would charge a fixed fee only. Thus, the optimal amount of fixed fee is
\[
\frac{(a-2c_2+c_j+\varepsilon)^2}{9} - \frac{(a-2c_2+c_j-\varepsilon)^2}{9},
\]
which is positive.

**Case (ii):** \( \frac{a+4c_2+\varepsilon}{5} > c_j > \frac{a+4c_2-\varepsilon}{5} \).

In this case the optimal royalty would be \( r = \frac{(a-5c_1+4c_2+\varepsilon)}{2} > 0 \) and this \( r < \varepsilon \) as well.

Therefore, in this case there would be fixed fee also. Thus, we have two part tariff licensing scheme.

**Case (iii):** \( \frac{a+4c_2-\varepsilon}{5} \geq c_j \).

Given the restriction that \( r \leq \varepsilon \), we have the optimal \( r^* = \varepsilon \). Given the optimal \( r^* \), it is also clear from the expression of fixed fee above that \( f^* = 0 \).

Thus, the optimal licensing contract can be characterized in the figure below.
So we have two-part tariff licensing under non drastic innovation for the parameter configurations described in case (ii). It is interesting to note that when the initial cost difference of the two firms are large then only fixed fee is charged; and when the initial cost difference is small then only royalty is charged. However, when the initial cost difference is in some intermediate level we find the existence of two part tariff as the optimal licensing contract.

Now we argue that this two-part tariff licensing is indeed optimal, that is, better than charging either fixed fee or royalty only for the above parameter configurations (i.e. case (ii)). Note that charging $r = 0$ implies that only fixed fee is charged. Now it is easy to check that the firm 1’s payoff is an increasing function of $r$ for $r$ close to zero. So the two-part tariff even with a very small $r$ yields a greater payoff to firm 1 than the fixed fee alone. Further, note that the payoff function of firm 1 is a strictly concave function of $r$ and the optimal royalty $r^* < \varepsilon$, which justifies charging of fixed fee as well. Therefore, the optimal two-part tariff generates a greater payoff to firm 1. Thus, to summarize we have the following result.

**Proposition 2**

*Under non-drastic innovation, the optimal licensing policy is as given below.*

(a) for $c_1 \geq \frac{a + 4c_2 + \varepsilon}{5}$, only fixed fee is charged.

(b) for $\frac{a + 4c_2 + \varepsilon}{5} > c_1 > \frac{a + 4c_2 - \varepsilon}{5}$, two part tariff is charged.

(c) for $\frac{a + 4c_2 - \varepsilon}{5} \geq c_1$, only royalty is charged.
4. **Drastic Innovation** \((\varepsilon \geq a - 2c_2 + c_1)\)

We have already assumed that in the pre-innovation stage (i.e. when \(c_i > c_2\)), both firms are active and producing positive quantities, this implies \((a - 2c_1 + c_2) > 0\). As before, for meaningful analysis we also assume \(c_2 - \varepsilon > 0\).

4.1 **Royalty Licensing**

Under royalty licensing the costs of firm 1 and firm 2 are \((c_1 - \varepsilon)\) and \((c_2 - \varepsilon + r)\) respectively, where \(r\) is the per-unit royalty.

In this case, the optimal royalty is solved as follows. Note that for a meaningful analysis under royalty licensing, the royalty rate should be such that the output of the firm 2 must be non negative. This restriction implies that \(r \leq \frac{a - 2c_2 + c_1 + \varepsilon}{2}\). Since \(\varepsilon \geq a - 2c_2 + c_1\) under drastic innovation, the royalty rate \(r\) must satisfy \(r \leq \frac{a - 2c_2 + c_1 + \varepsilon}{2} < \varepsilon\).

Thus, we maximize \((\pi_1 + rq_2)\) with respect to \(r\) subject to \(r \leq \frac{a - 2c_2 + c_1 + \varepsilon}{2}\).

The unconstrained maximization yields, \(r^* = \frac{a + \varepsilon - c_1 + 4c_2}{2}\).

Now \(r^* = \frac{a + \varepsilon - c_1 + 4c_2}{10} \leq \frac{a - 2c_2 + c_1 + \varepsilon}{2}\) follows from the fact that \(c_1 > c_2\).

Thus, total income of firm 1 under royalty is given by

\[
\pi^r = \pi_1 + r^*q_2 = \frac{(a - c_1 + \varepsilon)^2}{4} + \frac{(c_1 - c_2)^2}{5} \quad \text{(after simplification)}
\]

(5)

Now we state the following.

