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Low-Cost-Driven Leadership: A Theory for Price Dispersion in Competitive Markets

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Abstract

We consider markets where a large number of firms offer homogeneous products. Despite the competitive nature of these markets, there is extensive practical evidence for the price dispersion phenomenon, i.e., the homogeneous products are sold at different prices. We propose a new theory to explain this phenomenon. Our game-theoretical model indicates that the existence of price leadership driven by the low-cost advantage results in persistent and large price dispersion. Furthermore, we show that the market leader and all followers (with one exception) are able to make positive profits in such competitive markets, which explains the remarkable co-existence of a large number of firms in homogeneous-product markets. Finally, our results indicate that the leader has to lower her price as followers become more efficient in the interests of gaining higher profits, resulting in a wider range of prices and, thus, a larger degree of price dispersion.

Keywords: price dispersion, cost advantage, homogeneous-product market, competition

JEL classification: C72; D40.

1. Introduction

Price dispersion has long been observed in competitive markets. The strong and persistent phenomenon of firms charging different prices for essentially identical products has challenged theoretical researchers to provide a rationale. As online markets and e-tailers emerge and proliferate, one would expect that diminishing geographical boundaries and increasing levels of internet access would eventually eliminate price dispersion and help establish the law of one price in practice. However, online platforms have instead resulted in the phenomenon of online price dispersion (Baye and Morgan 2009).

This paper attempts to provide a theory to explain the high degree of price dispersion in competitive markets offering homogeneous products. In homogeneous-product markets, lower costs resulting from efficient operations can provide an industry player a remarkable advantage over others. In such markets, new

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technologies, global sourcing opportunities, innovative distribution channel strategies and any operational initiative that leads to higher levels of efficiency play a significant role in obtaining and retaining competitiveness.

We develop a game-theoretical framework where a price leader (hereafter, “she/her”) has a cost advantage over followers (hereafter, “he/they”), and investigate how a low (marginal) cost coupled with price leadership can impact equilibrium prices in homogeneous-product markets.

Our model indicates that regardless of the number of competitors, equilibrium prices feature large and stable price dispersion where all firms, with one exception, make strictly positive profits. Baye and Morgan (2009) provide a rationale for how a large number of firms can compete over price and yet make positive profit. This paper provides an alternative explanation for the presence of persistent and large price dispersion in such competitive markets. In addition, our model results in an equilibrium where prices are either high or low. This two-point distribution of prices, rather than a continuous range, seems to conform more to the real-world consumer perceptions that intermediate prices are rare and prices are typically either at a high or a low level (Varian, 1980).

Specifically, our model shows that the price leader utilizes her cost advantage to offer the lowest price to attract the segment of consumers who shop specifically for such a price. The followers, on the other hand, charge a high price and sell to their own loyal customers who do not put in the effort and time required to obtain information on market prices.

The dynamics of this competition provides a strong incentive for the followers to reduce their cost. We show that their cost-reduction efforts can cause the leader to reduce her price. Also, in our model, as expected in practice, higher levels of competition result in a lower price charged by the leader.

It is worth noting that our model does not rule out the possibility of temporal price dispersion resulting from promotional pricing and loss leadership among others. It intends to establish a rationale for the high degree of price dispersion that persists over time. In fact, a combination of the stable two-point price distribution and temporal sales suggests close similarities with the Everyday Low Price (EDLP) and Hi-Lo pricing policies commonly used in practice. The EDLP pricing strategy, which requires offering consumers consistently low prices over long periods of time, has been successfully implemented by Walmart. On the other hand, retailers such as Target and J.C. Penney have adopted the Hi-Lo pricing strategy (Loeb, 2017), which involves charging higher prices coupled with intermittent short-term promotions. This market environment features remarkable similarities to our model’s equilibrium, where a dominant player (e.g., Walmart) maintains a low level of prices over time, while the other market players set comparably higher base prices (which may be reduced temporarily during sales periods).

The rest of this paper is organized as follows: In Section 2, we review the relevant literature. In Section 3, we introduce our model. Section 4 contains the analysis of the model, and Section 5 provides some concluding remarks.

2. Literature Review

This paper studies the impact of low-cost-driven price leadership on the degree and the structure of price dispersion in a competitive market. For a long period of time, homogeneous products have been offered at different prices in several distinct business settings. The evidence for price dispersion has been so overwhelming that Varian (1980) stated that “the law of one price is no law at all.” Recently, several empirical studies confirm the deviation from the law of one price in a variety of competitive environments, including commodity markets (Froot et al., 2019), international trade (Elberg, 2016; Yilmazkuday, 2016), grocery retail (Wildenbeest, 2011), health care (Grennan and Swanson, 2019) and online markets (Baye and Morgan, 2009; De Los Santos, 2018; Dinerstein et al. 2018). Froot et al. (2019) analyze transaction prices in several commodity markets and find that deviations from the law of one price have been persistent in homogeneous-product markets over the past seven centuries. Wildenbeest (2011) shows that some grocery retailers charge higher prices than others and finds that most of the observed price dispersion in grocery items may be explained by the firm heterogeneity rather than by search frictions. Our study proposes a theory providing a rationale for persistent price dispersion based on the heterogeneity in the marginal costs of retailers.

An interesting feature of the price-dispersion phenomenon observed in practice is that a dominant market player offers products at significantly lower prices than do other competitors. For example, De Los Santos and Wildenbeest (2017) examine e-book pricing and observe that Amazon charges the lowest prices in the online e-book market. Walmart, on the other hand, is well known for its everyday low prices on a wide variety of consumer goods, made possible by low operational costs. Our results are consistent with these real-world observations since the price leader in our model sets a price that is considerably lower than those of her competitors. As such, our analysis indicates stable and large price dispersion among industry players.

Since the pioneering work of Stigler (1961), many scholars have developed game-theoretical models to explain the price-dispersion phenomenon observed in homogeneous-product markets. Researchers widely use game theory to analyze competitive interactions not only in business and economics but also in a variety of other disciplines including sociology, computer science, and health care (Cheng, 2012; ImaniMehr and DehghanTakhtFooladi, 2019; Blake and Carrol, 2016).

Our game-theoretical model is similar to previously developed models where a subset of consumers obtain information on the entire distribution of market prices from an “information clearinghouse” (Baye et al., 2006), which can be a newspaper or a price-comparison website, and purchase at the lowest listed price. Varian (1980), Baye and Morgan (2001), and Baye and Morgan (2009) are some examples of studies from the body of literature that incorporate an information clearinghouse into their models. These studies, however, assume homogeneous costs. Our present study departs from these papers by accounting for (marginal) cost differentials.

Reinganum (1979) was the first to show that cost heterogeneities can give rise to an equilibrium price dispersion when consumers engage in optimal sequential search. Our model, however, is intended to capture the environments where consumers are a few clicks away from finding the lowest price and, therefore, shoppers can access the relevant information with no incremental search cost. Spulber (1995) shows that price dispersion may occur when each firm's marginal cost is private information and, thus, is unknown to competitors. He assumes all consumers buy only from the firm charging the lowest price and, therefore, are all shoppers. We incorporate the presence of a loyal segment of consumers in our model and demonstrate that, even if firms have complete information on their rivals' costs, price leadership coupled with cost advantage can result in equilibrium prices that feature large degree of price dispersion. Among more recent studies, Shelegia (2012) shows that marginal cost differentials may drastically change the equilibrium prices obtained in homogeneous-cost models, and Shelegia and Wilson (2016) present a generalized model of sales where multiple dimensions of firm heterogeneity are allowed.

The above-mentioned studies, which incorporate cost differentials into their models, assume a simultaneous (Bertrand) game among the players. A distinctive feature of our model, however, is to consider that the firm with the lowest marginal cost acts as a price leader. Therefore, we analyze a sequential (Stackelberg) game, where first the leader sets her price, and then followers simultaneously set their own prices. This setting results in a high degree of price dispersion with no intermediary prices. In other words, the offered market prices are either at a low or a high level.

The literature investigating the linkage between cost advantage and price leadership dates back to the pioneering study of Ono (1978) who shows that, in a duopoly setting, if one player has a large cost advantage over the other, they are both better off if the lower-cost firm is the leader. More recently, van Damme and Hurkens (2004) and Amir and Stepanoava (2006) indicate that even if the rivals offer differentiated products, the lower-cost firm's leadership is a dominant equilibrium. This stream of literature focuses on duopoly settings and how cost differences can impact the price leadership role. In this paper, we assume, in line with previous findings, that the lower-cost firm is the price leader, but consider a competitive market, which may consist of two or more players. The main focus of our analysis is to explore how the cost advantage of the price leader can explain a high degree of price dispersion in a competitive market where a large number of firms offer homogeneous products.

In sum, our study complements and contributes to the previous literature by offering a new theory providing an alternative explanation for the large and persistent price dispersion phenomenon frequently observed in homogeneous-product markets.

3. Model

We consider a business environment where n firms compete over selling a homogeneous product. Consumers purchase at most one unit of the product, and are willing to pay at most r for the product, i.e., r is their reservation price. There are two types of consumers: "shoppers" and "loyals" (Baye and Morgan 2009). Shoppers spend the time and effort to obtain information on the distribution of prices in the market, and purchase at the lowest price. Loyals, on the other hand, buy from a single store no matter what the price may be. One may think of them as consumers whose search cost is too high to look for information. The size of the shopper and loyal segments is denoted by S, and M, respectively. Each firm's share of the loyal segment is denoted by L which is equal to M / n (Varian 1980).

One of the firms acts as a price leader, and the remaining $n - 1$ firms are followers. Our model captures the fact that the competing firms may feature heterogeneous cost structures. Specifically, the leader has a significant cost advantage over other players whose operational costs may be considered close to each other, but still different. We denote the total cost for firm $i = 1, 2, \ldots, n$ by $C_i = k + c_i q$, where k is the fixed cost, c_i is the marginal cost of firm i, and q is the number of products sold. Essentially, we allow for different firm-specific marginal costs in our model. Without loss of generality, we assume $c_i \leq c_j$ if $i < j$ $(i, j = 1, 2, \ldots, n)$, where subscript $i = 1$ is associated with the leader and the remaining $n - 1$ subscripts are associated with the followers. Specifically, we consider a cost advantage for the leader, i.e., $c_1 < c_i$ for $i = 2, \ldots, n$.

The timing of the game is as follows: First, the leader determines her selling price, denoted by P_1. Next, followers simultaneously set their own prices, denoted by P_i, $i = 2, \ldots, n$. The firm that charges the lowest price attracts all shoppers, and therefore, sells $L + S$ units of the offered good. Other stores are able to sell only to their loyal consumers and, thus, sell L units of the product. If two or more firms tie at the lowest price, they each obtain an equal share of the shoppers' segment. All players' objective is to maximize their profit, which can be expressed as $\Pi_i = P_i q - C_i(q)$.

We assume that the firm with the highest total cost earns zero profit if he sells only to his loyal customers, i.e., $rL - C_n(L) = 0$. This assumption, which we refer to as "zero-profit" assumption hereafter, implies that new market entries continue to lower L and eventually cause the firm with the most costly operations to make zero profit. In other words, entering the market with a higher cost than that of all current competitors is not economically viable.

4. Analysis

In this section, we explore how price leadership together with cost advantage impact equilibrium prices and thus, the structure of the price-dispersion phenomenon. First, in order to generate some insights into the impact of cost advantage and price leadership on market dynamics, we begin with a duopoly model (i.e., $n = 2$) where one leader and one follower compete with each other. One may consider this model as a "competitive duopoly" in the sense that, given the zero-profit assumption, the presence of two players is sufficient to make it infeasible for any new potential competitors to enter the market with a higher cost than the follower's and to sell only to their loyal customers.

Before proceeding with the analysis, let us define $\overline{c_i}$ as the average cost of firm i if he sells $L + S$ units of the product, i.e., $\overline{c_i} = C_i(L + S) / (L + S)$. Clearly, $\overline{c_i} \leq \overline{c_j}$ if $i < j$.

4.1 The Special Case of Competitive Duopoly

In this setting, the retailer with the lowest (marginal) cost acts as a Stackelberg leader by setting her selling price first. Subsequently, the follower determines his selling price. We use backward induction to analyze this game to obtain the subgame perfect Nash equilibrium (SPNE). We find that there is a unique SPNE with equilibrium prices that feature a significant gap between the leader's and the follower's price. Proposition 1 characterizes this equilibrium:

Proposition 1. In a competitive duopoly setting, there is a unique SPNE where $P_1 = \overline{c_2}$, $P_2 = r$, $\Pi_1 = (c_2 - c_1)(L + S)$, and $\Pi_2 = 0$.

Proof. Note that**,** in this setting, subscript 1 represents the leader and subscript 2 represents the follower. Using backward induction to examine the follower's decision in response to the leader's first move, we analyze two cases:

Case 1: $P_1 \in (\overline{c_2}, r]$. The follower will always undercut the leader and, thus, attract all shoppers. This is because charging a higher price than the leader's, at most, that occurs when the follower charges the highest possible price r, will result in zero profit.

Case 2: $P_1 = \overline{c_2}$. The follower avoids tying with the leader as it results in loss because, if both charge the same price, each gets half of the shoppers and, thus, the follower's profit becomes

$$\begin{aligned}\overline{c}_2.\left(L+\frac{S}{2}\right)-C_2\left(L+\frac{S}{2}\right) &= \frac{C_2\left(L+S\right)}{L+S}\left(L+\frac{S}{2}\right)-C_2\left(L+\frac{S}{2}\right)\\ &= C_2\left(L+S\right)-\frac{S}{2}\left[\frac{C_2\left(L+S\right)}{L+S}\right]-C_2\left(L+\frac{S}{2}\right)\\ &= c_2\frac{S}{2}-\frac{S}{2}\left[\frac{k+c_2.\left(L+S\right)}{L+S}\right]=\frac{S}{2}\left[c_2-\frac{k+c_2.\left(L+S\right)}{L+S}\right]<0,\end{aligned}$$

where the first equality is by the definition of the average cost and the third equality utilizes the definition of the cost function.

Therefore, the follower has no chance of selling to the shoppers and, thus, charges the highest possible price, i.e., $P_2 = r$, and sells only to his loyal customers.

In Case 1, given the foresight that the follower will always set a slightly lower price than the leader's, the best choice for the leader is to charge the highest possible price r. If $P_1 = r$, then $\Pi_1 = rL - C_1(L)$.

