Economics Letters 170 (2018) 71–75

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

Per unit vs. ad valorem royalty licensing☆

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HIGHLIGHTS

- We compare per unit vs. ad valorem royalty licensing by an incumbent innovator.
- Assuming antitrust authorities apply the same principle to review both contracts.
- Relaxing standard assumption about demand and cost profiles.
- We provide testable conditions that explain when either scheme should be observed.
- Per unit licensing is more profitable if and only if the licensor is more efficient.

ARTICLE INFO

Article history:
Received 16 March 2018
Received in revised form 29 May 2018
Accepted 1 June 2018
Available online 5 June 2018

MSC:
D21
L13
L24
L41

Keywords:
Innovation
Patent licensing
Royalty contracts
R&D
Optimal contracts

ABSTRACT

We consider licensing of non-drastic innovations by a patent holder who interacts with a potential licensee in a downstream market. We compare two kinds of license contracts: per unit and ad valorem royalties, combined with fixed fees. Assuming that antitrust authorities apply the same principle to review ad valorem licensing which they apply to per unit licensing, we show that per unit licensing is more profitable if the licensor is more efficient in using the innovation, whereas ad valorem licensing is more profitable if the licensee is more efficient. This explains why and when these licensing schemes should be observed.

1. Introduction

Patent licensing of cost reducing innovations typically involves contingent royalties combined with fixed fees. Royalties are predominantly linear in the licensees' output, revenue, or profit. These are generally referred to as per unit, ad valorem, and profit-share royalty licensing. All these schemes serve the purpose to alleviate the downward pressure on price induced by the reduction in licensees' cost that is associated with the transfer of superior technology.

Royalties may, of course, be misused to achieve collusive outcomes. In the extreme, they can be used to implement a monopoly outcome, either making the licensee or the licensor a monopoly, whichever allows the highest extraction of surplus. This is why antitrust authorities interfere if they suspect schemes that are geared to raise the equilibrium price. The literature on per unit royalty licensing has captured this interference by requiring that royalty rates cannot exceed the cost reduction induced by the transfer of technology.

The theoretical literature has almost exclusively focused on per unit royalties, in particular in the case when the patent holder is an incumbent firm that competes with potential licensees. The analysis of patent licensing by an incumbent firm was pioneered by Katz and Shapiro (1985). Later, Wang (1998) shows that there

☆ Research support by Korea University (Grant: K1710011) and the National Natural Science Foundation of China (Grant: 71371116) is gratefully acknowledged. We thank the referee for useful comments and suggestions.

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https://doi.org/10.1016/j.econlet.2018.06.002
0165-1765/

is a sharp distinction between the licensing of a non-drastic innovation by an *outside* innovator, who is not a player in the potential licensee's market game, and an incumbent patent holder who is a competitor in the product market of potential licensees. Whereas outside innovators are advised to auction patent licenses to a limited number of licensees (see Kamien et al., 1992; Kamien, 1992; Sen and Tauman, 2007),[1] inside patent holders are advised to employ per unit royalty contracts without fixed fees.[2]

However, the empirical literature indicates that ad valorem royalties are equally if not more widely used. In a sample of 286 French license contracts, Bousquet et al. (1998) report that 78% included royalties among which all but 9 used ad valorem royalties. This suggests that the theoretical literature should pay due attention to different royalty schemes and identify testable conditions that explain when either per unit or ad valorem royalties should be observed.

The analysis of ad valorem royalties by an inside patent holder was initiated by San Martín and Saracho (2010)[3] who consider a linear model and show that "*. . . in the classical . . . Cournot duopoly an internal patentee will always prefer the ad valorem royalty to a per unit royalty*". However, their analysis does not assume that antitrust authorities apply the same economic principle to review ad valorem royalty licensing which they apply to per unit royalty licensing and assumes a particular cost profile induced by the transfer of technology.[4]

In the present paper we compare the profitability of per unit and ad valorem royalty licensing, assuming consistent antitrust constraints. Unlike the literature, our analysis is not restricted to the case of linear demand, and we allow for all possible cost profiles induced by the transfer of technology. We identify testable conditions that explain when either per unit or ad valorem royalties should be observed: Specifically, per unit licensing is more profitable if the licensor is more efficient in using the innovation, whereas ad valorem licensing is more profitable if the licensee is more efficient.

These results have an intuitive explanation. Whereas per unit royalties serve the purpose to restrict the licensee's output, ad valorem royalties restrict the licensor's output. If the licensor is more efficient, it is in his interest to shift output to himself by increasing the licensee's marginal cost; if he is less efficient, it is in his interest to shift output to the licensee, which is achieved by ad valorem royalties.

The plan of the paper is as follows: In Section 2 we state the model. In Section 3 we derive some crucial properties of the oligopoly subgames induced by royalty licensing. In Section 4 we prove testable conditions for the optimality of either per unit or ad valorem royalty licensing. In Section 5 we close with a brief summary.

