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‘To sell or not to sell’: Patent licensing versus Selling by an outside innovator in the linear city framework

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Abstract

Licensing cost reducing innovations by an outside innovator to one or more incumbent firms has been extensively studied in the literature. However, the incentives of an outside innovator to license innovations vis-à-vis outright selling the property of the innovation to a single firm is not studied much in the literature. We address this problem here under spatial competition in a linear city framework with two competing asymmetric firms (the potential licensees). We show that the innovator is always better-off selling the innovation to one of the firms. This holds irrespective of the size of the innovation (i.e. drastic or non-drastic) and the degree of pre-innovation cost asymmetry between the firms. In case of licensing only, the optimal licensing contract is pure royalty contracts to both firms when the cost differentials between the firms are relatively small, otherwise it is fixed fee licensing to the efficient firm only.

Key Words: Outside innovator, Cost-reducing innovation, Licensing, Selling, Linear city model.

JEL Classification: D43, D45, L13.

1. Introduction:

Patent licensing is all pervasive in almost all industries anywhere. The innovator (also called licensor or patentee) earns profit from the licensees by transferring a new technology using various licensing contracts. The theoretical literature on patent licensing has considered various

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forms of licensing contracts viz. fixed fee licensing, per unit royalty licensing, auctioning certain number of licenses, and two-part tariff licensing. But very few have considered selling the property rights of the innovation to a prospective firm (who can then possibly license the new technology to other firms, if finds profitable to do that), a notion that is first introduced in the literature by Tauman and Weng (2012). In this paper, we examine the incentive of an outside innovator (e.g. an independent research lab) to sell the property rights of an innovation to a prospective incumbent firm and compare that with the different conventional licensing contracts in a spatial framework. We particularly chose a spatial model because we wanted to get out of standard price and quantity (Bertrand and Cournot) product differentiation framework where much of the licensing mechanisms (and selling in few instances) are discussed in the literature. Secondly, the research on patent licensing in spatial competition shows certain departure of the results on optimal licensing from the standard price/quantity competition framework. Thirdly, to the best of our knowledge, in a spatial framework the option to sell the innovation instead of licensing by an innovator is never considered.

The analytical framework we employ is the well-known Hotelling’s linear city model. Specifically, we assume that there is a non-producing outside innovator (research lab) who has a new cost reducing technology and there are two competing firms in the product market, namely, the two potential licensees. To incorporate generality in the model, we assume that the competing firms can be asymmetric in terms of the initial costs of production hence one firm could be more efficient than the other. The innovator can choose to license its innovation to a single firm or both the firms. Else it can opt for outright selling of its innovation to any one firm. For the licensing game, once the offer is made, in the second stage, the firms decide whether to accept or reject the licensing contract. Then in the third stage the firms compete in prices. The licensing contracts we examine are upfront fixed fee licensing, auctioning of one or two licenses, per unit royalty licensing, and two-part tariff licensing. For the selling the game, the innovator decides to sell its innovation to one of the two firms. Since the innovator is ultimately interested in maximizing the value of the patent (which maximizes its payoff as well),

1 Selling the property rights of the innovation to a firm is more appropriate when the innovator is an independent research lab and not a regular firm in the market. Also in practice, the licensing cost is not negligible and it provides extra incentive to the outside innovator to sell its innovation.

2 Note that the case of symmetric competing firms as potential licensees which is actually more often studied in the literature for patent licensing will be a special case of our analysis.

3 Note licensing is possible to more than one firm whereas selling the property right of innovation can be done to one firm only.
we compare whether it is profitable to the innovator, to license or sell the innovation.

Our main finding is selling of the innovation to any one of the firms dominates all forms of licensing contracts. By showing this, we are also able to extend and complement one of the main results of Tauman and Weng (2012). In particular, Tauman and Weng showed that in a Cournot model with linear demand an outside innovator with several symmetric potential licensees (firms), selling the innovation is strictly better than direct licensing strategy only when the innovation is significant but non-drastic, and the number of potential licensees is least four or more. On the other hand, for drastic innovation both the strategies yield same payoffs to the innovator. Our main result in the spatial framework is more general and robust in the sense that selling the innovation is always strictly better than any licensing strategy irrespective of the size of the innovations (drastic or non-drastic). Moreover, only two potential licensees (firms) are necessary to generate the result and at the same time we allow the firms to be asymmetric as well.

From another point of view, the literature of patent licensing in spatial framework is growing rapidly and our main finding also contributes to that growing literature. For example, recently Lu and Poddar (2014) examined the optimal licensing scheme of an insider patentee under spatial competition and found that two-part tariff licensing is always optimal. Our study complements and extends Lu and Poddar (2014) with an outsider patentee. Poddar and Sinha (2004) analyzed the case of outsider patentee with two incumbent potential licensees in the Hotelling’s linear city model. However, in that paper it was assumed that the firms are symmetric and the possibility of selling the property right of innovation to one of the licensees is not at all considered.

In this paper, we first characterize the equilibrium licensing outcomes under all forms of licensing arrangements. When fixed fee licensing is considered, we find that the innovator will always license its innovation to only one firm viz. the efficient firm. In the case of auction, where the innovator has the choice of auctioning one or two licenses, we find that the innovator will always auction one license and the efficient firm will win the auction. However, fixed fee licensing gives higher payoff than auction to the innovator. In the case of royalty licensing, the innovator would always license the technology to both the firms rather than a single firm. In the

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4 Sinha (2015) analyzes a similar problem with asymmetric potential licensees in a Cournot model.
5 The study of patent licensing in a spatial framework is first introduced by Poddar and Sinha (2004), followed by Matsumura and Matsushima (2008) among others.
case of two-part tariff licensing, the innovator will always license to both firms as well, and interestingly we also see that the optimal two-part tariff contract is in fact a pure royalty licensing (i.e. fixed fee part is zero). Comparing the payoffs of the outside innovator from all the licensing arrangements, we find that optimal licensing contract is pure royalty contracts to both firms when the pre-innovation cost differentials between the firms are relatively small, otherwise fixed fee licensing to the efficient firm is optimal. On the other hand, when we consider selling the property right of the innovation, we find that the outside innovator will sell the right to any one of the firms (who then further licenses to the other firm), and the payoff to the innovator from selling strictly dominates all the payoffs from optimal licensing arrangements. The result is true irrespective of the size of the innovations (drastic or non-drastic) and the degree of pre-innovation cost asymmetries between the competing firms.

In the spatial framework, throughout our analysis we keep the locations of the firms fixed at the two extremes of the linear city. We assume linear transportation costs of the consumers.\(^6\) One of the implications of extreme location of firms is that the consumers view the products as maximally differentiated and the extent of product differentiation is given. We conjecture that this is a reasonable assumption since we focus on the optimal licensing and/or selling strategies of an outside innovator and the optimal product differentiation or location choice of firms is not our focus.

A few words on what kind of industry and what nature of competition among firms one can analyze using the location model we use here. We believe that the linear city model described here is appropriate to study the behavior of the firms in industries with developed markets which are not growing and where differentiation over product brands is well established (in our model maximal differentiation) and is not rapidly changing. In a typical location model, with full market coverage, the quantity demanded at each price not very high does not change. This particular feature of this location model is important, when we compare across equilibrium profits of the firms under different licensing and/or selling regimes as the aggregate demand (or market size) remains constant across the regimes. In this sense location models have an advantage over standard models of product differentiation (a la Singh and Vives, 1984). In the Singh and Vives (1984) model we have elastic demand. Therefore, it is not proper to compare

\(^6\) It is well known that in the linear city model with linear transportation costs equilibrium in location choice might not exist. It exists if the firms are sufficiently far apart and in this paper we assume the firms to be at the extremes of the city. Thus existence related issues do not arise.
equilibrium values across different regimes and this could be misleading because of varying demand. Therefore, we think that the linear city model by Hotelling is a more appropriate place to study the outside innovator’s licensing or selling strategies when we consider industries with developed and matured markets.