**Lemma 2**

*Under drastic innovation, royalty licensing is better than no licensing for the patentee.*

Proof: By comparing (1) and (5), we find that the payoff from royalty is greater than no licensing.

It is also important to note that the optimal royalty under the royalty licensing is strictly less than the amount of cost reduction, \(\varepsilon\). Next we consider the fixed fee licensing policy.
### 4.2 Fixed Fee Licensing

Optimal fixed fee \( F^* = \frac{(a-2(c_2 - \varepsilon)+(c_1 - \varepsilon))^2}{9} - 0 = \frac{(a-2c_2 + c_1 + \varepsilon)^2}{9} \)

Thus, total payoff of firm 1 under fixed fee is given by

\[
\pi^F = \pi_1 + F^* = \frac{(a-2c_1 + c_2 + \varepsilon)^2}{9} + \frac{(a-2c_2 + c_1 + \varepsilon)^2}{9}
\]  

(6)

### 4.3 Comparison between Royalty and Fixed Fee

Let the initial difference in the (cost) efficiency levels between firm 1 and firm 2 is \( c_1 - c_2 = \delta \) (say). Note that since \( c_1 - \varepsilon < c_2 \), therefore, \( \delta < \varepsilon \).

**Proposition 3**

*For a given size of drastic innovation \( \varepsilon \), in a Cournot duopoly model with asymmetric pre-innovation costs, fixed fee licensing is superior to royalty licensing when \( \delta \) is relatively high.*

Formally, \( \pi^F > \pi^R \) when

\[
\frac{16 \delta}{5} + 2(a-c_1 + \varepsilon) > \frac{(a-c_1 + \varepsilon)^2}{4}
\]

and vice versa.

**Proof:** Follows by comparing (5) and (6). (see appendix for details).

The above result implies as long as initial cost difference between the patentee firm and the competitor is relatively high, it is better for the patentee to offer fixed fee license instead of royalty.

### 4.4 Analysis of Two-Part Tariff Licensing Scheme

Let us now consider the general licensing scheme involving both fixed fee and royalty together (i.e., as two part tariff) in the case of drastic innovation. As we have already noted, that for a meaningful analysis of licensing in the drastic case, the royalty should not be too high, i.e., \( r \leq \frac{a-2c_2 + c_1 + \varepsilon}{2} \); otherwise, the firm 2 cannot produce positive output.

Now the analysis for the optimal royalty plus fixed fee is similar to the non-drastic case. Thus, the routine calculation would entail the optimal royalty under the two part tariff scheme is:

\[
r = \frac{(a-5c_1 + 4c_2 + \varepsilon)}{2}
\]

Unlike the non-drastic case, here we show that \( r > 0 \) always. Since we are under drastic innovation; \( \min \varepsilon = a-2c_2 + c_1 \) and using this value of \( \varepsilon \) in the above expression of \( r \)
yields \((a - 2c_1 + c_2)\). Note that \((a - 2c_1 + c_2) > 0\) by assumption. Thus, for any \(\varepsilon \geq a - 2c_2 + c_1\); we always have \(r > 0\).

Now this optimal royalty is less than \(\frac{a - 2c_2 + c_1 + \varepsilon}{2}\). As a result both firms would operate in the market after licensing. It is also easy to verify that \(r = \frac{(a - 5c_1 + 4c_2 + \varepsilon)}{2} < \varepsilon\). Thus, the optimal fixed fee is always positive here. Now invoking the strict concavity of the payoff function with respect to \(r\), we argue that the payoff to firm 1 under two part tariff is greater than either only fixed fee or only royalty licensing. Now to see that the two part tariff licensing is in fact better than the no-licensing, note that \(r = \frac{a - 2c_2 + c_1 + \varepsilon}{2}\) is a feasible choice for the firm 1, which would lead to the situation that firm 2 remains out of the market. Thus, the optimal two-part tariff is the best licensing strategy for firm 1 in the case of drastic innovation. It is also interesting to note that even the drastic technology is licensed.

Thus we have the following result.

