# Fee versus royalty licensing in a Cournot duopoly model

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# Abstract

- This paper finds that royalty licensing can be superior to fixed-fee licensing for the patent-holding firm when the cost-reducing innovation is non-drastic.
- The reason for this result is that the patent-holding firm enjoys a cost advantage over the licensee under royalty licensing while the two firms compete on equal footing under fixed-fee licensing.

# Introduction

- The theoretical literature has overwhelmingly found that licensing by means of a fixed fee is superior to licensing by means of a royalty for both the patent holder and consumers
- The model that has been mostly studied in the literature is the licensing of a cost-reducing innovation to existing firms with inferior production technologies by a patent holder which is itself a non-producer.

- The key difference between the present model and models in the existing literature is that here the patent holder is also a producer in the industry
- An outside patent holder is only interested in the total licensing revenue while a patent-holding firm is interested in its total income
- The present paper studies and compares licensing by means of a fixed fee and licensing by means of a royalty in a homogeneous-good Cournot duopoly where one of the firms has a cost-reducing innovation.

- In contrast to the finding in the literature that fixed-fee licensing is generally better than royalty licensing for the patent holder, it is found here that licensing by means of a royalty is superior to licensing by means of a fixed fee from the viewpoint of the patent-holding firm when the innovation is non-drastic.
- For drastic innovation, the patent-holding firm becomes a monopoly and licensing does not occur. It is found that licensing by means of a fixed fee is at least as good as licensing by means of a royalty for consumers.

# Model

- Cournot duopoly producing an homogeneous product.
- The (inverse) market demand function is given by $p=a-Q$
- With the old technology, both firms produce at constant unit production cost $c$ ($0<c<a$).
- The cost-reducing innovation by firm 1 creates a new technology that lowers its unit cost by the amount of $\varepsilon$

- Stage 1, the patent-holding duopolist acts as a Stackelberg leader in setting a fixed licensing fee or a royalty rate.
- Stage 2, the other firm (the would-be licensee) acts as a Stackelberg follower in deciding whether to accept the offer from the patent holder.
- Stage 3, the two firms engage in a noncooperative competition in quantities.

# Benchmark Model

$$\Pi_1 = (a - q_1 - q_2 - c_1)q_1$$
$$\Pi_2 = (a - q_1 - q_2 - c_2)q_2$$

[FOC] $q_1 = (a - c_1 - q_2)/2.$

$$q_2 = (a - c_2 - q_1)/2$$

$$q_1^* = \frac{a - 2c_1 + c_2}{3} \text{ and } q_2^* = \frac{a - 2c_2 + c_1}{3}$$

$$\Pi_1^* = \frac{(a - 2c_1 + c_2)^2}{9} \text{ and } \Pi_2^* = \frac{(a - 2c_2 + c_1)^2}{9}$$

# *No licensing*

*Non-drastic innovation* ($\varepsilon < a - c$)

$$q_1^{\mathrm{NL}} = \frac{a - c + 2\varepsilon}{3} \text{ and } q_2^{\mathrm{NL}} = \frac{a - c - \varepsilon}{3},$$

$$\Pi_1^{\mathrm{NL}} = \frac{(a - c + 2\varepsilon)^2}{9} \text{ and } \Pi_2^{\mathrm{NL}} = \frac{(a - c - \varepsilon)^2}{9}$$

*Drastic innovation* ($\varepsilon \geq a - c$)

$$q_1^{\mathrm{NL}} = \frac{a - c + \varepsilon}{2} \text{ and } q_2^{\mathrm{NL}} = 0,$$

$$\Pi_1^{\mathrm{NL}} = \frac{(a - c + \varepsilon)^2}{4} \text{ and } \Pi_2^{\mathrm{NL}} = 0.$$

## *Licensing by a fixed fee*

The maximum license fee firm 1 can charge firm 2 is what will make firm 2 indifferent between licensing and not licensing the new technology. In the case that licensing occurs, both firms will produce at constant unit cost $c$-$\varepsilon$.

$$q_1^{\mathrm{F}} = q_2^{\mathrm{F}} = \frac{a - c + \varepsilon}{3},$$

$$\Pi_1^{\mathrm{F}} = \Pi_2^{\mathrm{F}} = \frac{(a - c + \varepsilon)^2}{9}.$$

*Non-drastic innovation* ($\varepsilon$ < *a*- *c*)

$$F = \Pi_2^{\mathrm{F}} - \Pi_2^{\mathrm{NL}} = \frac{(a-c+\varepsilon)^2}{9} - \frac{(a-c-\varepsilon)^2}{9} = \frac{4(a-c)\varepsilon}{9}.$$

$$\Pi_1^{\mathrm{F}} + F = \frac{(a-c+\varepsilon)^2}{9} + \frac{4(a-c)\varepsilon}{9}.$$

$\Pi_1^{\mathrm{F}} + F > \Pi_1^{\mathrm{NL}}$ if and only if $\varepsilon < 2(a-c)/3$

Hence, under fixed-fee licensing, firm 1 will license its innovation if $\varepsilon < 2(a-c)/3$ and it will not if $2(a-c)/3 \leq \varepsilon < a-c$

*Drastic innovation* ($\varepsilon \geq a - c$)

$$F = \Pi_2^{\mathrm{F}} - \Pi_2^{\mathrm{NL}} = (a - c + \varepsilon)^2/9$$

$$\Pi_1^{\mathrm{F}} + F < \Pi_1^{\mathrm{NL}}$$

Hence, under the fixed-fee licensing method firm 1 will not license its new technology and will become a monopoly when the innovation is drastic.