Quite a few papers in the literature have discussed the nature of licensing that should take place between the patentee and the licensees. In the complete information framework, in general competitive environment, if the patentee is an outside innovator, it has been generally shown that fixed fee licensing is optimal (see Katz and Shapiro (1986), Kamien and Tauman (1986), Kamien et al., (1992), Stamatopolous and Tauman (2009)) whereas per-unit royalty contract is optimal when the patentee is an insider (Wang (1998), (2002), Wang and Yang (2004), Kamien and Tauman (2002)). In this paper, we get a different and new result on optimal licensing contracts. We show pure royalty contracts to both firms are optimal when the pre-innovation cost differentials between the firms are relatively small, otherwise fixed fee licensing only to the efficient firm is optimal. Thus optimal licensing contracts are rather mixed depending on firms’ initial asymmetries. Moreover, none of the papers mentioned above consider outright selling of the innovation to one of the potential licensees.

There is also a huge literature on patent licensing which focuses on the optimal licensing arrangements. For a survey on patent licensing one can look at Kamien (1992). Also Sen and Tauman (2007) provide a comprehensive analysis for general licensing schemes and its impact on the market structure and the diffusion of a cost reducing innovation in a Cournot oligopoly industry. Regarding patent licensing by an outside innovator, Muto (1993) using a standard product differentiation framework and price competition showed that only royalty licensing is optimal (compared to auction and fixed fee). In his model Muto considered licensing policies with an external patentee and two potential licensees but he didn’t consider the option of the outside patentee selling the license to any one of the licensees. In a different work, Fauli-Oller and Sandonis (2002) developed a licensing game in differentiated product market with an insider patentee and found that two-part tariff licensing is optimal both under price and quantity competition. Mukherjee and Balasubramanian (2001) in a horizontal differentiation framework considered technology transfer in a Cournot duopoly market and found optimality of two-part tariff licensing with an insider patentee. Very recently, Bagchi and Mukherjee (2014) examined

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7 See also Sen (2005) to note the restriction when the number of licensees must be an integer.
the impact of product differentiation on optimal licensing schemes by an outsider patentee. They showed that royalty licensing is optimal for a certain range of product differentiation irrespective of quantity and price competition. It is worth pointing out that all of these studies focused on optimal licensing schemes by an insider or an outside innovator but doesn’t consider the optimality of selling the technology (innovation) vis-à-vis licensing. Again most of these studies are done in a standard framework of price and/or quantity competition with differentiated products whereas we do our analysis under spatial competition.

The rest of the paper is organized as follows. In section 2, we lay out the model. The licensing game is analyzed in detail in section 3. We analyze the selling game in section 4 and draw our main conclusion based on the analysis in section 3 and 4. We take up the welfare analysis in section 5. Section 6 concludes.

2. The Linear City Model
Consider two firms, firm A and firm B located in a linear city with unit interval [0,1]. Firm A is located at 0 whereas firm B is located at 1 that is at the two extremes of the linear city. Both firms produce homogenous goods with constant marginal cost of production and compete in prices. We assume that consumers are uniformly distributed over [0,1]. Each consumer purchases exactly one unit of the good either from firm A or firm B. The transportation cost per unit of distance is $t$. Therefore the utility function of a consumer located at $x$ is given by:

$$U = v - p_A - tx$$

if buys from firm A

$$U = v - p_B - (1 - x)t$$

if buys from firm B

We assume that the market is fully covered. The demand functions for firm A and firm B can be calculated as:

$$Q_A = \frac{1}{2} + \frac{p_B - p_A}{2t}$$

if $p_B - p_A \in (-t, t)$

$$= 0$$

if $p_B - p_A \leq t$

$$= 1$$

if $p_B - p_A \geq t$

and

$$Q_B = 1 - Q_A$$
There is a non-producing outside innovator (a research lab) which has a cost reducing innovation. The innovation helps reduce the per-unit marginal costs of the licensee firm(s) by $\epsilon$. $\epsilon$ is also known as the size of the innovation. The innovator has the option of licensing the innovation to a single firm or both firms. Alternatively, it can sell the innovation to any single firm. We will consider different forms of licensing viz. fixed fee licensing, auction policy, royalty licensing, and two-part tariff licensing. We will examine both non-drastic and drastic innovations. An innovation is drastic innovation when the size of the cost reducing innovation is sufficiently high such that the firm not getting the license goes out of the market and the licensee becomes the monopoly.\(^8\)

The timing of the game is given as follows:

**Stage 1:** The outside innovator decides to license its innovation (to either one or both firms) or to sell the innovation (to any one firm).

1a: The licensing game – One or two licensing contracts are offered. In case of offering one license if first firm rejects, the offer goes to the second firm.

1b: The selling game – Selling contract is offered to one of the firms. If one firm rejects the selling contract it goes to the other firm.

**Stage 2:** The firm(s) (potential licensees) accepts or rejects the offer following 1a or 1b.

**Stage 3:** The firms compete in prices and products are sold to consumers.

### 2.1. Absence of Outside Innovator – No Licensing or Selling

First we examine the case where the outside innovator is not in the scenario and two asymmetric firms A and B are competing in the market with old production technology. Let’s denote the constant marginal costs of production of firms A and B by $c_A$ and $c_B$ respectively and define $\delta = c_B - c_A$. To fix ideas suppose $\delta = c_B - c_A > 0$, i.e. firm A is the efficient firm\(^9\). We assume that $\delta \leq 3t$ so that the less efficient firm’s equilibrium quantity is positive before the innovation

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\(^8\) Following the definition of Arrow (1962) on drastic and non-drastic innovation.

\(^9\) Results and intuitions go through even if we assume $\delta = c_A - c_B > 0$, i.e. firm A is the inefficient firm.
takes place. Therefore, the no-licensing/no-selling equilibrium prices, demands and profits can be given as:

\[ p_A = \frac{1}{3} (3t + 2c_A + c_B) = c_A + \frac{1}{3} (3t + \delta) \]  
(1)

\[ p_B = \frac{1}{3} (3t + c_A + 2c_B) = c_B + \frac{1}{3} (3t - \delta) \]  
(2)

\[ Q_A = \frac{1}{6t} (3t - c_A + c_B) = \frac{1}{6t} (3t + \delta) \]  
(3)

\[ Q_B = \frac{1}{6t} (3t + c_A - c_B) = \frac{1}{6t} (3t - \delta) \]  
(4)

\[ \pi_A = \frac{1}{18t} (3t - c_A + c_B)^2 = \frac{1}{18t} (3t + \delta)^2 \]  
(5)

\[ \pi_B = \frac{1}{18t} (3t + c_A - c_B)^2 = \frac{1}{18t} (3t - \delta)^2 \]  
(6)

### 3. Presence of Outside Innovator – The Licensing Game

If the outside innovator licenses to firm A (the efficient firm), and if \( \epsilon > 3t - \delta \), then firm A becomes monopoly (B goes out of the market). On the other hand, if the outside innovator licenses to firm B (the inefficient firm), then firm B becomes monopoly (and firm A goes out of the market) only when \( \epsilon > 3t + \delta \). Recall that for licensing game, we have defined when one license is offered by the innovator if first firm rejects, the offer goes to the second firm. So when \( \epsilon > 3t - \delta \) but \( \epsilon < 3t + \delta \) then if firm A rejects and B gets, firm B doesn’t become a monopoly since the size of the innovation is not sufficient to drive firm A out of the market. Hence in our context, an innovation is drastic only when \( \epsilon > 3t + \delta \), otherwise it is non-drastic.