**Proposition 4**

*Under drastic innovation, the optimal licensing policy is always a two-part tariff licensing scheme.*

**5. Conclusion**

In the literature of patent licensing, most of the studies on licensing arrangement (in the case of insider patentee) are done where technology is transferred from a cost-efficient firm to a less (or equal) cost-efficient firm. In this paper, we consider a situation where the technology transfer takes place from a relatively high cost firm to a low cost firm. In reality, innovative firms are usually based in high-wage countries whereas cost-efficient firms are mostly based in low-wage countries. Technology transfer takes place from R&D intensive innovative firm to other firms where the recipient firms can be more cost-efficient than the patentee firm when it comes to the production of output. In other words, here, we distinguish between technological efficiency and cost efficiency, which by and large in the literature of patent licensing are assumed to be the same. Optimal licensing arrangements are studied under this new environment.
This analysis also provides a platform to bridge the literature on external and internal patentees. Previous literature showed fixed fee is better than royalty when the patentee is an outsider, whereas royalty is better than fixed fee when the patentee is an insider under symmetric initial costs. In our framework with asymmetric costs, we endogenize this feature of licensing arrangements. As the degree of cost asymmetry changes, we go from one extreme to another. At the same time, we show that when the cost asymmetry is moderate, a two-part tariff licensing scheme is optimal for non-drastic innovation. Also, quite interestingly, we find that the drastic technology is always licensed under two part tariff scheme.

In general, in the literature, a two-part tariff contract is shown to be optimal in situations with asymmetric information or uncertainty. We show the optimality of two-part tariff licensing contract under a complete information framework. Our analysis, thus, provides a theoretical rationale for the empirically observed licensing practices in reality.

References


Appendix

Proof of Proposition 1:

(a) Note that for \( \varepsilon \leq \theta \), \( \pi^R - \pi^F = \frac{1}{9} (a - 5c_1 + 4c_2) \) (using (3a) and (4) and simplifying).

(b) Assume \( Z = \pi^R - \pi^F \). It follows directly by comparing (3b) and (4) and simplifying that

\[
Z = c_i^2 + c_i(-10a - 90\varepsilon + 8c_2) + 25a^2 + 25\varepsilon^2 + 16c_2^2 - 30a\varepsilon + 120c_2\varepsilon - 40ac_2
\]

Note that \( \frac{\delta Z}{\delta c_i} < 0 \) in the relevant range (i.e., \( a > c_1 > c_2 \)) and \( \frac{\delta^2 Z}{\delta^2 c_i} > 0 \).

Now \( Z = 0 \) gives two roots of \( c_i \) given the quadratic nature of the function. Solving for the roots and simplifying we find the roots as \( 5a - 4c_2 + 45\varepsilon \pm 4\sqrt{5\varepsilon(6a - 6c_2 + 25\varepsilon)} \).

However, the higher roots of \( c_i \) is not admissible as it is greater than \( a \). Thus, the relevant range of the \( Z \) function behaves as for \( c_i < 5a - 4c_2 + 45\varepsilon - 4\sqrt{5\varepsilon(6a - 6c_2 + 25\varepsilon)} \), \( Z > 0 \) and for \( 5a - 4c_2 + 45\varepsilon - 4\sqrt{5\varepsilon(6a - 6c_2 + 25\varepsilon)} < c_i < a \), \( Z < 0 \).

Thus, we have for \( c_i < 5a - 4c_2 + 45\varepsilon - 4\sqrt{5\varepsilon(6a - 6c_2 + 25\varepsilon)} \), royalty licensing is better than fixed fee licensing and for \( 5a - 4c_2 + 45\varepsilon - 4\sqrt{5\varepsilon(6a - 6c_2 + 25\varepsilon)} < c_i < a \), fixed fee licensing is better than royalty licensing.

Proof of Proposition 3:

Given \( c_1 - c_2 = \delta \)

\[
\pi^F = \frac{(a - 2c_1 + c_2 + \varepsilon)^2}{9} + \frac{(a - 2c_2 + c_1 + \varepsilon)^2}{9}
\]

\[
= \frac{(a - 2c_1 + c_1 - \delta + \varepsilon)^2}{9} + \frac{(a - 2c_1 + 2\delta + c_1 + \varepsilon)^2}{9} \quad \text{(by simplifying)}
\]

\[
= \frac{1}{9} \left[ 2(a - c_1 + \varepsilon)^2 + 2\delta(a - c_1 + \varepsilon) + 5\delta^2 \right]
\]

\[
\pi^R = \frac{(a - c_1 + \varepsilon)^2}{4} + \frac{(c_1 - c_2)^2}{5} = \frac{(a - c_1 + \varepsilon)^2}{4} + \frac{\delta^2}{5}
\]

Now, by comparing \( \pi^R \) and \( \pi^F \), the result follows.