**Proposition 1**. *Under fixed-fee licensing*, *firm* 1 *will license its innovation to firm* 2 *if and only if* $\varepsilon < 2(a\text{-}c)/3$. *In particular*, *firm* 1 *will become a monopoly when the innovation is drastic*.

# *Licensing by a royalty*

Note that the maximum royalty rate firm 1 can charge obviously cannot exceed $\varepsilon$ (i.e., $0 \le r \le \varepsilon$).

$c_1 = c - \varepsilon$ and $c_2 = c - \varepsilon + r$

$$q_1^{\mathrm{R}} = \frac{a - c + \varepsilon + r}{3} \text{ and } q_2^{\mathrm{R}} = \frac{a - c + \varepsilon - 2r}{3}$$

$$\Pi_1^{\mathrm{R}} = \frac{(a - c + \varepsilon + r)^2}{9} \text{ and } \Pi_2^{\mathrm{R}} = \frac{(a - c + \varepsilon - 2r)^2}{9}$$

$$\Pi_1^{\mathrm{R}} + rq_2^{\mathrm{R}} = \frac{(a-c+\varepsilon+r)^2}{9} + \frac{r(a-c+\varepsilon-2r)}{3}$$

Choosing $r$ to maximize firm 1's total income, we obtain that if the innovation is non-drastic (i.e., $\varepsilon < a - c$) then the optimal $r = \varepsilon$ and if the innovation is drastic (i.e., $\varepsilon \geq a - c$) then the optimal $r = (a - c + \varepsilon) / 2$

*Non-drastic innovation* ($\varepsilon < a - c$)

substituting $r = \varepsilon$

$$q_1^{\mathrm{R}} = \frac{a - c + 2\varepsilon}{3} \text{ and } q_2^{\mathrm{R}} = \frac{a - c - \varepsilon}{3}$$

$$\Pi_1^{\mathrm{R}} = \frac{(a - c + 2\varepsilon)^2}{9} \text{ and } \Pi_2^{\mathrm{R}} = \frac{(a - c - \varepsilon)^2}{9}$$

$$\Pi_1^{\mathrm{R}} + rq_2^{\mathrm{R}} = \frac{(a - c + 2\varepsilon)^2}{9} + \frac{\varepsilon(a - c - \varepsilon)}{3}$$

$$\therefore \Pi_1^R + rq_2^R \geq \Pi_1^{NL}$$

*Drastic innovation* ($\varepsilon \geq a - c$)

substituting $r = (a - c + \varepsilon) / 2$ yields the monopoly outcome

Hence, licensing by a royalty is the same as not licensing

**Proposition 2**. *Under royalty licensing*, *firm* 1 *will license its innovation to firm* 2 *if the innovation is non-drastic*. *In the case of a drastic innovation*, *firm* 1 *will become a monopoly*.

# *Comparison: fee versus royalty licensing*

Case (1): $\varepsilon < 2(a\text{-}c)/3$

$$(\Pi_1^{\mathrm{F}} + F) - (\Pi_1^{\mathrm{R}} + rq_2^{\mathrm{R}}) = \left[\frac{(a-c+\varepsilon)^2}{9} + \frac{4(a-c)\varepsilon}{9}\right] - \left[\frac{(a-c+2\varepsilon)^2}{9} + \frac{\varepsilon(a-c-\varepsilon)}{3}\right]$$

$$= -\frac{(a-c)\varepsilon}{9} < 0.$$

Hence, for firm 1, licensing by means of a royalty is superior to licensing by means of a fee in this case

we have $q_1^{\mathrm{F}} + q_2^{\mathrm{F}} > q_1^{\mathrm{R}} + q_2^{\mathrm{R}}$

This implies that licensing by means of a fee is better than licensing by means of a royalty for consumers.

Case (2): $2(a\text{-}c)/3 \leq \varepsilon < a\text{-}c$

Firm 1 licenses its innovation under royalty licensing but does not license under fee licensing.

Hence, licensing by means of a royalty must be superior to licensing by means of a fee for firm 1

we have $q_1^{\mathrm{NL}} + q_2^{\mathrm{NL}} = q_1^{\mathrm{R}} + q_2^{\mathrm{R}}$

Hence, licensing by means of a fee is the same as licensing by means of a royalty for consumers

Case (3): $\varepsilon \geq a - c$

Firm 1 becomes a monopoly and licensing will not occur under either licensing method.

Hence, the two licensing methods yield the same outcome for both firms and consumers.

**Proposition 3**. *With either a non-drastic or a drastic innovation*, *licensing by means of a royalty is at least as good as licensing by means of a fee for the patent-holding firm* ( *firm* 1), *and licensing by means of a fee is at least as good as licensing by means of a royalty for consumers*.

- This proposition is in contrast to the result in the literature which purports that licensing by means of a fixed fee is at least as good as licensing by means of a royalty for both the non-producing patent holder and consumers

- The reason that licensing by a royalty can be better than licensing by a fee for the patent-holding firm is the following. The patent holder enjoys a cost advantage under royalty licensing while the two firms compete on equal footing (equal unit variable cost) under fee licensing.

# Extensions

1. an arbitrary number of firms in the industry
2. with a general industry demand function.

The basic result from the previous section that royalty licensing may be superior to fee licensing for the patent-holding firm continues to hold in these two extensions.

# Conclusion

- The innovation of this paper is to treat the patent holder as also a producer in the product market, as opposed to as an independent research unit in the existing literature.
- In contrast to the findings in the literature, this paper has found that licensing by means of a royalty may be superior to licensing by means of a fixed fee from the viewpoint of the patent-holding firm.

- This conclusion is found to hold when there is an arbitrary number of firms in the industry or when a general demand function is considered