Input Price Discrimination and Social Welfare in the Presence of Technology Licensing

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(This version 2013/05/30)

Abstract

The literature on input price discrimination has shown that third-degree price discrimination by an upstream firm is welfare-deteriorating as the upstream firm charges more (less) efficient downstream firms a higher (lower) input price which distorts the production efficiency. (See, for example, Katz (1987) and DeGraba (1990)) In this paper, we examine the welfare effect of third-degree input price discrimination in the presence of technology licensing by an outside innovator in a vertically related market with one upstream monopolist and \( n \) homogeneous downstream oligopolists. It is found that the innovator tends to license its technology to more downstream firms if the upstream firm engages in discriminatory pricing. This improves the overall production efficiency of the downstream firms and makes discriminatory pricing more socially desirable than uniform pricing, which is opposite to the general outcome in the literature.

Key words: Price Discrimination, Licensing, Vertically Related Markets

JEL Classification: L11, L24

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1. Introduction

There are policy disputes over price discrimination. Robinson (1933) investigates the output effects of price discrimination with two distinct markets. She shows that if the market demands are linear and the marginal cost of the monopolist is constant, price discrimination does not change the total output. Schmalensee (1981) extends Robinson’s results to an n-market case and points out that social welfare goes up only if price discrimination leads to higher output. Varian (1985) generalizes the result by incorporating into the model interdependent markets and increasing marginal cost. Both Schmalensee (1981) and Varian (1985) show that, with linear market demands, price discrimination always lowers social welfare since there is a negative welfare effect arising from output redistribution among the markets. However, their result does not hold in a spatial framework. Hwang and Mai (1990) show that, with an endogenous plant location, price discrimination may enhance social welfare.

The literature on price discrimination had focused primarily on output markets 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) puts forward a similar argument, concluding that price discrimination would suppress downstream firms’ incentives to engage in R&D and thus lower social welfare. Yoshida (2000) uses a generalized model to show that an increase in the total output of the final goods is a sufficient condition for welfare deterioration as it deepens the
production inefficiency.

Furthermore, Inderst and Valletti (2009) show that an input monopolist may charge the more efficient downstream firm a lower input price when facing a threat of demand-side substitution. As a result, production efficiency is restored and social welfare becomes higher under price discrimination. Inderst and Shaffer (2009), on the other hand, assume the input monopolist engages in two-part tariff pricing, that is, a fixed fee payment and a royalty rate per unit and reach the same conclusion. Furthermore, Tyagi (2001) shows that by widening the cost difference between the downstream firms, an input monopolist can break out the tacit collusion in the final good market, increasing its output and improving the social welfare.

In this paper, we shall examine the effects of price discrimination by introducing into the model technology licensing which nowadays is a popular business activity. We shall show that if there is an outside innovator (i.e., the innovator does not compete in the market) who licenses its technology to the downstream firms, price discrimination in the input markets can raise the output of the final goods and social welfare as well.

Our framework is similar to that in Mukherjee (2010). He employs a model with a vertically related market to discuss the optimal licensing contract from the perspective of an outside innovator. In his model, the upstream input market is represented by a monopolistic labor union which can set either a uniform wage or discriminatory wages against the downstream firms. He shows that the payoff for an outside innovator is higher under royalty licensing than fixed-fee licensing if bargaining power of the labor union is sufficiently high.

In practice, technology may be licensed by means of a fixed fee or a royalty rate or a combination of the two. In this paper, we shall focus on fixed fee licensing for
two reasons. First, it is often costly or sometimes impossible for an innovator to monitor licensees’ output. Second, Kamien and Tauman (1986, 2002), and Kamien et al. (1992) have shown that an outside innovator would license its technology to all the downstream firms if the technology is licensed by means of a royalty rate. If this is the case, the \( n \) homogeneous downstream firms in our model will remain homogeneous after licensing, leaving no room for the upstream monopolist to practice price discrimination.