In Case 2, $P_1 = \overline{c_2}$, and $P_2 = r$. Thus,

$$\Pi_1 = \overline{c}_2.\left(L+S\right)-C_1\left(L+S\right)=C_2\left(L+S\right)-C_1\left(L+S\right)=\left(c_2-c_1\right)\left(L+S\right)$$

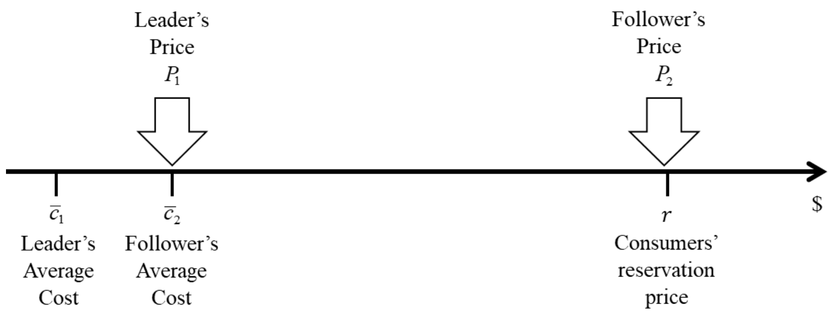
Observe that this case results in a higher profit for the leader than Case 1 because the profit in Case 1 can be re-written as $\Pi_1 = rL - C_2(L) + C_2(L) - C_1(L)$, but according to the zero-profit condition, $rL - C_2(L) = 0$, which implies $\Pi_1 = C_2(L) - C_1(L) = (c_2 - c_1)L$, which clearly is lower than $(c_2 - c_1)(L + S)$.

Consequently, in equilibrium, the leader chooses $P_1 = \overline{c_2}$, and the follower subsequently determines $P_2 = r$. The corresponding profit for the leader and the follower is $\Pi_1 = (c_2 - c_1)(L + S)$, and $\Pi_2 = 0$, respectively. ❑

In the equilibrium characterized in Proposition 1, the leader sets her price at the level equal to the average cost of the follower, i.e., $\overline{c_2}$. The follower, consequently, cannot afford to charge a lower price than the leader's and thus, has no chance of selling to the shoppers. Therefore, he offers the product to his own loyal customers at a high price, i.e., $P_2 = r$. In this competitive environment, the follower obtains no profit; however, the leader's profit is strictly positive.

It is important to observe that this setting results in a large and persistent price dispersion. The leader chooses to charge a low price consistently, which resembles the Everyday-Low-Price (EDLP) policy observed in practice. On the other hand, the follower avoids a price competition and decides to sell at a regular high price. Figure 1 depicts the gap between the equilibrium prices.

Figure 1. Equilibrium Prices in a Competitive Duopoly



It also is worth mentioning that our theoretical model does not capture and thus, does not rule out the possibility that the follower occasionally lowers his price for several different reasons such as sales, market clearance and loss leadership among others. In fact, the presence of the Hi-Lo pricing policy in practice may be explained by this possibility, i.e., that the follower charges a regular high price and may lower his price from time to time. On the other hand, the leader continuously maintains a low price.

Next, we explore the general case where one leader and $n - 1$ followers compete in a homogeneous-product market.

4.2 The General Case

This setting represents environments where the leader first sets her price and, then, $n - 1$ followers simultaneously determine their prices. The next proposition indicates that, in the general setting, the unique set of equilibrium prices features a high degree of price dispersion. Figure 2 demonstrates equilibrium prices in the general case.

Proposition 2. There is a unique SPNE characterized by $P_1 = \hat{P}_2$, $P_i = r$, $\Pi_1 = (\hat{P}_2 - \overline{c_1})(L + S)$, and $\Pi_i = rL - C_i(L)$ for $i = 2, 3, \ldots, n$, where $\hat{P}_2 = (rL + c_2S) / (L + S)$ and $\hat{P}_2 > \overline{c_2}$.

Proof. Consider the follower with the highest marginal cost (denoted by subscript n). If all other prices are above $\overline{c_n}$, this follower has an incentive to undercut other competitors so that he can sell to the shoppers in addition to his loyal customers. Otherwise, if he sells only to the latter, according to the zero-profit assumption, his profit is at best zero resulting from charging r as the selling price. Now consider the follower with the ith-lowest marginal cost (denoted by subscript i, where i = 2, 3, …, n). Let P_L be the lowest price among the prices charged by other competitors. Also, define $\hat{P}_i$ as the threshold price such that if P_L is above (below) $\hat{P}_i$, the ith-lowest-cost follower will have an (no) incentive to undercut all other competitors. Essentially, the follower is indifferent to the following two scenarios: (1) selling to the shoppers in addition to his loyal customers at $P_i = \hat{P}_i$, and (2) selling only to his own loyal customers at $P_i = r$. Thus, we can derive $\hat{P}_i$ by equating the profits associated with the above-mentioned scenarios as follows:

$$rL - C_i\left(L\right) = \hat{P}_i.\left(L+S\right) - C_i\left(L+S\right) \tag{1}$$

Expanding the cost functions and cancelling out the terms from both sides of the equation, we get

$$\hat{P}_i = \frac{rL + c_i S}{L+S} \tag{2}$$

Three observations can be made. First, $\hat{P}_i \le \hat{P}_j$ if $i < j$ (i, j = 2, 3, …, n – 1), since $c_i < c_j$ by assumption. Second, by zero-profit assumption, equation (1) results in $\hat{P}_n = C_n(L+S)/(L+S) = \overline{c_n}$, which is consistent with the earlier finding that as long as P_L is above $\overline{c_n}$, the highest-cost follower has an incentive to charge a lower price than P_L and thus, undercut all other competitors. Third, $\hat{P}_n \ge \hat{P}_{n-1}$ because from (2) we have $\hat{P}_{n-1} = (rL + c_{n-1}S)/(L+S)$. Therefore,

$$\hat{P}_n - \hat{P}_{n-1} = \frac{C_n\left(L+S\right)}{L+S} - \frac{rL + c_{n-1}S}{L+S} = \frac{k + c_n.\left(L+S\right) - rL - c_{n-1}S}{L+S} = \frac{k + \left(c_n - c_{n-1}\right)S}{L+S} > 0,$$

where the second equality results from the definition of the cost function and the third equality results from the zero-profit assumption.

As a result, we have $\hat{P}_i \le \hat{P}_j$ if $i < j$ for i, j = 2, 3, …, n.

Furthermore, note that $\hat{P}_i \le \overline{c_i}$ for i = 2, 3, …, n, because

$$\hat{P}_i - \overline{c}_i = \frac{\left(rL + c_i S\right) - \left(k + c_i.\left(L+S\right)\right)}{L+S} = \frac{rL - k - c_i L}{L+S} = \frac{rL - C_i\left(L\right)}{L+S} \ge 0,$$

which is positive, because $rL - C_i(L) \ge 0$, otherwise it would not be economically viable for the followers to operate in this business environment, which would result in a trivial case.

The leader takes the price thresholds of the followers into account. In order to prevent all the followers from selling to the shoppers, it is sufficient for the leader to charge a price equal to $\hat{P}_2$. In this case, the lowest-cost follower (denoted by subscript

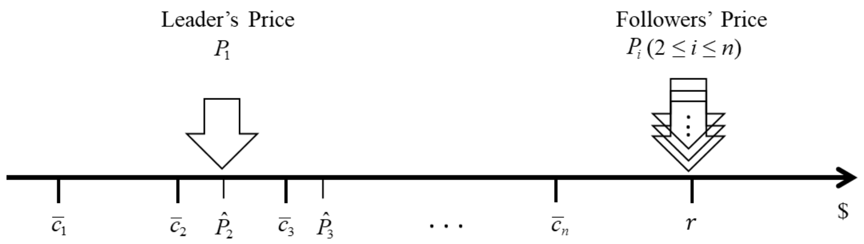
2) will be better off charging r than tying with the leader at $\hat{P}_2$, as shown in the proof of Proposition 1. All other followers will have no incentive to undercut the leader and therefore, also set the selling price at r.

Observe that if, alternatively, the leader charges r, there is no equilibrium where $P_i = r$ for all $i = 1, 2, 3, \ldots, n$ as all players would have incentives to deviate from this price and obtain a higher profit by setting a price slightly lower than r. This implies that if the leader sets her selling price at r, she will be undercut by some followers in any existent equilibrium. Thus, her profit, in this case, will be $rL - C_1(L)$. On the other hand, charging $\hat{P}_2$ leads to the profit $\hat{P}_2.(L + S) - C_1(L + S)$. The difference is:

$$\hat{P}_2.(L+S)-C_1(L+S)-\left[rL-C_1(L)\right]=(c_2-c_1)S>0$$

Therefore, the optimal choice for the leader is to charge $\hat{P}_2$. Followers, consequently, have no chance of selling to the shoppers, and therefore, all charge r. As a result, the leader's profit is $\Pi_1 = \hat{P}_2.(L + S) - C_1(L + S) = (\hat{P}_2 - \overline{c_1})(L + S)$, and the follower i's profit is $\Pi_i = rL - C_i(L)$ for $i = 2, 3, \ldots, n$. ❑

Figure 2. Equilibrium Prices in the General Case



Proposition 2 shows that regardless of the number of followers in the market, the leader lowers her price down to a level, i.e., $\hat{P}_2$, below which it is suboptimal for the lowest-cost follower (second-lowest-cost player) to set his price. Specifically, the lowest-cost follower is better off selling to his own loyal customers at the price $P_2 = r$ rather than reducing his price to such a low level as $\hat{P}_2$. Therefore, other followers, whose marginal costs are higher than that of the lowest-cost follower, have no incentive to lower their prices below this level either and, thus, they all set their prices at r and sell to their own loyal customers, as demonstrated in Figure 2.

It is important to note that, except the follower operating with the highest marginal cost, all competitors make a positive profit, in the equilibrium. In other words, only the highest-cost industry player is on the verge of exiting the market. Our model, therefore, presents a rationale for the observed fact that multiple companies can survive and operate profitably in homogeneous-product markets in spite of the intense competition in such markets. Given that the market players offer homogeneous products, it is the cost factor that plays a crucial role in a firm's competitiveness and performance. The lower the cost, the higher the chance of continuing the business with a healthy profit. In addition, this setting allows for a dynamic change in the set of market players, which in practice can occur due to improvement in business processes, technological advancements, and more efficient sourcing strategies among others. A new firm may enter the market and make positive profit as long as he can run his operations with a cost below that of the competitor with the highest cost.

More importantly, Proposition 2 indicates that price leadership driven by the cost advantage not only can result in large and persistent price dispersion among industry competitors, but also may feature an “either-high-or-low” distribution of prices. As noted in the business and economics literature as early as Varian (1980), we rarely observe a continuous range of intermediate prices in practice. Rather, base prices tend to be at either high or low levels, resulting in a large gap between the offered prices over time. As described above, this observation is reinforced by EDLP and Hi-Lo pricing policies widely adopted in practice. Proposition 2 suggests that our theoretical model enables us to explain some essential features of the empirically observed price-dispersion phenomenon.

One would expect that in this competitive business environment where operational efficiency is essential to the profitability of a firm, a follower would have a substantial incentive to lower his cost to gain a higher profit. Next, using comparative statics, we show how followers’ cost-reduction efforts may influence the leader’s equilibrium price $\hat{P}_2$. We also shed light on the impact of the segment size of shoppers (S) and the share of loyal consumers (L) on the leader’s equilibrium price.

Corollary 1. The leader’s equilibrium price ($\hat{P}_2$), (a) increases in c_2 with a below-one rate of change, (b) decreases in S, and (c) increases in L.

Proof. Taking the derivative of $\hat{P}_2$ (defined in Proposition 2) with respect to c_2, S, and L, respectively, we obtain the following results:

$$\frac{\partial \hat{P}_2}{\partial c_2} = \frac{S}{L+S} \in (0,1), \quad \frac{\partial \hat{P}_2}{\partial S} = -\frac{(r-c_2)L}{(L+S)^2} < 0, \quad \text{and} \quad \frac{\partial \hat{P}_2}{\partial L} = \frac{(r-c_2)S}{(L+S)^2} > 0. \ \square$$

This result indicates that the lowest-cost follower can impose downward pressure on the leader’s price. Any reduction in this follower’s cost causes the leader to lower her price; however, the reduction in the leader’s price is lower than that in the follower’s cost. In other words, the cost-reduction efforts of the most efficient follower, although impactful, does not fully translate into the reduction in the leader’s price. Specifically, the rate of impact on the leader’s price is equal to $S / (L + S)$, which illuminates how the size of the shopper and the loyal segments influence the effectiveness of the cost-reduction efforts. A larger segment of shoppers, i.e., higher S, puts more pressure on the leader to reduce her price, as c_2 decreases, because a larger S provides greater incentives for competitors to reduce their prices in order to attract shoppers. In response, at higher levels of S, the leader has to reduce her price at a higher rate as the lowest-cost follower becomes more cost-competitive.

Furthermore, the $S / (L + S)$ fraction implies that more intensive competition as well, enhances the effectiveness of the cost-reduction efforts. Notice that L = M / n is each firm's share of the loyal segment of consumers. As the number of competitors, i.e., n increases, L decreases and thus, that fraction increases. In other words, higher competition makes the shopper segment more attractive relative to the loyal segment, which causes the leader to lower her price at a higher rate as the lowest-cost follower reduces his cost.

Parts (b) and (c) of Corollary 1 reinforce the intuition on the impact of the shopper and the loyal segment size on the dynamics of the market. A smaller share of the loyal segment, which implies more intense competition, leads to a lower equilibrium price for the leader. This, interestingly, causes a higher degree of price dispersion, since followers keep charging r while the leader lowers her price (according to the equilibrium characterized in Proposition 2). In addition, a larger S also reduces the leader's equilibrium price because a larger number of shoppers causes market players to be willing to set lower prices in order to undercut their competitors and sell to the shoppers. Consequently, the leader must lower her price to prevent the followers from attracting the shoppers. These results seem to be in line with what is expected in practice.

4.3 The Case of Homogeneous Costs: Leadership with No Cost Advantage

In this section, we investigate how homogeneous costs affect equilibrium prices. Our model assumes that cost advantage and price leadership are directly linked. There is vast literature on the factors that impact price leadership. The low-cost advantage has been mentioned as one of the important driving forces (Ono, 1978; van Damme and Hurkens, 2004; Amir and Stepanova, 2006). It also is conceivable that, in a homogeneous-product market with little or no differentiation among products, the cost advantage becomes the main driving force of market leadership. In this section, we reinforce this assumption by demonstrating that in the absence of cost advantage, price leadership never benefits the leader and, therefore, it is not rational for competitors to assume leadership with no cost advantage, in this setting.

Let us denote the common cost by $C(q) = k + cq$, where c is the common marginal cost. Proposition 3 states the results:

Proposition 3. If costs are homogeneous, price leadership is not advantageous to any firms in a competitive market. Specifically, there are two SPNE, in one of which $P_1 = \hat{P}$, where $\hat{P} = (rL + cS) / (L + S) > c$, and, in the other, $P_1 = r$, both of which result in zero profit for the leader.

Proof. Note that a competitive market requires that $rL - C(L) = 0$. Otherwise, market entries lower L and eventually drive $rL - C(L)$ down to zero. As a result, $P_1 = r$ leads to zero profit. In addition, the profit from selling to both shoppers and loyals at $P_1 = \hat{P}$ is also zero, because we have

$$\Pi_1 = \hat{P}.(L+S) - C(L+S) = rL + cS - c.(L+S) - k = rL - cL - k = rL - C(L) = 0$$

where the second equality holds due to the definition of $\hat{P}$ and $C(q)$. In order to show $P_1 = r$ and $P_1 = \hat{P}$ represent the only two equilibrium prices, we use backward induction. If the leader charges $P_1 \in (\hat{P}, r]$, no pure-strategy equilibrium exists for the followers. In the mixed-strategy equilibrium, there is zero probability that all followers charge a price higher than P_1. The reason is twofold: First, charging a price higher than P_1 guarantees losing the opportunity to sell to the shoppers and thus, charging r is the best choice in the range $(P_1, r]$ for the followers. Second, r cannot be assigned a positive probability mass in any mixed strategy. This is because a follower is better off deviating from any strategy that assigns a positive probability to r and charge $P_1 - \varepsilon$ instead, with the same probability that other followers assign to r, due to the fact that as long as $P_1 - \varepsilon > \hat{P}$, charging $P_1 - \varepsilon$ leads to a positive profit, whereas charging r results in zero profit.

Thus, the leader will always be undercut if she sets her price at a $P_1 \in (\hat{P}, r]$. Consequently, charging r is the best option for the leader in the range $P_1 \in (\hat{P}, r]$. The only other viable choice is charging $\hat{P}$, which also results in zero profit as shown above. ❑

The intense competition over selling a homogeneous product is made even more intense by homogeneous costs, and price leadership provides no benefits to competitors. This proposition implies that cost differentials, and specifically the leader's cost advantage, are key to making the leadership role beneficial in a homogeneous-product market.

Moreover, the linkage between the cost advantage and leadership benefits can be shown by rewriting Π_1 expressed in Proposition 2, as follows:

$$\begin{aligned}\Pi_1 &= \left(\hat{P}_2 - \bar{c}_1\right).\left(L+S\right) = rL + c_2 S - C_1\left(L+S\right) \\ &= \left(r - c_1\right)L + \left(c_2 - c_1\right)S - k = rL - C_1\left(L\right) + \left(c_2 - c_1\right)S\end{aligned} \tag{3}$$

where the second equality utilizes the definition of $\hat{P}_2$ and $\overline{c_1}$, and the next two equalities result from the definition of $C(q)$. Note that, if the leader were one of the followers, her profit would be $rL - C_1(L)$. Equation (3) shows that the leadership advantage, i.e., $(c_2 - c_1)S$, is directly related with the leader's cost advantage over the closest competitor, i.e., $c_2 - c_1$, and the ability to sell to the shoppers as a result of this superiority.

4.4 The Case of Followers' Sequential Price Setting

In this section, we examine the case in which followers determine their prices sequentially rather than simultaneously. In our base model, we assume that, after the leader determines her price, the followers set their prices simultaneously. This assumption is intended to reflect the business environments where followers are similar in terms of their marginal costs, i.e., the differences in marginal costs among followers are not substantial, while the leader has a significant cost advantage. In this section, we analyze an alternative timing of the game as follows: First, the leader sets her price; then, the followers set their prices sequentially. A specific sequence for the followers, which is consistent with the general structure of our model, is that the order in which followers set their prices conforms to the order of their marginal costs. That is, the lowest-cost follower is the first to set his price (the second player after the leader), and the highest-cost follower sets his price last. The next proposition indicates that followers' sequential price setting results in the same equilibrium prices as does followers' simultaneous price setting. In addition, it states that the order in which the followers set their prices does not affect the equilibrium prices.

Proposition 4. If followers set their prices sequentially, (a) The unique SPNE is the same as that characterized in Proposition 2 by $P_1 = \hat{P}_2$, $P_i = r$, $\Pi_1 = (\hat{P}_2 - \overline{c_1})(L + S)$, and $\Pi_i = rL - C_i(L)$ for $i = 2, 3, \ldots, n$, where $\hat{P}_2 = (rL + c_2S) / (L + S)$; (b) The SPNE is the same regardless of the sequence by which followers set their price.

Proof. (a) Consider the lowest-cost follower (second-lowest-cost player). Assume that the lowest-cost follower is the i-th player to determine his price ($i = 2, 3, \ldots, n$). Define P_{L2} as the lowest price charged by $i - 1$ competitors, including the leader, who have previously set their prices. From Proposition 2, we note that the lowest-cost follower's profit from charging r and selling only to his loyal customers is equal to the profit from charging $\hat{P}_2 = (rL + c_2S) / (L + S)$ and selling to both his loyal customers and to the shoppers. Therefore, if P_{L2} is below $\hat{P}_2$, the follower has no incentive to set a price lower than P_{L2}. If P_{L2} is above $\hat{P}_2$, on the other hand, the lowest-cost follower is better off offering a lower price than P_{L2}. Specifically, as long as he charges a price at or below $\hat{P}_3$, the second-lowest-cost follower (third-lowest-cost player) and all other followers will have no incentive to undercut him due to the definition of $\hat{P}_i$ stated in equation (2). As such, he can sell to the shoppers by preventing all remaining followers from undercutting him.

Now, consider the leader's pricing decision (denoted by P_1). If $P_1 \leq \hat{P}_2$, the lowest-cost follower will not benefit from undercutting the leader. Other followers will have no incentive to undercut the leader either because $\hat{P}_i \leq \hat{P}_j$ if $i < j$ for $i, j = 2, 3, \ldots, n$ (according to Proposition 2). If $P_1 > \hat{P}_2$, on the other hand, at least one follower, being the lowest-cost one, will be better off undercutting the leader. Thus, the leader should consider two price choices: (1) $P_1 = \hat{P}_2$, which is the best choice for the $P_1 \leq \hat{P}_2$ range, and (2) $P_1 = r$, which is the dominant choice for the $P_1 > \hat{P}_2$ range. By the proof of Proposition 2, however, we note that $P_1 = \hat{P}_2$ leads to a higher profit than does $P_1 = r$.

As a result, the leader charges $\hat{P}_2$ which prevents all followers from undercutting her. It implies that all followers will be better off charging r, no matter by which sequence they set their prices. This proves part (b) as well. The resulting profits are the same as those derived in the proof of Proposition 2. ❑

This proposition establishes the robustness of our results to the timing of followers' pricing decisions and implies that equilibrium prices result in stable and wide price dispersion, regardless of the sequence of the other players' pricing decisions, as long as the most efficient market player acts as a price leader.

5. Concluding Remarks

The evidence for price dispersion in homogeneous-product markets is extensive. This paper complements the theoretical literature that provides potential rationales for this phenomenon. We consider the cost factor to be the main driving force of price leadership in such competitive markets. Using a game-theoretical approach, we show that cost advantage, coupled with price leadership, give rise to wide and stable price dispersion where two levels of prices, high or low, exist. In addition, all firms taking part in this competition, with one exception, gain positive profits. Therefore, our model provides an explanation for how intense competition in homogeneous-product markets can coexist with a large number of competitors, resulting in persistent price dispersion in practice.

Our model suggests that the leader benefits from her cost advantage by charging the lowest price in the market, which enables her to sell to shoppers who purchase at the lowest price. Followers who are unable to offer prices as low as the leader's sell to their loyal customers at the customers' reservation price, which seems to be consistent with empirical observations. Specifically, Walmart is well known for its everyday low price (EDLP) strategy capitalizing on its efficient operations. It has also been observed that Amazon charges the lowest price in the online e-book market (De Los Santos and Wildenbeest, 2017) where it can be considered a dominant market leader.

We establish the robustness of our results to the sequence by which followers set their prices by showing that equilibrium prices remain the same no matter whether followers determine their prices simultaneously or sequentially.

Several factors can influence the dynamics of the competition. As low cost is the main driver of profitability in the competitive setting we consider, followers have a strong incentive to become more efficient. Our results show that as followers reduce their (marginal) costs, the leader reduces her price in order to be able to keep selling to the shoppers. Furthermore, higher levels of competition, resulting from a higher number of firms in the market, impose downward pressure on the leader's price, which results in a wider range of prices. Finally, more informed consumers, i.e., a larger number of shoppers, induces the leader to lower her piece. This is because a larger shopper segment allows market players to charge lower prices in order to undercut their competitors; the leader, in response, is forced to reduce her price in order to continue selling to the shoppers. Our findings on the dynamics of the competition seem to be in line with some essential aspects of reality.

Future research can improve our study. Costs are common knowledge in our model. Although it seems conceivable to assume that all firms would be able to identify the lowest-cost competitor over time, future research may find it useful to consider asymmetric information on marginal costs (e.g., Yang 2010) in addition to price leadership. That is, even though the market players know their roles, i.e., leader or follower, their marginal costs can be considered private information and therefore, unknown to their competitors. We also assume that price leadership is directly linked with the cost advantage in our model. The literature proposes a number of factors that can potentially result in price leadership. For example, some recent studies explore the impact of customer returns (Chen et al., 2018), strategic acquisition of demand information (Gilpatric and Li, 2016), and whether the competing firms are private or public (Matsumura and Ogawa, 2017) on the optimality of price leadership. It would be insightful to explore whether drivers of price leadership other than cost advantage can contribute to the magnitude and stability of price dispersion in competitive markets.

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