2. Model

Consider a dynamic licensing game between an incumbent patent holder who owns a cost reducing innovation and one competitor who operates in the same product market. In the first stage, the incumbent offers a license contract in the form of a two-part tariff that prescribes either a per unit royalty rate, r, or an ad valorem royalty rate, s, together with a fixed fee, f. In the second stage, after the license contract has been either accepted or rejected, firms play a Cournot duopoly game.

Firms are indexed by $i \in \{0, 1\}$ where firm 0 is the incumbent patent holder and firm 1 the potential licensee. Prior to the innovation firms' unit costs are $(c_0, c_1) = (d', c)$; after using the innovation, the unit cost of firm 0 is reduced to $0 < d < c$ and that of firm 1 to $0 < x < c$. Either the licensee or the licensor can make better use of the innovation, and we call firm 0 "more efficient" if $x > d$ and firm 1 "more efficient" if $x < d$.

The innovation is non-drastic, i.e., the exclusive use of the innovation does not give rise to a monopoly. This requires that the monopoly price at unit cost d exceeds c and the monopoly price at unit cost x exceeds d' if licensing is exclusive and d if licensing is non-exclusive.

Firms' payoff functions in the oligopoly subgames under per unit and ad valorem royalty licensing are:

$$\pi_0^r(q_0, q_1) := (P(Q) - d)\, q_0 + rq_1 + f_r \tag{1}$$
$$\pi_1^r(q_1, q_0) := (P(Q) - x - r)\, q_1 - f_r \tag{2}$$
$$\pi_0^s(q_0, q_1) := (P(Q) - d)\, q_0 + sP(Q)q_1 + f_s \tag{3}$$
$$\pi_1^s(q_1, q_0) := ((1 - s)P(Q) - x)\, q_1 - f_s. \tag{4}$$

There $Q := q_0 + q_1$ and $P(Q)$ is the inverse demand function which is twice differentiable, decreasing when $P(Q)$ is positive, and satisfies $P''(Q) < {}^{-2P'(Q)}/_{Q}$ on $\{Q \mid P(Q) > 0\}$ (which includes concavity as a special case). As we show below, this assures uniqueness of equilibrium as well as the comparative static properties stated in Section 3.[5]

License contracts are regulated by antitrust authorities that interfere if they suspect collusive schemes that are geared to raise the equilibrium price. We capture these regulations by requiring that licensing cannot raise the equilibrium price above the level p^N that prevails without licensing:

$$P(Q) \le p^N \quad \text{(antitrust constraint)}. \tag{5}$$

Evidently, enforcing this constraint does not require information about firms' costs.

As Niu (2013) pointed out in an insightful paper on the equivalence of per unit and profit-share licensing, constraint (5) corresponds to the "upward pricing pressure" *(UPP)* methodology in merger policy that advises to approve mergers only if the upward pressure on price due to the change in market structure is compensated by a downward pressure due to efficiency gains (see Farrell and Shapiro, 2010; Willig, 2011). Therefore, constraint (5) assumes that antitrust authorities apply the same principle to review license contracts which they apply to review mergers.

In the case of per unit royalties, (5) is equivalent to the usual requirement that royalty rates cannot exceed the cost reduction[6] $:r \le c - x$, which in turn is equivalent to requiring that fixed fees must be non-negative. However, the latter does not also apply to ad valorem royalties; there, requiring $f \ge 0$, as in San Martín and Saracho (2010), is arbitrary and not justified.

Adding the usual boundary constraints, $r \ge 0$, $s \in [0, 1]$, the sets of feasible royalty rates are: $R := \left\{r \in \mathbb{R}_+ \mid P(Q^r(r)) \le p^N\right\} = \{r \in \mathbb{R}_+ \mid r \le c - x\}$, $S := \left\{s \in \mathbb{R}_+ \mid s \le 1, P(Q^s(s)) \le p^N\right\}$.

[1] Sen (2005) shows that per unit royalty contracts can be more profitable than license auctions. However, Giebe and Wolfstetter (2008) and Fan et al. (2013) show that supplementing license auctions with per unit royalty contracts for those who lose the auction is more profitable than per unit royalty contracts and license auctions.

[2] However, Poddar and Sinha (2010) and Fan et al. (2017) show at different levels of generality that an inside patent holder can generally increase his payoff by employing two-part tariffs rather than pure royalty contracts.

[3] Earlier, Bousquet et al. (1998) already consider ad valorem royalty licensing by an outside innovator.

[4] See also Heywood et al. (2014) who compare per unit and ad valorem royalty licensing in a binary model of incomplete information with linear demand, assuming the same specification of antitrust constraints.

[5] Of course, $P(0)$ must be greater than $\max\{d, x\}$ (otherwise firms could not profitably coexist) and $(P(Q)Q)'$ must be equal to firms' marginal costs for some finite $Q > 0$ (otherwise monopoly outputs could be infinitely large). These requirements are already implicit in the assumption that the innovation is non-drastic.

[6] The formal proof follows from two facts: (1) the equilibrium price is strictly increasing in r, see (9) below; (2) the equilibrium price without licensing is equal to the equilibrium price with licensing at the royalty rate $r = c - x$.