The main finding of this paper is that price discrimination may raise the output of the final good, leading to a higher social welfare level. This happens mainly because price discrimination can induce the innovator to license its technology to more firms which lowers the marginal production cost of the licensees and results in a lower market price for the final good.

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 charging a uniform pricing strategy is examined in Section 3 followed by the price discrimination equilibrium in Section 4. A comparison between the two pricing regimes and their impacts on social welfare are discussed in Section 5. We present a brief conclusion in Section 6.

2. The Model
Assume there is an industry consisting of \( n \) homogeneous downstream firms and one monopolistic upstream firm. The \( n \) homogeneous downstream firms purchase an input from the upstream monopolist, processing it into a final good and competing as Cournot oligopolists in the 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 charging a fixed fee. Firms equipped with this advanced technology can lower its marginal cost from $c$ to $c - \epsilon$, where $\epsilon$ stands for an innovation level. On the other hand, the monopolistic upstream firm, $M$, supplies its input to all the downstream firms by charging 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 production cost of the input is zero. The inverse demand function for the final good is $P = P(Q) = a - Q$, 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 supplied by the licensees (non-licensees), and $S$ represents the set of the licensees.

We use a three-stage game to illustrate the effects of technology licensing on price discrimination in the vertically related market. In the first stage, the innovator determines the optimal number of licenses and the licensing fee, $F$. Given this fixed licensing fee, the downstream firms decide whether to accept it or not. In the second stage, the upstream monopolist determines either a uniform input price or discriminatory input prices. Finally, taking the fixed fee and the input price(s) as given, the downstream firms compete in the final good market in Cournot fashion. As usual, the sub-game perfect equilibrium is derived by backward induction. Throughout the paper, we shall assume the new technology to be non-drastic,¹ i.e., no any downstream firms are driven out of the market after technology licensing.

¹ The definition of “non-drastic” innovation follows Arrow (1962).
3. The Equilibrium under Uniform Pricing

In this section, we shall focus on the uniform pricing case, that is, the upstream monopolist cannot price discriminate against the downstream firms. The profit functions for a representative licensee, $\Pi^l$, and a representative non-licensee, $\Pi^n$, are specified respectively as follows:

$$\Pi^l_i(x, y; w, k) = \pi^l_i(x, y; w, k) - F = [P(Q) - w - (c - \epsilon)]x_i - F, \quad \forall i \in S,$$

$$\Pi^n_i(x, y; w, k) = \pi^n_i(x, y; w, k) = [P(Q) - w - c]y_i, \quad \forall i \notin S.$$

where $\pi^l_i$ and $\pi^n_i$ are respectively the operating profits of the representative licensee and non-licensee, and $F$ again is the licensing fee charged by the innovator.

The first-order conditions for profit maximization for the representative licensee and non-licensee are respectively as follows:

$$\frac{\partial \Pi^l_i}{\partial x_i} = P(Q) + P'(Q)x_i - w - c + \epsilon = 0, \quad \forall i \in S,$$

$$\frac{\partial \Pi^n_i}{\partial y_i} = P(Q) + P'(Q)y_i - w - c = 0, \quad \forall i \notin S.$$

As the second-order conditions and the stability condition are all satisfied, we can solve these first-order conditions to derive the equilibrium outputs as follows:

$$x_i = x(w, k) = \frac{a - w - c + \epsilon(n - k + 1)}{1 + n}, \quad \forall i \in S,$$

$$y_i = y(w, k) = \frac{a - w - c - \epsilon k}{1 + n}, \forall i \notin S.$$

From (1), it is straightforward to show that the condition for the new technology to be non-drastic is $\epsilon < (a - w - c) / k$. This condition requires that the output of each non-licensee be positive after licensing. Moreover, we can obtain the comparative static effects of $w$ and $k$ on the outputs of the representative licensee and non-licensee as follows:
\[
x_w = y_w = -1/(1+n) < 0, \quad x_k = y_k = -\varepsilon/(1+n) < 0.
\]

As expected, an increase in the input price or the number of the licenses decreases the outputs of the licensee and non-licensee. But their effects on the total output become positive as by \( Q = kx + (n-k)y \), we can derive \( Q_w = -n/(1+n) < 0 \), and \( Q_k = \varepsilon/(1+n) > 0 \). The intuition for the latter effect is as follows: As the number of licenses increases, there are now more efficient downstream firms, which not only lowers the average cost of the downstream market but also raises the competition among the efficient firms, leading to a higher market output.