Now we consider different forms of licensing one by one. Suppose the outside innovator is licensing the innovation to firm A. We start with fixed fee licensing.

#### 3.1 Fixed Fee Licensing:

##### 3.1.1: Fixed fee licensing to one firm:

**Non-Drastic Case (i) \( \epsilon < 3t - \delta \):**

Consider the case where the innovator licenses its innovation to firm A by charging a fixed fee. The post licensing marginal cost of firm A will be \( c_A - \epsilon \) and that of firm B will be \( c_B \). In this
situation the equilibrium prices, demands and profits can be given as:

\[ P_A^F = c_A - \epsilon + \frac{1}{3} (3t + \delta + \epsilon) \]  

(7)

\[ P_B^F = c_B + \frac{1}{3} (3t - \delta - \epsilon) \]  

(8)

\[ Q_A^F = \frac{1}{6t} (3t + \delta + \epsilon) \]  

(9)

\[ Q_B^F = \frac{1}{6t} (3t - \delta - \epsilon) \]  

(10)

\[ \pi_A^F = \frac{1}{18t} (3t + \delta + \epsilon)^2 - F_A \]  

(11)

\[ \pi_B^F = \frac{1}{18t} (3t - \delta - \epsilon)^2 \]  

(12)

If firm A accepts the licensing contract, it’s payoff will be \( \frac{1}{18t} (3t + \delta + \epsilon)^2 - F_A \). If firm A rejects then firm B gets the license and in this situation firm A’s payoff can be calculated as \( \frac{1}{18t} (3t + \delta - \epsilon)^2 \). Therefore, firm A will accept if \( \frac{1}{18t} (3t + \delta + \epsilon)^2 - F_A \geq \frac{1}{18t} (3t + \delta - \epsilon)^2 \).

Therefore, the outside innovator can optimally charge \( F_A^* = \frac{1}{18t} (3t + \delta + \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 = \frac{2\epsilon (3t + \delta)}{9t} = R^*_F \) which is the revenue of the outside innovator.

**Non-Drastic Case (ii) \( (3t - \delta < \epsilon < 3t + \delta) \):**

Under this scenario, if firm A accepts the contract, it becomes monopoly and its payoff becomes \( (\epsilon + \delta - t) - F_A \). Firm A’s no-acceptance payoff is \( \frac{1}{18t} (3t + \delta - \epsilon)^2 \) given firm B gets the license. Therefore, firm A will accept the license iff \( F_A \leq (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) and therefore \( R^*_F = (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) when \( 3t - \delta < \epsilon < 3t + \delta \).

**Drastic Case \( (\epsilon > 3t + \delta) \):**

Here if firm A accepts the contract, its monopoly profit will be \( \pi_A^F = (\epsilon + \delta - t) - F_A \). But if firm A rejects then firm B gets the license and becomes a monopoly. Therefore, firm A’s no-acceptance payoff goes to zero. Therefore, in this case firm A will accept the contract iff \( F_A \leq (\epsilon + \delta - t) \). Therefore, the revenue of the outside innovator will be \( R^*_F = (\epsilon + \delta - t) \).
It is also evident from the profit expressions of firm A and B that under both drastic and non-
drastic innovations the outside innovator is better-off licensing it to the efficient firm i.e. firm A. Later we will also see the above result is robust to all licensing schemes.

3.1.2. Fixed Fee Licensing to both Firms:

Now consider the case when the outside innovator is licensing its innovation to both firms A and B by charging a fixed fee. In this situation the relevant variables are given below:

\[ p_A = c_A - \epsilon + \frac{1}{3}(3t + \delta) \]  
(13)

\[ p_B = c_B - \epsilon + \frac{1}{3}(3t - \delta) \]  
(14)

\[ Q_A = \frac{1}{6t}(3t + \delta) \]  
(15)

\[ Q_B = \frac{1}{6t}(3t - \delta) \]  
(16)

\[ \pi_A = \frac{1}{18t}(3t + \delta)^2 - F_A \]  
(17)

\[ \pi_B = \frac{1}{18t}(3t - \delta)^2 - F_B \]  
(18)

Non-Drastic Case (i) (\( \epsilon < 3t - \delta \)):

If both firms accept the contracts, then firm A’s payoff is \( \frac{1}{18t}(3t + \delta)^2 - F_A \). If firm A rejects then given that firm B gets the contract, firm A’s no-acceptance payoff will be \( \frac{1}{18t}(3t + \delta - \epsilon)^2 \).

Therefore, the outside innovator can charge \( \frac{1}{18t}(3t + \delta)^2 - \frac{1}{18t}(3t + \delta - \epsilon)^2 > 0 \) from firm A.

Now take firm B. If both firms accept then firm B’s payoff is \( \frac{1}{18t}(3t - \delta)^2 - F_B \). If firm B rejects then given that firm A gets the license, firm B’s payoff will be \( \frac{1}{18t}(3t - \delta - \epsilon)^2 \).

Therefore, the innovator can optimally charge \( \frac{1}{18t}(3t - \delta)^2 - \frac{1}{18t}(3t - \delta - \epsilon)^2 > 0 \) from firm B. Adding these two one can get the outside innovators total revenue as \( \text{Rev}^*_{\text{FixedBoth}} = \frac{e^{6t-\epsilon}}{9t} > 0 \).
Non-Drastic Case (ii) \((3t - \delta < \epsilon < 3t + \delta)\):

Under this scenario, we know if firm A accepts and B does not then firm A becomes monopoly, however, the reverse is not true. Hence, the innovator can extract \(\frac{1}{18t}(3t + \delta)^2 - \frac{1}{18t}(3t + \delta - \epsilon)^2\) from firm A and \(\frac{1}{18t}(3t - \delta)^2\) from firm B. Therefore \(\text{Rev}_{\text{FixedBoth}}^* = \frac{1}{18t}(3t + \delta)^2 - \frac{1}{18t}(3t + \delta - \epsilon)^2 + \frac{1}{18t}(3t - \delta)^2\).

Drastic Case \((\epsilon > 3t + \delta)\):

Here, the outside innovator can optimally extract \(\frac{1}{18t}(3t + \delta)^2\) from firm A and \(\frac{1}{18t}(3t - \delta)^2\) from firm B (respective monopoly profits from each firm) and its optimum revenue will be \(\text{Rev}_{\text{FixedBoth}}^* = \frac{1}{18t}(3t + \delta)^2 + \frac{1}{18t}(3t - \delta)^2\).

Comparing the payoffs of the innovator for one and two firms licensing, we get that

**Proposition 1:** Under fixed fee licensing the innovator will always license its innovation to only one firm viz. the efficient firm.

The intuition of the above result can be given as follows: the efficient firm’s gain from the new technology vis-à-vis no acceptance is higher compared to the inefficient firm and therefore the outside innovator will optimally offer the license to the efficient firm. Also when the innovation is licensed to both the firms then costs of both the firms get reduced. So the gain of one firm vis-a-vis the other falls since both are reaping the benefit of the cost reducing technology now. This competition effect drives down gain of both the firms and thus the outside innovator will be able to extract less from both the firms since the monopoly profit of the efficient firm exceeds the sum of payoffs of both the competing firms. Therefore, in equilibrium we get that the innovator will be able to extract more when it licenses the innovation to only one firm and specifically the efficient firm.

