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# Entry in a vertically separated industry: price vs. quantity competition[*]

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**Key Words:** Market entry, Price competition, Quantity competition, Welfare

**JEL Classification:** D43, L13, O34

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**Entry in a vertically separated industry: price vs. quantity competition**

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## 1. Introduction

Seade (1980) has suggested that entry of a firm reduces profit of the incumbent firm. This conclusion is based on the assumption that the marginal cost of the incumbent is not affected by entry. We show that entry may increase profit of the incumbent firm if entry affects the marginal cost of production. We find that if the input market is imperfectly competitive, entry in the final goods market reduces input price and increases optimal profit of the incumbent if the technology of the entrant is sufficiently inferior to that of the incumbent. This holds under both quantity and price competition.

Another related and interesting issue is to see how different types of competition (i.e., quantity competition and price competition) in the final goods market affect the outcomes under entry. More specifically, whether profits and social welfare are higher under quantity competition or price competition in the final goods market under entry. We show that optimal profit of the incumbent firm in the final goods market may be higher under entry with price competition than under entry with quantity competition. Industry profit under entry is also higher under price competition than quantity competition. These results are in sharp contrast to the previous research showing higher profits under quantity competition compared to price competition (see, e.g., Singh and Vives, 1984). Though imperfect competition in the input market alters several results on profits, we find that welfare always increases with entry and it is highest under entry with price competition. So, consumer surplus and, profit of the incumbent and the industry profit may be higher under a more competitive final goods market. Hence, this paper complements the recent work by López and Naylor (2004). While López and Naylor (2004) show the importance of the upstream agents' preferences and bargaining power between the upstream and the downstream agents, we show the importance of technological asymmetries between the downstream firms.

Empirical evidence shows that, like final goods market, the input markets are often characterized by imperfect competition. As demonstrated by Tyagi (1999), the market for microprocessors, aircraft-engines, packaged products and many others are characterized by oligopolistic competition. If the input markets are imperfectly competitive, this paper shows that entry in the final goods market has important strategic implications on market outcome and also on social welfare.

The present paper is related to Tyagi (1999), which also shows that entry in the final goods market may increase profit of the incumbent firm. While Tyagi (1999) shows the importance of the shape of the market demand curve, our focus is on the technological asymmetries between the firms.[1] Unlike Tyagi (1999), we also consider the effects of different types of product market competition (i.e., price and quantity

[1] Tyagi (1999) has found that entry always reduces profit of the incumbent for the demand function considered in this paper.

competition) in our analysis. We further show that input prices are 'invariant' to the number of final goods producers when they produce with the similar technologies, but input prices depend on the market structure of the final goods if there are technological asymmetries between the final goods producers.

We find that entry in the final goods market increases welfare for all feasible marginal cost differences between the incumbent and the entrant. This result supports competition policy that encourages entry in the final goods market. This is also in sharp contrast to Klemperer (1988) and Lahiri and Ono (1988), where entry reduces welfare if the entrant's marginal cost is sufficiently higher to that of the incumbent.

The remainder of the paper is organized as follows. Sections 2 and 3 consider the effects of entry for quantity competition and price competition respectively. Section 4 compares the situations under price and quantity competition under entry. Section 5 provides concluding remarks.

## 2. The case of quantity competition

Let us consider an economy with upstream and downstream markets. Assume that there is a monopolist in the upstream market supplying input to the downstream market. We assume that the upstream monopolist faces constant average cost of production, which is, for simplicity, assumed to be zero. The upstream monopolist charges a linear price, $w$, for its input.[2]

[2] Linear pricing for input considered here is similar to the assumption made in the literature on 'marketing', (e.g., Gerstner and Hess, 1995, Tyagi, 1999 and Rao and Srinivasan, 2001) and 'access pricing' (e.g., Armstrong et al., 1996, Armstrong and Vickers, 1998 and De Fraja and Price, 1999) among many others. If the demand and cost conditions of the upstream and the downstream firms vary over time, uniform pricing of input is optimal if significant costs are involved in re-writing the contracts between the upstream and downstream firms. So, like the above-mentioned literature, we consider that due to information asymmetries or other factors outside of this model, the upstream firm is compelled to charge linear price and cannot extract full surplus from the downstream firms.

Firms in the downstream market take the input prices as given while making their production decisions. For simplicity, we assume that the downstream firms need only this input to produce the final goods. We further assume that there are no other costs associated with final goods production.

To focus on the effect of entry in the final goods market, we consider following situations: (i) when there is a monopolist in the downstream market, and (ii) when the downstream market is duopoly. The inverse market demand for the final product is given by

$$P = a - q \, , \tag{1}$$

where the notations have usual meanings.

*2.1 Monopoly in the downstream market*

Let us consider a monopolist downstream firm, called incumbent, who needs one unit of input to produce one unit of output. We consider the following game. In stage 1, the upstream input supplier sets the price for its inputs. In stage 2, the incumbent chooses its output and the profits are realized. We solve the game through backward induction.

Given the input price $w$, optimal output of the incumbent and hence, input demand is

$$q_I = \frac{(a - w)}{2} \, . \tag{2}$$

The upstream monopolist maximizes following expression to determine the input price:[3]

[3] The upstream input supplier may also be considered as a monopolist union, who sets wage to maximize union rents.

$$\underset{w}{\text{Max}}\, \frac{w(a-w)}{2}. \tag{3}$$

Maximizing (3), we get the optimal input price as $\frac{a}{2}$. Hence, total input demand (which is also equal to total output of the incumbent) and optimal profit of the incumbent are $\frac{a}{4}$ and $\frac{a^2}{16}$ respectively.

Therefore, social welfare, which is the summation of consumer surplus and total profits of the upstream and downstream firms, is

$$W_{ne} = \frac{7a^2}{32}. \tag{4}$$

*2.2 Duopoly in the downstream market*

Let us now consider entry of a new firm, called entrant, in the downstream market. We assume that the entrant needs $\lambda$ units of input to produce one unit of output, where $\lambda > 1$.

Consider the following game. In stage 1, the upstream input supplier sets uniform price[4] for inputs.[5] In stage 2, the downstream firms produce homogeneous products simultaneously, i.e., the downstream firms compete like homogeneous Cournot duopolists. We solve the game through backward induction.

Given the input price, the incumbent and the entrant produce respectively

$$q_i^* = \frac{(a-2w+\lambda w)}{3} \quad \text{and} \quad q_e^* = \frac{(a-2\lambda w+w)}{3}. \tag{5}$$

[4] We assume away price discrimination by the upstream firm. This is reasonable with the possibility of arbitrage between the downstream firms. Often government policies (e.g., Robinson – Patman Act of the US) also prevent price discrimination for its anticompetitive nature (Viscusi et al., 2000).

[5] If we view the upstream agent as the rent maximizing union, this situation is consistent where the union sets an industry-wide wage rate to maximize its rent.

It is important to note that output of the entrant is zero for $w \geq \frac{a}{(2\lambda - 1)}$. Hence, total input demand is

$$q_I = q_i^* + \lambda q_e^* = \frac{(a(1+\lambda) - 2w(1+\lambda^2) + 2\lambda w)}{3}, \qquad \text{for } w \leq \frac{a}{(2\lambda - 1)} \tag{6}$$

and

$$q_I = q_i^* = \frac{(a-w)}{2}, \qquad \text{for } w \geq \frac{a}{(2\lambda - 1)}. \tag{7}$$

It is clear from (7) that there is no input demand for $w > a$.

### *2.2.1 Input prices and profits*

Given the input demand functions under entry, it is easy to understand that whether the upstream firm supplies for both downstream firms (i.e., the corresponding input price is less than $\frac{a}{(2\lambda - 1)}$) or only for the technologically efficient downstream firm (i.e., the corresponding input price is higher than $\frac{a}{(2\lambda - 1)}$) is also a decision of the upstream monopolist. We show in the *appendix* that the upstream monopolist supplies for both downstream firms if $\lambda$ is less than $2$. In the following analysis we assume $\lambda \in [1, 2)$, since, otherwise, entry does not have any real impact on our analysis.

The upstream firm maximizes following expression to determine the input price:

$$\operatorname*{Max}_{w} \frac{w(a(1+\lambda) - 2w(1+\lambda^2) + 2\lambda w)}{3}. \tag{8}$$

Maximizing (8) we get the optimal input price as $\frac{a(1+\lambda)}{(4+4\lambda^2-4\lambda)}$, which is less than $\frac{a}{(2\lambda-1)}$ for $\lambda \in [1,2)$.

**Proposition 1:** *If* $\lambda \in (1,2)$, *entry in the downstream market under quantity competition reduces price of the input.*

**Proof:** In case of entry and no entry, input prices are $\frac{a(1+\lambda)}{(4+4\lambda^2-4\lambda)}$ and $\frac{a}{2}$ respectively. Comparison of these prices proves the result. Q.E.D.

If the entrant and the incumbent in the downstream market have same technology of production, i.e., $\lambda = 1$, input price remains same under entry and no entry, which confirms the previous results of Greenhut and Ohta (1976) and Tyagi (1999). However, this result does not hold when the incumbent and entrant have different production technologies.

We find that given the optimal input price under entry, total input demand and profit of the incumbent are $\frac{a(1+\lambda)}{6}$ and $\frac{a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2}$ respectively.

**Proposition 2:** *If the technology of the entrant is sufficiently inferior to that of the incumbent, i.e.,* $\lambda \in (\lambda^*,2)$, *where* $\lambda^* \in (1,2)$, *entry in the downstream market increases profit of the incumbent.*

**Proof:** Profits of the incumbent under entry and no entry are $\frac{a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2}$ and $\frac{a^2}{16}$ respectively. We get $\frac{a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2} \gtreqless \frac{a^2}{16}$ if and only if

$$0 \gtreqless 1-2\lambda^2+2\lambda. \tag{9}$$

Right hand side (RHS) of (9) is positive at $\lambda = 1$ but negative at $\lambda = 2$. Further, RHS of (9) is continuous and decreases with $\lambda$ over $[1,2]$. This implies that there exists $\lambda$ between $[1,2]$, say $\lambda^*$, such that $\forall \lambda \in (\lambda^*, 2)$, RHS of (9) is negative. This proves the result. Q.E.D.

Intuition for the above result is the following. Entry in the final goods market makes the input demand curve more elastic and reduces input price. The downstream incumbent benefits from this lower input price. Entry also creates competition in the downstream market, which reduces profit of the incumbent for a given input price. If the technologies of the incumbent and the entrant are similar (i.e., $\lambda$ is low), the effect of competition dominates the effect of lower input price. In this situation, entry reduces profit of the incumbent. But, if the technology of the entrant is sufficiently inferior to that of the incumbent, the incumbent's benefit from lower input price is higher compared to its loss from competition due to entry. So, entry increases profit of the incumbent if the technology of the entrant is sufficiently inferior to that of the incumbent.

An interesting implication of the above proposition is that the incumbent firm may not have the incentive to either deter entry in the final goods market or to merge with the entrant.[6] So, this result complements Salant et al. (1983), which shows the possibility of non-profitable horizontal merger in oligopolistic markets. Unlike Salant et al. (1983), we find non-profitable merger in a duopolistic final goods market.

It is also easy to check that entry increases profit of the upstream firm when $\lambda \in (\lambda^*, 2)$. Hence, the above result also implies that entry not only increases profit of the incumbent under certain condition, it may also increase both total profit of the final goods producers and the industry profit, which is the summation of the profits of the downstream and the upstream firms.

*2.3 Welfare effects of entry*

We have considered the effect of entry on input price and profit. Now, we consider the effect of entry on social welfare.

It is straightforward to see that entry in the final goods market makes consumers and all firms better off and increases social welfare if $\lambda \in (\lambda^*, 2)$. Entry provides positive profit to the entrant and also increases profits of the incumbent and the upstream firm when $\lambda \in (\lambda^*, 2)$. Further, total final goods production under entry, which is $\frac{a(7 + 7\lambda^2 - 10\lambda)}{12(1 + \lambda^2 - \lambda)}$, is higher compared to that of under no entry, which is $\frac{a}{4}$. Hence, entry also makes the consumers better off.

Now, consider the situation where $\lambda \in (1, \lambda^*)$. In this situation, entry makes the upstream firm, the entrant and consumers better off while it reduces profit of the incumbent and therefore, it is not straightforward whether entry increases welfare. In general (i.e., for $\lambda \in (1,2)$), under entry, total output of the downstream firms is

[6] Naylor (2002) has also similar implication in a different context.

$\frac{a(7+7\lambda^2-10\lambda)}{12(1+\lambda^2-\lambda)}$ and profits of the upstream firm, the downstream incumbent and the entrant are respectively $\frac{a^2(1+\lambda)^2}{24(1+\lambda^2-\lambda)}$, $\frac{a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2}$ and $\frac{a^2(5+2\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2}$.

So, welfare under entry is

$$W_e^c = \frac{a^2(5+2\lambda^2-5\lambda)^2 + a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2} + \frac{a^2(1+\lambda)^2}{24(1+\lambda^2-\lambda)} + \frac{a^2(7+7\lambda^2-10\lambda)^2}{288(1+\lambda^2-\lambda)^2}. \tag{10}$$

We subtract (4) from (10) and plot this difference in Figure 1[7].

**Figure 1**

Figure 1 describes the following result.

**Proposition 3:** W*elfare is higher under entry compared to no entry for any* $\lambda \in [1,2)$.

Entry in the downstream market has three effects on welfare. First, entry increases competition in the downstream market and has a positive effect on welfare. Second, entry shifts production from the incumbent to the entrant. So, given the input price, entry reduces market share of the incumbent. If the entrant has inferior technology compared to the incumbent, entry creates production inefficiency by shifting production from the incumbent to the entrant. This production inefficiency under entry generates negative impact on welfare. However, entry, by affecting the input demand function, creates another effect on welfare. Input demand function becomes more elastic under entry and reduces optimal input price, which creates a positive effect on welfare because of a reduction in the marginal cost of production of the downstream firms. On the balance, the positive effects of more elastic input demand function and higher competition outweigh the negative effect of production inefficiency created by entry and thus, entry always increases social welfare.

In our analysis we restrict $\lambda$ to be greater than or equal to 1. If $\lambda < 1$, it implies that the entrant is technologically superior compared to the incumbent. In this situation, entry creates production efficiency by shifting output from the technologically inefficient incumbent to the technologically efficient entrant. So, when $\lambda < 1$, all the above-mentioned effects of entry have positive impacts on welfare and therefore, entry always increases welfare.

## 3. The case of price competition

Now, let us find out how the results of the previous section will be influenced if the product market is characterized by price (or Bertrand) competition. If there is monopoly in the final goods market, the equilibrium values are the same as shown in subsection 2.1. However, the analysis under price competition is different from quantity competition when there is entry in the downstream market.

*3.1 Input demand under entry*

In case of entry, we consider a game similar to subsection 2.2, except here the downstream firms choose prices instead of quantities. In stage 1, the upstream input supplier sets uniform price for the inputs. In stage 2, the downstream firms choose prices simultaneously for their homogeneous products, i.e., downstream firms compete like homogeneous Bertrand duopolists. We solve the game through backward induction.

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[7] We use 'The Mathematica 4.2' (see Wolfram, 1999) for the Figures of this paper.

If there is entry in the downstream market and the entrant needs $\lambda > 1$ units of input to produce one unit of output then, given the input price $w$, marginal cost of production of the entrant is $\lambda w$. So, the incumbent, who needs one unit of input to produce one unit of output, charges $\lambda w$ as the price for its product.[8] So, the input demand is

$$q_I = a - \lambda w. \tag{11}$$

*3.2 Input prices and profits*

The upstream firm maximizes following expression to determine the input price:

$$\underset{w}{Max}\, w(a - \lambda w). \tag{12}$$

Optimal input price is $w = \frac{a}{2\lambda}$.[9] So, total input supply (which is equal to the total final goods production) is $\frac{a}{2}$ and profit of the incumbent is $\frac{a^2(\lambda - 1)}{4\lambda}$.

Therefore, like quantity competition, input prices are different (the same) under entry and no entry when the technologies of the downstream firms are different (the same). So, the 'invariant' result of Greenhut and Ohta (1976) and Tyagi (1999) holds under price competition when the incumbent and the entrant has similar technology.

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[8] We assume that given the input price, monopoly price for the final good is greater than $\lambda w$. This happens if $\frac{a}{(2\lambda - 1)} > w$.

[9] Note that $\frac{a}{(2\lambda - 1)} > \frac{a}{2\lambda}$. It is also easy to check that the upstream firm has no incentive to charge $\frac{a}{(2\lambda - 1)}$ so that the incumbent can charge its monopoly price in the final goods market.

**Proposition 4:** *Under price competition, entry reduces price of the input for all* $\lambda \in (1,2)$.

**Proof:** In case of entry and no entry, input prices are $\frac{a}{2\lambda}$ and $\frac{a}{2}$ respectively. Comparison of these values proves the result. Q.E.D.

Intuition for the above result is similar to that of Proposition 1. Now, we see how entry affects profit of the incumbent firm.

**Proposition 5:** *Entry in the final goods market increases (reduces) profit of the incumbent if and only if* $\lambda \in (\frac{4}{3},2)$ *(*$\lambda \in (1,\frac{4}{3})$*).*

**Proof:** Profits of the incumbent under entry and no entry are $\frac{a^2(\lambda-1)}{4\lambda}$ and $\frac{a^2}{16}$ respectively. We get $\frac{a^2(\lambda-1)}{4\lambda} \underset{<}{\geq} \frac{a^2}{16}$ if and only if

$$\lambda \underset{<}{\geq} \frac{4}{3}, \tag{13}$$

which proves the result. Q.E.D.

We find that incumbent may earn higher profit under entry compared to no entry even under price competition. Hence, the final goods producers do not have the incentive to merge even under price competition when $\lambda \in (\frac{4}{3},2)$. Since, entry also increases profit of the upstream firm, it also follows from the above proposition that entry can increase total profit of the final goods producers as well as the industry profit.

### *3.3 Welfare effects of entry*

If there is price competition in the final goods market, welfare under entry is

$$W_e^b = \frac{a^2(\lambda - 1)}{4\lambda} + \frac{a^2}{4\lambda} + \frac{a^2}{8}. \tag{14}$$

**Proposition 6:** W*elfare is higher under entry compared to no entry for any* $\lambda \in [1,2)$.

**Proof:** Comparison of (4) and (14) proves the result. Q.E.D.

## 4. Comparison of price and quantity competition under entry

So far, we have considered the effects of entry under different types of product market competition. Now, we compare the outcomes under price and quantity competition under entry. That is, we want to see the implications of different types of competition in the final goods market under entry.

**Proposition 7:** *Under entry, price of the input is lower under price competition compared to quantity competition for all* $\lambda \in (1,2)$.

**Proof:** In case of entry, input prices under quantity competition and price competition are respectively $\frac{a(1+\lambda)}{(4+4\lambda^2-4\lambda)}$ and $\frac{a}{2\lambda}$. Comparison of these input prices shows that input price is lower under price competition compared to quantity competition if and only if

$$0 < 3\lambda - \lambda^2 - 2. \tag{15}$$

RHS of (15) is equal to $0$ at $\lambda = 1$ and $\lambda = 2$, and it is continuous, quadratic and concave with respect to $\lambda$ over $[1,2]$. This implies that condition (15) holds for all $\lambda \in (1,2)$. Q.E.D.

The above result along with Propositions 1 and 4 shows that input price is lowest under 'entry with price competition' compared to 'entry with quantity competition' and 'no entry'. Now, we see the impact of entry on the incumbent's profit under quantity competition and price competition in the final goods market.

**Proposition 8:** *In case of entry, profit of the incumbent is higher under price competition compared to quantity competition when the technology of the entrant is sufficiently inferior to that of the incumbent.*

**Proof:** In case of entry, profits of the incumbent under quantity competition and price competition are respectively $\frac{a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2}$ and $\frac{a^2(\lambda-1)}{4\lambda}$.

Profit of the incumbent is higher under price competition compared to quantity competition if and only if

$$\frac{(\lambda-1)}{\lambda} - \frac{(2+5\lambda^2-5\lambda)^2}{36(1+\lambda^2-\lambda)^2} > 0\,. \tag{16}$$

We plot the LHS of (16) in Figure 2 and inspection of Figure 2 proves the result.

**Figure 2**

Q.E.D.

The above result along with Propositions 2 and 5 implies that the incumbent earns higher profit under 'entry with price competition' compared to 'entry with quantity competition' and 'no entry' when the technology of the entrant is sufficiently inferior to that of the entrant. Prices of the input and the final goods are lowest under price competition. Further, in case of price competition, only the incumbent firm supplies the final goods. While the effects of lower input price and higher market share tend to increase profit of the incumbent, fierce competition under price competition tends to reduce profit of the incumbent. If the technology of the entrant is sufficiently inferior to that of the incumbent, the effect of competition in the final goods market is sufficiently small. In this situation, the benefits of lower input price and higher market share dominate the effect of competition and the incumbent earns higher profit under price competition.[10]

The above result shows that profit of the incumbent is higher under price competition but it is trivial that profit of the entrant is higher under quantity competition since the entrant gets positive profit under quantity competition and zero profit under price competition. In case of entry, total profits of the final gods producers under price competition and quantity competition are respectively

$$\pi_{d,e}^{c} = \frac{a^2(5+2\lambda^2-5\lambda)^2 + a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2} + \frac{a^2(1+\lambda)^2}{24(1+\lambda^2-\lambda)} \tag{17}$$

and

$$\pi_{d,e}^{b} = \frac{a^2(\lambda-1)}{4\lambda} + \frac{a^2}{4\lambda}. \tag{18}$$

We subtract (18) from (17) and plot the difference in Figure 3.

**Figure 3**

Figure 3 gives the following result.

[10] In different situations, Zanchettin (2003) and López and Naylor (2004) also find that profit of a firm may be higher under price competition compared to quantity competition. However, our result also shows that profit of the incumbent can be higher under entry with price competition compared to no entry, which is monopoly.

**Proposition 9:** *In case of entry, total profit of the final goods producers is higher under price competition than quantity competition for sufficiently higher values of* $\lambda$.

We find that, in case of entry, profit of the incumbent as well as total profit of the final goods producers is higher under price competition for higher values of $\lambda$. We also find that upstream firm earns higher profit under price competition for all $\lambda \in [1,2]$. It immediately implies that industry profit is higher under price competition for higher values of $\lambda$. However, it is not clear whether industry profit is also higher under price competition for lower values of $\lambda$.

Industry profits under quantity and price competition are respectively

$$\pi_e^c = \frac{a^2(5+2\lambda^2-5\lambda)^2 + a^2(2+5\lambda^2-5\lambda)^2}{9(4+4\lambda^2-4\lambda)^2} + \frac{a^2(1+\lambda)^2}{24(1+\lambda^2-\lambda)} \tag{19}$$

and

$$\pi_e^b = \frac{a^2(\lambda-1)}{4\lambda} + \frac{a^2}{4\lambda}, \tag{20}$$

for $\lambda \in [1,2)$. We subtract (20) from (19) and plot the difference in Figure 4.

**Figure 4**

Figure 4 gives the following result.

**Proposition 10:** *In case of entry, industry profit is higher under price competition compared to quantity competition for all* $\lambda \in [1,2)$.

Propositions 8 – 10 compare profits under price and quantity competition in case of entry and show that profit of the incumbent and the industry profit may be higher under a more competitive final goods market.

Now, we see the effects of different types of competition in the final goods market on social welfare. In case of entry, difference in social welfare under quantity competition and price competition can be found by subtracting (14) from (10), which has been plotted in Figure 5.

**Figure 5**

Figure 5 describes the following result.

**Proposition 11:** *In case of entry, welfare is higher under price competition compared to quantity competition for all* $\lambda \in [1,2)$.

Though the results on profitability show that profit of the incumbent and the industry profit may be higher under price competition compared to quantity competition, welfare analysis shows that it is always higher under price competition. So, there may not be conflict of interests between the consumers and firms when the input market is imperfectly competitive.

## 5. Concluding remarks

We show the effect of entry on profit and welfare in a vertically separated industry where the upstream firm has market power. We show that entry in the final goods market may increase profit of the downstream incumbent firm if the entrant has sufficiently inferior technology compared to the incumbent. This holds for both quantity and price competition. We also show that if the technology of the entrant is sufficiently inferior to that of the incumbent, profit of the incumbent is highest under ‘entry with price competition’ compared to ‘entry with quantity competition’ and ‘no entry’. Under entry, industry profit is also higher under price competition compared to quantity competition. We also show that entry always increases social welfare compared to no entry and welfare is highest under ‘entry with price competition’ compared to ‘entry with quantity competition’ and ‘no entry’.

Our analysis suggests that incumbent firms may not have the incentive to either deter entry in the final goods market or to merge with the entrant. Further, higher welfare under entry supports competition polices those are designed to attract entry in the final goods market.

Our analysis has similar caveats of the previous research in this area (Tyagi, 1999). We have abstracted our analysis from vertical integration. If feasible, the upstream firm could integrate with a downstream firm and create monopoly in the industry. However, there are reasons for not observing vertical integration always, such as, higher costs involved in vertical integration (Hart and Tirole, 1990). Vertical integration may also create market foreclosure, which is a serious concern to the policy makers (Viscusi et al., 2000). Hence, our analysis is consistent with the situations where vertical integration is not possible due to higher costs of vertical integration, government laws or some other reasons outside of this model. The concern about vertical integration may also be less worrying if the upstream agent is a labor union.

It is also worth mentioning that if the upstream firm could employ two-part tariff effectively to extract all profit from the downstream firm, it could eliminate the problem of double marginalization and entry would have no effect in our analysis. So, our results may not carry over where the upstream firm could use vertical restraints. However, it may be less likely to observe vertical restraints if the upstream agent is a labor union.

Lastly, the assumption of uniform pricing by the upstream firm under entry also needs attention. Since, the upstream firm charges uniform price for inputs, it has to lower input price compared to no entry to accommodate technologically inefficient entrant in the downstream market. Hence, the incumbent firm benefits from lower input price under entry. If the upstream firm could discriminate price between the downstream firms, the incumbent firm could not get this benefit of lower input price under entry. So, our analysis is useful under those institutional frameworks, which prevents upstream firms to discriminate price between the downstream firms.

## Appendix

**Condition required for the upstream firm to produce for both downstream firms under quantity competition:**

Under entry, if the upstream firm wants to supply for the downstream incumbent firm only (i.e., effectively the downstream market becomes a monopoly), the input demand function is given by condition (7) of the main text. Then, ignoring the constraint given in (7), optimal input supply and corresponding input prices will be $\frac{a}{4}$ and $\frac{a}{2}$ respectively. However, $\frac{a}{2} \geq \frac{a}{(2\lambda - 1)}$ provided $\lambda \geq \frac{3}{2}$. So, if the upstream firm wants only the downstream incumbent firm to buy inputs, optimal input price will be $\frac{a}{2}$ for $\lambda \in [\frac{3}{2}, 2)$. So profit of the upstream firm is $\frac{a^2}{8}$ when $\lambda \in [\frac{3}{2}, 2)$.

Since, the input price $\frac{a}{2}$ is less than $\frac{a}{(2\lambda - 1)}$ when $\lambda \in [1, \frac{3}{2}]$, if the upstream firm wants only the downstream incumbent firm to buy inputs, optimal input price needs to be $\frac{a}{(2\lambda - 1)}$ for $\lambda \in [1, \frac{3}{2}]$. So, profit of the upstream firm is $\frac{a^2(\lambda - 1)}{(2\lambda - 1)^2}$ when $\lambda \in [1, \frac{3}{2}]$.

Comparison of the profit levels shows that $\frac{a^2(1+\lambda)^2}{6(4 + 4\lambda^2 - 4\lambda)}$ is greater than both $\frac{a^2(\lambda - 1)}{(2\lambda - 1)^2}$ and $\frac{a^2}{8}$ for $\lambda < 2$. So, the upstream firm will supply for both downstream firms when $\lambda \in [1, 2)$.

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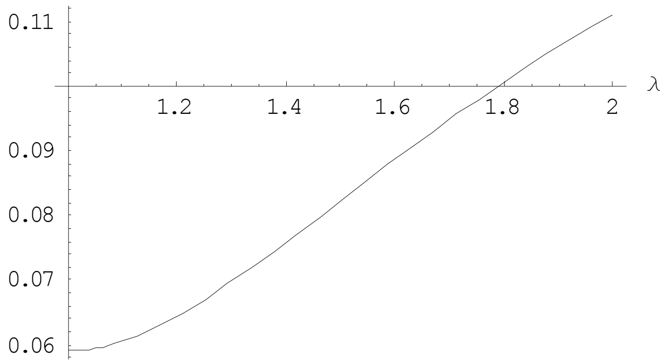


**Figure 1:** Subtracting (4) from (10).

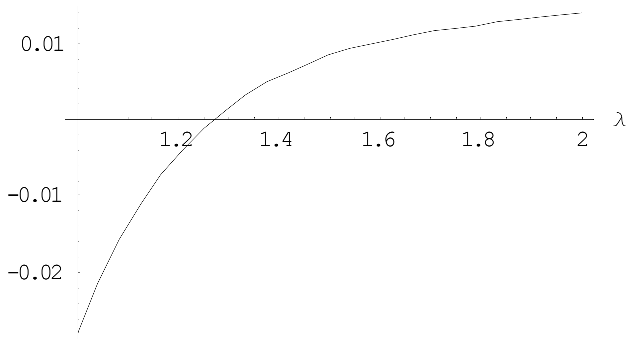


**Figure 2:** Left hand side of (16).

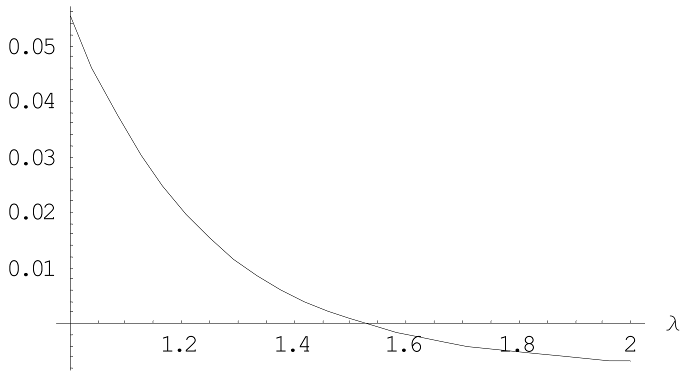


**Figure 3:** Subtracting (18) from (17).

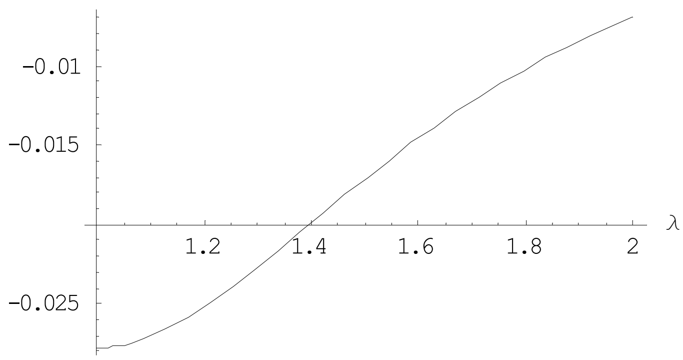


**Figure 4:** Subtracting (20) from (19).

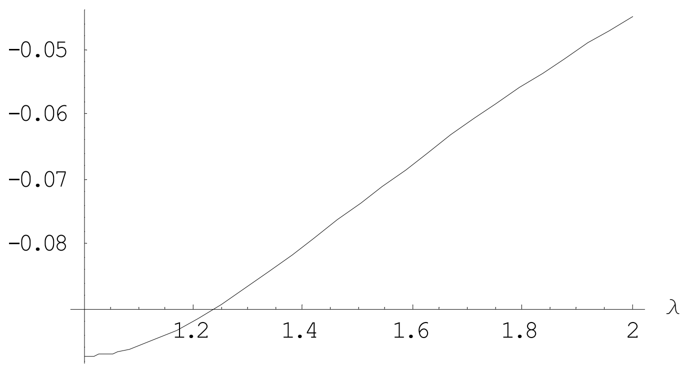


**Figure 5:** Subtracting (14) from (10).