We can now move to the second-stage game. In the second stage, given the derived demand, the upstream monopolist determines a uniform input price to maximize its profit. Since we have assumed the marginal cost of the input to be nil, the profit function of the upstream monopolist is specified as follows:

\[
\Omega(w; k) = wQ(w; k).
\]

Differentiating this profit function with respect to \( w \), we can derive the first-order condition for profit maximization as follows:

\[
\Omega_w = Q + wQ_w = 0.
\]

By solving the first-order condition, we can derive the optimal input price as follows:

\[
w = w(k) = \frac{1}{2} \left[ a - \left( c - \frac{k}{n} \right) \right], \quad (2)
\]

Substituting (2) into (1), we can derive the outputs of each licensee and non-licensee as follows:

\[
x = x(k) = \frac{n(a-c) + \varepsilon \left[ 2n(1+n) - k(1+2n) \right]}{2n(1+n)},
\]

\[
y = y(k) = \frac{n(a-c) - \varepsilon k(1+2n)}{2n(1+n)}.
\]
Utilizing (2) and (3), we can derive the equilibrium profit of the upstream monopolist as follows:

\[
\Omega = \Omega(k) = w(k)Q(k) = \frac{[n(a - c) + \varepsilon k]^2}{4n(1 + n)}.
\]

Moreover, from (2), we can derive \( w_i = dw/\,dk = \varepsilon / 2n > 0 \) which shows that the input price is positively related to the number of the licenses. The intuition is straightforward. If more downstream firms are licensed with the new technology, the average marginal cost of the downstream market becomes lower and the output becomes higher. This higher output will result in a higher derived demand for the input, leading to a higher input price. We summarize this result in the following lemma:

**Lemma 1.** With uniform pricing, the upstream monopolist tends to charge a higher input price if the innovator issues more licenses to the downstream firms.

The effects of the number of licenses, \( k \), on the outputs of the representative licensee and non-licensee are as follows:

\[
\frac{dx}{dk} = x_w w_i + x_t = -\frac{\varepsilon(1 + 2n)}{2n(1 + n)} < 0 \quad \text{and} \quad \frac{dy}{dk} = y_w w_i + y_t = -\frac{\varepsilon(1 + 2n)}{2n(1 + n)} < 0.
\]

These two equations show that raising the number of the licenses decreases both the outputs of each licensee and non-licensee.

The optimal licensing fee is determined by the profit difference of each licensee between accepting and rejecting the licensing offer, that is, \( F \leq \pi^l(k) - \pi^u(k - 1) \). Assume further that the innovator has all the bargaining power and can extract all the rent from licensing accruing to the licensees. Hence, the profit maximization problem
of the innovator is as follows:

$$\max_k \Lambda(k) = kF,$$

where $F = \pi^i(k) - \pi^x(k-1) = \left( x(w(k),k) \right)^2 - \left( y(w(k-1),k-1) \right)^2$. By taking the first derivative of the objective function with respect to $k$, we can obtain:

$$\frac{d\Lambda}{dk} = F + k \frac{d}{dk} \left( \left[ x(w(k),k) \right]^2 - \left[ y(w(k-1),k-1) \right]^2 \right)$$

$$= F + k \left[ 2x(k)(x_iw_i + x_i) - 2y(k-1)(y_iw_i + y_i) \right]$$

$$= F + 2k \left[ x_i x(k) - y_i y(k-1) \right] + 2kw_i \left[ x_i x(k) - y_i y(k-1) \right].$$