3.2. Auction Policy:

3.2.1. Auction Policy - Only one license offered:

**Non-Drastic Case (i) \((\epsilon < 3t - \delta)\):**

Suppose the innovator wants to license its innovation to only one firm through an auction and the highest bidder will get it by paying his bid, i.e. a first price auction. If firm A wins the license its
payoff will be \( \frac{1}{18t} (3t + \delta + \epsilon)^2 \) and if firm A loses the license (and firm B wins it) its payoff will be \( \frac{1}{18t} (3t + \delta - \epsilon)^2 \). Therefore, firm A will be willing a bid a maximum amount up to \( \frac{1}{18t} (3t + \delta + \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 = \frac{2\epsilon(3t+\delta)}{9t} \). On the other hand, if firm B wins the auction it will receive \( \frac{1}{18t} (3t - \delta + \epsilon)^2 \) whereas if it loses the auction (and firm A wins) firm B’s payoff will be \( \frac{1}{18t} (3t - \delta - \epsilon)^2 \). Thus firm B will be willing to bid a maximum \( \frac{1}{18t} (3t - \delta + \epsilon)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 = \frac{2\epsilon(3t-\delta)}{9t} \). Note that the inefficient firm B’s bid is always less than efficient firm A’s bid. Thus under complete information, firm A can always ensure that it wins the auction by bidding slightly higher than the maximum possible bid of firm B, i.e. \( b^*_A = \frac{2\epsilon(3t-\delta)}{9t} + k \) where \( k > 0 \) and small. The outside innovator’s payoff will be \( \frac{2\epsilon(3t-\delta)}{9t} + k \).

**Non-Drastic Case (ii) \((3t - \delta < \epsilon < 3t + \delta)\):**

Firm A’s net gain from winning the auction is \( (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) whereas firm B’s net gain will be \( (\epsilon - \delta - t) \). One can easily show that \( (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 > (\epsilon - \delta - t) \) for \( \forall \epsilon \in [3t - \delta, 3t + \delta] \). Therefore, firm A will again win the auction by bidding \( b^*_A = (\epsilon - \delta - t) + k \).

**Drastic Case \((\epsilon > 3t + \delta)\):**

Firm A’s payoff from winning the auction is \( (\epsilon + \delta - t) \) whereas firm B’s payoff from winning is \( (\epsilon - \delta - t) \). The losing payoff for both the firms is zero. Firm A therefore, can again win the auction by bidding \( b^*_A = (\epsilon - \delta - t) + k \), \( k > 0 \) which will be innovator’s revenue in this situation as well.\(^{10}\)

Therefore, we can state our next result:

**Lemma 1:** *When only one license is auctioned then the efficient firm will always win the auction irrespective of whether be the size of the innovation i.e. drastic or non-drastic.*

**3.2.2: Auction Policy - Two licenses offered:**

\(^{10}\)Note that here this first price auction de facto plays out like a second price auction under complete information.
Suppose the innovator offers two licenses to both the firms subject to a minimum floor bid of the bidders (i.e. firms). Both the bidders pay their respective bids.

*Non-Drastic Case (i) ($\epsilon < 3t - \delta$):*

If firm A gets the license and both firms get the license its payoff will be $\frac{1}{18t} (3t - \delta)^2$ and if firm A doesn’t get the license (and firm B gets it) its payoff will be $\frac{1}{18t} (3t + \delta - \epsilon)^2$. Therefore, firm A will be willing a bid a maximum amount $\frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 = \frac{\epsilon (6t + 2\delta - \epsilon)}{18t}$.

On the other hand, if firm B gets the license and both get it, firm B’s payoff will be $\frac{1}{18t} (3t - \delta)^2$ whereas if it loses the auction (and firm A wins) firm B’s payoff will be $\frac{1}{18t} (3t - \delta - \epsilon)^2$. Thus firm B will be willing to bid a maximum of $\frac{1}{18t} (3t - \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 = \frac{\epsilon (6t - 2\delta - \epsilon)}{18t}$. The outside innovator will set a minimum bid equal to the inefficient firm’s maximum possible bid, in this case firm B’s maximum bid $\frac{\epsilon (6t - 2\delta - \epsilon)}{18t}$, to ensure that both firms can possibly get the license and also the total revenue is maximized. Firm A being the efficient firm will optimally bid the minimum required to get the license, i.e. $b_A^* = \frac{\epsilon (6t - 2\delta - \epsilon)}{18t}$ which is equal to firm B’s optimum bid which is $b_B^* = \frac{\epsilon (6t - 2\delta - \epsilon)}{9t}$. The outside innovator’s payoff will be $\frac{\epsilon (6t - 2\delta - \epsilon)}{9t}$ and we note that it is strictly lower than the case of a single license being offered (see section 3.2.1).

*Non-Drastic Case (ii) ($3t - \delta < \epsilon < 3t + \delta$):*

Here, one can show that the optimal bids by both the firms will be $\frac{1}{18t} (3t - \delta)^2$ and the revenue of the innovator will be $\frac{1}{9t} (3t - \delta)^2$. This is lower than $(\epsilon - \delta - t)$ which is the innovator’s payoff of licensing one auction (see section 3.2.1).

*Drastic Case ($\epsilon > 3t + \delta$):*

The optimal bids by both firms will be $\frac{1}{18t} (3t - \delta)^2$ and the revenue of the innovator will be $\frac{1}{9t} (3t - \delta)^2$ and this is again lower than $(\epsilon - \delta - t)$ (see section 3.2.1).

Therefore, we can state our next result:

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11 We assume that the innovator will set a minimum floor bid above which the firms have to bid to get the license.
**Proposition 2:** Under auction policy the outside innovator will always offer one license and the efficient firm will win the auction.

Comparing the payoffs of the innovator between fixed fee and auction licensing, we also find the following.

**Corollary 1:** Fixed fee licensing is always better than auction for the innovator.

### 3.3. Royalty licensing:

#### 3.3.1. Royalty licensing to one firm:

Again to fix ideas suppose the outside innovator licenses the innovation to firm A by charging a per unit royalty fee denoted by \( r \). Therefore, firm A has to pay \( rQ_A \) to the outside innovator. Given this, firm A’s profit function will be \( \pi_A = p_AQ_A - (c_A - \epsilon + r)Q_A \) and firm B’s profit function can be written as \( \pi_B = p_BQ_B - c_BQ_B \). The equilibrium prices, demands and profits can be given as:

\[
P^R_A = c_A - \epsilon + r + \frac{1}{3}(3t + \delta + \epsilon - r) \tag{19}
\]

\[
P^R_B = c_B + \frac{1}{3}(3t - \delta - \epsilon + r) \tag{20}
\]

\[
Q^R_A = \frac{1}{6t}(3t + \delta + \epsilon - r) \tag{21}
\]

\[
Q^R_B = \frac{1}{6t}(3t - \delta - \epsilon + r) \tag{22}
\]

\[
\pi^R_A = \frac{1}{18t}(3t + \delta + \epsilon - r)^2 \tag{23}
\]

\[
\pi^R_B = \frac{1}{18t}(3t - \delta - \epsilon + r)^2 \tag{24}
\]

The outside innovator will maximize \( rQ_A \) and the optimum royalty rate should have been \( r^* = \frac{3t+\delta+\epsilon}{2} > 0 \). But one can easily check that \( \frac{3t+\delta+\epsilon}{2} > \epsilon \ \forall \ \epsilon < (3t + \delta) \). Therefore, for all non-drastic innovations the optimum \( r \) will be set at \( r^* = \epsilon \) which is the upper bound of \( r \).\(^{12}\) The

\(^{12}\) We assume royalty rate at \( r^* \leq \epsilon \), so that the potential licensee has the incentive to accept the licensing contract.
optimum revenue of the innovator will be \( \text{Rev}_R = \frac{e}{6t} (3t + \delta) \). In this situation if firm A accepts the royalty licensing contract it’s payoff will be \( \pi_A^R = \frac{1}{18t} (3t + \delta)^2 \). But if firm A rejects the contract then firm B gets the contract, and firm A’s profit would have been \( \frac{1}{18t} (3t + \delta)^2 \). Therefore, firm A is weakly better-off accepting this contract.

