Competition with Multi-services: Pickup or Delivery?

Yuta Yasui

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113-0033 Graduate School of Economics, the University of Tokyo, 7-3-1, Hongo, Bunkyo-ku, Tokyo, Phone: +81-3-3812-2111, E-mail: yasu.1127.econ@gmail.com

Abstract

In this paper, I examine competition with multi-services, where firms offer delivery prices *and* mill prices at the same time. In the equilibria, firms specialize in delivery services even if their transport costs are higher than consumers'. This result is robust in a monopoly setting as well and robust to the shape of transport cost functions.

Keywords: multi-services, menu pricing, delivery, oligopoly, linear city

JEL code: D43, L13, R32

1 Introduction

In some types of businesses, such as pizza restaurants, customers can choose whether to pick products up or to have them delivered to their homes. Even though this kind of consumer choice is ubiquitous throughout the world,[1] analysis of consumer choice considering pickup or

[1] Recently, convenience stores, supermarkets, and fast food restaurants have begun to deliver products with some additional fees in addition to selling at their stores. In furniture or electric appliance stores, delivery is also common (with or without additional fees).

delivery is limited. Only a few papers have analyzed it in the monopoly market. Furlong and Slotsve [1983] and Basu and Mazumdar [1995] explain why uniform delivery and discounts for pickup are offered at the same time in monopoly models; Basu et al. [2004] generalize it to N-zone menu pricing, where a consumer's fee is determined according to the zone s/he lives in. However, they do not deal with any competition. As to competition in a linear city with uniform delivery services, Kats and Thisse [1993] and Zhang and Sexton [2001] examine competitions in which firms can commit to uniform delivery or mill pricing, and Lederer [2011] examine a competition between a mail-order firm and local stores.[2] However, none of them allows multiple services by a single firm.

Another focus of this paper is the efficiency of transportation. Firms might offer free delivery services. It is seemingly beneficial for consumers to save their foot cost, but it might be better for consumers to purchase at a lower mill price and spend their foot cost. Some might say that this is beneficial for consumers since firms are more efficient in their delivery service because of their sophisticated transportation systems. However, it is unclear when many stores are agglomerated in one place — for example, at the center of the city or at a shopping center. In this case, the foot cost to visit an additional store is quite low, and a free delivery service might be superfluous. Therefore, the relationship between who is delivering and who is more cost-efficient should be carefully examined.

In this paper, I examine a competition in which firms can offer both delivery prices and mill prices, where consumers choose the better one. The results show that firms end up specializing in delivery by setting the mill prices sufficiently high even if their transport cost is higher than consumers'. It is worth noting that the concavity or convexity of the transport cost, which is often crucial for results on geographic issues, does not matter in this paper.

[2] Thisse and Vives [1988] also examine a competition where each firm can commit to free on board pricing (which is equivalent to pickup) or delivery with full discriminatory pricing.

2 The model

2.1 Consumers, firms, and transport costs

In this paper, I consider a local market in which consumers are uniformly distributed over $[0, 1]$. Each consumer has a unit demand; if s/he consumes a product, s/he feels a certain level of utility, $\bar{u} > 0$, and 0 otherwise.

In the market, there are two firms (firm 1 and firm 2) which are located at 0 and 1, respectively. They can offer their own menu prices $p_i = (p_{is}, p_{id}) \in [0, \bar{u}]^2$ $(i = 1, 2)$ at the same time, where p_{is} is firm i's *mill price*, which is the price consumers pay at firm i's store, and p_{id} is firm i's *delivery price* which is uniform across the market. It costs c to produce one unit of the product. The fixed cost is assumed to be 0.

If a consumer located at $r \in [0, 1]$ chooses delivery by firm 1 (firm 2), then firm 1 (firm 2) bears the transport cost $t_f(r)$ $(t_f(1-r))$. On the other hand, if the same consumer chooses pickup, s/he bears the foot cost $t_c(r)$ $(t_c(1-r))$.

In addition to the above transport costs for each service, I assume psychological *waiting costs*, which consumers have to spend regardless of pickup or delivery.[3] When a consumer at $r \in [0, 1]$ purchases products from firm 1 (firm 2), s/he bears $w(r)$ $(w(1-r))$.[4] Suppose $t_c(0) = t_f(0) = w(0) = 0$ and $t'_c(r)$, $t'_f(r)$, $w'(r) > 0$ for any $r \in [0, 1]$.

Therefore, *full prices*, which are the total burden for each consumer, are $p_{1d} + w(r)$ $(p_{2d}+w(1-r))$ for delivery from firm 1 (firm 2) and $p_{1s}+t_c(r)+w(r)$ $(p_{2s}+t_c(1-r)+w(1-r))$ for pickup from firm 1 (firm 2).

[3] The waiting cost is introduced to avoid demand discontinuity in delivery competition and guarantee existence of the (pure strategy) equilibria. For this purpose, scale of waiting costs can be arbitrariry small. In a monopoly model with fixed utility $\bar{u}$ (in Section 3), we need not to assume the waiting cost, given that $\bar{u}$ is so high that delivery for any consumers is profitable for a monopolist. In Section 4, where we analyze a random utility model, the waiting cost is a key factor to determine monopolist's behavior.

[4] We can also interpret this cost w in the following way. Consider the case in which each consumer has to visit a store to choose products and then chooses whether to bring them back or to use the delivery service. In this case, w can be interpreted as the foot cost to visit the store.

2.2 Notations for profit functions

Based on the above assumptions, when all consumers in $[r_1, r_2] \subset [0, 1]$ choose the delivery service of firm i, firm i's profit from the delivery service is written as $\Pi_{Di}(r_1, r_2, p_{id}) = \int_{r_1}^{r_2} \pi_{Di}(r, p_{id})dr \;\; (i = 1, 2)$, where $\pi_{D1}(r, p_{1d}) = q\left(p_{1d} + w(r)\right)\left(p_{1d} - c - t_f(r)\right)$, $\pi_{D2}(r, p_{2d}) = q\left(p_{2d} + w(1-r)\right)\left(p_{2d} - c - t_f(1-r)\right)$, and q is the demand at each point which is a function of the full price. On the other hand, when the consumers in $[r_1, r_2] \subset [0, 1]$ choose pickup from firm i, firm i's profit from such consumers is written as $\Pi_{Pi}(r_1, r_2, p_{is}) = \int_{r_1}^{r_2} \pi_{Pi}(r, p_{is})dr \;\; (i = 1, 2)$, where $\pi_{P1}(r, p_{1s}) = q\left(p_{1s} + t_c(r) + w(r)\right)\left(p_{1s} - c\right)$ and $\pi_{P2}(r, p_{2s}) = q\left(p_{2d} + t_c(1-r) + w(1-r)\right)\left(p_{2d} - c\right)$.

Using these notations, the firms' total profit when each firm provides goods through both services is written as $\Pi_1(p_1, p_2) = \Pi_{P1}(0, x_1, p_{1s}) + \Pi_{D1}(x_1, z, p_{1d})$, and $\Pi_2(p_1, p_2) = \Pi_{P2}(x_2, 1, p_{2s}) + \Pi_{D2}(z, x_2, p_{2d})$, where x_1, x_2, and z are thresholds for pickup or delivery from firm 1, pickup or delivery from firm 2, and delivery from firm 1 or firm 2, respectively.

3 The results

3.1 Duopoly model

In this model, each firm can employ different types of strategies: to provide only delivery service (only at the store) by setting its mill price (delivery price) sufficiently high, or to make some consumers choose pickup and others choose delivery. However, it turns out that only a certain type of strategy can support the equilibria.

Proposition 1 If $t_c'(r)\,r > t_f(r) - t_c(r)$ for all $r \in (0, 1]$, each firm provides only delivery service.

Proof. See the Appendix.

For instance, if $t_c = t_f$, which means that all agents face identical transport costs, the condition of the proposition holds regardless of the shape of the transport cost, and firms then provide only delivery service. As another example, specify transport costs as $t_j(r) = \tau_j r^\alpha$, where $\tau_j > 0$ ($j = c,\ f$) and $\alpha > 0$. This class of function includes a large number of concave or convex functions, and the condition holds when $t_f < (\alpha+1)t_c$. Thus, firms will specialize in delivery even if $\frac{1}{\alpha+1}t_f < t_c < t_f$, which means that their transport costs are higher than consumers'.

Intuition for specializing in delivery is explained as follows. Suppose that firms are providing only delivery. If firms set p_{is} smaller than p_{id}, consumers close to each firm chose pickup. However, this is not profitable for firms since these consumers were already served by delivery and cost-saving effect by substitution from delivery to pickup is smaller than revenue-decreasing effect since such consumers are close to each firm (as long as $t'_c(r)\,r > t_f(r) - t_c(r)$ for all $r \in (0,\ 1]$).

3.2 Monopoly model

Since this incentive is not related to the other's pricing,[5] a similar result is expected also in the monopoly market. Assume a monopoly market in which there exists only firm 1 at 0, where all the other assumptions are the same as before. Redefine z as the threshold at which consumers are indifferent between purchasing products or not; the profit function is rewritten as follows: $\Pi_1(p_1) = \Pi_{P1}(0,\ z,\ p_{1s})$ if $p_1 \in P$, $\Pi_1(p_1) = \Pi_{D1}(0,\ z,\ p_{1d})$ if $p_1 \in D$, and $\Pi_1(p_1) = \Pi_{P1}(0,\ x_1,\ p_{1s}) + \Pi_{D1}(x_1,\ z,\ p_{1d})$ if $p_1 \in PD$, where P, D, and PD are the sets of actions resulting in only pickup, only delivery, and a combination of them, respectively. Here, the following proposition holds.

Proposition 2 The monopolist provides only delivery if $t'_c(r)\,r > t_f(r) - t_c(r)$ for all $r \in (0,\ 1]$.

[5] Firm 2's prices affect $\Pi_{D1}(x_1,\ z,\ p_{1d})$ only through z and does not affect $\Pi_{P1}(0,\ x_1,\ p_{1s})$, so the first order derivatives of firm 1's profit w.r.t. p_{1s} are identical among the duopoly model and the monopoly model.

Proof. See the Appendix.

Thus, inclination to delivery is also predicted in the monopoly model.

3.3 Welfare implications

Since all consumers have a unit demand, change in price cause just a transfer of surplus among firms and consumers, given length of served market. Given that $\bar{u}$ is sufficiently high, all consumers are served and only choice of pickup/delivery affects the social welfare. Then, the above propositions imply that firms will specialize in delivery even if mill price competition (or monopoly mill pricing) is welfare maximizing.[6] If $\bar{u}$ is low, there can be other source of inefficiency depending on other parameters. For instance, if w' is large, firm(s) give up to serve distant consumers and set high price for close consumers.

The intuition of this welfare implication is as follows. When a firm specializes in sales at the store, close consumers, who face low foot costs, will gain some surplus because the firm sets its mill price low in order to induce demand from distant consumers. On the other hand, when a firm specializes in delivery service, it can impose a high price since the firm compensates the consumer for the whole foot cost except for the waiting cost. Consumers close to the store also face this high price and gain only a slight surplus caused by their low waiting cost. Thus, firms can extract a larger consumer surplus by delivery than by sales at their stores.[7] Therefore, firms have a large incentive to specialize in delivery even if welfare

[6] As to distribution of surplus and pickup/delivery, given high $\bar{u}$, I have slight implication from the general specification. Delivery competition results in $p_{1d} = c + t_f(\frac{1}{2}) + w'(\frac{1}{2})$ (shown in proof of Lemma 2 in the Appendix) while mill price competition results in $p_{1s} = c + t'_c(\frac{1}{2}) + w'(\frac{1}{2})$. Then, a consumer at $\frac{1}{2}$ benefit from delivery competition if the condition of the above propositions holds. The reason is that slope of full prices at $\frac{1}{2}$ determines competitiveness at $\frac{1}{2}$. However, when the higher consumer surplus is achieved depends on specifications of t_c and t_f. (e.g., under linear specification, all consumers benefit from delivery competition, but it is not the case when t_c and t_f are strongly concave and $t'_c(\frac{1}{2})$ is almost zero.)

[7] Since more distant consumers can be considered to have less willingness to pay, uniform delivery, which compensates for all foot costs except for the waiting cost, is same as discriminating mill prices according to willingness to pay. This implies that delivery with full discriminatory (and zone pricing as its approximation) results in a similar price schedule to uniform delivery in the monopoly model with a unit demand,. Especially, in a case where w' is very small, discriminatory delivery price will be almost flat. Duopoly with full discriminatory pricing is examined by Thisse and Vives [1988]. Duopoly with zone pricing should be examined in the future research since roles of zone choice in the model with strategic interactions is not unraveled yet.

decreasing.

As to distribution of surplus and market structure, consumers benefit from competition given high $\bar{u}$. Duopoly price is $p_{id} = c + t_f(\frac{1}{2}) + w'(\frac{1}{2})$ $(i = 1, 2)$ (shown in proof of Lemma 2 in the Appendix) while the monopoly price is close to $\bar{u}$ and the monopolist absorbs almost of all social welfare by $p_{1d} = \bar{u} - w(1)$.

4 Discussion: Robustness of the Results

In the previous literature, Furlong and Slotsve [1983], Basu and Mazumdar [1995], Basu et al. [2004] showed that a monopolist firm can maximize its profit by combining pickup and delivery. However, in this article, I showed that firm can maximize its profit by providing only either services. This difference comes from difference in specifications of demand function. In this paper, each consumer has a unit demand. On the other hand, in the previous researches mentioned above, each consumer has a downward sloping demand function. Then, in contrast to this article, firms have incentive to set lower mill price to induce additional demand from close consumers. Here, I bridge contradicting two results by introducing a model which nests model of Furlong and Slotsve [1983] and this paper.

For this purpose, I confine my attention to a monopoly model with a linear transport cost. A firm is located at point 0, which costs $tr\,(t > 0)$ to deliver a good to a consumer at $r \in [0, 1]$. On the other hand, a consumer at $r \in [0, 1]$ bears waiting cost $wr\,(w > 0)$ for obtaining a good either by pickup or delivery, and pays foot cost tr if s/he chooses pickup. Here, I assume that each consumer's utility level from a good, u, is distributed independently identically with a uniform distribution $U\,(\underline{u}, \bar{u})$. Then, a case with linear demand functions is expressed by $\underline{u} = 0$ and a case with unit demand is described by $\underline{u} = \bar{u}$. Suppose that $(\bar{u} - \underline{u})$ is large and w is small (see Fig.1 in the Appendix). In this case, for any $p_{1d} \in (\underline{u}, \bar{u})$, by setting setting p_{1s} slightly smaller than p_{1d}, the firm can induce additional demand (increase total demand) and decrease its transport cost. The firm would balance such positive impacts on profit and negative an impact (i.e., small revenue from each customer) as shown by Furlong and Slotsve [1983]. Then, a combination of pickup and delivery would be used in this case. On the other hand, suppose that $(\bar{u} - \underline{u})$ is small and w is large (see Fig.2 in the Appendix). Then, the firm cannot increase total demand by setting p_{1s} slightly smaller than p_{1d}, and then, the same incentive as in Section 3 arises. Even though the firm can increase total demand by setting p_{1s} much smaller than p_{1d}, such pricing demolish its revenue. Therefore, only delivery would be used in this setting. Thus, neither of previous researches or this paper analyzes a peculiar model, but each of them captures two types of results in a general setting, by using tractable specifications.

5 Concluding remarks

In this paper, I analyzed a competition in which each firm can offer two prices, a mill price and a uniform delivery price, at the same time. As a result, firms specialize in delivery service in the equilibria even if they transport products less efficiently than consumers do. In addition, this result is robust to a monopoly market. These results are considered to be valid for markets in which all consumers benefit from a goods at a certain level.

In this paper, specialization in delivery service is also interpreted as free delivery (i.e., $p_{is} = p_{id}$). Considering the above results, a firm's offer of free delivery does not imply that it transports efficiently; it may be trying to absorb consumer surplus through uniform delivery.

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Appendix

A Proofs

In order to prove proposition 1, I simplify the discussion by showing that certain kinds of strategies cannot be the best response to any of the any opponent's strategies. The following lemma shows that any combination of delivery and sales at the store cannot be the best response. In other words, firms will specialize in either service if a certain condition holds. Here, I suppose that $\bar{u}$ is sufficiently high so that all consumers are served by either firms. If $\bar{u}$ is low and some consumers in the middle is not served by either firms, the market can be considered as two separate monopoly markets. Such a case is proved as Proposition 2.

Lemma 1 Suppose a firm provides both services at the same time. Then, the firm can increase its profit by increasing (decreasing) its mill price if $t_c'(r)\, r > t_f(r) - t_c(r)$ ($t_c'(r)\, r < t_f(r) - t_c(r)$) for all $r \in (0, 1]$.

Proof of lemma 1. Firm 1's first order derivative w.r.t. p_{1s} is written as follows:

$$\begin{aligned}
\frac{d\Pi_1(p_1, p_2)}{dp_{1s}} &= \{\pi_{P1}(x_1, p_{1s}) - \pi_{D1}(x_1, p_{1d})\} \frac{1}{t_c'(x)}(-1) + \frac{\partial \Pi_{P1}(0, x_1, p_{1s})}{\partial p_{1s}} \\
&= \{p_{1s} - p_{1d} + t_f(x_1)\} \frac{1}{t_c'(x_1)}(-1) + x_1 \\
&= \frac{t_c'(x_1)\, x_1 + t_c(x_1) - t_f(x_1)}{t_c'(x_1)}.
\end{aligned}$$

Since transport costs are assumed to be strictly increasing and I suppose that both services are used, that is, $x_1 \in (0, z) \subset (0, 1]$, the first order derivative w.r.t. p_{1s} is always positive (negative) if $t_c'(r)\, r > t_f(r) - t_c(r)$ ($t_c'(r)\, r < t_f(r) - t_c(r)$) for all $r \in (0, 1]$. The discussion for firm 2 is symmetric.■

Therefore, each firm has an incentive to increase or decrease its mill price to a level at which all its customers choose the same service. Then, firms will specialize in either service.

In addition, we can show a sufficient condition by which firms specialize in delivery service but not in-store sales. Let $BR_{Pi}(p_j)$ $(j \neq i)$ be the set of firm i's best responses among actions that result in only pickup service. Then, the following lemma holds.

Lemma 2 If $t_c'(r)\, r > t_f(r) - t_c(r)$ for any $r \in (0,\, 1]$, then $\forall i = 1,\, 2$, $\forall p_j \in [c,\, \bar{u}]^2$ $(j \neq i)$, firm i makes a larger profit by providing only delivery service than only in-store sales.

Proof of lemma 2. For any $(\hat{p}_{1s},\, \hat{p}_{1d}) \in BR_{P1}(p_2)$, denote by $\hat{z}$ the threshold of whether to purchase from firm 1 or from firm 2. Here, $\hat{z}$ is larger than 0 since firm 2's full prices at 0 must be larger than c and firm 1 can obtain a positive profit by offering a mill price that is slightly lower than firm 2's full prices at 0 and higher than c. Then, the profit for firm 1 is written as $\hat{\Pi}_{P1} = \hat{p}_{1s}\hat{z}$, and the full price at $\hat{z}$ is written as $\hat{p}_{1s} + t_c(\hat{z}) + w(\hat{z})$. Consider a deviation to only delivery service, maintaining the threshold. Then, the delivery price is set to hold $\hat{p}_{1d} + w(\hat{z}) = \hat{p}_{1s} + t_c(\hat{z}) + w(\hat{z}) \Leftrightarrow \hat{p}_{1d} = \hat{p}_{1s} + t_c(\hat{z})$. In this case, the profit for firm 1 is written as

$$\begin{aligned} \hat{\Pi}_{D1} &= \hat{p}_{1d}\hat{z} - \int_0^{\hat{z}} t_f(r)dr \\ &= \hat{\Pi}_{P1} + t_c(\hat{z})\hat{z} - \int_0^{\hat{z}} t_f(r)dr. \end{aligned}$$

If $t_c(\hat{z})\hat{z} - \int_0^{\hat{z}} t_f(r)dr = t_c(\hat{z})\hat{z} - \int_0^{\hat{z}} t_c(r)dr - \int_0^{\hat{z}} \{t_f(r) - t_c(r)\}\, dr > 0$, firm 1 is better off providing only delivery service. This inequality holds if $t_c'(r)\, r > t_f(r) - t_c(r)$ for all $r \in (0,\, 1]$. A symmetric discussion applies for firm 2. ■

Finally, by using lemmas 1 and 2, I can show proposition 1 in the following way.

Proof of proposition 1. By lemmas 1 and 2, if there exist any equilibria, they must be those with delivery services whenever $t_c'(r)\, r > t_f(r) - t_c(r)$ for all $r \in (0,\, 1]$. In fact, there exists a set of equilibria in which both firms provide only delivery services. When both firms provide goods only through delivery service, profits are written as $\Pi_1(p_1,\, p_2) =$

$\Pi_{D1}(0,\, z,\, p_{1d})$ and $\Pi_2(p_1,\, p_2) = \Pi_{D2}(z,\, 1,\, p_{2d})$. The threshold z is determined by the following equation: $w(z) - w(1-z) = p_{2d} - p_{1d}$. Since $\tilde{w}(z) \equiv w(z) - w(1-z)$ is strictly increasing in z, the threshold is determined as $z = \tilde{w}^{-1}(p_{2d} - p_{1d})$. Then, the first order conditions are as follows:

$$\begin{aligned} 0 = \frac{d\Pi_1(p_1,\, p_2)}{dp_{1d}} &= \frac{\partial \Pi_{D1}(0,\, z,\, p_{1d})}{\partial p_{1d}} + \frac{\partial \Pi_{D1}(0,\, z,\, p_{1d})}{\partial z}\frac{\partial z}{\partial p_{1d}} \\ \Leftrightarrow \frac{\partial \Pi_{D1}(0,\, z,\, p_{1d})}{\partial p_{1d}} &= \pi_{D1}(z,\, p_{1d})\frac{1}{\tilde{w}'(z)} \\ \Leftrightarrow z &= \frac{p_{1d} - c - t_f(z)}{\tilde{w}'(z)} \end{aligned} \tag{1}$$

$$\begin{aligned} 0 = \frac{d\Pi_2(p_1,\, p_2)}{dp_{2d}} &= \frac{\partial \Pi_{D2}(z,\, 1,\, p_{2d})}{\partial p_{2d}} + \frac{\partial \Pi_{D2}(z,\, 1,\, p_{2d})}{\partial z}\frac{\partial z}{\partial p_{2d}} \\ \Leftrightarrow \frac{\partial \Pi_{D2}(z,\, 1,\, p_{2d})}{\partial p_{2d}} &= \pi_{D2}(z,\, p_{2d})\frac{1}{\tilde{w}'(z)} \\ \Leftrightarrow 1 - z &= \frac{p_{2d} - c - t_f(1-z)}{\tilde{w}'(z)} \end{aligned} \tag{2}$$

By subtracting (1) from (2),

$$1 - 2z = \frac{\tilde{w}(z) - \{t_f(1-z) - t_f(z)\}}{\tilde{w}'(z)}.$$

Since the RHS is equalized to zero at $z = \frac{1}{2}$ and is positive (negative) for $z > \frac{1}{2}$ $(z < \frac{1}{2})$, $z = \frac{1}{2}$ is the unique root of the above equation. Therefore, $\{(p_1, p_2)\,|\forall i = 1, 2\ p_{id} = c + t_f(\frac{1}{2}) + w'(\frac{1}{2})$ and $p_{id} \leq p_{is} \leq \bar{u}\}$ is the set of the equilibria.■

In order to prove proposition 2, I can reduce the domain as in the proof of proposition 1. Replacing $\Pi_1(p_1,\, p_2)$ with $\Pi_1(p_1)$, Lemma 1 still holds in the monopoly model, and the following lemma is proved in an analogous way to lemma 2.

Lemma 2' If $t'_c(r)\, r > t_f(r) - t_c(r)$ for all $r \in (0,\, 1]$, then the firm makes a larger profit by providing only delivery service than only in-store sales.

Proof of lemma 2'. For any $(\hat{p}_{1s},\, \hat{p}_{1d}) \in \underset{p_1 \in P}{\arg\max} \Pi_1(p_1)$, denote by $\hat{z}$ the threshold of whether to purchase or not at this set of prices. Then, the profit for firm 1 is written as $\hat{\Pi}_{1s} = \hat{p}_{1s}\hat{z}$, and the same logic follows as in the proof of lemma 2.■

Then, I can prove proposition 2 analogously to proposition 1.

Proof of proposition 2. By lemmas 1 and 2', the profit is not maximized by providing both services at the same time or by providing only in-store sales if $t'_c(r)\, r > t_f(r) - t_c(r)$ for all $r \in (0,\, 1]$. Therefore, the profit maximizing strategy will be to provide only delivery service if the maximizer exists. In fact, there exist such maximizers since $D = \{p_{1s}, p_{1d} \mid p_d \leq p_s, \text{ and } 0 \leq p_{1s},\, p_{1d} \leq \bar{u}\}$ is a compact set and the profit function in this domain is continuous. ■

B Figures

Following figures show how monopolist revenue would change when a monopolist set its mill price p_{1s} smaller than delivery price p_{1d} in a model with random utility discussed in Section 4.

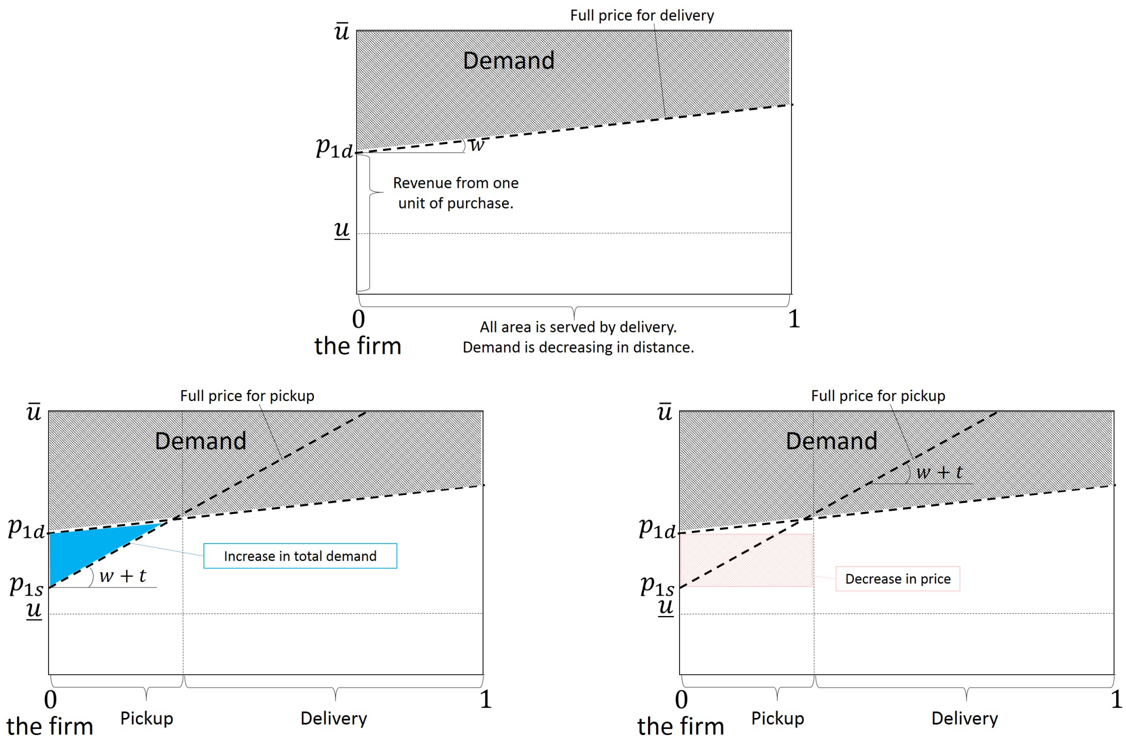

Figure 1: A case with small w and large $(\bar{u} - \underline{u})$. Upper: an example of demand when monopolist use only delivery. Lower left: Positive impact of low mill price on revenue. Lower right: Negative impact of low mill price on revenue.

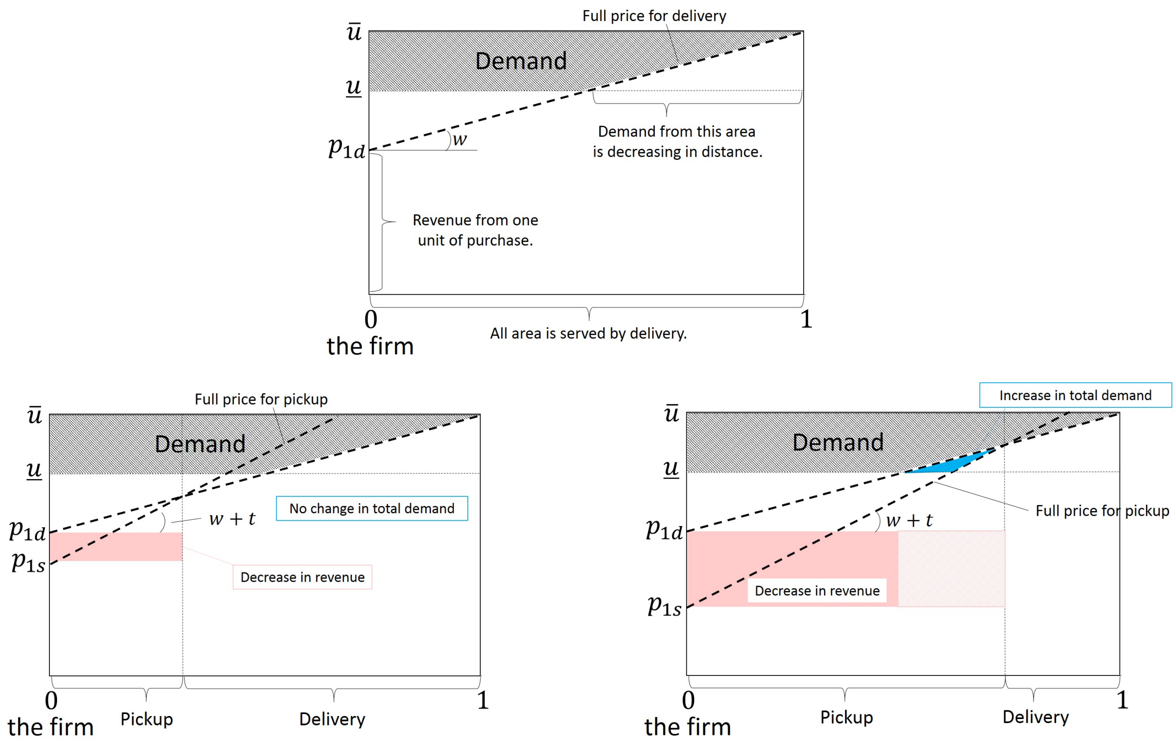

Figure 2: A case with large w and small $(\bar{u} - \underline{u})$. Upper: an example of demand when monopolist use only delivery. Lower left: A case where a monopolist set p_{1s} slightly lower than p_{1d}. Lower right: A case where a monpolist set p_{1s} much lower than p_{1d}.