The optimal number of the licenses is determined by the three terms in the RHS of (4). The first term is the fixed fee effect which is positive. It shows that by licensing to an additional downstream firm, the innovator can acquire an additional fixed fee. The second term captures the output effect which is negative. It shows that an increase in the number of the licenses decreases the output of both the licensee and non-licensee firms, which in turn reduces the profits earned by each licensee firm and therefore the fixed fee charged by the innovator. The third term is called the input price effect which is also negative. It shows that, as the number of the licenses increases, the average cost of the downstream firms decreases which raises the total output of the final good and also the derived demand for the input. With a higher derived demand, the input price set by the upstream monopolist would also become higher. This higher input price decreases the outputs of the licensee and non-licensee firms, which erodes the profits of the downstream firms and also the rent of the innovator.

Substituting (3) into (4) and setting it to zero, we can derive the optimal number
of the licenses under uniform pricing as follows:  

\[ k^U = \frac{(1+4n+2n^2)}{4(1+2n)} + \frac{n(a-c)}{2(1+2n)\varepsilon}, \]  

(5)

where the superscript “\(U\)” denotes the variable is associated with the uniform pricing regime.

4. The Equilibrium under Discriminatory Pricing

Under this regime, the upstream monopolist can charge different input prices, \(w^L\) to licensees and \(w^N\) to non-licensees. The profit functions of the licensed and non-licensed downstream firms are as follows:

\[ \Pi_i^L(x_i, y_i; w^L, w^N, k) = \pi_i^L(x_i, y_i; w^L, w^N, k) - F = \left[ P(Q) - w^L - (c - \varepsilon) \right] x_i - F, \forall \in S, \]

\[ \Pi_i^N(x_i, y_i; w^L, w^N, k) = \pi_i^N(x_i, y_i; w^L, w^N, k) = \left[ P(Q) - w^N - c \right] y_i, \quad \forall \in S. \]

Choosing \(x_i\) to maximize \(\Pi_i^L\) and \(y_i\) to maximize \(\Pi_i^N\), we can derive the first-order conditions for profit maximization for the downstream market as follows:

\[ \frac{\partial \Pi_i^L}{\partial x_i} = P(Q) + P'(Q)x_i - w^L - c + \varepsilon = 0, \quad \forall \in S, \]

\[ \frac{\partial \Pi_i^N}{\partial y_i} = P(Q) + P'(Q)y_i - w^N - c = 0, \quad \forall \in S. \]

It is straightforward to show that the second-order and the stability conditions are both satisfied. Solving these first-order conditions simultaneously, we can have the equilibrium outputs for the final good market as follows:

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2 The optimal number of licenses under uniform pricing is, in general, negatively related with \(\varepsilon\). It has a corner solution of \(k^U = n\) if \(\varepsilon \leq 2n(a - c)/(6n^2 - 1)\).
\[ x_i = x(w^l, w^v, k) = \frac{a - (n - k + 1)w^l + (n - k)w^v - c + \varepsilon(n - k + 1)}{1 + n}, \quad \forall i \in S, \]  
\[ y_i = y(w^l, w^v, k) = \frac{a + kw^l - (k + 1)w^v - c - \varepsilon k}{1 + n}, \quad \forall i \not\in S. \]  

From (6), the comparative static effects of the input prices, \( w^l \) and \( w^v \), and the number of licenses, \( k \), on the outputs of each licensee and the non-licensee are as follows:

\[ x_{w^l} = -(n - k + 1) / (1 + n) < 0, \quad x_{w^v} = (n - k) / (1 + n) > 0, \quad x_i = (w^l - w^v - \varepsilon) / (1 + n), \]
\[ y_{w^l} = k / (1 + n) > 0, \quad y_{w^v} = -(1 + k) / (1 + n) < 0, \quad y_i = (w^l - w^v - \varepsilon) / (1 + n). \]

These comparative static effects indicate that the output of each licensee is negatively (positively) related to \( w^l \) (\( w^v \)). On the other hand, the output of each non-licensee is positively (negatively) related to \( w^l \) (\( w^v \)). However, the comparative static effect of \( k \) on the outputs of each licensee and non-licensee is ambiguous as it depends on \( (w^l - w^v - \varepsilon) \).