Note that in case of royalty licensing the licensee firms effective marginal cost of production is \((c_A - \epsilon + r)\) and at \( r^* = \epsilon \) the effective marginal cost becomes \( c_A \). Therefore, we don’t need to distinguish between drastic and non-drastic innovation as the licensee firm will never become a monopoly post licensing. Therefore, whatever be the size of the innovation the payoff of firm a will be \( \pi_A^R = \frac{1}{18t} (3t + \delta)^2 \) even if it accepts or rejects the license and the previous analysis is relevant.\(^{13}\)

Therefore, we can state the following:

**Corollary 2:** The outside innovator will prefer fixed fee licensing over royalty licensing when only one license is offered and this holds for both drastic and non-drastic innovation.

### 3.3.2. Royalty Licensing to both Firms:

Consider the case where the outside innovator licenses the technology to both firms through per-unit royalty licensing. To start with suppose we assume asymmetric royalty rates for both firms i.e. \( r_A \) for firm A and \( r_B \) for firm B where \( r_A \neq r_B \). Also to fix ideas denote \( \Delta r = r_A - r_B > 0 \).

The optimal prices, quantities and profits can therefore be calculated as

\[
\begin{align*}
    p_A^{RBoth} &= c_A - \epsilon + r_A + \frac{1}{3} (3t + \delta - \Delta r) \\
    p_B^{RBoth} &= c_B - \epsilon + r_B + \frac{1}{3} (3t - \delta + \Delta r) \\
    Q_A^{RBoth} &= \frac{1}{6t} (3t + \delta - \Delta r) \\
    Q_B^{RBoth} &= \frac{1}{6t} (3t - \delta + \Delta r)
\end{align*}
\]

\(^{13}\) Note that if the innovator offers the royalty contract to the inefficient firm B, then its payoff is \( \text{Rev}_R = \frac{e}{6t} (3t - \delta) \), strictly a lower payoff than offering the contract to the efficient firm A.
\[ \pi_A^{RBoth} = \frac{1}{10t} (3t + \delta - \Delta r)^2 \]  

\[ \pi_B^{RBoth} = \frac{1}{10t} (3t - \delta + \Delta r)^2 \]

Note the incentives for firm A. When firm A accepts its payoff is given by (29) whereas when firm A rejects (but firm B accepts) it’s payoff will be \( \frac{1}{10t} (3t + \delta - \epsilon + r)^2 \). Given \( r \leq \epsilon \) firm A’s decision will depend on the relative values of \( \Delta r \) and \( \epsilon - r \). As we will see that the innovator is better off charging \( r \) as close to \( \epsilon \) as possible and therefore \( \epsilon - r \approx 0 \) (in fact at the optimum \( r = \epsilon \)) and thus given \( \Delta r > 0 \), firm A is better-off not accepting this asymmetric royalty contract. Again if we assume \( \Delta r = r_A - r_B < 0 \) we can see that firm B is better off not accepting the contract. Therefore, with asymmetric royalty rates any one firm will not accept the contract and we go back to the single firm case. Put differently, asymmetric royalty rates cannot exist together. So to make both the firms accept we need to assume symmetric royalty rates, without loss of generality. To fix ideas, we assume \( r_A = r_B \). Now given this, when both firms get the license, from (27) and (28) we get that the industry output is 1 and therefore the total revenue of the outside innovator is \( Rev_{royaltyBoth}^* = r \). Thus the outside innovator will optimally choose \( r = \epsilon \) and it’s revenue will be \( \epsilon \). Only we need to check whether both firm A and B accepts this contract under the alternative assumption. Under symmetric royalty if firm A accepts it’s profit will be \( \frac{1}{10t} (3t + \delta)^2 \) whereas if firm A rejects then assuming that firm B is accepting, firm A’s payoff will be \( \frac{1}{10t} (3t + \delta)^2 \). Again if firm B accepts and both accepts, it’s profit will be \( \frac{1}{10t} (3t - \delta)^2 \) whereas if firm B rejects then assuming that firm A is accepting, firm B’s profit will be \( \frac{1}{10t} (3t - \delta)^2 \). So both firms will accept this symmetric royalty contract (weakly better off). So \( r = \epsilon \) is indeed optimal for the outside innovator’s revenue will be \( Rev_{royaltyBoth}^* = \epsilon \).

Again we don’t need to distinguish between drastic and non-drastic innovation in this case and the preceding analysis is relevant for innovation of all sizes. Note that \( \epsilon > \frac{\epsilon}{6t} (3t + \delta) \) since \( \delta < 3t \) (by assumption) and therefore offering two licenses are optimal for the innovator.

Therefore, we can state our next proposition:
Proposition 3:
In case of royalty licensing the innovator will always license its innovation to both the firms irrespective of the size of innovation.

3.4. Two-part Tariff licensing:

3.4.1. Two-part Tariff licensing to any one firm:
Suppose the outside innovator is licensing the innovation to firm A by charging a two-part tariff i.e. a combination of fixed fee $F_A$ and a per unit royalty $r$. This situation is similar to the royalty licensing except that a fixed fee is charged in addition to the per-unit royalty. In this situation the equilibrium prices, demands and profits can be given as:

$$P_A^{TPT} = c_A - \epsilon + r + \frac{1}{3}(3t + \delta + \epsilon - r)$$  (31)

$$P_B^{TPT} = c_B + \frac{1}{3}(3t - \delta - \epsilon + r)$$  (32)

$$Q_A^{TPT} = \frac{1}{6t}(3t + \delta + \epsilon - r)$$  (33)

$$Q_B^{TPT} = \frac{1}{6t}(3t - \delta - \epsilon + r)$$  (34)

$$\pi_A^{TPT} = \frac{1}{18t}(3t + \delta + \epsilon - r)^2 - F_A$$  (35)

$$\pi_B^{TPT} = \frac{1}{18t}(3t - \delta - \epsilon + r)^2$$  (36)

The revenue for the outside innovator will be $Rev_{TPT} = rQ_A^{TPT} + F_A = \frac{r}{6t}(3t + \delta + \epsilon - r) + \frac{1}{18t}(3t + \delta + \epsilon - r)^2 - \frac{1}{18t}(3t + \delta - \epsilon + r)^2$ and the outside innovator will maximize this subject to $r$ and one can calculate the optimal two-part tariff royalty rate as $r^{TPT} = \epsilon$ which is similar to the royalty case Therefore the optimum $F_A$ will be set at $F_A^{TPT} = 0$. Therefore, we have the following result.

Lemma 2: The optimum two-part tariff contract is in fact the royalty licensing contract.

