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Input price discrimination, technology licensing and social welfare

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A B S T R A C T

This paper examines the welfare effect of third-degree input price discrimination in the presence of technology licensing by an outside innovator. It is found that discriminatory pricing induces the innovator to issue more licenses to downstream firms which improves the overall production efficiency of the downstream market and makes discriminatory pricing more socially desirable than uniform pricing. However, if the level of innovation is endogenously determined by the outside innovator, price discrimination suppresses his R & D incentive, which reduces the social welfare and makes the welfare effect of price discrimination ambiguous.

1. Introduction

The literature on price discrimination had focused primarily on output markets not until Katz (1987) who was the first to examine price discrimination in input markets. Assuming the downstream firms differ in marginal costs and cannot backward-integrate, he shows that price discrimination by an upstream monopolist necessarily lowers social welfare as it distorts market efficiency by charging the more (less) efficient downstream firm a higher (lower) input price. DeGraba (1990) concludes that price discrimination suppresses downstream firms' incentives to engage in R & D, lowering social welfare. Yoshida (2000) uses a generalized model and also concludes that input price discrimination is welfare-deteriorating.

In this paper, we tackle the issue from a different perspective and come up with a different outcome. We will show that price discrimination in an input market can become welfare-improving if technology licensing from an outside innovator to the downstream firms is introduced into the model. Assume there is an outside licensor (*i.e.*, the licensor which does not compete in the output market) who licenses its technology to downstream firms by means of auction.[1] We assume this new technology to be non-drastic,[2] *i.e.*, no downstream firms are driven out of the market after the technology being licensed. As we shall demonstrate in the paper, the innovator tends to issue fewer licenses if the upstream monopolist engages in uniform than discriminatory pricing. The fewer licenses under uniform pricing worsen the production efficiency of the downstream market, making uniform pricing more socially undesirable than discriminatory pricing.

We also consider the welfare effect of price discrimination in the long run by assuming that the innovator can endogenously determine its R & D and the resulting innovation level. We shall show that price discrimination distorts the R & D incentive of the innovator, reducing the social welfare. As a result, the welfare effect of price discrimination becomes ambiguous in the long run.

The remainder of this paper is organized as follows. In Section 2, we briefly introduce the model and its game structure. The equilibrium with the upstream monopolist implementing uniform pricing is examined in Section 3 followed by the discriminatory pricing

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[1] We assume the outside innovator licenses its technology by means of auction for two reasons. First, it is often difficult for an innovator to monitor the outputs of the licensees. Second, the licensee may imitate or invent around the licensed technology to avoid paying royalty. See Katz and Shapiro (1985), Mukherjee and Mukherjee (2013), Kuo, Lin and Peng (2015), Chang, Lin and Tsai (2016), and Wang, Wang and Liang (2016) for more details.

[2] The definition of "non-drastic" innovation follows Arrow (1962).

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equilibrium in Section 4. A comparison between the two pricing regimes and their effects on social welfare are discussed in Section 5. In Section 6, we investigate the welfare effect of price discrimination in the long run. A brief conclusion is made in Section 7.

2. The model

Assume there are vertically related markets with one upstream monopolist selling a homogeneous input to n homogeneous downstream firms which compete as Cournot oligopolists in a final good market. For simplicity, we assume that producing one unit of the final good needs one unit of the input. Furthermore, there is an outside innovator who owns an advanced production technology and can choose to license it to k out of the n downstream firms by means of auction. Firms equipped with this advanced technology can lower its marginal cost from c to $c-\varepsilon$, where ε stands for an innovation level. The monopolistic upstream firm can charge either discriminatory input prices $-w^L$ for the k licensed downstream firms and w^N for the $n-k$ non-licensed downstream firms, or a uniform input price w. For simplicity, we assume that the marginal cost of the input is zero and the inverse demand function for the final good is $P=P(Q)$, with $P'(Q)<0$ and $P''(Q)=0$, where $Q=\sum_{i\in S}x_i+\sum_{i\notin S}y_i$ is the output of the final good, $x_i(y_i)$ is the output of a licensed (non-licensed) firm, and S represents the set of the licensed firms.

The game in the model consists of three stages. In the first stage, given the level of innovation, the innovator determines the optimal number of licenses, k, to be auctioned off among downstream firms. In the second stage, the upstream monopolist determines either a uniform input price (under the uniform pricing regime) or discriminatory input prices (under the discriminatory pricing regime). Finally, taking the number of licenses and the input price(s) as given, the downstream firms compete in the final good market in a Cournot fashion. The sub-game perfect equilibrium is derived by backward induction. This is regarded as the short-run analysis in which the innovation level is exogenously determined. We shall also examine the long-run equilibrium in which the innovator can endogenously determine its innovation level, and compare it with the short-run one in Section 6.

3. The short-run equilibrium under uniform pricing

Under the uniform pricing regime, the profit functions for a representative licensed firm before it pays the licensing fee, π_i^L, and a representative non-licensed firm, π_i^N, are specified respectively as follows:

$$\pi_i^L(x_i;\, Q,\, w,\, k)=[P(Q)-w-(c-\varepsilon)]\,x_i,\quad \forall\, i\in S,$$

$$\pi_i^N(y_i;\, Q,\, w,\, k)=[P(Q)-w-c]\,y_i,\quad \forall\, i\notin S.$$

By differentiating π_i^L and π_i^N with respect to x_i and y_i respectively, we can derive the equilibrium outputs for the licensed and non-licensed firms as follows:

$$\frac{\partial\pi_i^L}{\partial x_i}=P(Q)+P'x_i-w-c+\varepsilon=0,\quad i\in S,$$
$$\frac{\partial\pi_i^N}{\partial y_i}=P(Q)+P'y_i-w-c=0,\quad i\notin S. \tag{1}$$

By symmetry, we have $x_i=x$ and $y_i=y$ and $Q=kx+(n-k)y$. Substituting them into (1) and then subtracting one from the other, we can obtain:

$$x=y-\frac{\varepsilon}{P'}. \tag{2}$$

It implies that each licensed firm produces more final good than each non-licensed firm.

Totally differentiating (1) with respect to x, y, w, k and ε yields:

$$x_w\equiv\frac{\partial x}{\partial w}=\frac{1}{(n+1)P'}<0,\ x_k\equiv\frac{\partial x}{\partial k}=\frac{\varepsilon}{(n+1)P'}<0,\ x_\varepsilon\equiv\frac{\partial x}{\partial \varepsilon}=\frac{n-k+1}{-(n+1)P'}>0,\ y_w\equiv\frac{\partial y}{\partial w}=\frac{1}{(n+1)P'}<0,$$
$$y_k\equiv\frac{\partial y}{\partial k}=\frac{\varepsilon}{(n+1)P'}<0,\ y_\varepsilon\equiv\frac{\partial y}{\partial \varepsilon}=\frac{k}{(n+1)P'}<0. \tag{3}$$

It shows that a higher input price lowers the outputs of both the licensed and the non-licensed firms. Moreover, the outputs of the licensed and the non-licensed firms all decrease with the number of licenses since it implies that there are now more downstream firms with a lower marginal cost. Furthermore, the output of the representative licensed (non-licensed) firm increases (decreases) with the innovation level.

In the second stage, given the derived demand for the input, the upstream monopolist determines a uniform input price to maximize its profit. The profit function of the upstream monopolist is specified as follows:

$$\Omega(w;\, k)=wQ(w;\, k).$$

By differentiating this profit function with respect to w and setting it to zero, we can derive the first-order condition for profit maximization as follows:

$$\frac{\partial\Omega}{\partial w}=Q+wQ_w=0, \tag{4}$$