In the second stage, the upstream monopolist determines the optimal input prices to maximize its profits. The profit function of the upstream monopolist is specified as follows:

\[ \Omega(w^l, w^v; k) = w^l k x(w^l, w^v; k) + w^v(n - k) y(w^l, w^v; k). \]

The first-order conditions for profit maximization are as follows:

\[ \Omega_{w^l} = k x + w^l k x_{w^l} + w^v(n - k) y_{w^l} = 0, \]
\[ \Omega_{w^v} = (n - k) y + w^l k x_{w^v} + w^v(n - k) y_{w^v} = 0. \]

By solving the two first-order conditions, we can derive the optimal input prices as follows:

\[ w^l = \frac{a - c + \varepsilon}{2} \quad \text{and} \quad w^v = \frac{a - c}{2}. \]
It shows that the upstream monopolist charges the more (less) efficient downstream firms a higher (lower) input price. Moreover, we can immediately derive from (7) that \( w_k^e = 0 \) and \( w_k^v = 0 \).\(^3\) These two comparative static effects show that the optimal input prices do not depend on the number of licenses. Based on the above discussions, we can establish the following lemma:

**Lemma 2.** If the upstream monopolist engages in third-degree price discrimination in the input market, its optimal input prices are independent of the number of the licenses.

This result is different from the one we derived under the uniform price regime in which the optimal input price is positively related to the number of licenses (by (2)).

By substituting (7) into (6), we can rewrite the output for each licensee firm and non-licensee firm as follows:

\[
x = x(k) = \frac{a - c + \varepsilon (n - k + 1)}{2(1 + n)} \quad \text{and} \quad y = y(k) = \frac{a - c - \varepsilon k}{2(1 + n)}. \quad (8)
\]

Moreover, by substituting (7) into \( x_k \) and \( y_k \), and utilizing \( w_k^e = w_k^v = 0 \), we can derive the followings: 

\[
dx/dk = x_{w, w} w_k^e + x_{w, v} w_k^v + x_k = x_k = -\varepsilon / 2(1 + n) < 0 \quad \text{and} \quad dy/dk = y_{w, w} w_k^e + y_{w, v} w_k^v + y_k = y_k = -\varepsilon / 2(1 + n) < 0.
\]

Raising the number of licenses decreases the outputs of each licensee and non-licensee. Hence, in the first stage of the game, the objective function of the innovator is specified as follows:

\[
\max_k \Lambda(k) = kF,
\]

\(^3\) With a non-linear demand, these comparative static effects become ambiguous, depending on the curvature of the derived demand, the variance of the output distribution, and the effect of the number of license on the variance of output distribution. It will not be pursued this case.
where \( F = \pi^i(k) - \pi^v(k-1) = \left[ x(w^i(k), w^v(k), k) \right]^2 - \left[ y(w^i(k-1), w^v(k-1), k-1) \right]^2 \).

Substituting the \( F \) equation into the objective function and taking the first derivative with respect to \( k \), we can obtain:

\[
\frac{d\Lambda}{dk} = F + k \frac{d}{dk} \left[ x(w^i(k), w^v(k), k) \right]^2 - \left[ y(w^i(k-1), w^v(k-1), k-1) \right]^2 \\
= F + 2k \left[ x(w^i + w^v + x, w^v + y) x(k) - (y, w^v + y) y(k-1) \right] \\
= F + 2k \left[ x, x(k) - y, y(k-1) \right],
\]

(9)

By substituting (8) into (9) and set (9) equals to zero, we can derive the optimal number of licenses under discriminatory pricing as follows:

\[
k^D = \frac{2 + n}{4} + \frac{a - c}{2\epsilon},
\]

where the superscript “\( D \)” denotes the variable is associated with the discriminatory pricing regime.