The outside innovator’s payoff will be exactly equal to the royalty licensing payoff, i.e. $\frac{\epsilon}{6t}(3t + \delta)$ when only one license is offered and the same analysis holds for innovation of all sizes drastic
3.4.2. Two-part tariff licensing to both firms:

We consider the case where the innovator licenses its innovation to both the firms using a uniform royalty and fixed fee, i.e. \(r_A = r_B = r\) and \(F_A = F_B\). The equilibrium variables in this case will be

\[
P_A^{TPTBoth} = c_A - \epsilon + r + \frac{1}{3}(3t + \delta) \quad (37)
\]

\[
P_B^{TPTBoth} = c_B - \epsilon + r + \frac{1}{3}(3t - \delta) \quad (38)
\]

\[
Q_A^{TPTBoth} = \frac{1}{6t}(3t + \delta) \quad (39)
\]

\[
Q_B^{TPTBoth} = \frac{1}{6t}(3t - \delta) \quad (40)
\]

\[
\pi_A^{TPTBoth} = \frac{1}{18t}(3t + \delta)^2 - F_A \quad (41)
\]

\[
\pi_B^{TPTBoth} = \frac{1}{18t}(3t - \delta)^2 - F_B \quad (42)
\]

We consider non-drastic innovation first. The outside innovator can optimally charge a royalty rate \(r\) and can extract \(F_A = \frac{1}{18t}(3t + \delta)^2 - \frac{1}{18t}(3t + \delta - \epsilon + r)^2\) from firm A and \(F_B = \frac{1}{18t}(3t - \delta)^2 - \frac{1}{18t}(3t - \delta - \epsilon + r)^2\) from firm B. The outside innovator’s payoff will therefore be \(r + \left[\frac{1}{18t}(3t + \delta)^2 - \frac{1}{18t}(3t + \delta - \epsilon + r)^2\right] + \left[\frac{1}{18t}(3t - \delta)^2 - \frac{1}{18t}(3t - \delta - \epsilon + r)^2\right]\). It is easy to verify that optimal \(r^* = \epsilon\). Both the firms accept the contract and \(F_A^* = 0\) and \(F_B^* = 0\).

The revenue of the innovator will be \(R_{TPTBoth}^* = \epsilon\). Therefore, we have the following result.

**Lemma 3:** When two licenses are offered, the optimal two-part tariff licensing is a pure royalty contract.

Note that \(\epsilon > \frac{\epsilon}{6t}(3t + \delta)\) since \(\delta < 3t\) (by assumption) and therefore when innovation is non-drastic the innovator will offer two licenses and again the same analysis holds for drastic innovations.
Therefore, we can state our next result.

**Proposition 4:**

In case of two-part tariff licensing

(a). The innovator will optimally offer two licenses for all kinds of innovations.

(b). The optimal two-part tariff licensing is in fact royalty licensing and this holds irrespective of whether one license or two licenses are offered and also for innovations of all sizes.

### 3.5. Optimal Licensing Policy

We know that fixed fee licensing to a single firm is better than offering two licenses and also all kinds of auctioning of licenses. Also we know that royalty licensing to two firms is the optimal two-part tariff licensing scheme. Therefore, to get the optimal licensing scheme we need to compare the payoff of the outside innovator from single firm fixed fee licensing and royalty licensing to both firms. When \( \epsilon < 3t - \delta \), \( \text{Rev}_{\text{royaltyBoth}}^* = \epsilon > \frac{2\epsilon(3t+\delta)}{9t} = R_F^* \) if \( \delta \leq \frac{3t}{2} \). If \( 3t - \delta < \epsilon < 3t + \delta \) then \( \delta \leq t \) is a sufficient condition for \( \text{Rev}_{\text{royaltyBoth}}^* = \epsilon > (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 = R_F^* \). When \( \epsilon > 3t + \delta \) then \( \text{Rev}_{\text{royaltyBoth}}^* = \epsilon > (\epsilon + \delta - t) = R_F^* \) if \( \delta \leq t \). Thus, we state the main result below.

**Proposition 5:**

(a). If the innovation is non-drastic and when \( \epsilon < 3t - \delta \) then royalty licensing to both firms is optimal if \( \delta \leq \frac{3t}{2} \). Otherwise fixed fee licensing to a single firm is optimal. The payoff to the innovator \( R^* = \epsilon \) if \( \delta \leq \frac{3t}{2} \), otherwise \( R^* = \frac{2\epsilon(3t+\delta)}{9t} \).

(b). If the innovation is non-drastic and if \( 3t - \delta < \epsilon < 3t + \delta \) then royalty licensing to both firms is optimal if \( \delta \leq t \). However, this is a sufficient condition but not necessary. The payoff to the innovator \( R^* = \epsilon \) if \( \delta \leq t \), otherwise \( R^* = (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \).

(c). If innovation is drastic (i.e. \( \epsilon > 3t + \delta \)) royalty licensing to both the firms is optimal if \( \delta \leq t \). Otherwise fixed fee licensing to only one firm is optimal. The payoff to the innovator is \( R^* = \epsilon \) if \( \delta \leq t \), otherwise \( R^* = \epsilon + \delta - t \).
Given that we have considered various licensing schemes we now examine what will happen if the innovator decides to sell the property rights of the innovation to any one of the firms.

4. Selling Game:

We consider the possibility where the innovator wants to sell the innovation to one of the firms by charging a fixed price (or fee). Note that selling can be done to only one firm in contrast to licensing where it can be done to both firms. If one firm rejects the selling contract, then it goes to the other firm. Again to fix ideas we assume that the innovator decides to sell the innovation to firm A. Now firm A is the owner of the innovation. Firm A now has the option of licensing the innovation to firm B. This issue in this structure has been analyzed in detail by Lu and Poddar (2014) and we invoke their result in our analysis here.

Result (Lu and Poddar (2014)): In Hotelling’s linear city model, the patentee’s optimal licensing strategy is to license its (drastic or non-drastic) innovation using two-part tariff no matter whether the patentee is ex-ante efficient of inefficient or equally efficient as the other firm.

In this structure when the innovation is non-drastic and $\epsilon < 3t - \delta$, in case of two-part tariff firm A’s optimal $r$ and $F$ are $r^{TPT} = \epsilon$ and $F^{TPT} = \frac{1}{18t} (3t - \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2$. Firm A’s total payoff in case of two-part tariff will be $\frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2$. This is the maximum that Firm A can get by licensing the technology to firm B. If firm A rejects, then firm B becomes the owner of the innovation. Then firm B will optimally offer the two-part tariff contract to firm A and in that case firm A can at most earn its no-licensing payoff of this licensing sub-game which firm B will optimally leave for firm A. So firm A’s non-acceptance payoff of this selling game is $\frac{1}{18t} (3t + \delta - \epsilon)^2$. Therefore, firm A’s maximum net gain from purchasing the innovation from the outside innovator is $\frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2$. The outside innovator can potentially extract this amount and still get firm A to accept the purchase. That is the innovator can potentially charge $F_{Sell} = \epsilon + \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2$.

14 In Lu and Poddar (2014), $\delta$ is defined as $c_A - c_B$ hence the difference in the corresponding expressions.
\[ \frac{1}{18t} (3t + \delta - \epsilon)^2. \] This will be the innovator’s maximum revenue while selling the innovation. Previously, we have shown the innovator’s maximum possible profit from licensing its innovation is \( \epsilon \) if \( \delta \leq \frac{3t}{2} \) and \( R^* = \frac{2\epsilon(3t+\delta)}{9t} \) otherwise. Calculations show that \( F^{Sell} \) exceeds both \( \epsilon \) and \( \frac{2\epsilon(3t+\delta)}{9t} \) and this holds for all values of \( \delta \). Therefore, when innovation is non-drastic and \( \epsilon < 3t - \delta \), it is optimum for the innovator to sell the innovation.

