

# Technology licensing in a vertically differentiated duopoly

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## Abstract

In this paper, we develop a vertically differentiated duopoly model where a high-quality producer competes against a low-quality producer, *a la* Cournot competition. The high-quality firm has both a new technology and an obsolescent technology. After first deciding whether to license, the firm then chooses which of the two technologies to license. We show that, irrespective of the licensing contract, licensing the new technology is *always superior* to licensing the obsolescent technology. This finding poses a sharp contrast to the conventional wisdom.

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## 1. Introduction

Licensing represents an important form of technology transfer between two or more firms. The existing literature focuses on either optimal licensing contracts<sup>1</sup> or on welfare implications.<sup>2</sup> These papers mainly analyze cost-reducing innovations, and seldom consider vertical product innovations. However, competition between vertically differentiated firms is common in many countries. For example, multinational firms compete with local firms in many developing countries, and products produced by multinational firms are often superior in quality to those produced by local firms. Despite the practical significance in the real world, the literature overlooks the licensing behaviors between vertically differentiated firms.

In addition, the previous studies assume away licensing choices between technologies by modeling that the innovating

firm has a single innovation.<sup>3</sup> Although, this assumption may help to simplify the model analysis, it is important to recognize that a firm that produces a high-quality product may have both a new technology and an obsolescent technology. Therefore, the firm has to make a choice between licensing the obsolescent technology and licensing the new technology. Licensing the obsolescent technology, while keeping the new one for its own use, may allow the patent-holding firm to obtain some licensing revenue, as well as maintain its advantage in competing with its competitors. In contrast, licensing the new technology enables the patent holder to realize higher licensing income, but intensifies market competition. The patent-holding firm has to balance these effects when making its licensing decision.

It is widely observed that patent-holding firms are reluctant to transfer their advanced technologies to their competitors, and, instead, they may have incentives to sell their old technologies. For instance, a German firm declined to transfer its magnetic levitation technology when it negotiated with Chinese government over the Maglev train project. It is also reported that multinational firms in China have strong incentives to prevent their new technologies from being

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<sup>1</sup> One strand of this literature is to model an innovating firm as a non-producing firm, for example, Kabiraj (2004), Kamien and Tauman (1986) and Li and Geng (2008). Another strand assumes an innovating firm as a producer, such as Erkal (2005), Kamien and Tauman (2002), Katz and Shapiro (1985), Poddar and Sinha (2004), Wang (1998) and Wang and Yang (1999).

<sup>2</sup> For instance, Erkal (2005), Fauli-Oller and Sandonis (2002, 2003), Kabiraj (2005), Liao and Sen (2005), Lin (1996), Mukherjee (2005) and Mukherjee and Mukherjee (2005).

<sup>3</sup> An exception is Rockett (1990) who extends the licensing literature to permit firms to choose the age of their technology. However, she focuses on cost-reducing innovations by assuming that the licensor and the licensee are homogenous duopolists in the output market.

transferred to their Chinese rivals. This paper studies a vertically differentiated duopoly where one firm produces a high-quality product and the other produces a low-quality product. The two firms compete in choosing outputs.<sup>4</sup> The high-quality firm has both a new innovation and an obsolescent innovation. The purpose of the present work is to investigate the choice between licensing the obsolescent technology and licensing the new technology.

In this paper, we concentrate the analysis on Cournot competition rather than on Bertrand competition. This deserves some comment. As we are interested in the licensing choice between the obsolescent technology and the new technology, this is a natural assumption. From a theoretical perspective, two papers, by De Fraja (1996) and Avenel and Caprice (2006), support the assumption of quantity competition by indicating that Bertrand competition eliminates head-to-head competition. Casual observation shows that many firms compete head-on with their rival firms. For example, in China, Gome Corporation and Suning Group sell identical household appliances, in different cities. Another example is China Unicom and China Mobile, which also provide similar services. Therefore, both theoretical analysis and casual evidence suggest that our quantity assumption is very reasonable.

In contrast to the conventional wisdom, it is shown that, irrespective of the licensing contract, licensing the new technology is *always superior* to licensing the obsolescent technology, from the perspective of the innovating firm. Although licensing the new innovation increases market competition and reduces the licensor's competitive advantage, it permits the patent-holding firm to extract more licensing revenue from its licensee. The increased benefit exceeds the loss from fiercer competition. Another interesting result is that the optimal licensing contract involves output royalty alone, even if both royalties and fixed-fees are feasible. However, consumer surplus and social welfare are higher under fixed-fee licensing.

The remainder of the paper is organized as follows: In the next section we provide the basic model. In Section 3, we study the licensing decision and derive the main results, by considering fixed-fee, royalty and two-part tariff contracts. In Section 4, we conclude the paper with some discussions. Some proofs are displayed in Appendix A.

## 2. The model

There are two firms, 1 and 2, in a market. Firm 1 is high-quality producer and firm 2 is low-quality producer. Each produces a single product with quality  $s_i$ ,  $i = 3, 2$ . Where  $s_2 = \beta s_3$ ,  $\beta \in (0, 1)$ . To simplify the notation,  $s_3$  is fixed at  $s_3 = 1$ , and hence,  $s_2 = \beta$ . The parameter  $\beta$  captures the degree of

vertical product differentiation. A larger  $\beta$  implies closer substitutability between the two products. A smaller  $\beta$  indicates a larger quality difference. Firm 1 also has an obsolescent technology, which may enable it to produce a product with quality  $s_1$ . Where  $s_1 = t s_3 = t$  and  $s_2 = \lambda s_1 = \lambda t \equiv \beta$ .  $t \in (0, 1)$  and  $\lambda \in (0, 1)$  reflect the degrees of product differentiation.

Consumers buy, at most, one unit of the vertically differentiated product. The utility function is

$$U = \begin{cases} \theta s_i - p_i & \text{if he buys a good with quality } s_i \\ 0 & \text{if he does not buy} \end{cases}$$

where  $s_i$  reflects the quality of the product,  $i = 1, 2, 3$ .  $\theta \in [0, 1]$  is a taste parameter with uniform distribution. The density function is one.  $p_i$  is the price. The population is normalized to one. For the sake of simplicity, we further stipulate that the marginal costs of both firms are zero. It is worth mentioning that, under this assumption, firms have no incentive to supply low-quality products if they have an advanced technology. Hence, each firm produces only one product, whether licensing occurs or not.

The licensing game involves three stages. In the first stage, firm 1 decides whether to license its technology and chooses a technology to license. If firm 1 has an incentive to license its technology, it makes firm 2 a “take-it-or-leave-it” offer, by setting either a fixed-fee or a royalty rate, or both. In the second stage, firm 2 decides whether to accept the offer. In the third stage, the two firms engage in quantity competition.<sup>5</sup>

## 3. Model analysis

### 3.1. Pre-licensing equilibrium

We begin our analysis by considering the case where licensing does not occur. In this case, the quality levels of the two firms are  $s_3 = 1$  and  $s_2 = \beta$ , respectively. The marginal consumer is determined by

$$\theta - p_1 = \beta\theta - p_2, \quad \theta_1 = \frac{p_1 - p_2}{1 - \beta}. \quad (1)$$

The demands are

$$q_1 = \int_{\theta_1}^1 d\theta = 1 - \frac{p_1 - p_2}{1 - \beta} \quad (2)$$

and

$$q_2 = \int_{p_2/\beta}^{\theta_1} d\theta = \frac{p_1 - p_2}{1 - \beta} - \frac{p_2}{\beta}. \quad (3)$$

Solving the inverse demands yields<sup>6</sup>:

$$p_1 = 1 - q_1 - \beta q_2 \quad (4)$$

<sup>4</sup> If the two firms compete in pricing, they have strong incentives to maintain a high level of differentiation, thus licensing cannot occur. To be precise, it is easy to understand that licensing new technology cannot take place. We can also show that licensing obsolescent technology is not profitable for the patent-holding firm. The proofs are available from the authors, upon request.

<sup>5</sup> We will come back to this assumption in Section 4.

<sup>6</sup> Motta (1993) and Avenel and Caprice (2006) also take this approach, in order to model output competition between vertically differentiated duopolies.

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