Subtracting (5) from (10), the difference of the optimal license numbers between the two pricing regimes is as follows:

\[
k^D - k^U = \frac{1 + n}{1 + 2n} \left( \frac{1}{4} + \frac{a - c}{2\epsilon} \right) > 0.
\]

It implies that the innovator tends to license his technology to more downstream firms under price discrimination than that under uniform pricing. We can therefore establish the following proposition:

**Proposition 1.** The innovator licenses to more downstream firms under
The intuition is as follows. Under the uniform pricing regime, the input price is positively related to the number of licenses by Lemma 1. It gives the innovator an incentive to issue fewer licenses so as to induce a lower input price, which increases the profits of the licensee firms and thus the fixed fee charged by the innovator. But this effect does not exist if the upstream monopolist engages in price discrimination since the input prices are independent of the number of licenses by Lemma 2.

5. A Comparison on Social Welfare

We are interested in the comparison of social welfare under uniform pricing and third-degree price discrimination in the input market. It is generally believed in the literature on input price discrimination that social welfare is higher under uniform pricing than under price discrimination. The intuition goes as follows. If the upstream monopolist engages in input price discrimination, it charges more efficient downstream firms a higher input price which creates a distortion in output allocation among the downstream firms and makes price discrimination socially undesirable.\(^6\) This ranking may not hold in our model as the innovator tends to license to more downstream firms under price discrimination which is a gain to social welfare and this gain reverses the welfare ranking.

Before we compare the welfare under the two regimes, let us compare the output and consumer surplus first. By substituting (3) into \(Q = kx + (n - k)\gamma\), we can derive the total output under the uniform pricing regime as follows:

---

\(^6\) See, for example the explanations in Yoshida (2000).
\[ Q^U = \frac{n(a - c) + k^U \varepsilon}{2(1 + n)}. \]  

Similarly, utilizing (8), we can derive the total output under price discrimination as follows:

\[ Q^D = \frac{n(a - c) + k^D \varepsilon}{2(1 + n)}. \]

Since the number of the licenses under discriminatory pricing is higher than that under uniform pricing by Proposition 1, we have \( Q^D > Q^U \). This leads to the following proposition:

**Proposition 2.** The total output, and hence the consumer surplus, under third-degree price discrimination is higher than that under uniform pricing.

This output ranking differs from those in Katz (1987), DeGraba (1990), and Yoshida (2000). They assume no technology licensing and conclude that total output remains unchanged under price discrimination. In our model, the innovator licenses to more downstream firms under the price discrimination regime, which leads to a lower average marginal cost and thus greater total output of the final good. Moreover, since \( Q^D > Q^U \), it implies that consumer surplus under discriminatory pricing is also higher than that under uniform pricing.

We move to the welfare comparison. Let \( SW \) stand for social welfare which is defined as the sum of consumer surplus, the profits of the upstream monopolist, the downstream firms and the innovator. The social welfare function can be specified as
follows:

\[
SW = \int_0^T P(t)dt - \left[(c - \varepsilon)X + cY\right] = \left[ a - \frac{Q}{2} - \left(c - \frac{k}{\varepsilon}\right)\right]Q + \frac{\varepsilon}{n}k(n-k)(x-y).
\] (13)

The first term on the RHS of (13) is the output effect; the larger the final output is, the higher the social welfare. The second term captures the output allocation effect.

This effect is larger if the licensed firms become more efficient (i.e., a higher \(\varepsilon\)) and/or produce more output than the non-licensed firms (i.e., the value of \((x - y)\) is higher).

By substituting (8) into (13), we can derive the social welfare function under price discrimination as follows:

\[
SW^D = \left[ a - \frac{Q^D}{2} - \left(c - \frac{k^D}{\varepsilon}\right)\right]Q^D + \frac{\varepsilon^2}{2n}k^D(n-k^D).
\] (14)

By substituting (3) into (13) and then proceeding as before, we can derive the social welfare function under uniform pricing as follows:

\[
SW^U = \left[ a - \frac{Q^U}{2} - \left(c - \frac{k^U}{\varepsilon}\right)\right]Q^U + \frac{\varepsilon^2}{n}k^U(n-k^U).
\] (15)

Substituting \(Q^D\) and \(Q^U\) from (12) and (11) into (14) and (15) respectively, the social welfare comparison between the two pricing regimes can be carried out as follows:

\[
SW^D - SW^U = \left[ \frac{\varepsilon(4 + 3n)}{2(1 + n)} \right] \left[ \frac{2n(a - c) + \varepsilon(k^D + k^U)}{4n(1 + n)} \right] (k^D - k^U) + \frac{\varepsilon^2}{2n} \left[ k^D(n - k^D) - 2k^U(n - k^U) \right].
\] (16)

The first term of the welfare difference function captures the difference between the output effects while the second term captures the difference in output allocation.
effects between the two regimes. If \( k^D = k^U \), the first term vanishes, and the second term reduces to \(-\varepsilon k^U (n - k^U)/2n\) which shows that the social welfare under price discrimination is necessarily less than that under uniform pricing. This is the result found in Katz (1987), DeGraba (1990) and Yoshida (2000).

However, by Proposition 1, the innovator tends to license to more downstream firms under price discrimination than uniform pricing, i.e., \( k^D > k^U \). By substituting \( k^D \) and \( k^U \) from (5) and (10) into (16), and the assumption of the innovation being non-drastic, we can easily find that the welfare is higher under the discriminatory pricing regime (i.e., \( SW^D(k^D) - SW^U(k^U) > 0 \)). Accordingly, we can then establish the following proposition:

**Proposition 3.** With technology licensing from an outside innovator, third-degree price discrimination in an upstream market necessarily increases the total output of the final good and improves social welfare.

Katz (1987), DeGraba (1990), and Yoshida (2000) all show that the total outputs are the same under the two pricing regimes, but social welfare is definitely lower under price discrimination. However, we have shown that both the total output and the social welfare are higher under price discrimination once technology licensing is introduced into the model.

6. **Conclusions**

In this paper, we have examined the welfare effects of third-degree price discrimination in an input market in the presence of technology licensing. If the
upstream monopolist adopts a uniform pricing strategy, the innovator can force the upstream monopolist to lower its input price by issuing fewer licenses. However, this is not the case when the upstream monopolist adopts a discriminatory pricing strategy. Katz (1987) and DeGraba (1990) have shown that third-degree price discrimination by an upstream monopolist is welfare-deteriorating as the upstream monopolist tends to charge more (less) efficient firms a higher (lower) input price which distorts the production efficiency. By contrast, we have shown that with technology licensing from an outside innovator, the innovator tends to issue more licenses to downstream firms which improves overall production efficiency and leads to higher social welfare under discriminatory pricing than under uniform pricing.

References


**Appendix**

This appendix shows that the welfare under discriminatory pricing is larger than that
under uniform pricing if the innovation is non-drastic.

By substituting \( k^D \) and \( k^U \) from (5) and (10) into (16), we can derive the welfare difference as follows:

\[
SW^D(k^D) - SW^U(k^U) = \frac{\varepsilon^2}{128(1+n)(1+2n^2)} \left\{ 4n(11+29n+16n^2)\left[\left(\frac{a-c}{\varepsilon}\right)^2 + \right] + 8n(5+14n+9n^2)\left[\left(\frac{a-c}{\varepsilon}\right) + \right] \right. \\
\left. (4+21n+7n^2-88n^3-128n^4-48n^5) \right\}
\]

which is strictly positive if \( \frac{a-c}{\varepsilon} \geq n \). By the assumption of non-drastic innovation, the output of each non-licensee firm under uniform pricing should be positive, i.e., \( y^U(k^U) > 0 \). By substituting (5) into (3), we have:

\[
y^U(k^U) = \frac{\varepsilon}{4(1+n)} \left[ \frac{(a-c)}{\varepsilon} - n - \frac{(1+4n)}{2n} \right] > 0,
\]

which implies \( \frac{a-c}{\varepsilon} \geq n \).