When the innovation is non-drastic and \( 3t - \delta < \epsilon < 3t + \delta \), the maximum payoff that firm A can get from licensing is \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \). The no acceptance payoff of firm A in this situation is \( \frac{1}{18t} (3t + \delta - \epsilon)^2 \) since firm A will not go out of the market if it refuses and firm B gets the license. Therefore, the outside innovator can possibly extract a maximum of \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) from firm A. Note again that this exceeds both \( \epsilon \) and \( (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) (the profits under licensing) since \( \epsilon + \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 \geq (\epsilon + \delta - t) \) for \( 0 \leq \delta \leq 3t \). Thus selling is optimal for the innovator even if \( 3t - \delta < \epsilon < 3t + \delta \).

Finally, when the innovation is drastic and \( \epsilon > 3t + \delta \), the patentee’s optimal licensing contract is \( r^{TPT} = \epsilon \) and \( F^{TPT} = \frac{1}{18t} (3t + \delta)^2 \). Since firm A will extract the entire surplus from firm B, \( \pi^A_{TPT} = \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \). If firm A refuses to purchase the innovation, then firm B gets it. Since the innovation is drastic firm A’s no-acceptance payoff goes to zero in this case and therefore the outside innovator can possibly extract the entire amount \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \) from firm A. Therefore, the outside innovator can sell the innovation and get maximum revenue \( F^{Sell} = \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \). Now one can easily show that this exceeds both \( (\epsilon + \delta - t) \) and \( \epsilon \) (the profits under licensing) and therefore selling is also optimal when innovation is drastic and this holds irrespective of the value of \( \delta \).

Thus, we show that the outside innovator is unambiguously better off selling the innovation to any one firm than licensing to one or both the firms. We also note that the selling payoffs of the innovator do not depend on whether the innovator sells it to the efficient or the inefficient firm.
The intuition is even if the inefficient firm gets the new technology it can further license it to the efficient firm and can potentially extract all the benefit from the efficient firm which in turn can be potentially extracted by the outside innovator. Therefore, the innovator will be indifferent between selling the innovation to the efficient firm or the inefficient firm and in both situations it gets the same payoff.

Therefore, we can state the main result of our paper:

**Proposition 6:**

*It is optimum for the innovator to sell the license to any one firm and this holds irrespective of whether the innovation is drastic or non-drastic.*

The optimality of the selling comes from the fact that in case of selling the purchasing firm has the right to subsequently license it to the other firm and extract more from the other firm. This in turn can be extracted by the outside innovator and the resultant payoff will be higher. Whereas in case of licensing the licensee doesn’t have the right to license the technology to the other firm (or take any further action with the technology) and therefore the innovator can extract less if it licenses the technology. This makes selling unambiguously preferred over licensing for the outside innovator.

**5. Welfare analysis:**

From the above analysis now it is clear that selling is privately optimal to the outside innovator. Now is this outcome socially optimal as well? This is important if we want to make some policy recommendations regarding the optimum organization of technology transfer from a normative point of view. Thus in this section we will make the welfare comparisons when the innovator goes for outright selling vis-à-vis licensing of the innovation. We consider the case of licensing of the innovation first:

**Welfare under Optimal Licensing:**

(i). *Royalty:*
While analyzing the licensing of the innovation first we point out that when $\epsilon < 3t - \delta$ and $\delta \leq \frac{3t}{2}$ holds and also when $\epsilon > 3t + \delta$ and $\delta \leq t$ holds then royalty licensing to both firms with $r^A = r^B = \epsilon$ is optimal. Given this one can easily check that from equations 25-30 that the post innovation prices and the profits of both the firms are same as that of the no-licensing case. Therefore, under royalty licensing the consumer surplus and the producer surplus remain the same as that of the no-licensing scenario. The entire gain or surplus is appropriated by the outside innovator and who receives a payoff of $\epsilon$. Therefore, the increase in social welfare is $\epsilon$.

Also, when $3t - \delta < \epsilon < 3t + \delta$ and $\delta \leq t$ then again royalty licensing is optimal and the social welfare gain is $\epsilon$.

(ii). Fixed Fee:

But if $\epsilon < 3t - \delta$ and $\delta > \frac{3t}{2}$ holds then fixed fee to the efficient firm is optimal and we need to calculate the increase in producers surplus and the consumers surplus in this situation. In case of fixed fee licensing, firm A gets $\frac{1}{18t}(3t + \delta - \epsilon)^2$ after paying the licensing fee, firm B gets $\frac{1}{18t}(3t - \delta - \epsilon)^2$ and the outside innovator extracts $\frac{1}{18t}(3t + \delta + \epsilon)^2 - \frac{1}{18t}(3t + \delta - \epsilon)^2$.

Adding all these the total producers’ and innovator’s surplus can be written as $\frac{1}{18t}(3t + \delta)^2 + \frac{1}{18t}(3t - \delta)^2 + \frac{2\epsilon^2 + 4\delta \epsilon}{18t}$ and therefore the increment in surplus is $\frac{2\epsilon^2 + 4\delta \epsilon}{18t}$. To calculate the increment in consumer surplus we need to segment the entire market into three parts, i.e. $[0, \frac{1}{2}, \frac{\delta}{6\epsilon}], [\frac{1}{2}, \frac{\delta}{6\epsilon}, \frac{1}{2} + \frac{\delta}{6\epsilon}], [\frac{1}{2} + \frac{\delta}{6\epsilon}, \frac{\delta}{6\epsilon} + \frac{\epsilon}{6\epsilon}, 1]$. The first segment pre-licensing purchased from firm A and after licensing is still purchasing from firm A. The second segment pre-licensing purchased from firm B but post licensing purchases from firm A. The final segment pre-licensing purchased from firm B and after licensing is still purchasing from firm B. One can also calculate the change in prices post licensing where the price of firm A falls by $\frac{2\epsilon}{3}$ and the price of firm B falls by $\frac{2\epsilon}{3}$. Also we need to calculate the difference in post licensing price of A and pre-licensing price of B and the post licensing price of A is smaller by $\frac{(2\epsilon + \delta)}{3}$. Therefore, consumers in all the segments gain and since we assumed that the consumers are uniformly distributed and purchase only one unit of the good the total change in consumer surplus can be calculated by multiplying the price changes and the length of the intervals and after calculating
the total increase in consumer surplus is found as \( \frac{\epsilon(3t + 2\delta + \epsilon)}{6t} \). Therefore, the total increase in welfare compared to no-licensing is found by adding the increase in consumer surplus and the producers and innovator’s surplus which we get as \( \frac{\epsilon(3t + 2\delta + \epsilon)}{6t} \).

