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] \quad q_1 = \frac{(a - c_1 - q_2)}{2}, \quad q_2 = \frac{(a - c_2 - q_1)}{2}

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

\[ \Pi_1^* = \frac{(a - 2c_1 + c_2)^2}{9} \quad \text{and} \quad \Pi_2^* = \frac{(a - 2c_2 + c_1)^2}{9} \]
No licensing

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

\[
q_{1}^{NL} = \frac{a-c+2\varepsilon}{3} \quad \text{and} \quad q_{2}^{NL} = \frac{a-c-\varepsilon}{3},
\]

\[
II_{1}^{NL} = \frac{(a-c+2\varepsilon)^2}{9} \quad \text{and} \quad II_{2}^{NL} = \frac{(a-c-\varepsilon)^2}{9}
\]

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

\[
q_{1}^{NL} = \frac{a-c+\varepsilon}{2} \quad \text{and} \quad q_{2}^{NL} = 0,
\]

\[
II_{1}^{NL} = \frac{(a-c+\varepsilon)^2}{4} \quad \text{and} \quad II_{2}^{NL} = 0.
\]
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 $c - \varepsilon$.

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

\[ \Pi_1^F = \Pi_2^F = \frac{(a - c + \varepsilon)^2}{9}. \]
Non-drastic innovation ($\varepsilon < a - c$)

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

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

$\Pi_1^F + F > \Pi_1^{NL}$ 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** \((\varepsilon \geq a - c)\)

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

\[
\Pi_1^F + F < \Pi_1^{NL}
\]

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 $\varepsilon < \frac{2(a-c)}{3}$. 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., $0 \leq r \leq \varepsilon$).

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

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

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

$$\Pi_1^R + r q_2^R = \frac{(a - c + \varepsilon + r)^2}{9} + \frac{r(a - c + \varepsilon - 2r)}{3}$$
Non-drastic innovation \((\varepsilon < a - c)\)

substituting \(r = \varepsilon\)

\[
q_1^R = \frac{a - c + 2\varepsilon}{3} \quad \text{and} \quad q_2^R = \frac{a - c - \varepsilon}{3}
\]

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

\[
\Pi_1^R + r q_2^R = \frac{(a - c + 2\varepsilon)^2}{9} + \frac{\varepsilon(a - c - \varepsilon)}{3}
\]

\[
\therefore \quad \Pi_1^R + r q_2^R \geq \Pi_1^{NL}
\]
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-dramatic. In the case of a drastic innovation, firm 1 will become a monopoly.
Comparison: fee versus royalty licensing

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

\[
(II_1^F + F) - (II_1^R + rq_2^R) = \left[ \frac{(a-c + \varepsilon)^2}{9} + \frac{4(a-c)\varepsilon}{9} \right] - \left[ \frac{(a-c + 2\varepsilon)^2}{9} + \frac{\varepsilon(a-c-\varepsilon)}{3} \right] = -\frac{(a-c)\varepsilon}{9} < 0.
\]

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

We have $q_1^F + q_2^F > q_1^R + q_2^R$.

This implies that licensing by means of a fee is better than licensing by means of a royalty for consumers.
Case (2): \(2(a-c)/3 \leq \varepsilon < a-c\)

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 \(q_1^{NL} + q_2^{NL} = q_1^R + q_2^R\)

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.