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Abstract

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To pioneer or not? This is one of the most fundamental marketing decisions. The theoretical literature in marketing and economics shows that pioneers have first-mover advantages by preempting scarce resources and market positions. Conversely, pioneers have disadvantages when followers obtain more information about consumer demand by adopting a "wait-and-see" strategy. This paper, however, demonstrates first-mover disadvantage even in the absence of follower's informational advantage. We assume that consumers differ in their tastes not only along attributes that firms manage strategically, but also along attributes that the firms cannot manage due to their unobservability. We examine the effect of consumer heterogeneity on first-mover advantage in a duopoly model of sequential entry. This paper shows that the first mover attains lower sales and profits when consumers exhibit sufficiently large idiosyncratic preferences due to their differing tastes along unobservable attributes. On the other hand, under conditions where consumer tastes vary mainly along the strategic attributes, our findings are consistent with past research that argues for first-mover advantage.

(First-Mover Disadvantage, Consumer Heterogeneity, Unobservable Attributes, Duopoly, Sequential Entry)
1. Introduction

Should you enter a new market before or after your rivals? This is one of the most fundamental marketing decisions as it has significant consequences for the long-term market performance of a product. In the last decade, numerous conceptual and empirical studies have shown that pioneers achieve substantial advantages and are likely to be market leaders in their product categories (to mention a few, Robinson and Fornell 1985, Urban et al. 1986, Robinson 1988, Parry and Bass 1990, Kalyanaram and Urban 1992). A growing body of recent empirical evidence, however, questions the pioneering advantages and presents the cases of first-mover disadvantage (Lieberman and Montgomery 1988, Lilien and Yoon 1990, Kerin et al. 1992, Golder and Tellis 1993, Shankar et al. 1998).

Previous conceptual literature has focused on identifying the advantages and/or disadvantages associated with pioneering. It examines the mechanisms through which either pioneers or late movers outperform their rivals and empirically tests their advantages using diverse econometric and statistical tools. Even though the conceptual work has produced valuable insights about the pioneer's as well as the late mover's comparative advantages and the strategies available to them, it has not taken into account their competitive strategic interactions.

In entering a new market, a pioneering firm will anticipate a following firm's strategic decisions and incorporate such decisions into making its own strategic decisions. The follower, in turn, will choose its strategy given the pioneer's decisions. Consequently, the pioneer's strategy depends on the follower's strategy and vice versa. These recursive strategic interactions have not been investigated in the previous conceptual and empirical studies and they call for a game-theoretic analysis for the investigation.

There have been only a handful of game-theoretic studies on first-mover advantage (see Eliashberg and Chatterjee [1985] and Moorthy [1985] for a detailed review). What is worse, there have been only two game-theoretic studies showing first-mover disadvantage, i.e., Gal-Or (1987) and Chatterjee and Sugita (1990). Both studies present the follower's informational advantage as a source of first-mover disadvantage. Pioneers take the risk of new product failure due to the uncertainty of consumer demand whereas late movers can elimi-
nate this uncertainty by taking a "wait-and-see" strategy. Late movers achieve higher sales and profits when their informational advantage prevails over the pioneers' advantages arising from preemption and switching costs.

In this paper, however, we show first-mover disadvantage even in the absence of the follower's informational advantage. We assume that consumers differ in their tastes not only along attributes that firms manage strategically (i.e., "strategic" attributes such as product features), but also along attributes that the firms cannot manage due to their unobservability (i.e., "unobservable" attributes such as brand associations). We further assume inelastic demand and firms' identical information sets of consumer preferences in order to eliminate asymmetric market conditions and informational advantage as a possible source of first-mover disadvantage. Given this model, we examine the effect of consumer heterogeneity on first-mover advantage.

Our findings are as follows. When consumers differ in their tastes mainly along the strategic attributes, a pioneer preempts its follower by positioning itself at the market center in order to capture the largest number of consumers. The follower then positions away from the pioneer in order to avoid cut-throat price competition. Thus, the pioneer earns higher sales and profit under its positional advantage at the center. However, when consumers exhibit sufficiently large idiosyncratic preferences due to their differing tastes along unobservable attributes, they are not loyal to the product which yields the largest utility with respect to the strategic attributes. Hence, preemptive positioning on the strategic attributes becomes ineffective in competition. Furthermore, as idiosyncratic preferences along unobservable attributes generate choice variations over the entire market, the follower moves toward the center in order to capture more choice variations. Anticipating the follower's aggressive approach, the pioneer moves away from the center in order to avoid destructive price competition. In equilibrium, the follower positions itself closer to the market center and attains higher sales and profits.

The rest of the paper is organized as follows. In Section 2, we briefly review the relevant game-theoretic literature. In Section 3, we clarify the idea of unobservable attributes in consumer choice and their implications for demand and profit in a formal model. In Section
4, we obtain a pure strategy equilibrium and examine the effect of consumer heterogeneity on first-mover advantage. In the last section, we draw managerial implications of the results and suggest areas for future research.

2. Literature

Most theoretical literature in marketing and economics examines the issue of first-mover advantage from the perspective of the firms’ sequential market entry. When firms have perfect knowledge regarding consumer preferences, a Stackelberg leader predicts individual consumer choices correctly and anticipates the following firms’ reactions to its strategies. Under perfect foresight, a pioneering brand takes a leadership role in positioning and preempts later entrants by adopting the best market positions (Prescott and Visscher 1977, Lane 1980, Moorthy 1988). Preemptive positioning then enables the pioneer to charge premium prices and leads to greater market performance. In less attractive segments, on the other hand, later entrants should offer bargain prices in order to compete with pioneering incumbents and attain lower sales and profits. Pioneers may also preempt superior strategic resources in the factor market (Barney 1991). Thus, comparative advantages in production and distribution will generate above normal returns for the pioneers (Rao and Rutenberg 1979, Lippman and Rumelt 1982).

Schmalensee (1982) shows that imperfect information on the part of consumers leads to first-mover advantage as well. There is a vast literature in consumer behavior and psychology indicating that attitudes which result from direct consumption experience tend to be more accessible in memory and directive of the next purchase than similar attitudes formed without such experiences (Fazio 1986, Kardes and Kalyanaram 1992, Smith 1993). If consumers are satisfied with the first brand in a new product category, they will favor it over later entrants not only because they are uncertain that the followers’ brands satisfy their needs, but also because they form more positive attitudes toward the first brand. Pioneers will then sustain high market share and profits so long as experience remains as a crucial information source of product quality. In addition, pioneers can increase switching costs by developing brand-specific user skills and influencing consumers’ evaluation of products (Stigler and Becker
Conversely, Chatterjee and Sugita (1990) show first-mover disadvantage by introducing the assumption that firms have imperfect information regarding consumer demand. They assume that a market pioneer obtains higher profits due to advantages arising from preemptive positioning and switching costs, but it faces the risk of costly new product failure due to demand uncertainty. Later entrants, however, may earn higher profit in infinitely repeated purchase occasions because their wait-and-see strategy eliminates demand uncertainty. Chatterjee and Sugita (1990) examine the trade-off between the profitability of a new product and the uncertainty of its profitability and derive conditions under which a wait-and-see strategy is optimal.

Gal-Or (1987) also demonstrates the disadvantages of moving first even when both pioneer and later entrant are equally able to assess demand through marketing research. Gal-Or models a duopoly where firms choose output quantities under the assumption of incomplete information regarding stochastic demand. The follower has an informational advantage not only because it directly observes market conditions, but also because it makes inferences about market conditions based on the first-mover's quantity choice. Thus, informational advantage enables the follower to attain higher market share and profit.¹

In contrast to the above models which focus on either a pioneer's market preemption or a follower's informational advantage, we show consumer heterogeneity as a determinant of first-mover advantage/disadvantage by using a Hotelling framework (1929). This paper, however, differs from previous literature cast in a Hotelling framework (e.g., Lane 1980, Moorthy 1988). The previous research assumes that consumers differ in their tastes only along strategically controllable attributes, but not along attributes that firms cannot manage due to their unobservability. In other words, consumer preferences are assumed to be completely accounted for by attributes on which the firms strategically position. Thus, consumers patronize the product that yields the largest utility with respect to the strategic

¹This result occurs when the firms' reaction functions are upwards sloping (Gal-Or 1985). Gal-Or (1987) assumes that firms are exogenously endowed with private information of given precision. Though firms are allowed to determine endogenously how precisely to conduct their marketing research, Gal-Or conjectures that the follower always earns higher profits than the pioneer and that the pioneer may refrain from any marketing research in order to eliminate the follower's indirect inference.
attributes. Consumers who have the same taste on the strategic attributes always purchase identical products across various choice occasions.

We explicitly assume that consumers differ in their tastes along both strategic and unobservable attributes.\(^2\) Such unobservable attributes might include underlying characteristics of brand-specific associations and reputation and unspecified situational influences (Belk 1975, Broniarczyk and Alba 1994). Even though their tastes are identical with respect to the strategic attributes, consumers may choose different products due to their idiosyncratic tastes along the unobservable attributes. Furthermore, this paper differs from Chatterjee and Sugita (1990) and Gal-Or (1987) because we assume neither first-mover advantage \textit{a priori} nor a single strategic variable such as output quantity. We assume that each firm strategically chooses its own product position as well as price.

3. The Model

Two firms are considering market entry strategies. Consumers will purchase one unit of product per period. Their tastes are heterogeneous and characterized by two attributes, \(X\) and \(Y\). The first attribute, \(X\), represents characteristics that the firms are able to observe and measure. Such attributes would include, for example, particular product features. Hence, given consumers' differing tastes, each firm positions its own product strategically on one such attribute. We call this attribute the "strategic" attribute and model it in the standard Hotelling paradigm (1929).

Differing tastes across consumers on the attribute \(X\) are described in terms of different ideal points (Coombs 1950). We assume a continuum of ideal points uniformly distributed on the interval \( I \equiv [0, 1] \). While such a distribution is empirically rare, the assumption of uniform tastes enables us to focus on parametric variations of more immediate interest and importance (Lancaster 1979, p. 47). In other words, this assumption eliminates "lumpy" distributions as a possible explanation of first-mover disadvantage (Hauser 1988, Moorthy 1988).

\(^2\)This approach has been used in research on price discrimination (Anderson and de Palma 1988) and product differentiation (de Palma et al. 1985, Rhee et al. 1992, Rhee 1996).
We further assume a quadratic utility loss as in d’Aspremont et al. (1979). Specifically, when a consumer with ideal point \( x \in I \) consumes product \( i \) containing the attribute level \( x_i \), the utility is reduced by \( \delta(x_i - x)^2 \), where the parameter \( \delta > 0 \) is the importance weight associated with the strategic attribute. Such importance weights are widely accepted in consumer attitude and choice research (Bettman et al. 1991).

The attribute \( Y \) represents characteristics that the firms cannot observe, but that consumers take into account when choosing a product. Products may differ by latent brand-specific characteristics and consumers may have idiosyncratic preferences along these characteristics (Guadagni and Little 1983). For example, products may be identical functionally, but differ in consumers' brand-specific associations and reputation (Broniarczyk and Alba 1994). Furthermore, product choice may also be affected by unspecified situational influences (Belk, 1975) and by other attributes that consumers themselves may not be aware of (Hogarth, 1987). Therefore, product choices vary across individuals and purchase occasions due to idiosyncratic preferences along such unobservable attributes, even when consumers have identical tastes with respect to the strategic and controllable attributes.

Consumer heterogeneity along the attribute \( Y \) may be viewed as an error in judgment on the part of consumers. When search costs are relatively high compared to the potential benefit of making a correct decision (e.g., low involvement) or when consumers have difficulty assessing their ideals and product characteristics, errors in accurately measuring the utility of a product will generate diverse product choices that cannot be accounted for by the strategic attribute. In addition, heterogeneity along attribute \( Y \) may occur because current analytical tools cannot predict consumer choices perfectly. Though the firms observe the distribution of differing tastes along the attribute \( Y \), they cannot manage it strategically because of the intractability of its underlying characteristics.

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3Alternatively, consumer utility can be modeled using a linear utility loss as in Lerner and Singer (1937). However, the nature of the problem remains the same even in the linear case and we obtain fundamentally identical results. A detailed formal investigation in the linear case is available from the authors upon request.

4Unspecified situational factors can be interpreted as temporary changes in a consumer’s value of time or other inputs into Becker’s (1976) household production function.

5Consumer variety-seeking could be a source of idiosyncratic preferences along unobservable product attributes, following Pessemier’s (1978) view that consumers could better handle their uncertain tastes by purchasing a portfolio of products.
The unobservable attribute, $Y$, captures the remaining consumer heterogeneity which is unexplained by the strategic attribute $X$. Thus, we assume $X$ and $Y$ to be uncorrelated. A consumer of type $y \in \mathbb{R}$ on the attribute $Y$ has valuation $e_i(y)$ of product $i$. We further assume that both firms equally assess information regarding consumer preferences and attempt to model choices in the same manner. This assumption eliminates informational advantage as a possible source of first-mover disadvantage.

A consumer of type $(x, y)$ obtains following (indirect) utility in consuming product $i$:

$$U_i(x, y) = V - \delta(x - x_i)^2 - p_i + e_i(y),$$

where $V$ is a positive constant and may be viewed as gross benefits that the consumer can obtain from the strategic attribute of the product, and $p_i$ is the price charged by firm $i$. We assume that $V$ is large enough for the consumer to buy either product. Consequently, the consumer decision is over which product to buy, not over whether to buy. The assumption of inelastic demand has an advantage of eliminating asymmetric market conditions as a possible source of first-mover disadvantage. If we allow the existence of consumers who are served by neither firm, some consumers may not purchase either product if consumption generates negative utility. The resulting asymmetric market conditions would confound the effect of consumer heterogeneity on first-mover advantage, which is what we wish to investigate.

Because the firms cannot observe the underlying characteristics of attribute $Y$, they do not know the exact value of $e_i(y)$ on any given purchase occasion. Thus, from the firms' perspective, consumer valuations are random along the unobservable attribute. When estimating sales and profits, the firms treat the valuation, $e_i(y)$, as a random disturbance $\varepsilon_i$. As a result, a firm's prediction of consumer choice will be probabilistic in nature. The probability $Pr_i(x)$ that a consumer of type $x$ will purchase product $i$ over $j$ (i.e., $\text{Prob}[U_i(x, y) \geq U_j(x, y)]$) is

$$Pr_i(x) = Pr[\varepsilon \geq p_i - p_j + \delta(x_i - x_j)(x_i + x_j - 2x)],$$

where $\varepsilon = \varepsilon_i - \varepsilon_j$. We assume that $\varepsilon$ has the logistic distribution with mean zero and standard deviation $\pi\sigma/\sqrt{3}$.\(^6\) Thus, the parameter $\sigma \geq 0$ measures the degree of consumer

\(^6\)Though the normal distribution is an obvious candidate due to the central limit theorem, it does not provide a tractable form for the choice probability. However, it is well known that the logistic distribution not only closely approximates the normal but provides a closed-form expression for the choice probability as well (Ben-Akiva and Lerman 1985).
heterogeneity along the unobservable attribute. It also represents the importance weight associated with the unobservable attribute. See Bass (1974) and Manski (1977) for detailed discussions of random components in stochastic brand choice behavior.

Each firm offers one product and competes non-cooperatively on price and position along the strategic attribute $X$. Without loss of generality, we assume that firm 1 positions to the left of firm 2; i.e., $x_1 \leq x_2$. We further assume that the firms have identical cost structures. This assumption eliminates the possibility that first-mover advantage may arise from technological dominance (Barney 1991). Marginal costs are constant and normalized to zero. Fixed costs are not considered in this paper.

Hence, a consumer of type $x$ will purchase a product from firm 1 with the probability

$$Pr_1(x) = \left[ 1 + \exp \left( a + bx \right) \right]^{-1},$$

where

$$a \equiv \frac{p_1 - p_2 + \delta (x_1^2 - x_2^2)}{\sigma} \quad \text{and} \quad b \equiv \frac{2 \delta (x_2 - x_1)}{\sigma}.$$

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Insert Figure 1 here

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Figure 1 illustrates the choice probabilities. Notice that $Pr_2(x) = 1 - Pr_1(x)$ under the assumption of inelastic category demand. The probability monotonically decreases for firm 1 whereas it increases for firm 2. Furthermore, the inflection point of $Pr_1(x)$ occurs at

$$\hat{x} = -\frac{a}{b} = \frac{x_1 - x_2}{\delta} + \frac{p_2 - p_1}{2 \delta (x_2 - x_1)}.$$

$Pr_1(x)$ is strictly concave over $0 \leq x \leq \hat{x}$ and strictly convex over $\hat{x} \leq x \leq 1$. Consumers to the left of $\hat{x}$ have a higher probability of purchasing a product from firm 1, whereas consumers to the right have a higher probability of purchasing from firm 2. A consumer at the inflection point has identical probabilities of purchasing a product from either firm ($Pr_1(\hat{x}) = 1/2$).
When \( \sigma = 0 \), the probabilistic choice becomes deterministic as in d'Aspremont et al. (1979),

\[
Pr_1(x) = \begin{cases} 
1 & \text{if } 0 \leq x \leq \tilde{x} \\
0 & \text{if } \tilde{x} \leq x \leq 1
\end{cases}
\]

All consumers to the left of \( \tilde{x} \) patronize firm 1 whereas all consumers to the right patronize firm 2. As consumers are increasingly heterogeneous along the unobservable attribute, their choice probabilities become flatter. When \( \sigma \to \infty \), the firms merely expect equal choice probability of either product (1/2), regardless of consumer tastes on the strategic attribute.

Given the uniform taste distribution on the attribute \( X \), firm 1's expected demand is

\[
Q_1(p_1, p_2; x_1, x_2) = \int_0^1 Pr_1(x) \, dx = 1 - \frac{1}{b} \ln \left[ \frac{1 + \exp(a + b)}{1 + \exp(a)} \right].
\]

(3)

Note that \( Q_2 = 1 - Q_1 \). The expected demands are non-negative for \( \sigma = 0 \) and strictly positive for \( \sigma > 0 \). Under the assumption of constant (zero) marginal costs, the expected profits are

\[
\Pi_1 = p_1 Q_1, \quad \Pi_2 = p_2 Q_2.
\]

(4)

The expected profits are continuous functions of position and price over the strategy set, \( \mathbb{R}^2 \times \mathbb{R}^2 \), for any \( \sigma \geq 0 \). Although the firms are uncertain as to a particular consumer's choice due to heterogeneity along the unobservable attribute, they know the distribution of \( \varepsilon \) and are then able to compute their expected sales and profits with certainty. Therefore, the firms have perfect information regarding expected market demand.

4. Sequential Entry under Price Competition

We model competition in a two-stage sequential game as in the previous literature. In the first stage, a Stackelberg leader chooses a position on the strategic attribute \( X \). After observing the leader's position, the follower chooses its position on the attribute \( X \). In the second stage, each firm determines its own price competitively. The intuition is that price can be more easily adjusted than product positions. Consequently, when choosing a position on the strategic attribute, the firm anticipates the impact of this decision on price competition. Given any pair of product positions on the strategic attribute, we first obtain price equilibrium in pure strategies.
4.1. Price Competition

Under the assumption of quadratic utility loss, consumer utility is linear in $\varepsilon$ and $x$ for given $x_1$ and $x_2$. The joint density of $\varepsilon$ and $x$ in the utility function (i.e., the logistic times the uniform densities) is log-concave.\(^7\) Thus, a unique price equilibrium exists for any $\sigma \geq 0$ given any pair of positions $x_1$ and $x_2$ (Caplin and Nalebuff 1991). Though it is difficult to find closed-form solutions for the equilibrium prices in the general case, we can obtain the closed-form solution in the case of symmetric positions, where $x_2 = 1 - x_1$. The first-order conditions provide a symmetric price solution $p_1^* = p_2^* = p^*$ satisfying

$$1 + \frac{1}{2\theta} \ln \left[ \frac{1 + \exp (\theta)}{1 + \exp (-\theta)} \right] - \frac{p}{2\theta \sigma} \left[ \frac{\exp (\theta) - 1}{\exp (\theta) + 1} \right] = 0,$$

where $\theta = \delta (1 - 2x_1) / \sigma$. Hence, the symmetric equilibrium prices are

$$p^* = p_1^* = p_2^* = \sigma \theta \left[ \frac{\exp (\theta) + 1}{\exp (\theta) - 1} \right] = \sigma \theta \coth \left( \frac{\theta}{2} \right).$$

The comparative statics in the case of symmetric positions are consistent with intuition. Since $\partial p^*/\partial x_1 < 0$, firms lower their prices in equilibrium due to intense price competition as their positions get closer along the strategic attribute $X$. Further, $\partial p^*/\partial \delta > 0$ and $\partial p^*/\partial \sigma > 0$ show that firms have more leeway to post higher prices in equilibrium as either $\delta$ or $\sigma$ increases. This is so because price competition is alleviated as consumers assign more weight in product choice to the strategic attribute (i.e., increasing $\delta$) or unobservable attributes (i.e., increasing $\sigma$). Such a lowering of price competition leads to a price increase.

As $\sigma$ increases, consumers are more concerned about their idiosyncratic preferences along the unobservable attribute in making their choices. Thus, pricing becomes increasingly dependent on differing tastes along the unobservable attribute, but less so on product positions along the strategic attribute. When $\sigma \to \infty$, equilibrium prices are invariant across product positions along the attribute $X$. The firms then charge identical prices ($p^* \approx 2\sigma$) regardless of given product positions on the strategic attribute.\(^\text{8}\)

\(^7\)The function $f(x)$ is called log-concave in $x$ when $\ln |f(x_1)| \geq \lambda \ln |f(x_0)| + (1 - \lambda) \ln |f(x_1)|$ where $0 \leq \lambda \leq 1$.

\(^8\)A formal proof is given in Appendix II.
4.2. Positioning Competition

The previous section shows that a unique price equilibrium exists given any pair of positions \( x_1 \) and \( x_2 \). In equilibrium, \( p_1^*(x_1, x_2) \) and \( p_2^*(x_1, x_2) \) are functions of these positions. When we substitute prices in the profit functions with the equilibrium prices, we obtain profits that depend solely on each firm’s position along the strategic attribute, \( x_1 \) and \( x_2 \).

\[
\Pi_1 \left( x_1, x_2, p_1^*(x_1, x_2), p_2^*(x_1, x_2) \right) \equiv \hat{\Pi}_1(x_1, x_2) ,
\]

\[
\Pi_2 \left( x_1, x_2, p_1^*(x_1, x_2), p_2^*(x_1, x_2) \right) \equiv \hat{\Pi}_2(x_1, x_2) .
\]

Without loss of generality, we assume that firm 1 positions before firm 2 in the sequential entry game. Specifically, given firm 1’s choice of \( x_1 \), firm 2 chooses \( x_2 \) in order to maximize profits, \( \hat{\Pi}_2(x_1, x_2) \). Hence, the equilibrium position \( x_2^*(x_1) \) is a function of \( x_1 \). On the other hand, firm 1 will choose \( x_1 \) anticipating firm 2’s positioning strategies. In other words, duplicating the follower’s likely reasoning process, the first-mover forms accurate predictions about the follower’s likely behavior (“perfect foresight”), which are then treated as parameters in its profit function. Consequently, replacing \( x_2 \) in \( \hat{\Pi}_1(x_1, x_2) \) with \( x_2^*(x_1) \), firm 1 estimates its profit with its position \( x_1 \) only.

The Stackelberg equilibrium is then derived from following first-order conditions,

\[
\frac{d\hat{\Pi}_1}{dx_1} = \frac{\partial \hat{\Pi}_1}{\partial x_1} + \frac{\partial \hat{\Pi}_1}{\partial x_2} \frac{dx_2}{dx_1} \leq 0 , \tag{5}
\]

\[
\frac{\partial \hat{\Pi}_2}{\partial x_2} \geq 0 , \tag{6}
\]

where \( dx_2/dx_1 \) is equal to \(- (\partial^2 \hat{\Pi}_2/\partial x_2 \partial x_1)/(\partial^2 \hat{\Pi}_2/\partial x_2^2) \) using the implicit function theorem under the first-order condition \( d\hat{\Pi}_2/dx_2 = 0 \). Note that the second term in equation (5) represents the effect of the first-mover’s position on its profit via the follower’s positioning strategies.

**Proposition 1:** When \( \sigma = 0 \), the equilibrium positions and prices are

\[
(x_1^*, x_2^*) = \left( \frac{1}{2}, \frac{3}{2} \right) \quad \text{and} \quad (p_1^*, p_2^*) = \left( \frac{4 \delta}{3}, \frac{2 \delta}{3} \right) .
\]

**Proof:** See Appendix I.
When consumer tastes are identical in the unobservable attribute \((\sigma = 0)\), we obtain results consistent with previous findings (Lane 1980, Moorthy 1988). The first-mover preempts the follower by positioning itself at the market center and attracts the largest number of consumers. The follower then positions itself away from the first-mover in order to avoid cut-throat price competition. Consequently, the first-mover attains higher market share and profit,

\[
(Q_1^*, Q_2^*) = \left(\frac{2}{3}, \frac{1}{3}\right) \quad \text{and} \quad (\Pi_1^*, \Pi_2^*) = \left(\frac{8\delta}{9}, \frac{2\delta}{9}\right),
\]

respectively.

**Proposition 2:** When \(\sigma\) is large enough, there exists an agglomerated equilibrium at the market center, \(x_1^* = x_2^* = 1/2\), and corresponding equilibrium prices are \(p_1^* = p_2^* = 2\sigma\).

**Proof:** See Appendix II.

When consumer tastes are very heterogeneous along the unobservable attribute, their product choices are almost completely determined by their idiosyncratic preferences along the unobservable attribute. Hence, as shown in the previous section, given any pair of positions on the strategic attribute, both firms earn identical profit margins in the price equilibrium. Consequently, competitive positioning on the strategic attribute declines in importance. Firms merely search for the position which appeals to the largest number of consumers. Therefore, as in the case of simultaneous entry (Rhee et al. 1992), both firms position at the market center in equilibrium, regardless of entry order, and charge identical prices, \(2\sigma\). Neither firm has a strategic positioning advantage based on order of entry. Both firms have identical sales, \(Q_1^* = Q_2^* = 1/2\), and profits, \(\Pi_1^* = \Pi_2^* = \sigma\).

The complexity of the problem makes it difficult to find closed-form solutions for the equilibrium positions when \(\sigma\) is not large enough to yield an agglomerated equilibrium at the market center. We therefore resort to numerical computations. The profits are computed

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9 In this paper, we assume that firms can choose any position on the strategic attribute \(X\). Alternatively, we can restrict product positions to lie within the consumer market, \([0, 1]\), as in d’Aspremont et al. (1979). However, the nature of the problem remains the same even in the restricted case and we obtain fundamentally identical results. A detailed formal investigation in the restricted case is available from the authors upon request.

10 Though Rhee et al. (1992) show an agglomerated equilibrium under the assumption of linear utility loss, the functional form of consumer utility (either linear or quadratic) does not change the nature of the problem. We also obtain identical results in the linear case under sequential entry. A detailed formal proof in the linear case is available from the authors upon request.

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with a grid size of $10^{-2}$ for $0 \leq \sigma/\delta \leq 1$. Note that $\sigma/\delta$ represents the relative importance of the unobservable attribute compared to the strategic attribute in product choice. We obtain the following results through numerical computations:

**Proposition 3:**

(a) When $0 \leq \sigma/\delta < 0.38$, there are dispersed equilibria,\(^{12}\) in which $x_1^*$ is closer to the market center than $x_2^*$.

(b) When $0.38 \leq \sigma/\delta < 0.76$, there are dispersed equilibria, in which $x_2^*$ is closer to the market center than $x_1^*$.

(c) When $\sigma/\delta \geq 0.76$, there exists an agglomerated equilibrium at the market center, $x_1^* = x_2^* = 1/2$.

Figure 2 illustrates changes in equilibrium positions with respect to $\sigma/\delta$. Figures 3 and 4 describe the effect of $\sigma/\delta$ on first-mover advantage in terms of market share and profit. Note that the firm which positions itself closer to the market center charges a higher price and obtains higher market share and profit. As shown in proposition 1, equilibrium positions are $x_1^* = 0.5$ and $x_2^* = 1.5$ in the case of $\sigma = 0$.

As $\sigma/\delta$ increases in the interval of $0 \leq \sigma/\delta < 0.38$, $x_1^*$ moves away from the market center whereas $x_2^*$ moves toward the center. This is consistent with intuition because we view a large $\sigma$ as assigning more weight to the unobservable attribute in product choice. As consumer choices increasingly depend on their idiosyncratic preferences along the unobservable attribute, they become less loyal to the product which yields the largest utility along the strategic attribute. Then, preemptive positioning on the strategic attribute becomes

\(^{11}\)For each case of $\sigma/\delta$, equilibrium prices are computed with a grid size of $10^{-3}$ for $-2 \leq x_1 \leq x_2$ and $x_1 \leq x_2 \leq 2$. Specifically, given $x_1$ and $x_2$, price equilibrium is obtained from the simultaneous first-order conditions using the Newton-Raphson method. In order to check the second-order conditions, we fix $p_1$ ($p_2$) at the equilibrium level and change $p_2$ ($p_1$). We confirm that $\Pi_2$ ($\Pi_1$) is decreasing as $p_2$ ($p_1$) moves away from the equilibrium level. Taking the equilibrium prices into account, we obtain $x_2^*$ which generates the largest profit for each given $x_1$. Then, we choose $x_1^*$ which provides firm 1 with the largest profit.

\(^{12}\)There are two dispersed equilibria for firm 2's position to the left or to the right of firm 1.
less effective in competition. Furthermore, idiosyncratic preferences along the unobservable attribute generate choice variations over the entire market as well. Hence, the follower (who positions itself far away from the center) moves toward the market center in order to capture more choice variations. Anticipating the follower's approach, the first-mover insulates itself from intense price competition by moving away from the market center. By doing so, however, the first-mover erodes its initial strategic advantages. Thus, its sales and profit decrease. Nevertheless, since \( x_1^* \) is closer to the center than \( x_2^* \) in the interval of \( 0 \leq \sigma / \delta < 0.38 \), the first-mover still obtains higher sales and profit: i.e., \( Q_1^* \geq Q_2^* \) and \( \Pi_1^* \geq \Pi_2^* \). When \( \sigma / \delta = 0.38 \), these two firms, which have evolved in opposite directions, are equidistant from the center. The symmetric positions then produce identical sales and profits.

Choice variation arising from idiosyncratic preferences along the unobservable attribute leads not only the follower but also the first-mover toward the market center where demand is greatest. As shown in the second term of equation (5), however, the first-mover should take the follower's approach into account in its positioning whereas the follower takes the first-mover's position as given. Consequently, the follower is more aggressive in capturing the choice variations. When \( 0.38 < \sigma / \delta < 0.76 \), anticipating the follower's aggressive positioning, the first-mover realizes that its positioning for higher market share would generate destructive price competition. Hence, the first-mover positions farther away from the center and leaves more consumers for the follower to capture. The follower, therefore, obtains greater sales and profits under its positional advantage: i.e., \( Q_2^* \geq Q_1^* \) and \( \Pi_2^* \geq \Pi_1^* \).\(^{13}\)

Note that \( x_1^* \) moves back to the market center as \( \sigma / \delta \) increases over 0.47. As consumer choices depend more on their differing tastes along the unobservable attribute, the strategic attribute becomes ineffective in attracting consumers and the firm's incentive for product differentiation decreases. When \( \sigma / \delta > 0.47 \), the incentive for greater demand prevails over the incentive for product differentiation. Thus, the first-mover gravitates toward the market center. When \( \sigma / \delta \) exceeds 0.76, both first-mover and follower position themselves at the

\(^{13}\)When each firm can choose either a "pioneering" or "wait-and-see" strategy as in Chatterjee and Sugita (1990), the results from the numerical computations show that, under high levels of heterogeneity along the unobservable attribute (i.e., \( 0.38 < \sigma / \delta < 0.76 \)), we obtain a pure strategy Nash equilibrium where one firm chooses a pioneering strategy whereas the other firm chooses a wait-and-see strategy. See Appendix III.
market center as shown in proposition 2.

5. Summary and Discussion

The late mover's informational advantage has been advanced as a source of first-mover disadvantage in previous game-theoretic literature (Chatterjee and Sugita 1990, Gal-Or 1987). This paper, however, presents consumers' idiosyncratic preferences along unobservable attributes as another source and shows the disadvantage of entering a new market first even in the absence of informational advantage.

Market preemption is not always a consequence of moving first. The degree of pioneering advantage is determined by how much consumer heterogeneity is accounted for by attributes on which a pioneering firm can preempt strategically. When their tastes vary mainly along strategic attributes, consumers invoke their judgments along the strategic attributes in making their choices. Thus, a later entrant is sensitive to the pioneering incumbent's strategic positioning and strives to move away from the incumbent in order to avoid cutthroat price competition. Anticipating the later entrant's defensive positioning, the pioneer preempts the best market position and earns higher sales and profit.

However, as consumer choices depend more on their idiosyncratic preferences along unobservable attributes, they exhibit increasingly large choice variations over the entire market. The later entrant then moves aggressively to the center in order to capture more choice variations. Conversely, preemptive positioning on the strategic attributes becomes an ineffective means of competition. Therefore, anticipating the later entrant's aggressive approach, the pioneer positions farther away from the market center in order to alleviate destructive price competition. The later entrant then attains higher sales and profit under its positional advantage. In other words, when a large portion of consumer heterogeneity cannot be identified along strategic attributes, our results recommend a wait-and-see strategy because a later entrant obtains greater demand and profits even in the absence of informational advantage.

This paper shows that sufficiently large consumer heterogeneity along unobservable attributes is a source of first-mover disadvantage. It can occur due to a random component of consumer utility from firms' perspective: e.g., consumers' idiosyncratic valuations of di-
verse brand-specific characteristics, brand associations and reputation, etc. When consumers show differing preferences for a product along these brand-specific attributes, the intractability of the underlying characteristics enables late movers to attain a comparative advantage in competition. This finding prescribes that pioneering brands should not only preempt the best market positions, but should also maintain consistent and positively evaluated brand associations across consumers in order to sustain their pioneering advantages.

The random component may also be attributed to errors in judgment on the part of consumers. Such error may occur when the effort associated with information search is relatively costly compared to the potential benefit of making a correct decision. It is well known in consumer behavior research that most consumer purchases in many product categories are not involving, either situationally or on an enduring basis (Hawkins and Hoch 1992). Judgment errors will be prevalent in the low involvement decision making. We would then expect higher possibility of later entrants outperforming pioneers in such consumer markets.

Alternatively, the random component may be an artifact of not being able to conduct marketing research that uncovers all factors contributing to consumer preference. During the last several decades, much progress has been made in consumer behavior and research methodology. As the sophistication of research methods and related information technology improves, firms will be more proficient in countering consumer heterogeneity through more accurate understanding of consumers' true preferences. This leads us to expect that firms will have more leeway in adopting a pioneering strategy.

We derive the results under somewhat restrictive assumptions in order to secure the internal and construct validity. In particular, the assumptions of inelastic category demand and uniform taste distribution enable us to focus on the causality between idiosyncratic preferences along unobservable attributes and first-mover disadvantage. An extension would be to relax these assumptions in order to check whether the causal relationship would be generalized to other settings (Moorthy 1993). We conjecture that idiosyncratic preferences along unobservable attributes will lead to first-mover disadvantage even under the relaxation. However, we expect the first-mover disadvantage to be at higher levels of heterogeneity along unobservable attributes than in the current model because of local monopoly under finite
reservation prices and a concentrated mass of consumers with similar tastes. In addition, we assume a duopoly in order to focus on the disadvantage of being the first-mover. We would extend this research to examine the effect of a potential entrant’s threat on the findings by increasing the number of competing firms in the market.

Another extension would be the case of a quality-type attribute, rather than a ideal-point type one. Drawing upon the findings of Moorthy (1988) and Rhee (1996), we would expect to obtain fundamentally consistent results even when each firm strategically chooses a level of product quality. Multi-dimensional competition would be an interesting extension as well. Furthermore, as the results generate testable hypotheses, careful empirical studies should be called for in order to gain real-life insights about the critical values of $\sigma/\delta$. 
References


Rewards to Pioneering Brands: An Empirical Analysis and Strategic Implications,”
Management Science, 32, 645-659.
Appendix I: Equilibrium under $\sigma = 0$

When $\sigma = 0$, the firms' demands are

\[ Q_1 = \frac{x_2 + x_1}{2} + \frac{p_2 - p_1}{2\delta (x_2 - x_1)} \quad \text{and} \quad Q_2 = 1 - Q_1. \]

The first derivatives of $\Pi_1$ and $\Pi_2$ (defined in equation [4]) with respect to prices are

\[ \frac{\partial \Pi_1}{\partial p_1} = \frac{\delta (x_2 - x_1) (x_2 + x_1) + p_2 - 2p_1}{2\delta (x_2 - x_1)} \quad \text{and} \quad \frac{\partial \Pi_2}{\partial p_2} = \frac{\delta (x_2 - x_1) (2 - x_2 - x_1) + p_1 - 2p_2}{2\delta (x_2 - x_1)}. \]

The first-order conditions yield following closed-form solutions,

\[ p_1^* = \frac{\delta (x_2 - x_1) (x_2 + x_1 + 2)}{3} \quad \text{and} \quad p_2^* = \frac{\delta (x_2 - x_1) (4 - x_2 - x_1)}{3}. \]

The firms' profits are twice differentiable with respect to prices,

\[ \frac{\partial^2 \Pi_1}{\partial p_1^2} = \frac{\partial^2 \Pi_2}{\partial p_2^2} = \frac{-1}{\delta (x_2 - x_1)}, \]

which is always negative. This ensures that the second-order conditions are satisfied.

When we substitute prices in $\Pi_1$ and $\Pi_2$ with $p_1^*$ and $p_2^*$,

\[ \hat{\Pi}_1 = \frac{\delta (x_2 - x_1) (2 + x_2 + x_1)^2}{18} \quad \text{and} \quad \hat{\Pi}_2 = \frac{\delta (x_2 - x_1) (4 - x_2 - x_1)^2}{18}. \]

Since firm 2 determines $x_2$ taking $x_1$ as given, we obtain firm 2's reaction function $x_2^* = (4 + x_1)/3$ from the first-order condition,

\[ \frac{\partial \hat{\Pi}_2}{\partial x_2} = \frac{\delta (4 - x_2 - x_1) (4 - 3x_2 + x_1)}{18} = 0. \]

$\hat{\Pi}_2$ is twice differentiable with respect to $x_2$. At $x_2^*$, we obtain $\frac{\partial^2 \hat{\Pi}_2}{\partial x_2^2} = -2\delta (2 - x_1)/9$. Hence, the second-order condition will be satisfied unless $x_1 > 2$.

Replacing $x_2$ in $\hat{\Pi}_1$ with $x_2^*$, we obtain $\hat{\Pi}_1$ which is then determined by $x_1$ only,

\[ \hat{\Pi}_1 = \frac{4\delta}{243} \left( 50 + 15x_1 - 12x_1^2 - 4x_1^3 \right). \]

The first derivative of $\hat{\Pi}_1$ with respect to $x_1$ is

\[ \frac{\partial \hat{\Pi}_1}{\partial x_1} = \frac{4\delta}{81} (2x_1 - 1) (2x_1 + 5). \]

The first-order condition yields the following Stackelberg equilibrium positions and corresponding equilibrium prices,

\[ (x_1^*, x_2^*) = \left( \frac{1}{2}, \frac{3}{2} \right) \quad \text{and} \quad (p_1^*, p_2^*) = \left( \frac{4\delta}{3}, \frac{2\delta}{3} \right). \]
The second-order condition is satisfied because \( \frac{\partial^2 \hat{\Pi}_1}{\partial x_1^2} = -16\delta/27 \) at \( x_1^* = 1/2 \). In equilibrium, the firms obtain the following demands and profits,

\[
(Q_1^*, Q_2^*) = \left( \frac{2}{3}, \frac{1}{3} \right) \quad \text{and} \quad (\Pi_1^*, \Pi_2^*) = \left( \frac{8 \delta}{9}, \frac{2 \delta}{9} \right).
\]
Appendix II: Equilibrium under $\sigma \to \infty$

Given the firms' demands and profits in equations (3) and (4), we obtain the following first-order conditions:

$$\frac{\partial \Pi_1}{\partial p_1} = Q_1 + p_1 \frac{\partial Q_1}{\partial p_1} = 0 \quad \text{and} \quad \frac{\partial \Pi_2}{\partial p_2} = Q_2 + p_2 \frac{\partial Q_2}{\partial p_2} = 0. \quad \text{(II-1)}$$

From equation (II-1), we obtain

$$p_2^* = -Q_2 \left[ \frac{\partial Q_2}{\partial p_2} \right]^{-1} = \sigma \frac{[1 + \exp(a)][1 + \exp(a + b)]}{[\exp(a) - \exp(a + b)]} \ln \left[ \frac{1 + \exp(a)}{1 + \exp(a + b)} \right].$$

Note that

$$\lim_{\sigma \to \infty} p_2^* = \lim_{\sigma \to \infty} \sigma \frac{[1 + \exp(a)][1 + \exp(a + b)]}{[\exp(a) - \exp(a + b)]} \ln \left[ \frac{1 + \exp(a)}{1 + \exp(a + b)} \right] \lim_{\sigma \to \infty} \ln \left[ \frac{1 + \exp(a)}{1 + \exp(a + b)} \right] \frac{1}{[\exp(a) - \exp(a + b)]}$$

$$= \sigma \lim_{\sigma \to \infty} [1 + \exp(a)][1 + \exp(a + b)] \lim_{\sigma \to \infty} \ln \left[ \frac{1 + \exp(a)}{1 + \exp(a + b)} \right] \frac{1}{[\exp(a) - \exp(a + b)]}$$

$$= 2\sigma,$$

because

$$\lim_{\sigma \to \infty} [1 + \exp(a)][1 + \exp(a + b)] = 4,$$

$$\lim_{\sigma \to \infty} \ln \left[ \frac{1 + \exp(a)}{1 + \exp(a + b)} \right] \frac{1}{[\exp(a) - \exp(a + b)]} \quad \text{by l'Hopital's rule}$$

$$= \lim_{\sigma \to \infty} \frac{[\exp(a + b) - \exp(a)]a + \exp(a + b)[1 + \exp(a)]b}{[1 + \exp(a)][1 + \exp(a + b)] \{\exp(a + b) - \exp(a)\}a + \exp(a + b)b}$$

$$= \frac{1}{2}.$$

Hence, $p_2^* \approx 2\sigma$ when $\sigma$ is sufficiently large. By the same procedure, we obtain $p_1^* \approx 2\sigma$.

At $p_1^*$ and $p_2^*$, the second derivatives of $\Pi_1$ and $\Pi_2$ with respect to prices are non-positive,

$$\frac{\partial^2 \Pi_1}{\partial p_1^2} = \frac{[\exp(a) - \exp(a + b)][2 + \exp(a) + \exp(a + b)]}{\delta(x_2 - x_1)[1 + \exp(a)]^2[1 + \exp(a + b)]^2} \leq 0,$$

$$\frac{\partial^2 \Pi_2}{\partial p_2^2} = \frac{[\exp(a) - \exp(a + b)][2\exp(a)\exp(a + b) + \exp(a) + \exp(a + b)]}{\delta(x_2 - x_1)[1 + \exp(a)]^2[1 + \exp(a + b)]^2} \leq 0,$$

because $\exp(a + b) \geq \exp(a)$. Thus, the second-order conditions are satisfied.

As $\sigma \to \infty$, equilibrium prices approach $2\sigma$ regardless of the given positions. Hence, the first-order condition of $\tilde{\Pi}_2$ with respect to $x_2$ (given $x_1$) becomes

$$\frac{\partial \tilde{\Pi}_2}{\partial x_2} \approx 2\sigma \frac{\partial Q_2}{\partial x_2}$$

$$= 2\sigma \left[ \frac{1}{b(x_2 - x_1)} \ln \left\{ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right\} \right. \left. + \frac{1}{(x_2 - x_1)} \left\{ x_2[\exp(a') - \exp(a' + b)] + \exp(a' + b)[1 + \exp(a')] \right\} \right] = 0, \quad \text{(II-2)}$$

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where \( a' = \delta (x_1^2 - x_2^2) / \sigma \). From the first-order condition, we obtain

\[
x_2 - x_1 = -\frac{\sigma}{2 \delta} \ln \left[ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right] \cdot \frac{1 + \exp(a')}{1 + \exp(a' + b)} \frac{[1 + \exp(a')] \cdot [1 + \exp(a' + b)]}{x_2 \exp(a' + b) + \exp(a' + b)/[1 + \exp(a')]}. \tag{II-3}
\]

The right-hand side of equation (II-3) approaches zero as \( \sigma \to \infty \) because

\[
\lim_{\sigma \to \infty} \ln \left[ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right] = 0.
\]

Further, \( \partial \hat{P}_2 / \partial x_2 \) (shown in equation II-2) is always positive under sufficiently large \( \sigma \). This ensures that firm 2's best reaction given \( x_1 \) is positioning as close to \( x_1 \) as possible.

When \( \sigma \) is sufficiently large, the first-order condition of \( \hat{P}_1 \) with respect to \( x_1 \) becomes

\[
\frac{\partial \hat{P}_1}{\partial x_1} \approx 2 \sigma \frac{\partial \hat{Q}_1}{\partial x_1} = 2 \sigma \left[ \frac{1}{b(x_2 - x_1)} \ln \left\{ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right\} \right. \\
+ \left. \frac{1}{(x_2 - x_1)} \left\{ \frac{x_1 [\exp(a') - \exp(a' + b)] + \exp(a' + b) [1 + \exp(a')] \right\} \right] = 0. \tag{II-4}
\]

From the first-order condition, we obtain

\[
\frac{1}{b(x_2 - x_1)} \ln \left[ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right] + \frac{\exp(a' + b)}{(x_2 - x_1) [1 + \exp(a' + b)]} \\
+ \frac{x_1 [\exp(a') - \exp(a' + b)]}{(x_2 - x_1) [1 + \exp(a')] [1 + \exp(a' + b)]} = 0. \tag{II-5}
\]

As \( x_2 \to x_1 \), the first term on the left-hand side of equation (II-5) becomes

\[
\lim_{x_2 \to x_1} \frac{1}{b(x_2 - x_1)} \ln \left[ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right] = \lim_{x_2 \to x_1} \frac{\sigma}{2 \delta (x_2 - x_1)} \lim_{x_2 \to x_1} \frac{1}{(x_2 - x_1)} \ln \left[ \frac{1 + \exp(a')}{1 + \exp(a' + b)} \right]
\]

by l'Hopital's rule

\[
= \lim_{x_2 \to x_1} \frac{\sigma}{2 \delta (x_2 - x_1)} \lim_{x_2 \to x_1} \left\{ \frac{2 \delta}{\sigma} \left( \frac{x_2 [\exp(a') - \exp(a' + b)] + \exp(a' + b) [1 + \exp(a')] \right)}{[1 + \exp(a')] [1 + \exp(a' + b)]} \right\}
\]

\[
= \lim_{x_2 \to x_1} \frac{\sigma}{2 \delta (x_2 - x_1)} \left\{ \frac{\delta}{\sigma} \right\} = - \lim_{x_2 \to x_1} \frac{1}{2 (x_2 - x_1)}.
\]

The last term of equation (II-5) becomes

\[
\lim_{x_2 \to x_1} \frac{x_1 [\exp(a') - \exp(a' + b)]}{(x_2 - x_1) [1 + \exp(a')] [1 + \exp(a' + b)]} = \lim_{x_2 \to x_1} \frac{x_1}{[1 + \exp(a')] [1 + \exp(a' + b)]} \lim_{x_2 \to x_1} \frac{\exp(a') - \exp(a' + b)}{x_2 - x_1}.
\]

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by l'Hopital's rule
\[
\lim_{z_2 \to z_1} \frac{x_1}{[1 + \exp(a')][1 + \exp(a' + b)]} \cdot \lim_{z_2 \to z_1} \left[ \frac{2 \delta}{\sigma} \left[ \exp(a' + b)(x_2 - 1) - \exp(a')x_2 \right] \right] = \lim_{z_2 \to z_1} \frac{2 \delta x_1}{\sigma [1 + \exp(a')][1 + \exp(a' + b)]}.
\]

Therefore, as \(x_2\) approaches \(x_1\), equation (II-5) becomes
\[
\lim_{z_2 \to z_1} \frac{\exp(a' + b) - 1}{2(x_2 - x_1)[1 + \exp(a' + b)]} = \lim_{z_2 \to z_1} \frac{2 \delta x_1}{\sigma [1 + \exp(a')][1 + \exp(a' + b)]} \cdot \frac{2 \delta x_1}{\sigma [1 + \exp(a')][1 + \exp(a' + b)]}
\]
\[
= \frac{1}{4} \lim_{z_2 \to z_1} \left[ \frac{\exp(a' + b) - 1}{x_2 - x_1} \right] - \frac{\delta x_1}{2 \sigma} \quad \text{by l'Hopital's rule}
\]
\[
= \frac{1}{4} \lim_{z_2 \to z_1} \left[ \frac{2 \delta(1 - x_2)\exp(a' + b)}{\sigma} \right] - \frac{\delta x_1}{2 \sigma}
\]
\[
= \frac{\delta(1 - x_1)}{2 \sigma} - \frac{\delta x_1}{2 \sigma} = 0. \quad (II-6)
\]

As \(\sigma \to \infty\), \(\partial \bar{\Pi}_1/\partial x_1\) (shown in equation II-4) is always positive. Thus, equation (II-6) leads to the following Stackelberg equilibrium positions:
\[
(x_1^*, x_2^*) = \left( \frac{1}{2}, \frac{1}{2} \right).
\]

Consequently, under sufficiently large \(\sigma\), two firms position themselves at the market center with an infinitesimal distance between them. In equilibrium, they charge identical prices, \(p_1^* = p_2^* = 2\sigma\), and obtain identical demands and profits: \(Q_1^* = Q_2^* = 1/2\) and \(\Pi_1^* = \Pi_2^* = \sigma\).
Appendix III: Duopoly Entry Game

Consider the following duopoly entry game in which each firm has two alternative strategies: (1) a "pioneering" strategy under which a firm introduces a new product before the rival (i.e., first-mover) or (2) a "wait-and-see" strategy under which a firm waits for the rival's new product before introducing its product (i.e., follower). The choice of strategy has to be made prior to the two-stage game of positioning and price.

Table A.1
Strategic Form Representation of a Duopoly Entry Game

<table>
<thead>
<tr>
<th>Firm 1's Strategy</th>
<th>Firm 2's Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First-Mover</td>
</tr>
<tr>
<td>First-Mover</td>
<td>$(\Pi_s, \Pi_s)^a$</td>
</tr>
<tr>
<td>Follower</td>
<td>$(\Pi_f, \Pi_p)$</td>
</tr>
</tbody>
</table>

*a The first term in the parentheses represents firm 1's expected profit, whereas the second term is firm 2's expected profit.

Table A.1 shows the strategic form of the duopoly entry game with the payoff matrix. If both firms choose a pioneering strategy, they enter the market simultaneously and obtain $\Pi_s$. When one firm chooses a pioneering strategy whereas the other firm chooses a wait-and-see strategy, the first-mover and follower obtain $\Pi_p$ and $\Pi_f$, respectively. If both firms choose a wait-and-see strategy, they do not enter the market and wait until the rival enters. Consequently, they will obtain zero profit. The results from the numerical computations show that $\Pi_f \geq \Pi_s \geq \Pi_p$ in the interval of $0.38 \leq \sigma/\delta \leq 0.76$ under quadratic utility loss and in the interval of $0.52 \leq \sigma/\delta \leq 2.26$ under linear utility loss. Therefore, the strategy pairs on the off-diagonal of the matrix are Nash equilibrium (i.e., one firm's pioneering strategy and the other firm's wait-and-see strategy). Detailed numerical results are available from the authors upon request.
Figure 1: The choice probability that a consumer will purchase a product from firm 1 or 2.

Figure 2: Equilibrium positions with respect to $\sigma/\delta$. 
Figure 3: Equilibrium market shares with respect to $\sigma/\delta$.

Figure 4: Equilibrium profits with respect to $\sigma/\delta$. 
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