When \( \epsilon \geq 3t - \delta \) and \( \delta > t \), the outside innovator goes for fixed fee licensing to firm A and we calculate the change in total welfare similarly. In this situation post licensing firm A becomes the monopolist and charge \( P_A^F = c_B - t \). Firm A gets a net payoff of \( \frac{1}{18t} (3t + \delta - \epsilon)^2 \) and the innovator extracts \( (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) from firm A. Firm B gets zero. So total post innovative producers and innovator’s surplus will be \( (\epsilon + \delta - t) - \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t + \delta)^2 \). To calculate the increase in consumers’ surplus we note that post licensing all consumer’s purchase from firm A and therefore \( [0, \frac{1}{2} + \frac{\delta}{6t}] \) will continue to purchase from firm A whereas \( [\frac{1}{2} + \frac{\delta}{6t}, 1] \) will now purchase from firm A. Price of good A falls by \( \frac{2(3t - \delta)}{3} \) (magnitude) with respect to its pre-licensing price and it falls by \( \frac{(6t - \delta)}{3} \) (magnitude) compared to the pre-licensing price of firm B. Therefore, the increase in consumer surplus will be \( \frac{\delta(3t - \delta)}{6t} \). Thus the total increase in welfare will be \( (\epsilon + \delta - t) - \frac{1}{18t} (3t - \delta)^2 - \frac{1}{18t} (3t + \delta)^2 + \frac{\delta(3t - \delta)}{6t} \). This also holds for the case where \( 3t - \delta \leq \epsilon \leq 3t + \delta \) and fixed fee licensing is optimal for the innovator.

Now we look at the welfare increment when the innovator goes for selling of the patent right.

**Welfare under Selling:**

In case of selling we know following Lu and Poddar (2014) that the patentee firm (in our case firm A) post purchase goes for two-part tariff licensing agreement with firm B and the optimal two-part tariff contract that firm A offers in our structure will be are \( r^{TPT} = \epsilon \) and \( t^{TPT} = \frac{1}{18t} (3t - \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 \) when \( \epsilon < 3t - \delta \). Again the optimal price that both firm A and B charges will be \( p_A = c_A + \frac{1}{3} (3t + \delta) \) and \( p_B = c_B + \frac{1}{3} (3t - \delta) \) which is exactly equal to the pre-innovation prices. Therefore, the consumers do not gain and the consumer surplus remains exactly the same as in the pre-innovation/no-selling scenario. The optimal profit of the
firms will also be exactly equal to the pre-innovation level and the outside innovator will extract the entire additional surplus accruing from the innovation. Therefore, the total increase in social welfare will be exactly equal to the fixed fee that the innovator charges while selling the innovation, i.e. \( \epsilon + \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 \).

Again when \( \epsilon > 3t - \delta \), by similar argument the increment will social surplus will be \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \) while both the consumers surplus and the producers remain at the pre-innovation/no-innovation level.

**Welfare Comparison - Selling vs. Licensing:**

We can now compare the changes in welfare in both the situations.

When \( \epsilon < 3t - \delta \) and \( \delta \leq \frac{3t}{2} \) holds then certainly \( \epsilon + \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) exceeds \( \epsilon \) and therefore selling is also socially optimal.

When \( \epsilon > 3t + \delta \) and \( \delta \leq t \) then definitely \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \) exceeds \( \epsilon \) and therefore again selling welfare dominates licensing. Similarly, when \( 3t - \delta \leq \epsilon \leq 3t + \delta \) and \( \delta \leq t \) then also \( \frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \) exceeds \( \epsilon \) and therefore selling leads to greater increased welfare compared to licensing.

When \( \epsilon < 3t - \delta \) and \( \frac{3t}{2} \), then the increment in welfare from licensing is \( \frac{\epsilon (3t + 2\delta + \epsilon)}{6t} \) which is a sum of the increased consumer surplus \( \frac{\epsilon (9t + 2\delta + \epsilon)}{18t} \) and the increase in producer’s surplus \( \frac{2\epsilon^2 + 4\delta \epsilon}{18t} \).

One can check that \( \epsilon > \frac{\epsilon (9t + 2\delta + \epsilon)}{18t} \) and \( \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 \). Therefore, the total welfare under selling \( \epsilon + \frac{1}{18t} (3t - \delta)^2 + \frac{1}{18t} (3t + \delta)^2 - \frac{1}{18t} (3t - \delta - \epsilon)^2 - \frac{1}{18t} (3t + \delta - \epsilon)^2 \) exceeds the total welfare under fixed fee licensing \( \frac{\epsilon (3t + 2\delta + \epsilon)}{6t} \) and thus we get that selling is welfare-optimal for all \( \epsilon < 3t - \delta \).
Finally, for the remaining two cases, i.e. $\epsilon > 3t + \delta$ and $\delta > t$ holds and also the case where fixed fee licensing is optimal when $3t - \delta \leq \epsilon \leq 3t + \delta$ the increment in total welfare is $(\epsilon + \delta - t) - \frac{1}{18t} (3t - \delta)^2 - \frac{1}{18t} (3t + \delta)^2 + \frac{6\delta(t - \delta)}{6t}$ which is again can be shown to be less than the increment in welfare under selling i.e. $\frac{1}{18t} (3t - \delta)^2 + \epsilon + \frac{1}{18t} (3t + \delta)^2 \forall \delta > t$ and $\epsilon > 3t + \delta$. Thus, taking all the above results into account we conclude the following.

**Proposition 7:**

*Outright sell of innovation leads to greater increase in welfare vis-à-vis licensing of innovation.*

The above result has an interesting policy implication that selling innovation is not only privately optimal, it is also socially optimal. Hence the optimal policy instrument is to encourage the sell of patent rights than licensing of patents whenever possible.

6. **Conclusion:**

There is a volume of theoretical work on patent licensing studying about the optimal licensing policies from the innovator to the potential licensee(s) under various possible scenarios. Due to that and along with the empirical studies, we now fairly understand how the patent licensing works optimally in any given scenario for the innovator. However, the option to sell the property right of the innovation to one of the competing firms (who can further license if it wishes to do that) is an area very much under-researched till date. Given that, in this paper, we examine the incentive of an outside innovator to sell an innovation to prospective incumbents and compare that with different available licensing schemes. Specifically, in this analysis we assume that there is a non-producing outside innovator (research lab) who has a new cost reducing technology and there are two incumbent firms (the potential licensees) in the product market. The firms are asymmetric in terms of cost of production. The analytical framework we use is the Hotelling’s linear city framework. The innovator can choose to license its innovation to a single firm or both the firms or can opt for outright selling of its innovation to any one of the firms. Our main finding is the innovator will always sell the innovation to one of the competing firms rather than licensing it to either one or two firms. The result is fairly robust as it true for any drastic and non-drastic innovation as well as any pre-innovation cost asymmetries between
the competing firms. The study also extends and complements Tauman and Wang’s (2012) findings done in a Cournot framework to the case of spatial competition.

In the process of coming to the main conclusion, we also characterize the equilibrium licensing outcomes under all forms of licensing mechanisms. We show when licensing is the only option available to the innovator, it would always license the technology to both the firms using pure royalty contracts when the initial cost differentials between the firms are relatively small, otherwise it will opt for fixed fee licensing to the efficient firm only.

The highlight of the paper is to show the importance of selling the property right of innovation to any one of the competing firms in the industry. Our main finding not only shows the clear dominance of selling over different types of licensing contracts but also points to the case that in all the previous studies of patent licensing where optimal licensing policies are derived, all will possibly become suboptimal when we provide the selling option to the outside innovator. This is certainly true in a spatial competition as we see here, and we believe is most likely to be true in various other scenarios. This is our conjecture. In our future research, we would like substantiate the claim by analyzing the problem in a general competitive environment (i.e. outside the spatial framework). This would not only provide the innovator a stronger incentive to innovate when it sells since it maximizes the private value of the innovation but from the society’s point of view it is welfare improving as well compared to any licensing scheme. Thus we get a Pareto improvement. A strong enough reason for the policy makers to create a policy environment where selling the right of innovation is generally encouraged across industries.
References:


