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Competitive Retailer Strategies for New Market Research, Entry and Positioning Decisions

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Abstract

This paper investigates strategies for new market research and positioning of stores and/or products by competing retailers in a duopoly setting. We examine the scenario where the two retailers are considering entry into an uncertain new market that is an extension of their existing markets. The retailers must make decisions on whether or not to first do research about the new market's location relative to their existing markets and its size before deciding on their own positioning in it. We first study a sequential-move leader-follower setup to highlight the choice of an "innovate-or-imitate" strategy. We find when the potential new market is small, neither retailer is adequately incentivized to do research to acquire information about the new market. As the size of the new market increases, the follower is induced to do such research. When the new market is very sizable, the leader conducts research and knows the new market's location while the follower free-rides. We then examine a simultaneous-move setup, in which one retailer might decide against acquiring new market information even when the cost of doing so is low. We further observe that differentiation (e.g., in terms of products or store locations) is greater in the

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simultaneous-move setup than in the sequential setup.

Keywords: market research; positioning; retail market uncertainty; competitive strategies; game theory

1 Introduction

It can be a rewarding retailing practice for competing retailers to enter new markets. However, the emergence of a new market is typically uncertain, because retailers often know little *a priori* about the nature or extent of the new demand. To optimally position their products or decide on store locations, retailers may rely on market research to explore the new market. But, due to a variety of reasons, such as new market uncertainty and market research cost, some retailers oftentimes neglect the new market, giving a leeway for their rivals to encroach on the new market. For example, despite the prevalence of big-box retail chains, such as Wal-Mart, over the last several decades, Whole Foods Market has enjoyed wild success selling organic groceries over much of the past 30 years (Patton and Giammona, 2015).

Similar new market exploration can be observed in the game video retailing industry. When Nintendo created the Wii, it decided to target a broader demographic, besides the existing market dominated by Sony (PlayStation) and Microsoft (Xbox), to include people who showed no interest in video games (for example, mothers, young women, and the elderly). With its market research and corresponding retailing efforts, in the first half of 2007, Nintendo sold more units of Wii in the United States than the Xbox 360 and PlayStation 3 combined (Kuchera, 2007).

The above examples reveal the first-mover advantage when competing retailers act sequentially on market research upon the uncertain new market. In practice, a rival retailer may have two options. First, it can wait and imitate the move of the leading retailer. As an example, although Whole Foods Market benefited from the first-mover advantage, as the organic foods market grows substantially large, the recent imitation of big-box retail chains, such as Costco, Walmart and Target, has significantly intensified the retailing competition on organic offerings (Randall, 2015). Second, the rival retailer may act simultaneously

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together with the other firm by "moving up" its own market research decision. This scenario occurs when the competing retailers recognize the existence of a new market at about the same time. For instance, XM and Sirius compete simultaneously in the satellite radio industry in the late 1990s (Godes and Ofek, 2003) and hardware giants battle concurrently in today's Virtual Reality market (Roettgers, 2016).

The above examples demonstrate that retailers may pursue different strategies on market research and product positioning. Whereas some retailers may choose to conduct market research about the new market to savor the first-mover advantage, others may instead focus on existing markets opting for a wait-and-imitate strategy. Given that no literature has discussed the impact of new market exploration and decision timing on competing retailers' product positioning and pricing decisions, this paper attempts to fill this gap and address the following research questions.

- In either sequential or simultaneous set-up, is it always beneficial for one retailer or both to conduct market research on the uncertain new market?
- How does retailers' market research, together with the order of market entry, affect their product positioning decisions?
- If retailers could endogenize the timing of their entry into a market, how would new market uncertainty affect their choices of timing?

To answer the above questions, we construct a stylized model in which two retailers face an existing market and a new but uncertain market. Consumers have heterogeneous preferences and reside on a Hotelling line segment. The new market is an uncertain extension that can emerge on either the left-hand or the right-hand side of the existing market. Retailers may do market research about the new market's location and its size before deciding the product positioning. In general, our position-then-price framework applies to both retailers' geographical location and new product introduction problems. For simplicity, they are collectively called the positioning problem.

In a sequential set-up, the leader decides whether or not to conduct market research to acquire new market information and chooses its position before the follower's reaction. This sequential-move setup allows us to uncover both players' rationales and highlight the choice of an "innovate-or-imitate" strategy. Our analysis reveals that retailers might decide against acquiring new market information even when it is inexpensive to do so. We identify three economic forces that drive the market equilibrium, in addition to the first-mover effect. Acquiring new market information certainly leads to an improved *positioning* strategy. However, this information is inevitably leaked to the competitor, as the information can be inferred from simply observing the retailer's position. This *free-riding* incentive undermines the benefit of new market research. Moreover, if the location of the new market is known, the retailers can price their products more aggressively to extract the consumers' surplus. This new market information reduces the differentiation (e.g., in terms of products and store locations) between the two retailers and therefore *intensifies price competition*.

When a new market is small, both retailers refrain from acquiring information about it to avoid intense competition. As a result, retailers choose not to acquire new market information and the unresolved uncertainty acts as a differentiating force to soften competition. Once a new market has grown to a moderate size, the follower may be incentivized to acquire information about it. Lastly, when a new market is very sizable, the leader acquires information about it and positions itself at its optimal location, while the follower free-rides.

We further observe that an increase in the size of a new market can lead to either an upward or a downward jump in differentiation. When a new market is relatively small, both retailers determine their positions without acquiring information about the new market. An increase in the size of the new market may first induce the follower to acquire information about it, at which point the follower voluntarily deviates from the leader to avoid intense competition. This result leads to a substantial and abrupt increase in differentiation. When the new market becomes very sizable, the increased market incentivizes the leader to acquire information about it, and the follower's imitation of the leader leads to a sharp reduction in differentiation. The two retailers' pricing strategies strongly reflect their positioning, as higher differentiation leads to higher retail prices.

In a simultaneous-move setup, there is no first-mover or free-ride effect and retailers are mostly concerned about softening competition. Given that an information advantage would only generate negligible benefits, neither retailer acquires new market information in this state of equilibrium. By comparing sequential and simultaneous-move games in positioning, we find that when the new market is sufficiently large, the leader is incentivized to acquire information about it. The follower observes this information and imitates the leader by positioning itself closer to the new market. This imitation reduces both differentiation and profit, which encourages the leader to delay its positioning (from sequentially leading to simultaneous) to prevent the situation from arising in the first place. In addition, when a new market is relatively small, the first-mover advantage dominates the other three effects. Since the leader is entitled to choose its position first, it will occupy the center of the market and capitalize on its first-mover advantage.

The positioning problem studied in this paper follows Hotelling's approach of location-then-price competition among firms/retailers (Hotelling, 1929; d'Aspremont et al., 1979; Cai and Chen, 2011). This approach typically only considers cases in which firms are completely informed about demand conditions. Several papers introduce some form of demand uncertainty into this framework. For example, Balvers and Szerb (1996) study the effects of random shocks on product desirability under fixed prices. Casado-Izaga (2000) and Harter (1996) examine the uncertainty in the form of a uniformly distributed random shift of the (uniform) consumer distribution, and they differ in whether the firms decide their positions simultaneously or sequentially. Meagher and Zauner (2004) and Boneina and Turolla (2009) introduce uncertainty over the center of the consumer distribution from the perspective of simultaneous market entry and sequential market entry, respectively. In contrast, the uncertainty in our framework is captured by the uncertain extension of the existing market. In addition, none of these authors explicitly discuss the role of new market research in position-then-price games. In Daughety and Reinganum (1994), firms are allowed to acquire demand information simultaneously. They show that if the acquisition of demand information is costly, only one firm do so in a state of equilibrium. We deviate from their approach by considering not only a simultaneous but also a sequential-move leader-follower setup, and we model the market uncertainty differently.

The impact of asymmetric information in the leader-follower setup is also examined in the context of war of attrition and preemption games. For example, Mailath (1993) shows that this option is always exercised if the well-informed player has the option of moving first. Normann (2002) also examines the quantity competition game when some firms are more informed than others. Levin and Peck (2003) consider a case where firms are endowed with heterogeneous entry costs. In all of these models, information is exogenous, and their primary focus is on the second mover's advantage from learning (see also Hirokawa and Sasaki, 2001; Rasmusen and Yoon, 2012). Some papers also investigate market information acquisition decisions in a vertical (upstream-downstream) relationship (Guo and Iyer, 2010), direct channel retailing strategy (Cai, 2010), and retailer competition (Cai et al., 2012; Choi and Coughlan, 2006; Ingene and Parry, 2000). In contrast, we study the competing retailers' decisions and focus on the strategic interplay between new market research, entry and positioning.

The remainder of this paper is organized as follows. Section 2 introduces the model. Section 3 performs the equilibrium analysis for the sequential-move game in acquiring new market information and positioning. Section 4 analyzes the simultaneous-move game. Section 5 investigates the retailers' timing decisions. Section 6 discusses the impact of size uncertainty of the new market on retailers' decisions. Section 7 summarizes the results. All proofs are relegated to the Appendix.

2 Model

We consider a stylized model in which two retailers face an existing market and a new, but uncertain, market. We denote product a as the product offered by retailer a, and product b by retailer b. The production costs of the retailers are assumed to be constant and normalized to zero, and for simplicity, the retailers have unlimited production capacity.

Markets. Each consumer is willing to purchase at most one unit of the products. The consumers' preferences of both products are heterogeneous and each consumer is represented by an ideal point, x, which lies in a Hotelling city. The existing market is modeled as a line segment normalized to a unit interval $[-1/2, 1/2]$, where consumers are uniformly distributed. The location of the existing market is therefore deterministic.

The new market, however, is uncertain. We capture this uncertainty by extending a line segment on either side of the existing market with an equal probability. More specifically, with probability $1/2$, the new market appears in $[1/2, 1/2 + N]$; otherwise, in $[-1/2 - N, -1/2]$. N represents the size of this new market[1] and is also a random variable with mean μ (μ could be smaller or larger than 1) and variance σ^2.

[1]In classic Hotelling models, consumers are assumed to be uniformly distributed along a line segment. As for consumers, there is a variety of tastes such that each consumer has a most preferred position. In turn, each position is most preferred by the same density (e.g., M) of consumers. The distribution of tastes is uniform and M can be set to 1 without loss of generality. So, the length of this line segment represents both the range of consumer preferences and the market size. The uncertainty we introduced is captured by the uncertain extension of the existing line segment. Hence, N, the length of the new line segment, represents the size of this new market.

The *market uncertainty* is described by the ambivalence of where the new market would appear and how large N would be. Similarly, consumers in this new market are uniformly distributed.

Consumer preferences. Upon purchasing the product, a consumer obtains a (gross) valuation v, irrespective of the product identity. Since the ideal point x may differ from the retailers' locations, the consumer incurs a "transportation cost," which captures the negative utility arising from the discrepancy between its ideal point and the retailers' location. Specifically, let x_a and x_b denote the positions of retailers a and b (which will be the retailers' strategic decisions as we elaborate later on). If a consumer locating at x purchases product a, its net utility is $v - t(x - x_a)^2 - p_a$, where t measures the magnitude of this disutility, and p_a is the price charged by retailer a. Likewise, its net utility is $v - t(x - x_b)^2 - p_b$ while purchasing from retailer b (with p_b being the price of product b). This quadratic transportation cost model has been adopted in a number of papers, for example, d'Aspremont et al. (1979) and Tyagi (2000). Furthermore, the consumers' valuation v is assumed to be sufficiently high to ensure full market coverage.

Information acquisition. In this paper, *information acquisition* is defined as the market research on locating the new market and learning its size. *Ex ante*, each retailer is aware that the new market can be either a right-hand or a left-hand extension of the existing market, but neither of them can perfectly predict which side it will be or how large the new market size will be. Each retailer can decide whether or not to do research to acquire information about the new market's location. If a retailer conducts such research, it pays a cost, $C > 0$ and knows perfectly which side the new market will be but not its size. If it chooses not to do such research, it remains uninformed about the new market's location. Each retailer's decision on acquiring new market information is publicly observable, but the outcome is only privately known to itself. This assumption captures the idea that a costly, resource-consuming market investigation cannot be conducted completely under the radar, but the outcome of this market investigation becomes the retailer's business secret. For example, when requesting a consumer feedback report or carrying out a large-scale sample testing to verify the consumers' attitudes, a retailer's actions are observed at large (especially by its competitors); nonetheless, the content of reports and sampling test results are kept confidential.

Given the duopoly model, there are four possible outcomes in the information acquisition stage:

1. Case AA: Both retailers do research to acquire new market information;
2. Case AU: Retailer a acquires information but retailer b does not;
3. Case UA: Retailer b acquires information but retailer a does not;
4. Case UU: Neither retailer acquires new market information.

Sequential-move setup. In a sequential-move setup, we consider the following game setting: Retailer a is the market leader on information acquisition and positioning; retailer b makes decisions on information acquisition and positioning after observing retailer a's decisions. This sequential-move setup allows us to uncover the rationales for both the market leader and follower, and highlight the choice of an "innovate-or-imitate" strategy. On the other hand, the prices are determined simultaneously because pricing tends to be easily adjustable and can only be finalized after the products have been put on the market.

This location-then-price sequence reflects the idea that product design and store positioning decision is a longer-term and more strategic decision than the pricing of a product. Hence, the sequence of events proceeds as follows: 1) Retailer a decides whether or not to do research to acquire new market information. If so, it observes the location of the new market. 2) Given retailer a's information acquisition decision, retailer b decides whether or not to acquire new market information. If yes, it observes the location of the new market. Otherwise, it stays uninformed until after having observed retailer a's position. 3) Retailer

a determines its position. 4) After observing retailer a's position, retailer b determines its position. 5) After observing the positions, both retailers simultaneously determine their prices. 6) Sales occur and both retailers collect their revenues.

Simultaneous-move setup. In a simultaneous-move setup, we consider the following game setting: both retailers simultaneously make decisions on information acquisition and positioning. In addition, we allow the retailers to decide their selling prices simultaneously. The sequence of events proceeds as follows: 1) Both retailers first decide whether or not to do research to acquire new market information and then determine their positions simultaneously. If they acquire information, they observe the location of the new market. 2) Both retailers simultaneously determine the prices. 3) Sales occurs and both retailers collect their revenues.

For mathematical tractability, we initially assume no size uncertainty ($\sigma = 0$) in Sections 3, 4 and 5. In Section 6, we numerically investigate the impact of uncertainty over the size of the new market on the retailers' decisions. In both the sequential-move and the simultaneous-move setups, we assume that retailers' pricing decisions are made after they have complete information about the location and size of the new market. This assumption is sensible as it is easier in reality for retailers to adjust prices than product characteristics or the geographic location of a store.

In our model, the retailers could position themselves anywhere on the real line, including outside the bounded line where consumers' ideal points lie. This assumption is made for the following reasons: first, it is known from prior work (see, e.g., Tabuchi and Thisse, 1995; Lambertini, 1997; Tyagi, 2000; Liu and Tyagi, 2011) that in the standard Hotelling model with a uniform distribution of consumer preferences and quadratic transportation cost, retailers would find it optimal to locate outside the market space. Second, there are practical examples in which retailers' decision makers tend to position outside the ideal points of the majority of consumers. For example, when choosing the location of designer factory outlets, retailers often locate factory outlets on the outskirts or even outside the city in which the majority of consumers live.

3 Sequential positioning and information acquisition

This section performs the equilibrium analysis on retailers' information acquisition and positioning decisions under the sequential-move setup where retailer a is the leader.

In the sequential-move game, by backward induction, we start with the last stage in which the consumers make their purchasing decisions after observing the prices and product positions. Then, we examine how the retailers set the prices simultaneously given their positions. Afterwards, we study how retailer b chooses its position given retailer a's position, and then examine how retailer a decides its position by anticipating retailer b's reaction. Finally, we consider retailers' sequential decisions on acquiring new market information. The sequential information acquisition game can be represented in the extensive form in Figure 1.

[Figure 1 is about here]

To illustrate the information learning dynamics, we consider the case that the leader (retailer a) chooses to acquire new market information as an example. Observing that retailer a has acquired information, retailer b (the follower) has two options: acquire information or not. Hence, there are two possible outcomes: 1) both retailers acquire information (AA), and 2) retailer a acquires information but retailer b does not (AU). After observing retailer a's position, retailer b also knows the location of the new market; it can then choose to go either right or left of retailer a. Considering the possible locations of the new market, there are four possible scenarios here: 1) the new market appears on the left-hand side and retailer b goes right of retailer a; 2) the new market appears on the left-hand side and retailer b goes left of retailer a; 3) the new market appears on the right-hand side and retailer b goes right of retailer a; and 4) the new market appears on the right-hand side and retailer b goes left of retailer a. Following the same procedure, we can characterize the equilibrium outcomes of each subgame.

3.1 Retailer a chooses to acquire information

We first consider Cases AA and AU, where retailer a chooses to acquire information. We first state the tie-break rule as follows.

Definition 1 ***(Tie Breaker)*** *When the follower (retailer b) has multiple equivalent choices to position itself, it chooses the one that is closest to the center of the existing market.*

This assumption simplifies the equilibrium characterization, and it is beneficial to the follower especially when the leader attempts to send a wrong signal to the follower by deviating its position to the opposite side.

Following Tyagi (2000), we let the retailers position themselves at x_L and x_R ($x_R \geq x_L$) and charge prices p_L and p_R, respectively. We call the retailer located at x_L as L and the retailer at x_R as R. The marginal consumer who is indifferent between buying from either retailer is located at $\widehat{x}$ as defined by $v - t(\widehat{x} - x_L)^2 - p_L = v - t(\widehat{x} - x_R)^2 - p_R$. Hence, we have $\widehat{x} = \frac{p_R - p_L + t(x_R^2 - x_L^2)}{2t(x_R - x_L)}$ if $\widehat{x}$ is in the support of consumer distribution.[2]

3.1.1 Retailer b acquires information (AA)

Case AA is a game of complete information. The demand and profits can be calculated as follows. When the new market appears on the left-hand side, retailer L's demand is $D_L = \widehat{x} + 1/2 + N$ and retailer R's

[2]For ease of exposition, the subscripts L and R are used to indicate retailers L or R, respectively. For example, x_L, p_L and π_L are retailer L's position, price and profit, respectively. In proofs, we also use the superscripts L and R to represent the scenarios when the new market appears on the left-hand side and right-hand side, respectively. For example, x_a^L, p_a^L and π_a^L are retailer a's position, price and profit when the new market appears on the left-hand side.

demand is $D_R = 1/2 - \widehat{x}$. When the new market appears on the right-hand side, retailer L's demand is $D_L = \widehat{x} + 1/2$ and retailer R's demand is $D_R = 1/2 + N - \widehat{x}$. Their profits are $\pi_L = p_L D_L - C$ and $\pi_R = p_R D_R - C$, respectively.

We focus on pure-strategy subgame-perfect equilibria of this position-then-price game. The equilibrium solutions for Case AA are characterized in the following lemma.

Lemma 1 *When both retailers choose to acquire information (i.e., AA), a unique pure-strategy equilibrium exists.*

1. *When the new market appears on the left-hand side, the equilibrium positions are* $x_a^* = -\frac{\mu}{2}$ *and* $x_b^* = 1 + \frac{\mu}{2}$*; when the new market appears on the right-hand side, the equilibrium positions are* $x_a^* = \frac{\mu}{2}$ *and* $x_b^* = -(1 + \frac{\mu}{2})$*. The degree of differentiation* $(i.e., |x_b^* - x_a^*|)$ *is* $1 + \mu$.
2. *The equilibrium prices are* $p_a^* = \frac{4t(1+\mu)^2}{3}$ *and* $p_b^* = \frac{2t(1+\mu)^2}{3}$*; the equilibrium profits are* $\pi_a^* = \frac{8t(1+\mu)^3}{9} - C$ *and* $\pi_b^* = \frac{2t(1+\mu)^3}{9} - C$*, irrespective of the location of the new market.*

In AA, both retailers know the location of the new market at the time of positioning decisions. As the market leader, retailer a has an advantage by preempting the most attractive position, allowing itself to charge a premium price and earn greater profits. Retailer b positions away from retailer a in order to soften price competition. Retailer b's strategy results from the trade-off between the benefit of a larger market share from moving closer to the market center and the loss in profits due to fiercer price competition.

By taking a closer look at the equilibrium positions, we find that when the size (μ) of the new market becomes larger, retailer a positions at the same side of the new market but further away from the center of the existing market while retailer b moves its position further away to the opposite side of the new market. Hence, in equilibrium, increase in the size of the new market leads to greater differentiation. Indeed, the equilibrium differentiation is given by $\Delta_{\text{seq}}^{AU} = |x_b^* - x_a^*| = 1 + \mu$ and obviously we have $\frac{d\Delta_{\text{seq}}^{AU}}{d\mu} > 0$. One can also check that in equilibrium $\frac{dp_a^*}{d\mu} > 0$, $\frac{dp_b^*}{d\mu} > 0$, $\frac{d\pi_a^*}{d\mu} > 0$, $\frac{d\pi_b^*}{d\mu} > 0$. Therefore, increase in the size of the new market also leads to higher prices and greater profits.

3.1.2 Retailer b acquires no information (AU)

The positioning interaction in AU is a game of incomplete information in which the second mover (retailer b) infers the information of the first mover (retailer a) based on the first one's positioning decision. Therefore, the solution concept in AU is that of Bayesian equilibrium. Multiplicity of equilibria is a well-known problem in Bayesian games because off-equilibrium beliefs are not uniquely determined by the standard Bayesian Nash solution concept. However, as shown in the proof of Lemma 2, the tie-break rule described in Definition 1 serves as a suitable refinement that imposes restrictions on off-equilibrium beliefs and hence subgames on off-equilibrium paths do not arise. A unique Bayesian equilibrium can be derived in the following lemma.

Lemma 2 *When retailer a chooses to acquire information but retailer b does not (i.e., AU), a unique Bayesian equilibrium exists.*

1. *When the new market appears on the left-hand side, the equilibrium positions are* $x_a^* = -\frac{\mu}{2}$ *and* $x_b^* = 1 + \frac{\mu}{2}$*; when the new market appears on the right-hand side, the equilibrium positions are* $x_a^* = \frac{\mu}{2}$ *and* $x_b^* = -(1 + \frac{\mu}{2})$*. The degree of differentiation* $(i.e., |x_b^* - x_a^*|)$ *is* $1 + \mu$.
2. *The equilibrium prices are* $p_a^* = \frac{4t(1+\mu)^2}{3}$ *and* $p_b^* = \frac{2t(1+\mu)^2}{3}$*; the equilibrium profits are* $\pi_a^* = \frac{8t(1+\mu)^3}{9} - C$ *and* $\pi_b^* = \frac{2t(1+\mu)^3}{9}$*, irrespective of the location of the new market.*

Again, the market leader, retailer a, occupies the most attractive position, charges a higher price and earns greater profits, while the follower, retailer b, positions away from retailer a and beyond the limit of the market. By comparing the equilibrium solutions in Lemma 1 and Lemma 2, we notice that the two games generate exactly the same results. This result seems surprising since the positioning game in AA is a game of complete information while the positioning game in AU is a game of incomplete information. However, as shown in Lemma 2, retailer b's strategy of choosing the position that is closest to the existing market center is weakly dominant. Because it is not beneficial for retailer a to send a wrong signal to retailer b by deviating its position to the opposite side, retailer b knows the location of the new market after observing retailer a's position. Hence, in Case AU, retailer b just free rides and becomes perfectly informed about the location of the new market without paying an information acquisition cost C.

Regarding location decisions, fast-food restaurants, coffee shops, and retailing markets contain many examples exhibiting a similar pattern to our prediction here. For instance, Starbucks captures a large market share of coffee drinks in USA by occupying the best location and leaves small coffee shops on side streets or in small towns (Simon, 2011). In China, the development of Starbucks in various main cities and the emergence of independent coffee houses also reflect the equilibrium outcome described in Case AU (Harrison et al., 2005). In the retailing industry, previous studies provide support for national chain stores' propensity to catch most of the demand by preempting the space between the market center and the inner suburb, forcing "mom and pop" stores to locate themselves away in geographical niches (Boneina and Turolla, 2009; Haltiwanger et al., 2010). As a result, the market follower has to price lower to attract consumers.

3.2 Retailer a does not acquire information

In this case, retailer a chooses not to acquire information at the beginning. Facing an uninformed leader, retailer b needs to decide whether or not to acquire information. Therefore, there are two possible information acquisition outcomes: UA and UU.

3.2.1 Retailer b acquires information (UA)

As shown in the proof of Lemma 3, without knowing which side the new market would appear, retailer a shall simply position itself at center of the existing market. Consequently, retailer b would go right of retailer a when the new market appears on the right-hand side and would go left of retailer a when the new market appears on the left-hand side. It is straightforward to show that retailer b's equilibrium profits are lower if it does the opposite. The equilibrium is characterized in Lemma 3.

Lemma 3 *When retailer a does not acquire information but retailer b does, a unique pure-strategy equilibrium exists.*

1. *The equilibrium positions are $x_a^* = 0$ and $x_b^* = -(1 + \frac{4\mu}{3})$ when the new market appears on the left-hand side, and $x_b^* = 1 + \frac{4\mu}{3}$ when the new market appears on the right-hand side. The degree of differentiation is $|x_b^* - x_a^*| = 1 + \frac{4\mu}{3}$.*
2. *The equilibrium prices are $p_a^* = \frac{2t(3+4\mu)(6+5\mu)}{27}$ and $p_b^* = \frac{2t(3+4\mu)^2}{27}$; the equilibrium profits are $\pi_a^* = \frac{2t(3+4\mu)(6+5\mu)^2}{243}$ and $\pi_b^* = \frac{2t(3+4\mu)^3}{243} - C$, irrespective of the location of the new market.*

In this case, the uninformed retailer moves first and occupies the center of the existing market, charges a higher price and earns greater profits. The informed follower positions on the same side of the new market but beyond the limit of the overall market. The reason is as follows. As the uninformed leader, retailer a has no chance to observe the informed retailer's position and hence the location of the new market. This makes it indifferent between selecting "left" and "right." Given the uninformed leader's position, the informed follower positions far away from its competitor in order to avoid fierce price competition. In addition, we also find that, in equilibrium, increase in the size of the new market leads to greater differentiation, higher prices and higher profits, because a bigger new market enables the retailers to position in a wider horizon. In fact, the pure existence of the location uncertainty can be a differentiation force, because retailers can benefit from positioning differently rather than identically when they are unsure where the new market would appear.

As discussed previously, the organic foods market illustrates this particular setting. Organic foods was first sold by specialty stores. Unlike big-box retail chains, specialty stores' information acquisition capability is limited and they have to deal with a high level of uncertainty when exploring this new market. Only in recent years have big-box retail chains tried to enter this market more aggressively. So in this context, specialty stores acted as the uninformed market leader and enjoyed price premiums due to the first-mover advantage. Regarding positioning decisions, specialty stores usually locate in adjoin neighborhoods of the city center while big-box retail chains such as Walmart and Costco stay far away from them.

The game console retailing competition provides another suitable example. Indeed, the then market leaders, Microsoft and Sony, paid little attention to the new market and strategically allocated resources to focus on the existing market, whereas Nintendo conducted market research and became informed about the new market. As a result, Nintendo developed the Wii to target a new demographic, while the rival PlayStation 3 and Xbox 360 remained catering to existing consumers. Regarding positioning decisions, it is interesting to note that Nintendo, the informed follower, decided not to go head to head with the leading video game sellers Sony PlayStation and Microsoft Xbox.

3.2.2 Retailer b acquires no information (UU)

In this case, neither retailer acquires information. As shown in the proof of Lemma 4, without knowing the exact location of the new market, it is rational for retailer a to position itself in the middle of the existing market. Retailer b would choose to go either right or left of retailer a. Without loss of generality, we assume that retailer a positions itself on the left-hand side of the existing market (i.e., $x_a \leq 0$), then it is rational for retailer b to position itself on the right. Otherwise, if retailer a positions itself on the right half of the existing market, (i.e., $x_a \geq 0$), then it is rational for retailer b to position on the left. The above position-then-price game can be solved backward. The equilibrium is characterized in Lemma 4.

Lemma 4 *When neither retailer decides to acquire information, a unique pure-strategy equilibrium exists.*

1. *The equilibrium positions are given by the pair* $x_a^* = 0$, $x_b^* = \frac{6(1+\mu)-D}{3}$, *where*[3]

$$D \triangleq \sqrt{9 + 18\mu + 6\mu^2}.$$

The degree of differentiation is $|x_b^* - x_a^*| = 2(1+\mu) - \frac{D}{3}$.

[3] This is the case when retailer b goes right of retailer a. The equilibrium corresponding to the case when retailer b goes left of retailer a can be obtained by flipping all positions 180 degrees around the vertical axis.

2. *When the new market appears on the left-hand side, the equilibrium prices are*

$$p_a^* = \frac{t(15+18\mu-D)(6+6\mu-D)}{27}, \textit{ and}$$
$$p_b^* = \frac{t(3+D)(6+6\mu-D)}{27};$$

When the new market appears on the right-hand side, the equilibrium prices are

$$p_a^* = \frac{t(15+12\mu-D)(6+6\mu-D)}{27}, \textit{ and}$$
$$p_b^* = \frac{t(3+6\mu+D)(6+6\mu-D)}{27}.$$

3. *The equilibrium profits are*

$$\pi_a^* = \frac{t(6+6\mu-D)\left[39+78\mu+40\mu^2-5(1+\mu)D\right]}{81}, \textit{ and}$$
$$\pi_b^* = \frac{t(6+6\mu-D)\left[3+6\mu+4\mu^2+(1+\mu)D\right]}{81}.$$

In this case, both retailers are uninformed when choosing their positions. The leader (retailer a) occupies the center of the existing market while the follower (retailer b) positions beyond the limit of the overall market. It can be verified that the differentiation here is greater than that of cases AA and AU but smaller than that of case UA. The positioning result here again indicates that the location uncertainty could be a differentiation force. Similar to previous cases, we also find that in equilibrium, increase in the size of the new market leads to greater differentiation, higher prices, and higher profits. In retailing markets, competing "mom and pop" stores, independent coffee stores, and bookstores are in line with this story because they may know their potential market but cannot recognize specific locations of consumers before deciding on the place in which they are going to establish themselves.

3.3 The information acquisition equilibrium

We now compare the retailers' payoffs to determine the market equilibrium of the full game. The expected equilibrium payoffs are summarized in Table 1. Based on Table 1, we can identify the retailers' equilibrium strategies at the information acquisition stage, which is characterized in Proposition 1.

Retailer a \ Retailer b	A	U
A	$\frac{8t}{9}(1+\mu)^3 - C$, $\frac{2t}{9}(1+\mu)^3 - C$	$\frac{8t}{9}(1+\mu)^3 - C$, $\frac{2t}{9}(1+\mu)^3$
U	$\frac{2t(3+4\mu)(6+5\mu)^2}{243}$, $\frac{2t(3+4\mu)^3}{243} - C$	$\frac{t(6+6\mu-D)\left[39+78\mu+40\mu^2-5(1+\mu)D\right]}{81}$, $\frac{t(6+6\mu-D)\left[3+6\mu+4\mu^2+(1+\mu)D\right]}{81}$

Table 1: Expected payoffs at information acquisition stage (The Sequential Case)

Proposition 1 *There exist two cutoff levels N_1 and N_2 such that in equilibrium,*[4]

1. *The leader acquires information about the new market but the follower does not if $\mu \geq N_1$;*
2. *The leader chooses not to acquire information about the new market but the follower does if $N_2 \leq \mu < N_1$;*
3. *Neither retailer acquires information about the new market if $\mu < N_2$, where $\mu = E[N]$.*

[Figure 2 is about here]

Figure 2 provides a graphic illustration of Proposition 1. From Figure 2, even when the information acquisition is not costly, it is not always optimal for the market leader to acquire information unless the new market is sufficiently large (i.e., $\mu \geq N_1$). Acquiring information certainly leads to a better positioning strategy. But, this information can be inferred by the competitor upon observing the position. This free-riding feature undermines the benefit of information acquisition. Moreover, if the location of the new market is known (either the leader or the follower acquires the information), the retailers can set prices more aggressively to extract the consumers' surplus. In return, the differentiation generated by the location uncertainty of the new market reduces, intensifying the price competition.

Our analysis reveals that the above three economic forces, together with the first-mover effect, drive the market equilibrium. When the new market size is small (i.e., $\mu < N_2$), both retailers have fewer incentives

[4] The cutoff level N_1 uniquely solves $\frac{8t(1+\mu)^3}{9} - \frac{2t(3+4\mu)(6+5\mu)^2}{243} = C$, and N_2 solves $\frac{2t(3+4\mu)^3}{243} - \frac{t(6+6\mu-D)[3+6\mu+4\mu^2+(1+\mu)D)]}{81} = C$.

to acquire information about the new market as the unresolved uncertainty acts as a differentiation force and softens competition.[5] In our model, the leader trades off the advantages of being informed against the disadvantages of revealing its information. Once the leader acquires information, it observes the location of the new market perfectly. The follower knows that the leader has accurate information and chooses to imitate and move closer to the leader. This reduces the degree of differentiation and intensifies competition. The leader knows this and hence chooses not to acquire information when the new market is not sizable.

As the new market size becomes moderately large (i.e., $N_2 \leq \mu < N_1$), the potential benefit of acquiring new market information increases; however, the benefit is not sufficient for the leader to acquire information since the leader dominates the existing market and its main concern is to prevent the follower's free riding. The underlying drivers behind the leader are the first-mover effect and concern of the follower's free riding. In contrast, a moderate size of the new market is sufficient for the follower to conduct research to acquire new market information. The underlying driver behind the follower is the better positioning effect. Thus, the UA case emerges as the market equilibrium. Finally, when the new market is very sizable (i.e., $\mu \geq N_1$), the leader's benefit of acquiring new market information outpaces the disadvantage of information leakage.

In the organic foods market, specialty stores are considered as the pioneer. Initially, specialty stores and big-box retail chains can be considered equivalent to case UU in our model. As the market grows, specialty stores benefited from the first-mover advantage and captured a market share of over 60% in 1990s in the US market (Dimitri and Oberholtzer, 2009). In this period, it corresponds to case UA in our model. More recently, when the organic foods market went mainstream and became very sizable, big-box retail chains tried to enter this market more aggressively on a national scale. The scenario then becomes case AU in

[5] For instance, the entry behavior of independent coffee stores in developing regions illustrates this finding.

our setup, with big-box retail chains being the informed market leader.[6] The market equilibrium of organic foods is in line with our theoretical predictions.

3.4 Positioning in equilibrium

Here we further discuss how the equilibrium positions react to the location uncertainty of the new market. To this end, we start with three *separate* cases. First, in Case UU, both retailers are uninformed. To exercise its first-mover advantage, the leader (retailer a) positions at the center of the existing market (i.e., $x_a^* = 0$), whereas the follower (retailer b) positions beyond the market boundary to avoid intense price competition (i.e., $x_b^* = \frac{6(1+\mu)-D}{3}$). The differentiation in equilibrium is given by the distance $|x_b^* - x_a^*| = 2(1+\mu) - \frac{D}{3}$ and this distance increases as μ becomes larger.

In Case UA, the uninformed leader (retailer a) stays at the center of the existing market, i.e., $x_a^* = 0$. The informed follower (retailer b) observes the location of the new market, and it positions at $x_b^* = -(1+\frac{4\mu}{3})$ or $(1+\frac{4\mu}{3})$ when the new market appears on the left- or right-hand side, respectively. In fact, the follower positions further away beyond the market boundary compared to the choice when it is uninformed. This is because it anticipates that the leader will infer the information from its position and ultimately the price competition gets intensified. To escape from this undesirable outcome, the follower voluntarily stays far away from the leader, and positions itself $(\frac{1}{2} + \frac{\mu}{3})$ beyond the anticipated boundary of the new market. Finally, in Case AU, the leader positions itself at the most attractive location while the follower positions $\frac{1}{2}(1+\mu)$ beyond the anticipated market boundary in view of price competition. More specifically, the leader positions at $x_a^* = -\frac{\mu}{2}$ or $\frac{\mu}{2}$ and the follower positions at $(1+\frac{\mu}{2})$ or $-(1+\frac{\mu}{2})$ when the new market appears

[6] For example, one factor explaining Costco's recent success in organic foods sales is its strategy to court a younger demographic (Gonzalez, 2015) while Whole Foods targets toward high-end consumers who are more affluent. Starting in 2016, Whole Foods is building its new 365 stores which cater to younger and less affluent shoppers (Kessler, 2016). This new development shows that nowadays, big-box retail chains are more informed about the new consumer trends and have become the leader in the organic foods market.

on the left- or right-hand side, respectively.

[Figures 3 and 4 are about here]

Combining the equilibrium information acquisition strategies and the above positioning decisions, we can then articulate the impact of location uncertainty of the new market on the positioning strategies. For ease of illustration, in Figures 3 and 4 we plot the retailers' positions and differentiation versus the size of the new market. We fix the transportation parameter $t = 1$ and acquisition cost $C = 1$, and illustrate the instance in which the new market appears on the right-hand side.

As demonstrated in Figures 3 and 4, when the size of the new market increases at around $\mu = 1$, differentiation experiences a non-trivial jump. This is because the follower is incentivized to acquire new market information, and consequently, it voluntarily stays far away from the leader to avoid intense competition. More interestingly, when $\mu \approx 2.15$, an increased market size can lead to a lower level of differentiation. This downward jump arises because the leader finds it optimal to acquire new market information before deciding its position. Since its decision clearly indicates the location realization of the new market, the follower imitates by moving its position closer to the new market. The stories of specialty stores vs. big-box retail chains in organic foods market is in line with our findings. The pricing decisions follow closely the positioning strategies.

4 Simultaneous positioning and information acquisition

This section carries out the equilibrium analysis on retailers' information acquisition and positioning decisions under the simultaneous-move setup, which is exemplified by XM and Sirius in the satellite radio industry in the late 1990s (Godes and Ofek, 2003) and hardware giants in the current Virtual Reality market (Roettgers, 2016). In this setting, both retailers first decide whether or not to acquire new market information and then determine their positions simultaneously. After observing the positions, they set prices simultaneously. By backward induction, we shall start with the last stage in which the consumers make their purchasing decisions after observing the prices and positions. Then, we examine how the retailers decide the prices given their positions, and how they choose their positions given their information acquisition decisions. Finally, we consider retailers' decisions in the information acquisition stage.

Similar to the sequential game, there are also four possible outcomes in the information acquisition stage where retailers make their decisions simultaneously: both retailers acquire information (Case AA); one retailer acquires information and the other does not (Case AU or UA); neither retailer acquires information (Case UU). We first characterize the equilibrium outcomes of each subgame.

4.1 Both retailers acquire information (AA)

If both retailers acquire information at the beginning, they know the location but not the exact size of the new market prior to their respective positioning and pricing decisions. Without loss of generality, we assume that $x_a < x_b$ since the retailers' equilibrium positions are "symmetric" no matter where the new market appears. We focus on pure-strategy subgame-perfect Nash equilibria of this position-then-price game. The equilibrium solutions for Case AA are characterized in the following lemma.

Lemma 5 *If both retailers acquire information at the beginning, a unique pure strategy equilibrium exists for the position-then-price game.*

1. *The equilibrium positions are* $x_a^* = -\frac{3+5\mu}{4}$, $x_b^* = \frac{3+\mu}{4}$ *when the new market appears on the left-hand side, and* $x_a^* = -\frac{3+\mu}{4}$, $x_b^* = \frac{3+5\mu}{4}$ *when the new market appears on the right-hand side.*
2. *The equilibrium prices are* $p_a^* = p_b^* = \frac{3t(1+\mu)^2}{2}$; *the equilibrium profits are* $\pi_a^* = \pi_b^* = \frac{3t(1+\mu)^3}{4} - C$, *irrespective of the location of the new market.*

The equilibrium differentiation is given by $\Delta_{sim}^{AA} = |x_b^* - x_a^*| = \frac{3}{2}(1 + \mu)$, which is greater than that of the sequential AA case. This means that when both retailers are informed, they position further apart under simultaneous positioning than under sequential positioning. This result reflects the fact that, not knowing the competitor's position, both retailers choose to position far apart to avoid the fierce price competition. Consequently, the price competition turns out to be less intense when positioning decisions are made simultaneously than sequentially. Similar to the sequential-move setup, in equilibrium, increase in the size of the new market leads to greater differentiation, higher prices and higher profits. By examining equilibrium prices, we find that equilibrium prices increase more rapidly in simultaneous positioning than their counterparts in the sequential-move setup owing to higher differentiation.

4.2 Neither retailer acquires information (UU)

If neither retailer chooses to acquire information at the beginning, no retailer knows the location of the new market while making positioning decisions. However, we assume that retailers' pricing decisions are made after they have the complete information about the location of the new market. Without loss of generality, we assume that $x_a < x_b$ since the retailers' equilibrium solutions are "symmetric" no matter where the new market appears. We again focus on pure-strategy subgame-perfect equilibria of this position-then-price game. The equilibrium results are given by the following lemma.

Lemma 6 *When neither retailer acquires information at the beginning, a unique pure strategy equilibrium exists for the position-then-price game.*

1. *The equilibrium positions are* $x_a^* = -\frac{9+18\mu+10\mu^2}{12(1+\mu)}$, *and* $x_b^* = \frac{9+18\mu+10\mu^2}{12(1+\mu)}$.
2. *The equilibrium prices are* $p_a^* = \frac{t(3+4\mu)(9+18\mu+10\mu^2)}{18(1+\mu)}$, $p_b^* = \frac{t(3+2\mu)(9+18\mu+10\mu^2)}{18(1+\mu)}$ *when the new market appears on the left-hand side; and vice versa when the new market appears on the right-hand side. The equilibrium profits are* $\pi_a^* = \frac{t(9+18\mu+10\mu^2)^2}{108(1+\mu)}$, $\pi_b^* = \frac{t(9+18\mu+10\mu^2)^2}{108(1+\mu)}$.

The equilibrium differentiation is given by $\Delta_{sim}^{UU} = |x_b^* - x_a^*| = \frac{9+18\mu+10\mu^2}{6(1+\mu)}$, which is greater than that of the sequential UU case. This again shows that both retailers position further apart in simultaneous positioning than in sequential positioning. Within the simultaneous-move setup, differentiation is greater in case UU than in case AA. In addition, one can check that $\frac{d\Delta_{sim}^{UU}}{d\mu} > 0$, $\frac{dp_a^*}{d\mu} > 0$, $\frac{dp_b^*}{d\mu} > 0$, $\frac{d\pi_a^*}{d\mu} > 0$, and $\frac{d\pi_b^*}{d\mu} > 0$. Therefore, in equilibrium, increase in the size of the new market leads to greater differentiation, higher prices and higher profits.

4.3 Only one retailer acquires information

Now suppose that only one retailer has acquired information and becomes informed. The information acquisition decision is publicly observable, but the outcome is privately known to the informed retailer. Again, we consider the position-then-price game: retailers first simultaneously choose their positions and then decide their prices. In the positioning stage, information is asymmetric: the informed retailer knows the location of the new market but the other retailer doesn't. The uninformed retailer makes positioning decision *ex ante*. In the pricing stage, both retailers know the positions and the location of the new market.

We now consider AU, where retailer a acquires information and retailer b does not. Case UA can be analyzed exactly the same with roles switched between retailer a and b. In AU, retailer a has acquired information at the beginning. Because of the unobservable outcome, retailer b faces an *ex post* information asymmetry vis-a-vis retailer a. From retailer b's perspective, it *ex post* faces two possible types of retailer a: the type that observes the new market on the left-hand side (Type L), and the type that observes the new market on the right-hand side (Type R). We summarize our results below.

Lemma 7 *When retailer a decides to acquire information at the beginning but retailer b does not, a unique pure strategy equilibrium exists for the position-then-price game.*

1. *The equilibrium position of retailer a is $x_a^* = -\frac{3+4\mu}{3}$ when the new market appears on the left-hand side, and is $x_a^* = \frac{3+4\mu}{3}$ when the new market appears on the right-hand side. retailer b's equilibrium positions are $x_b^* = 0$ in both scenarios.*
2. *The equilibrium prices are $p_a^* = \frac{2t(3+4\mu)^2}{27}$ and $p_b^* = \frac{2t(3+4\mu)(6+5\mu)}{27}$; the equilibrium profits are $\pi_a^* = \frac{2t(3+4\mu)^3}{243} - C$ and $\pi_b^* = \frac{2t(3+4\mu)(6+5\mu)^2}{243}$, irrespective of the location of the new market.*

Similar to that in the sequential-move case, the informed retailer positions beyond the limit of the existing market, while the uninformed retailer positions at the center of the existing market. However, the differentiation is greater here than in the sequential AU case. This again shows that price competition is less intense when positioning decisions are made simultaneously than sequentially. In addition, by examining the equilibrium positions, we find that when the size of the new market becomes larger, retailer a (the informed retailer) positions on the same side of the new market but further away from the center of the existing market. Hence, in equilibrium, increase in the size of the new market leads to greater differentiation. In addition, it can also be easily verified that increases in the size of the new market lead to higher prices and higher profits.

4.4 The information acquisition equilibrium

After characterizing the above pricing and positioning strategies in each subgame, we then return to the information acquisition stage. We summarize the payoffs of all possible outcomes at the information acquisition stage in Table 2. From the above payoff matrix, we can find the equilibria of the full information acquisition game by comparing the payoffs between two decisions (A or U). The equilibrium of the simultaneous information acquisition game is demonstrated in Proposition 2.

		Retailer b: A	Retailer b: U
Retailer a	A	$\frac{3t(1+\mu)^3}{4}-C$, $\frac{3t(1+\mu)^3}{4}-C$	$\frac{2t(3+4\mu)^3}{243}-C$, $\frac{2t(3+4\mu)(6+5\mu)^2}{243}$
	U	$\frac{2t(3+4\mu)(6+5\mu)^2}{243}$, $\frac{2t(3+4\mu)^3}{243}-C$	$\frac{t(9+18\mu+10\mu^2)^2}{108(1+\mu)}$, $\frac{t(9+18\mu+10\mu^2)^2}{108(1+\mu)}$

Table 2: Expected Payoffs at Information Acquisition Stage (The Simultaneous Case)

Proposition 2 *The state that neither retailer acquires information about the new market is the unique pure-strategy equilibrium in the simultaneous information acquisition stage.*

It seems intuitive that superior market information would give a retailer competitive advantage over its competitor. However, this proposition shows that if retailers cannot endogenize timing of positioning decisions and have to choose positions simultaneously, acquiring new market information would not generate more benefits. Because in such scenarios, there is no leadership in either positioning or pricing stage. Intuitively, the underlying driving forces behind the two retailers are symmetric and so are the equilibrium results. Because there is no first-mover or free-ride effect, retailers are most concerned with alleviating the direct competition, as demonstrated by greater differentiation in UU than in AA and AU. This is especially true in our model since price competition under quadratic transportation costs is fierce (Tabuchi and Thisse, 1995). By acquiring no information and staying uninformed, retailers position far apart from each other and hence soften price competition. This observation is in line with previously known results that uncertainty increases the degree of differentiation (for example, Casado-Izaga, 2000; Meagher and Zauner, 2004).

5 The timing decision: Sequential or simultaneous?

According to Tabuchi and Thisse (1995) and Lambertini (1997), the choice of either simultaneous or sequential play should be part of retailers' decisions. Considering both simultaneous and sequential-move games allows us to explore how uncertainty would affect retailers' timing decisions and to uncover additional insights from their choice of roles given endogenous positioning. A retailer with market information may want to delay its positioning time to trade off the advantages of moving first against the disadvantages of publicly revealing its choice, whereas a retailer without market information may choose to decide on its position earlier to preempt the market. We now investigate the retailers' timing decisions and the respective benefits of sequential and simultaneous positioning and information acquisition. For ease of illustration, we fix the transportation parameter $t = 1$ and acquisition cost $C = 1$.

5.1 The follower's choice

We first compare the follower's expected profits in both games to see whether it should wait (sequential positioning) or make its positioning decision earlier (simultaneous positioning). The results are characterized in Figure 5 and summarized in Proposition 3.

[Figure 5 and Figure 6 are about here]

Proposition 3 *The follower will always be better off by making its positioning decision earlier* (*from sequential to simultaneous*) *and the benefit of doing so increases as the size of the new market increases.*

In our model setting, we find that the follower will always benefit from making its positioning decision earlier. This result is in line with the typical disadvantages to a follower, particularly because it loses a significant market share as a result of positioning itself after the leader (Lieberman and Montgomery, 1988; Kerin et al., 1992). As Figure 5 depicts, the benefit of positioning itself earlier increases with the size of the new market. However, in reality, followers, especially small businesses, may not have the technological or informational capability to position themselves earlier.

5.2 The leader's choice

Now we compare the leader's expected profits to determine whether it would be beneficial for it to delay its positioning decision. The results are characterized in Figure 6 and summarized in Proposition 4.

Proposition 4 *The leader is better off by delaying its positioning decision* (*from sequential to simultaneous*) *when the size of the new market is sufficiently large.*

Proposition 4 suggests that being the leader does not always result in greater profits. The outcome depends on the size of the new market and the retailers' information acquisition strategy. Recalling the retailers' positions in equilibrium, retailer a positions itself further away from the center of the existing market in the simultaneous-move setup compared to the sequential-move setup. By contrast, retailer b positions itself closer to the center of the existing market in the simultaneous-move setup.

As shown in Figure 7, in equilibrium, differentiation increases as the size of the new market increases. Differentiation is greater in the simultaneous-move setup than in the sequential-move setup. As a result, price competition is less intense when positioning decisions are made simultaneously than sequentially. In the sequential-move setup, taking into account the size of the new market, differentiation shows an upward jump if the follower is informed and a downward jump if the leader is informed. As we have discussed, when the size of the new market increases to around $\mu = 1$, differentiation experiences an upward jump and when $\mu \approx 2.15$, differentiation experiences a downward jump.

[Figure 7 is about here]

The intuition is as follows. When the size of the new market is sufficiently large, the leader is incentivized to acquire information about it. The follower observes this information and imitates the leader's move by positioning itself closer to the location of the leader. This imitation reduces differentiation and profit, which encourages the leader to delay its timing of positioning to prevent the follower's imitation. It trades off the advantages of moving first against the disadvantages of revealing its position. As a result, it prefers a simultaneously-timed positioning.

On the contrary, when the size of the new market is relatively small, the leader has less of an incentive to acquire information and therefore may not be better informed than the follower. As such, the follower is less likely to imitate the leader. Since the leader is entitled to choose its position first in the sequential-move setup, it will occupy the center of the market (i.e., the existing market without information or the overall market with information) and capitalizes on its first-mover advantage. In this situation, the first-mover advantage in the sequential-move setup greatly exceeds the benefits of differentiation in the simultaneous-move setup. The leader therefore prefers a sequential timing of positioning.

6 The impact of new market size uncertainty

Until now, we consider only the uncertainty of location, not size, of the new market in our analysis. The main reason for skipping the size uncertainty was mathematical tractability. This section extends our analysis to numerically examine how size uncertainty would impact our main results. In order to avoid computational difficulties arising from different levels of information, we assume that acquiring information about the new market enables the retailers to resolve the location uncertainty, but not the size uncertainty. This is a reasonable abstract representation of reality. For example, when chain stores expand into a virgin market such as a new workplace or residential area, they know the location of this new market but not its exact size.

We first compare the retailers' profits to determine the market equilibrium of the sequential-move game. For ease of illustration, we fix the transportation parameter $t = 1$. Since there is no closed-form expression for certain subgames, we numerically examine the equilibria by fixing the size uncertainty (σ) at various values. The market equilibria at various size uncertainties exhibit similar pattern as in Proposition 1. We illustrate here graphically two examples ($\sigma = 0.125$ and $\sigma = 0.25$).

[Figures 8 and 9 are about here]

Both Figures 8 and 9 show that there exist two cutoff levels ($N_1^{'}, N_2^{'}$ or $N_1^{''}, N_2^{''}$), such that in equilibrium, the leader acquires information but the follower does not if $\mu \geq N_1^{'}$ or $\mu \geq N_1^{''}$; the leader chooses not to acquire information but the follower does if $N_2^{'} \leq \mu < N_1^{'}$ or $N_2^{''} \leq \mu < N_1^{''}$; and neither retailer acquires information if $\mu < N_2^{'}$ or $\mu < N_2^{''}$.

These results are generally in line with Proposition 1. However, by comparing Figures 8 and 9, we notice that there is some subtle difference. The AU region shrinks upward as the size uncertainty increases.

This is more pronounced when the new market size is expected to be small. This shows that more uncertainty in the new market size makes the leader less likely to acquire information, especially when the market size is not expected to be sizable. This is in line with known result that uncertainty is a differentiation force in Hotelling-type models with quadratic transportation costs.

[Figures 11, 12 and 13 are about here]

We then discuss how the equilibrium positions and differentiations react to the size uncertainty of the new market. As shown in Figures 8 and 9, depending on how large μ and C are, either UU, UA or AU could emerge as the market equilibrium. For ease of illustration, we fix the acquisition cost $C = 1$. For $\sigma \in [0, 0.5]$, UU emerges as the market equilibrium when μ is relatively small ($\mu < 1$); UA emerges as the market equilibrium when μ becomes moderately large (approximately, $1 < \mu < 2.3$), and when μ is very sizable ($\mu > 2.3$), AU turns out to be the market equilibrium. We describe these three possible equilibrium cases: UU, UA and AU in which the expected values of new market size are taken at 0.5, 1.5 and 2.5, respectively, graphically in Figures 11, 12 and 13. We observe the same pattern as in the case of null size uncertainty. In Case UU, the leader (retailer a) positions at the center of the existing market to exercise its first-mover advantage while the follower (retailer b) positions away from the leader to avoid intense price competition. In Case UA, the uninformed leader (retailer a) stays at the center of the existing market and the informed follower (retailer b) positions further away from the leader compared to the choice when it is uninformed. In both cases, the follower positions further away as the size uncertainty increases. As a result, the differentiation increases as σ becomes larger. Finally, in Case AU, the leader positions itself at the most attractive location while the follower positions closer to the leader compared to its position in Case UA. This result occurs because the leader finds it optimal to acquire information and to know the exact location of the new market, while the follower imitates by moving the position closer to the new market.

7 Conclusion and Discussion

This paper investigates competing retailers' strategies for new market research and positioning of stores and/or products in a duopoly setting. The new uncertain market can be either a left-hand or a right-hand-side extension of the existing market. If the retailers sequentially conduct market research, neither retailer is adequately incentivized to do research to acquire information about the new market when the potential new market is small. As the size of the new market grows, the follower is induced to do such research. When the new market is very sizable, the leader conducts research and knows the new market's location while the follower free-rides. An increase in the size of the new market can lead to either an upward or a downward jump in product position differentiation, and its influence can be non-monotonic as information acquisition is endogenous.

If retailers would conduct market research simultaneously, they are most concerned with alleviating the direct competition and hence decide against acquiring new market information even when the cost of doing so is low. We also observe that differentiation is greater in the simultaneous-move setup than in the sequential-move setup. We further numerically examine the impact of size uncertainty on information acquisition and positioning decisions and find that when facing greater uncertainty, the retailers position themselves further apart.

Our findings carry several implications for retailing managers, provided that our position-then-price framework applies to the introduction of new products, store brand positioning, and geographic location. First, our analysis suggests that when retailers enter the market simultaneously, unless the new market is very sizable, it is beneficial for a retailer to decide on market positioning without acquiring new market information beforehand. On the other hand, it would be beneficial for managers to conduct market research in large niche markets. If retailers enter the market sequentially, the first-mover has an advantage, but it attracts imitators, and as a result, the advantage may not sustain as the market grows. Our model predicts that when the new market is sufficiently large, an informed leader may benefit from delaying its positioning to avoid the disadvantages of revealing its choice earlier.

Second, in terms of geographic location, market research and positioning decisions are clearly crucial to retailers. Our analysis reveals that when facing more uncertainty, the retailers position themselves further apart and thereby increase the differentiation between their product offerings. As products are more distinct from each other in the simultaneous-move setup, retailers themselves become more differentiated to soften the horizontal competition. In a sequential-move setup, the difference in timing of product availability provides another dimension in which retailers can differentiate themselves.

Finally, in a channel context, when upstream suppliers carry more differentiated products, competition at the downstream level is likewise reduced. As suppliers can introduce their products either simultaneously or sequentially, retailers should collaborate vertically with manufacturers to effectively communicate and distribute their products to end customers. The retailers must also develop sales strategies accordingly, including retail pricing and promotion, and perform sales forecasts based on the characteristics of their products and consumers.

This paper can be extended in several directions. First, in our framework, we assume that acquiring information about the new market enables a retailer to resolve uncertainty in terms of its location but not its size. This assumption is made in the interest of simplicity, as different levels of information on market size add another dimension of the informational gap between retailers. Nevertheless, the issue merits further exploration. Second, for mathematical tractability, we have limited our discussion to two retailers. The presence of additional retailers would inevitably lead to more intense competition, and it is therefore possible that the simultaneous-move setup could be preferable in this situation as its greater differentiation can limit horizontal competition. Third, in a supply chain context, if the market research and product positioning decisions are made by manufacturers, it is therefore interesting to explicitly model retailer behavior based on the decisions taken by manufacturers. Finally, our model assumes a single-period model with multiple decision stages. In reality, competition between retailers often consists of multiple periods, which could be another future research direction.

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Appendix: Online Supplements

Proof of Lemma 1. We illustrate the solution procedure backward with pricing decisions at first and then positioning decisions. Because both retailers know the location of the new market prior to their respective positioning and pricing decisions, there is no ambivalence regarding where the new market would appear but the prices are set before the exact size of the new market becomes known. In equilibrium, both retailers' prices and profits are exactly the same no matter where the new market would be located, and the retailers' equilibrium positions are "symmetric" in the two possible locations of the new market. Hence, we only discuss the scenario where the new market appears on the left-hand side in detail.

We start with retailers' pricing decisions. Because the retailers decide prices simultaneously, we solve the first-order conditions $\frac{\partial \pi_L}{\partial p_L} = 0$ and $\frac{\partial \pi_R}{\partial p_R} = 0$ simultaneously to obtain the following pricing reaction functions of retailers:

$$\widehat{p}_L = \frac{t(x_R - x_L)(3 + 4u + x_R + x_L)}{3}, \text{ and } \widehat{p}_R = \frac{t(x_R - x_L)(3 + 2u - x_R - x_L)}{3}.$$

The corresponding second-order conditions $\frac{\partial^2 \pi_L}{\partial p_L^2} = \frac{\partial^2 \pi_R}{\partial p_R^2} = -\frac{1}{t(x_R - x_L)} < 0$, hence the optimal pricing equilibrium solution is unique. Plugging $\widehat{p}_L$ and $\widehat{p}_R$ into the expressions of expected profits results in

$$\widehat{\pi}_L = \frac{t(x_R - x_L)(3 + 4u + x_R + x_L)^2}{18} - C, \text{ and } \widehat{\pi}_R = \frac{t(x_R - x_L)(3 + 2u - x_R - x_L)^2}{18} - C.$$

We then discuss retailers' positioning decisions. We first consider retailer b's positioning decision. If retailer b goes right of retailer a, then retailer b is R and retailer a is L. Given retailer a's position at x_L (i.e., $x_a = x_L$), retailer b chooses $\widehat{x}_R$ to maximize $\widehat{\pi}_R$. The first-order condition for profit maximization $\frac{\partial \widehat{\pi}_b}{\partial x_b} = \frac{\partial \widehat{\pi}_R}{\partial x_R} = 0$ yields two roots: $3 + 2u - x_a$ and $\frac{3+2u+x_a}{3}$. The first root leads to zero profit and hence we obtain the solution as $\widehat{x}_b = \widehat{x}_R = \frac{3+2u+x_a}{3}$. Indeed, the second-order conditions $\frac{\partial^2 \widehat{\pi}_b}{\partial x_b^2}$ evaluated at the second root (i.e., $\frac{3+2u+x_a}{3}$) yields $-\frac{t(3+2u-x_a)}{9} < 0$, hence we know $\widehat{x}_b = \frac{3+2u+x_a}{3}$ is local optimum. In addition, retailer $b's$ expected profits at two boundary points (i.e., $x_b = x_a$ and $x_b = 3 + 2u - x_a$) are both zero excluding the constant term C. Therefore, retailer $b's$ positioning solution $\frac{3+2u+x_a}{3}$ (denoted as $\widehat{x}_b^R$) is optimal and the corresponding optimal profit is $\frac{2t(3+2u-2x_a)^3}{243} - C$ (denoted as $\widehat{\pi}_b^R$). Similarly, if retailer b goes left of retailer a, we obtain the optimal position as $\widehat{x}_b^L = -\frac{3+4u-x_a}{3}$ and the corresponding optimal profit as $\widehat{\pi}_b^L = \frac{2t(3+4u+2x_a)^3}{243} - C$. It can be easily verified that $\widehat{\pi}_b^R \geqslant \widehat{\pi}_b^L$ when $x_a \leqslant -\frac{u}{2}$; and $\widehat{\pi}_b^R \leqslant \widehat{\pi}_b^L$ when $x_a \geqslant -\frac{u}{2}$. Therefore, if $x_a \geqslant -\frac{u}{2}$, retailer b chooses to go left of retailer a; if $x_a \leqslant -\frac{u}{2}$, retailer b chooses to go right of retailer a.

We then discuss retailer a's positioning decision. If retailer a chooses to be L (hence, $x_a \leq -\frac{u}{2}$), it incorporates the positioning reaction function of retailer b, that is, $\widehat{x}_b^R = \widehat{x}_R = \frac{3+2u+x_a}{3}$, into the profit function $\widehat{\pi}_L$ and gets $\widehat{\pi}_a = \frac{2t(3+2u-2x_a)(6+7u+2x_a)^2}{243} - C$. Therefore, retailer a's problem is

$$\max\ \widehat{\pi}_a = \frac{2t(3+2u-2x_a)(6+7u+2x_a)^2}{243} - C \text{ subject to } x_a \leq -\frac{u}{2}. \tag{1}$$

We obtain a unique solution: $\widehat{\lambda} = 0, \widehat{x}_a = -\frac{u}{2}$. We can verify that this is indeed a maximizer as it is feasible and optimal. Similarly, if retailer a chooses to be R (hence $x_a \geqslant -\frac{u}{2}$), we find that retailer a's optimal decision is to position at $-\frac{u}{2}$. Therefore, $x_a^* = -\frac{u}{2}$. Plugging $x_a^* = -\frac{u}{2}$ back into retailer b's positioning reaction functions, we obtain $x_b^* = 1 + \frac{u}{2}$ if retailer b goes right of retailer a, and $x_b^* = -(1 + \frac{3u}{2})$ if retailer b goes left of retailer a. According to the tie-breaking rule, we obtain retailer b's equilibrium position as $x_b^* = 1 + \frac{u}{2}$.

Substituting x_a^* and x_b^* into the respective expressions of prices and profits, we obtain the equilibrium prices and profits of retailer a and b as follows:

$$p_a^* = \frac{4t(1+u)^2}{3}, p_b^* = \frac{2t(1+u)^2}{3},$$
$$\pi_a^* = \frac{8t(1+u)^3}{9} - C, \pi_b^* = \frac{2t(1+u)^3}{9} - C.$$

When the new market appears on the right-hand side, we can repeat the above solution procedure. We obtain the equilibrium positions of retailers a and b as $x_a^* = \frac{\mu}{2}$, and $x_b^* = -(1 + \frac{\mu}{2})$. The equilibrium prices and profits of retailers a and b are the same as those in the scenario when the new market appears on the left-hand side. □

Proof of Lemma 2. The positioning interaction in AU is a game of incomplete information in which the second mover (retailer b) infers the information of the first mover (retailer a) from its positioning decision. Hence, the solution concept is that of Bayesian equilibrium. The proof proceeds as follows: we first use the sub-game perfect equilibrium as the equilibrium concept. Then we show that the subgame perfect equilibrium derived is actually the unique Bayesian equilibrium. We only discuss the scenario where the new market appears on the left-hand side in detail. The scenario where the new market appears on the right-hand side can be handled similarly.

We start with retailers' pricing decisions. By solving the first-order conditions $\frac{\partial \pi_L}{\partial p_L} = 0$ and $\frac{\partial \pi_R}{\partial p_R} = 0$ simultaneously, we obtain retailers' pricing reaction functions as follows:

$$\widehat{p}_L = \frac{t(x_R - x_L)(3 + 4u + x_R + x_L)}{3}, \text{ and } \widehat{p}_R = \frac{t(x_R - x_L)(3 + 2u - x_R - x_L)}{3}.$$

The corresponding second-order conditions $\frac{\partial^2 \pi_L}{\partial p_L^2} = \frac{\partial^2 \pi_R}{\partial p_R^2} = -\frac{1}{t(x_R - x_L)} < 0$, hence the optimal pricing equilibrium solution is unique. Plugging $\widehat{p}_L$ and $\widehat{p}_R$ into the expressions of expected profits (excluding the constant C) results in

$$\widehat{\pi}_L = \frac{t(x_R - x_L)(3 + 4u + x_R + x_L)^2}{18}, \text{ and } \widehat{\pi}_R = \frac{t(x_R - x_L)(3 + 2u - x_R - x_L)^2}{18}.$$

We then discuss retailers' positioning decisions. We first consider retailer b's positioning decision. If retailer b goes right of retailer a, then retailer b is R and retailer a is L. Given retailer a's position at x_L (i.e., $x_a = x_L$), retailer b chooses $\widehat{x}_R$ to maximize $\widehat{\pi}_R$. The first-order condition for profit maximization

$\frac{\partial \widehat{\pi}_b}{\partial x_b} = \frac{\partial \widehat{\pi}_R}{\partial x_R} = 0$ yields two roots: $3 + 2u - x_a$ and $\frac{3+2u+x_a}{3}$. The first root leads to zero profit and hence we obtain the solution as $\widehat{x}_b = \widehat{x}_R = \frac{3+2u+x_a}{3}$. Indeed, the second-order conditions $\frac{\partial^2 \widehat{\pi}_b}{\partial x_b^2}$ evaluated at the second root (i.e., $\frac{3+2u+x_a}{3}$) yields $-\frac{t(3+2u-x_a)}{9} < 0$, hence we know $\widehat{x}_b = \frac{3+2u+x_a}{3}$ is local optimum. In addition, retailer $b's$ expected profits at two boundary points (i.e., $x_b = x_a$ and $x_b = 3 + 2u - x_a$) are both zero. Therefore, retailer $b's$ positioning solution $\frac{3+2u+x_a}{3}$ (denoted as $\widehat{x}_b^R$) is optimal and the corresponding optimal profit is $\frac{2t(3+2u-2x_a)^3}{243}$ (denoted as $\widehat{\pi}_b^R$). Similarly, if retailer b goes left of retailer a, we obtain the optimal position as $\widehat{x}_b^L = -\frac{3+4u-x_a}{3}$ and the corresponding optimal profit as $\widehat{\pi}_b^L = \frac{2t(3+4u+2x_a)^3}{243}$. It can be easily verified that $\widehat{\pi}_b^R \geqslant \widehat{\pi}_b^L$ when $x_a \leqslant -\frac{u}{2}$; and $\widehat{\pi}_b^R \leqslant \widehat{\pi}_b^L$ when $x_a \geqslant -\frac{u}{2}$. Therefore, if $x_a \geqslant -\frac{u}{2}$, retailer b chooses to go left of retailer a; if $x_a \leqslant -\frac{u}{2}$, retailer b chooses to go right of retailer a.

We then discuss retailer a's positioning decision. If retailer a chooses to be L (hence, $x_a \leq -\frac{u}{2}$), it incorporates the positioning reaction function of retailer b, that is, $\widehat{x}_b^R = \widehat{x}_R = \frac{3+2u+x_a}{3}$, into the profit function $\widehat{\pi}_L$ and gets $\widehat{\pi}_a = \frac{2t(3+2u-2x_a)(6+7u+2x_a)^2}{243} - C$. Therefore, retailer a's problem is

$$\max \ \widehat{\pi}_a = \frac{2t(3 + 2u - 2x_a)(6 + 7u + 2x_a)^2}{243} - C \text{ subject to } x_a \leq -\frac{u}{2}. \tag{2}$$

We obtain a unique solution: $\widehat{\lambda} = 0$, $\widehat{x}_a = -\frac{u}{2}$. We can verify that this is indeed a maximizer as it is feasible and optimal. Similarly, if retailer a chooses to be R (hence $x_a \geqslant -\frac{u}{2}$), we find that retailer a's optimal decision is to position at $-\frac{u}{2}$. Therefore, $x_a^* = -\frac{u}{2}$. Plugging $x_a^* = -\frac{u}{2}$ back into retailer b's positioning reaction functions, we obtain $x_b^* = 1 + \frac{u}{2}$ if retailer b goes right of retailer a, and $x_b^* = -(1 + \frac{3u}{2})$ if retailer b goes left of retailer a. According to the tie-breaking rule, we obtain retailer b's equilibrium position as $x_b^* = 1 + \frac{u}{2}$.

Substituting x_a^* and x_b^* into the respective expressions of prices and profits, we obtain the equilibrium prices and profits of retailer a and b as follows:

$$p_a^* = \frac{4t(1+u)^2}{3}, p_b^* = \frac{2t(1+u)^2}{3},$$
$$\pi_a^* = \frac{8t(1+u)^3}{9} - C, \pi_b^* = \frac{2t(1+u)^3}{9}.$$

Now we show that the subgame perfect equilibrium derived is actually the unique Bayesian equilibrium. The positioning interaction in AU can be modeled as the following game: Nature first decides which side the new market would appear and retailer a becomes informed after acquiring information. Nature chooses left new market with probability 0.5 and right new market with probability 0.5. Then retailer a decides whether to position to the LEFT or RIGHT of the existing market center. Accordingly, we refer to retailer a as LEFT if it positions to the LEFT of the existing market center and RIGHT if it positions to the RIGHT of the existing market center. If retailer a is of LEFT type, it can choose a point x (< 0) on the Hotelling line; if retailer a is of RIGHT type, it can choose a point x (> 0) on the Hotelling line. Retailer b observes retailer a's position and then chooses its position: either to the left or right of retailer a. The extensive-form representation of the positioning game is pictured in Figure 10.

[Figure 10 is about here]

Consider the case where retailer a is of LEFT type. For any given x_a (< 0) by retailer a, retailer b believes that the new market appears on the left-hand side. According to the tie-break rule, retailer b chooses to go right of retailer a and sets its position at $\frac{3+2u+x_a}{3}$. When retailer a does not cheat, it chooses its position at $x_a = -\frac{\mu}{2}$ and expects to receive a profit of $\frac{8t(1+u)^3}{9} - C$. When retailer a cheats, there are two scenarios. First, retailer a positions at a point that is different from $-\frac{\mu}{2}$ but in the same side of the new market, i.e., $x_a < 0$, $x_a \neq -\frac{\mu}{2}$ and the new market appears on the left-hand side. Then, retailer a expects to receive a profit $\widehat{\pi}_a = \frac{2t(3+2u-2x_a)(6+7u+2x_a)^2}{243} - C$. It can be shown that $\widehat{\pi}_a$ decreases in x_a when $-\frac{\mu}{2} < x_a < 0$

and increases in x_a when $x_a < -\frac{\mu}{2}$.[7] Hence, retailer a has no incentive to deviate to any other point that is different from $-\frac{\mu}{2}$ in the same side of the new market. Then, we check whether retailer a has the incentive to deviate its position to the opposite side in attempting to send retailer b a wrong signal. Suppose the new market appears on the right-hand side but retailer a chooses its position at $x_a < 0$. Although retailer b believes the new market appears on the left-hand side, the tie-break rule drives it to go right of retailer a and hence cover a bigger market segment. Obviously, retailer a cannot be better off by deviating its position to the opposite side. Hence, we have shown that when retailer a is of LEFT type, it chooses not to cheat and set its position at $x_a = -\frac{\mu}{2}$. Similarly, we can also show that when retailer a is of RIGHT type, it chooses its position at $x_a = \frac{\mu}{2}$. In summary, retailer a's strategy of positioning at the expected center of the overall market results in higher expected profit than that of deviating its position to any other point on the Hotelling line. In this sense, the location of new market is made known to retailer b after observing retailer a's position.

Therefore, the tie-break rule described in Definition 1 serves as a suitable refinement that imposes restrictions on off-equilibrium beliefs and hence multiple equilibria can be ruled out. A unique Bayesian equilibrium (indeed, it is the subgame perfect equilibrium) can be derived. $\square$

Proof of Lemma 3. Denote the location of indifferent consumer as $\widehat{x}_L$ when the new market appears on the left-hand side and $\widehat{x}_R$ when the new market appears on the right-hand side. The demand can be calculated as follows:

The new market appears on the left-hand side: the demand of retailer L and R are $D_L = \widehat{x}_L + \frac{1}{2} + N$ and $D_R = \frac{1}{2} - \widehat{x}_L$.

[7] It it true since when $-\frac{\mu}{2} < x_a < 0$,
$\frac{\partial \widehat{\pi}_a}{\partial x_a} = -\frac{4t}{81}(7u^2 + 6u + 12x_a + 16ux_a + 4x_a^2) \leq -\frac{4t}{81}(7u^2 - 28x_a^2) = -\frac{28t}{81}(u + 2x_a)(u - 2x_a) < 0$,
and when $x_a < -\frac{\mu}{2}$,
$\frac{\partial \widehat{\pi}_a}{\partial x_a} = -\frac{4t}{81}(7u^2 + 6u + 12x_a + 16ux_a + 4x_a^2) \geq -\frac{4t}{81}(7u^2 - 28x_a^2) = \frac{28t}{81}(2x_a + u)(2x_a - u) > 0$.

The new market appears on the right-hand side: the demand of retailer L and R are $D_L = \widehat{x}_R + \frac{1}{2}$ and $D_R = \frac{1}{2} + N - \widehat{x}_R$.

Retailer a chooses its product position based on its expected profit. Retailer b becomes informed after acquiring information. Given retailer a's position, retailer b would choose to go either left or right of retailer a. It can be verified that when the new market appears on the left-hand side, retailer b would choose to go left of retailer a and hence retailer a is R and retailer b is L. Their prices are denoted by p_a^L and p_b^L, respectively. Similarly, it can be verified that when the new market appears on the right-hand side, retailer b would choose to go right of retailer a, and hence retailer a is L and retailer b is R. Their prices are denoted by p_a^R and p_b^R, respectively.[8]

In the positioning stage, retailer a acts based on its expected profit and chooses x_a to maximize

$\pi_a = \frac{1}{2}[(\frac{1}{2} - \widehat{x}_L)p_a^L] + \frac{1}{2}[(\widehat{x}_R + \frac{1}{2})p_a^R]$.

After observing the location of the new market and retailer a's position, retailer b will set x_b^L to maximize $E[(\widehat{x}_L + \frac{1}{2} + N)p_b^L - C]$ if the new market turns out to be on the left-hand side, and set x_b^R to maximize $E[(\frac{1}{2} + N - \widehat{x}_R)p_b^R - C]$ otherwise.

In the pricing stage, both retailers choose prices simultaneously after observing positions. The profit functions for pricing decisions are as follows:

The new market appears on the left-hand side: Retailer a chooses p_a^L to maximize $\pi_a = E[(\frac{1}{2} - \widehat{x}_L)p_a^L]$, and retailer b chooses p_b^L to maximize $\pi_b = E[(\widehat{x}_L + \frac{1}{2} + N)p_b^L - C]$.

The new market appears on the right-hand side: Retailer a chooses p_a^R to maximize $\pi_a = E[(\widehat{x}_R +$

[8]When the new market appears on the left-hand side, retailer b could choose to go either left or right of retailer a. Similar to what we have done in Proof of Lemma 1, by comparing retailer b's expected profits between the two scenarios, one can easily verify that retailer b would choose to go left of retailer a when the new market appears on the left-hand side. Similarly, retailer b would choose to go right of retailer a when the new market appears on the right-hand side.

$\frac{1}{2})p_a^R]$, and retailer b chooses p_b^R to maximize $\pi_b = E[(\frac{1}{2} + N - \widehat{x}_R)p_b^R - C]$.

Similarly, this position-then-price game here can be solved by backward induction. We first consider retailers' pricing decisions. As before, we solve the first-order conditions for profit maximization $\frac{\partial \pi_a}{\partial p_a} = 0$ and $\frac{\partial \pi_b}{\partial p_b} = 0$ simultaneously to get the following pricing reaction functions of retailers. When the new market appears on the left-hand side,

$$\widehat{p}_a^L = \frac{t(x_a - x_b^L)(3 + 2\mu - x_a - x_b^L)}{3}, \text{ and } \widehat{p}_b^L = \frac{t(x_a - x_b^L)(3 + 4\mu + x_a + x_b^L)}{3}.$$

The corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial (p_a^L)^2} = \frac{\partial^2 \pi_b}{\partial (p_b^L)^2} = -\frac{1}{t(x_a - x_b^L)} < 0$ since in this case we have $x_b^L < x_a$, and hence the second-order conditions for profit maximization are satisfied.

When the new market appears on the right-hand side,

$$\widehat{p}_a^R = \frac{t(x_b^R - x_a)(3 + 2\mu + x_a + x_b^R)}{3}, \text{ and } \widehat{p}_b^R = \frac{t(x_b^R - x_a)(3 + 4\mu - x_a - x_b^R)}{3}.$$

The corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial (p_a^R)^2} = \frac{\partial^2 \pi_b}{\partial (p_b^R)^2} = \frac{1}{t(x_a - x_b^R)} < 0$ since in this case we have $x_b^R > x_a$, and hence the second-order conditions for profit maximization are satisfied. Plugging $\widehat{p}_a^L$, $\widehat{p}_b^L$, $\widehat{p}_a^R$ and $\widehat{p}_b^R$ into the expressions of retailer b's profits, we get

$$\widehat{\pi}_b^L = \frac{t(x_a - x_b^L)(3 + 4\mu + x_a + x_b^L)^2}{18} - C, \text{ and } \widehat{\pi}_b^R = \frac{t(x_b^R - x_a)(3 + 4\mu - x_a - x_b^R)^2}{18} - C.$$

Then, we consider retailer b's positioning decisions. Solving the first-order condition $\frac{\partial \widehat{\pi}_b^L}{\partial x_b^L} = 0$, we get $\widehat{x}_b^L = -\frac{3+4\mu-x_a}{3}$, and the corresponding profit is $\widehat{\pi}_b^L = \frac{2t(3+4\mu+2x_a)^3}{243} - C$. Similarly, solving the first-order condition $\frac{\partial \widehat{\pi}_b^R}{\partial x_b^R} = 0$, we get $\widehat{x}_b^R = \frac{3+4\mu+x_a}{3}$, and the corresponding profit is $\widehat{\pi}_b^R = \frac{2t(3+4\mu-2x_a)^3}{243} - C$.

Now, we consider retailer a's positioning decision. Recall that retailer a's expected profit for positioning can be expressed as $\pi_a = \frac{1}{2}[(\frac{1}{2} - \widehat{x}_L)p_a^L] + \frac{1}{2}[(\widehat{x}_R + \frac{1}{2})p_a^R]$. Substituting $\widehat{p}_a^L$, $\widehat{p}_b^L$, $\widehat{p}_a^R$, $\widehat{p}_b^R$, $\widehat{x}_b^L$, and $\widehat{x}_b^R$

into this profit function, we get

$$\widehat{\pi}_a = \frac{2t}{243}[(3+4\mu)(6+5\mu)^2 - 12(3+2\mu)x_a^2].$$

The first-order condition $\frac{\partial \widehat{\pi}_a}{\partial x_a} = -\frac{16t}{81}(3+2\mu)x_a = 0$, and hence we obtain a unique solution $\widehat{x}_a = 0$. The corresponding second-order condition $\frac{\partial^2 \widehat{\pi}_a}{\partial x_a^2} = -\frac{16t}{81}(3+2\mu) < 0$ holds. Hence, the equilibrium position of retailer a are $x_a^* = 0$. Substituting $x_a^* = 0$ into the expressions of $\widehat{x}_b^L$ and $\widehat{x}_b^R$, we get $x_b^* = -\frac{3+4\mu}{3}$ when the new market appears on the left-hand side and $x_b^* = \frac{3+4\mu}{3}$ when the new market appears on the right-hand side. Finally, we can substitute x_a^* and x_b^* back into the expressions of respective prices and profits and obtain the equilibrium prices and profits as stated in the lemma. $\square$

Proof of Lemma 4. Let retailers position their products at x_a and x_b. Without loss of generality, we assume $x_b > x_a$ and the marginal consumer who is indifferent between buying from either retailer is located at $\widehat{x} = \frac{p_b - p_a + t(x_b^2 - x_a^2)}{2t(x_b - x_a)}$. When the new market appears on the left-hand side, the demand of retailers a and b are $D_a^L = \widehat{x} + \frac{1}{2} + N$ and $D_b^L = \frac{1}{2} - \widehat{x}$. When the new market appears on the right-hand side, the demand of retailers a and b are $D_a^R = \widehat{x} + \frac{1}{2}$ and $D_b^R = \frac{1}{2} + N - \widehat{x}$. Denote by p_a^L and p_b^L retailers a's and b's respective prices when the new market appears on the left-hand side and denote by p_a^R and p_b^R retailers a's and b's respective prices when the new market appears on the right-hand side.

In the positioning stage, retailer a acts based on its expected profit and chooses x_a to maximize

$$\pi_a = E[\frac{1}{2}(\widehat{x} + \frac{1}{2} + N)p_a^L + \frac{1}{2}(\widehat{x} + \frac{1}{2})p_a^R]. \tag{3}$$

After observing retailer a's position, retailer b will choose x_b to maximize

$$\pi_b = E[\frac{1}{2}(\frac{1}{2} - \widehat{x})p_b^L + \frac{1}{2}(\frac{1}{2} + N - \widehat{x})p_b^R]. \tag{4}$$

In the pricing stage, both retailers know the location of the new market and choose prices simultaneously. The profit functions for pricing decisions are as follows:

The new market appears on the left-hand side: Retailer a chooses p_a^L to maximize $E[(\widehat{x}+\frac{1}{2}+N)p_a^L]$, and retailer b chooses p_b^L to maximize $E[(\frac{1}{2}-\widehat{x})p_b^L]$.

The new market appears on the right-hand side: Retailer a chooses p_a^R to maximize $E[(\widehat{x}+\frac{1}{2})p_a^R]$, and retailer b chooses p_b^R to maximize $E(\frac{1}{2}+N-\widehat{x})p_b^R]$. Using backward induction we derive the optimal product positions, prices and profits. As we mentioned before, retailer a moves first. After observing retailer a's position, retailer b would choose to go either left or right of retailer a. One can verify that retailer b would go right if retailer a's position $x_a \leq 0$ and go left if retailer a's position $x_a \geq 0$ by comparing retailer b's expected profits between the two scenarios. The equilibrium in one scenario can be obtained by flipping all positions in the other scenario 180 degrees around the vertical axis. This indeed leads to the same expected equilibrium prices and profits. Hence, we illustrate here only the scenario when retailer a positions on the left-half of the existing market (i.e., $x_a \leq 0$) and retailer b goes right of retailer a.

1) Pricing decisions:

Because retailers decide prices simultaneously, we solve the first-order conditions $\frac{\partial \pi_a}{\partial p_a}=0$ and $\frac{\partial \pi_b}{\partial p_b}=0$ simultaneously to get the following pricing reaction functions of retailers. When the new market appears on the left-hand side,

$$\widehat{p}_a^L=\frac{t(x_b-x_a)(3+4\mu+x_a+x_b)}{3}, \text{ and } \widehat{p}_b^L=\frac{t(x_b-x_a)(3+2\mu-x_a-x_b)}{3}.$$

When the new market appears on the right-hand side,

$$\widehat{p}_a^R=\frac{t(x_b-x_a)(3+2\mu+x_a+x_b)}{3}, \text{ and } \widehat{p}_b^R=\frac{t(x_b-x_a)(3+4\mu-x_a-x_b)}{3}.$$

The corresponding second-order conditions in both scenarios turn out to be $\frac{\partial^2 \pi_a}{\partial p_a^2}=\frac{\partial^2 \pi_b}{\partial p_b^2}=-\frac{1}{t(x_b-x_a)}<0$, and hence the second-order conditions for profit maximization are satisfied.

2) Positioning decisions:

Now we study the positioning problems.

Retailer b's positioning decision:

Plugging $\widehat{p}_a^L$, $\widehat{p}_a^R$, $\widehat{p}_b^L$ and $\widehat{p}_b^R$ into (4), we obtain retailer b's expected profit for positioning decision as $\widehat{\pi}_b = \frac{t(x_b-x_a)[10\mu^2+6\mu(3-x_b-x_a)+(3-x_b-x_a)^2]}{18}$. Given retailer a's position at x_a, retailer b chooses x_b to maximize $\widehat{\pi}_b$. The first-order condition for profit maximization $\frac{\partial \widehat{\pi}_b}{\partial x_b} = 0$ yields $\widehat{x}_b = \frac{(6+6\mu-x_a-B)}{3}$, where $B = \sqrt{6\mu^2 + 6\mu(3-2x_a) + (3-2x_a)^2}$. The corresponding second-order condition can be verified to hold within the feasible region.

Retailer a's positioning decision:

Plugging $\widehat{x}_b$, together with $\widehat{p}_a^L$, $\widehat{p}_a^R$, $\widehat{p}_b^L$ and $\widehat{p}_b^R$, into (3), we obtain retailer a's expected profit for positioning decision as

$$\widehat{\pi}_a = \frac{t(6+6\mu-4x_a-B)[(15+15\mu+2x_a-B)^2+9\mu^2]}{486},$$

where B is defined above. Retailer a chooses position $x_a \leq 0$ to maximize $\widehat{\pi}_a$. So retailer a's optimization problem is

$$\max\ \widehat{\pi}_a = \frac{t(6+6\mu-4x_a-B)[(15+15\mu+2x_a-B)^2+9\mu^2]}{486} \tag{5}$$
$$\text{subject to } x_a \leq 0.$$

The KKT conditions for the problem in (5) are

$$\frac{\partial L(x_a,\lambda)}{\partial x_a} = 0, \lambda \geq 0, g(x_a) \leq 0, \text{ and } \lambda g(x_a) = 0,$$

where $L(x_a,\lambda)$ is the Lagrangian defined as $L(x_a,\lambda) = \widehat{\pi}_a - \lambda g(x_a)$ and $g(x_a) = x_a$. By solving the KKT conditions, we obtain the solution $\widehat{x}_a = 0$.We can verify that the second-order condition $\frac{\partial^2 \widehat{\pi}_a}{\partial x_a^2} < 0$ when evaluated at $\widehat{x}_a = 0$. So, the solution is a local maximum. In addition, the non-negativity of demand imposes a lower bound on x_a, that is $x_a \geq -\frac{36+57\mu+23\mu^2}{12+10\mu}$. Also, the non-negativity of demand imposes an upper bound $\frac{3+\mu}{2}$ on x_a. Since the upper bound is greater than 0 and hence is ignored. We can show that $\widehat{\pi}_a$ is larger at $x_a = 0$ than at $x_a = -\frac{36+57\mu+23\mu^2}{12+10\mu}$. Therefore, retailer a's optimal position is $x_a^* = 0$. Plugging $x_a^* = 0$ back into retailer b's positioning reaction functions, we obtain $x_b^* = \frac{6+6\mu-D}{3}$, where $D = \sqrt{9+18\mu+6\mu^2}$.

Substituting x_a^* and x_b^* into the expressions of respective prices and profits, we obtain the equilibrium prices and profits of retailers a and b as stated in the lemma. □

Proof of Proposition 1. When retailer a chooses to acquire information, retailer b would not acquire information because paying a cost C does not generate additional benefits in the sequential setting. If retailer a chooses not to acquire information, then retailer b prefers to acquire information if $\frac{2t(3+4\mu)^3}{243} - C \geq \frac{t(6+6\mu-D)\left[3+6\mu+4\mu^2+(1+\mu)D\right]}{81}$, that is, $\mu \geq N_2$ where N_2 solves $\frac{2t(3+4\mu)^3}{243} - \frac{t(6+6\mu-D)\left[3+6\mu+4\mu^2+(1+\mu)D\right]}{81} = C$. Otherwise, when $\mu < N_2$, retailer b chooses not to acquire information.

Knowing retailer b's decision rule, retailer a decides whether or not to acquire information. Basically, retailer a compares its payoffs between AU, UA and UU. Retailer a will choose to acquire information when $\frac{8t(1+\mu)^3}{9} - C \geq \max\{\frac{2t(3+4\mu)(6+5\mu)^2}{243}, \frac{t(6+6\mu-D)\left[39+78\mu+40\mu^2-5(1+\mu)D\right]}{81}\}$. One can verify that $\frac{8t(1+\mu)^3}{9} - C \geq \frac{2t(3+4\mu)(6+5\mu)^2}{243} \geq \frac{t(6+6\mu-D)\left[39+78\mu+40\mu^2-5(1+\mu)D\right]}{81}$ when $\mu \geq N_1$, where N_1 uniquely solves $\frac{8t(1+\mu)^3}{9} - \frac{2t(3+4\mu)(6+5\mu)^2}{243} = C$. Hence, retailer a will choose to acquire information when $\mu \geq N_1$ and will not otherwise. □

Proof of Lemma 5. We in the sequel focus on the scenario where the new market appears on the left-hand side; the scenario where the new market appears on the right-hand side can be handled similarly.

We first consider the retailers' pricing decisions. Because the retailers set prices simultaneously, we solve the first-order conditions for profit maximization $\frac{\partial \pi_a}{\partial p_a} = 0$ and $\frac{\partial \pi_b}{\partial p_b} = 0$ simultaneously to get the following pricing reaction functions of retailers:

$$\widehat{p}_a = \frac{t}{3}(x_b - x_a)(3 + 4\mu + x_b + x_a), \text{ and } \widehat{p}_b = \frac{t}{3}(x_b - x_a)(3 + 2\mu - x_b - x_a).$$

It can be verified that the corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial p_a^2} = \frac{\partial^2 \pi_b}{\partial p_b^2} = -\frac{1}{t(x_b - x_a)} < 0$ since we assume that $x_a < x_b$ without loss of generality, and hence the second-order conditions for profit maximization are satisfied. Plugging $\widehat{p}_a$ and $\widehat{p}_b$ into the expressions of profits, we get

$$\widehat{\pi}_a = \frac{t}{18}(x_b - x_a)(3 + 4\mu + x_b + x_a)^2 - C, \text{ and } \widehat{\pi}_b = \frac{t}{18}(x_b - x_a)(3 + 2\mu - x_b - x_a)^2 - C.$$

Now we consider the positioning decisions. Since retailers determine their positions simultaneously, we solve the first-order conditions for profit maximization $\frac{\partial \widehat{\pi}_a}{\partial x_a} = 0$ and $\frac{\partial \widehat{\pi}_b}{\partial x_b} = 0$ simultaneously and obtain the following pairs of roots $(\widehat{x}_a, \widehat{x}_b)$:

$$(-3 - \frac{7\mu}{2}, -\frac{\mu}{2}), (-\frac{\mu}{2}, 3 + \frac{5\mu}{2}), \text{and } (-\frac{3}{4} - \frac{5\mu}{4}, \frac{3}{4} + \frac{\mu}{4}).$$

One can check that the second-order conditions $\frac{\partial^2 \widehat{\pi}_a}{\partial x_a^2} < 0$ and $\frac{\partial^2 \widehat{\pi}_b}{\partial x_b^2} < 0$ hold at the third pair of root; hence, it is a local maximal solution.

Now let us verify whether this local maximal solution is indeed the only equilibrium solution by comparing it with the boundary solutions. The non-negativity of demand and prices requires $-3 - 4\mu \leq x_a + x_b \leq 3 + 2\mu$. The first two pairs of roots happen to be on the lower and upper bounds, respectively. We can further verify that either retailer a or retailer b has a non-positive profit at the first two pairs of roots. Observe that the non-negativity of demand and prices gives only the feasible region of $x_a + x_b$. Thus, let us check two additional boundary solutions, $(-\frac{3}{4} - \frac{5\mu}{4}, \frac{15}{4} + \frac{13\mu}{4})$ and $(-\frac{15}{4} - \frac{17\mu}{4}, \frac{3}{4} + \frac{\mu}{4})$. These are obtained by fixing x_a (x_b) at the local maximum and varying x_b (x_a) such that $x_a + x_b = -3 - 4\mu$ or $x_a + x_b = 3 + 2\mu$ and satisfying $x_a < x_b$. From the above profit functions, it can be easily verified that these two boundary solutions produce a non-positive profit at either retailer a or retailer b. Hence, we have $x_a^* = -\frac{3}{4} - \frac{5\mu}{4}$, and $x_b^* = \frac{3}{4} + \frac{\mu}{4}$.

Substituting x_a^* and x_b^* back into the expressions of $\widehat{p}_a$, $\widehat{p}_b$, $\widehat{\pi}_a$, and $\widehat{\pi}_b$, we obtain the equilibrium prices and profits as stated in the lemma. $\square$

Proof of Lemma 6. First, consider the retailers' pricing decisions. Because the retailers set prices simultaneously, we solve the first-order conditions for profit maximization $\frac{\partial \pi_a}{\partial p_a} = 0$ and $\frac{\partial \pi_b}{\partial p_b} = 0$ simultaneously.

When the new market appears on the left-hand side, we get the following pricing reaction functions of retailers:

$$\widehat{p}_a^L = \frac{t}{3}(x_b - x_a)(3 + 4\mu + x_b + x_a), \text{ and } \widehat{p}_b^L = \frac{t}{3}(x_b - x_a)(3 + 2\mu - x_b - x_a).$$

When the new market appears on the right-hand side, we get the following pricing reaction functions of retailers:

$$\widehat{p}_a^R = \frac{t}{3}(x_b - x_a)(3 + 2\mu + x_b + x_a), \text{ and } \widehat{p}_b^R = \frac{t}{3}(x_b - x_a)(3 + 4\mu - x_b - x_a).$$

It can be verified that the corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial p_a^2} = \frac{\partial^2 \pi_b}{\partial p_b^2} = -\frac{1}{t(x_b - x_a)} < 0$ since we assume that $x_a < x_b$ without loss of generality, and hence the second-order conditions for profit maximization are satisfied. The corresponding profits when the new market appears on the left-hand side are

$$\widehat{\pi}_a^L = \frac{t}{18}(x_b - x_a)(3 + 4\mu + x_b + x_a)^2, \text{ and } \widehat{\pi}_b^L = \frac{t}{18}(x_b - x_a)(3 + 2\mu - x_b - x_a)^2.$$

The corresponding profits when the new market appears on the right-hand side are

$$\widehat{\pi}_a^R = \frac{t}{18}(x_b - x_a)(3 + 2\mu + x_b + x_a)^2, \text{ and } \widehat{\pi}_b^R = \frac{t}{18}(x_b - x_a)(3 + 4\mu - x_b - x_a)^2.$$

Now we consider the positioning decisions. The profits for positioning decisions are $\widehat{\pi}_a = \frac{1}{2}(\widehat{\pi}_a^L + \widehat{\pi}_a^R)$ and $\widehat{\pi}_b = \frac{1}{2}(\widehat{\pi}_b^L + \widehat{\pi}_b^R)$. Since retailers determine their positions simultaneously, we solve the first-order conditions for profit maximization $\frac{\partial \widehat{\pi}_a}{\partial x_a} = 0$ and $\frac{\partial \widehat{\pi}_b}{\partial x_b} = 0$ simultaneously. This gives rise to the following pairs of roots $(\widehat{x}_a, \widehat{x}_b)$:

$$
\begin{aligned}
&(-\frac{3+3\mu+\sqrt{9+18\mu+8\mu^2}}{2}, \frac{3+3\mu-\sqrt{9+18\mu+8\mu^2}}{2}),\\
&(-\frac{3+3\mu-\sqrt{9+18\mu+8\mu^2}}{2}, \frac{3+3\mu+\sqrt{9+18\mu+8\mu^2}}{2}),\\
&(-\frac{9+18\mu+10\mu^2}{12(1+\mu)}, \frac{9+18\mu+10\mu^2}{12(1+\mu)}).
\end{aligned}
$$

One can check that the second-order conditions $\frac{\partial^2 \widehat{\pi}_a}{\partial x_a^2} < 0$ and $\frac{\partial^2 \widehat{\pi}_b}{\partial x_b^2} < 0$ at the third pair of roots and hence it is a local maximum. Now let us verify whether this local maximum solution is the only equilibrium. The non-negativity of demand and prices requires $-3 - 2\mu \leq x_a + x_b \leq 3 + 2\mu$. Therefore, the first two pairs of roots are outside the feasible region. We only need to verify whether the boundary solutions $(-\frac{9+18\mu+10\mu^2}{12(1+\mu)}, -\frac{27+42\mu+14\mu^2}{12(1+\mu)})$ and $(-\frac{9+18\mu+10\mu^2}{12(1+\mu)}, \frac{45+78\mu+34\mu^2}{12(1+\mu)})$, obtained by fixing x_a at the local maximum and allowing x_b to take boundary values, could produce higher profits to both retailers. It can be easily verified that retailer b cannot be better off by taking boundary values compared to the local maximum solution. Hence, we have $x_a^* = -\frac{9+18\mu+10\mu^2}{12(1+\mu)}$, and $x_b^* = \frac{9+18\mu+10\mu^2}{12(1+\mu)}$.

Substituting x_a^* and x_b^* back into the expressions of $\widehat{p}_a^L$, $\widehat{p}_b^L$, $\widehat{p}_a^R$, $\widehat{p}_b^R$, $\widehat{\pi}_a^L$, $\widehat{\pi}_b^L$, $\widehat{\pi}_a^R$, and $\widehat{\pi}_b^R$, we obtain the equilibrium prices and profits as stated in the lemma. □

Proof of Lemma 7. We first consider the retailers' pricing decisions. As before, we solve the first-order conditions for profit maximization $\frac{\partial \pi_a}{\partial p_a} = 0$ and $\frac{\partial \pi_b}{\partial p_b} = 0$ simultaneously to get the following pricing reaction functions of retailers. When the new market appears on the left-hand side,

$$
\widehat{p}_a^L = \frac{t}{3}(x_b - x_a^L)(3 + 4\mu + x_b + x_a^L), \text{ and } \widehat{p}_b^L = \frac{t}{3}(x_b - x_a^L)(3 + 2\mu - x_b - x_a^L).
$$

The corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial (p_a^L)^2} = \frac{\partial^2 \pi_b}{\partial (p_b^L)^2} = -\frac{1}{t(x_b - x_a^L)} < 0$ since in this case we have $x_a^L < x_b$, and hence the second-order conditions for profit maximization are satisfied.

When the new market appears on the right-hand side,

$$\widehat{p}_a^R = \frac{t}{3}(x_a^R - x_b)(3 + 4\mu - x_a^R - x_b), \text{ and } \widehat{p}_b^R = \frac{t}{3}(x_a^R - x_b)(3 + 2\mu + x_a^R + x_b).$$

The corresponding second-order conditions $\frac{\partial^2 \pi_a}{\partial (p_a^R)^2} = \frac{\partial^2 \pi_b}{\partial (p_b^R)^2} = \frac{1}{t(x_b - x_a^R)} < 0$ since now we have $x_a^R > x_b$, and hence the second-order conditions for profit maximization are satisfied. Plugging $\widehat{p}_a^L$, $\widehat{p}_b^L$, $\widehat{p}_a^R$ and $\widehat{p}_b^R$ into the expressions of profits for positioning, we get

$$\widehat{\pi}_a^L = \frac{t}{18}(x_b - x_a^L)(3 + 4\mu + x_b + x_a^L)^2 - C, \text{ and } \widehat{\pi}_a^R = \frac{t}{18}(x_a^R - x_b)(3 + 4\mu - x_a^R - x_b)^2 - C,$$

and

$$\widehat{\pi}_b = \frac{t}{36}[(x_b - x_a^L)(3 + 2\mu - x_b - x_a^L)^2 + (x_a^R - x_b)(3 + 2\mu + x_a^R + x_b)^2].$$

Now we consider the positioning decisions. Since the retailers determine their positions simultaneously, we solve the first-order conditions for profit maximization $\frac{\partial \widehat{\pi}_a^L}{\partial x_a^L} = 0$, $\frac{\partial \widehat{\pi}_a^R}{\partial x_a^R} = 0$, and $\frac{\partial \widehat{\pi}_b}{\partial x_b} = 0$ simultaneously and obtain the six sets of roots including $x_a^L = -\frac{1}{3}(3 + 4\mu)$, $x_a^R = \frac{1}{3}(3 + 4\mu)$, and $\widehat{x}_b = 0$. One can check that the second-order conditions $\frac{\partial^2 \widehat{\pi}_a^L}{\partial (x_a^L)^2} < 0$, $\frac{\partial^2 \widehat{\pi}_a^R}{\partial (x_a^R)^2} < 0$ and $\frac{\partial^2 \widehat{\pi}_b}{\partial x_b^2} < 0$ at the set of roots $x_a^L = -\frac{1}{3}(3 + 4\mu)$, $x_a^R = \frac{1}{3}(3 + 4\mu)$, and $\widehat{x}_b = 0$. It can be shown that the other roots either produce a non-positive profit or contradict with the condition that $x_a^L < x_a^R$.

Now, let us check whether there are boundary solutions that could produce higher profits to both retailers. The non-negativity of demand and prices requires $-3 - 4\mu \le x_a^L + x_b \le 3 + 2\mu$ and $-3 - 2\mu \le x_a^R + x_b \le 3 + 4\mu$. Due to symmetry, we need only consider the case when the new market appears on the left-hand side. The feasible boundary solutions $(-3 - 4\mu, 0)$ and $(3 + 4\mu, 0)$ is obtained by fixing x_b at the local maximum solution 0 and allowing x_a to take boundary values. At boundary solutions $(-3 - 4\mu, 0)$ and

$(3+4\mu, 0)$, retailer a obtains non-positive profit and hence would deviate to the local maximum solution. Therefore, the equilibrium positions of retailer a are $x_a^* = -\frac{3+4\mu}{3}$ when the new market appears on the left-hand side and $x_a^* = \frac{3+4\mu}{3}$ when the new market appears on the right-hand side, retailer b's equilibrium positions are $x_b^* = 0$ in both scenarios.

Substituting x_a^* and x_b^* back into the expressions of respective prices and profits, we obtain the equilibrium prices and profits as stated in the lemma. □

Proof of Proposition 2. The simultaneous information acquisition game has four possible outcomes, namely, AA, AU, UA and UU. The expected payoffs of these outcomes at the information acquisition stage are listed in Table 2. First, we show that UU is an equilibrium. From Table 2, we obtain that $\pi_a^{UU} - \pi_a^{AU} = \pi_b^{UU} - \pi_b^{UA} = \frac{1}{972(1+\mu)}(388\mu^4 + 1576\mu^3 + 2520\mu^2 + 1836\mu + 513) + C > 0$ since $\mu \geq 0$ and $C \geq 0$. Hence, we have $\pi_a^{UU} > \pi_a^{AU}$ and $\pi_b^{UU} > \pi_b^{UA}$, that is, UU is an equilibrium. Furthermore, we can verify that AA is not an equilibrium because $\pi_a^{AA} - \pi_a^{UA} = \pi_b^{AA} - \pi_b^{AU} = -\frac{1}{972}(71\mu^3 + 333\mu^2 + 405\mu + 135) - C < 0$ since $\mu \geq 0$ and $C \geq 0$. Hence, we have $\pi_a^{AA} < \pi_a^{UA}$ and $\pi_b^{AA} < \pi_b^{AU}$. Therefore, UU is the only pure strategy equilibrium. □

Proof of Proposition 3. The results can be obtained directly by comparing the follower's payoffs in Tables 1 and 2. Take $\pi_b^{UU-sim} - \pi_b^{UA-\text{seq}}$ for example. From Tables 1 and 2, we obtain $\pi_b^{UU-sim} - \pi_b^{UA-\text{seq}} = \frac{10476\mu^4+42552\mu^3+68040\mu^2+75816\mu+40095}{26244(1+\mu)} > 0$ and obviously this difference in profits is increasing as μ increases. Similarly, we can verify $\pi_b^{UU-sim} - \pi_b^{UU-\text{seq}} > 0$ and $\pi_b^{UU-sim} - \pi_b^{AU-\text{seq}} > 0$ and both profit differences are increasing as μ increases. □

Proof of Proposition 4. It can be verified that when $\mu \leq 2.15$, $\pi_a^{UU-sim} - \pi_a^{UU-\text{seq}} < 0$ and $\pi_a^{UU-sim} - \pi_a^{UA-\text{seq}} < 0$ by comparing the leader's payoffs in Tables 1 and 2. Now we proceed to prove the second half of the proposition, that is, the leader would be better off by delaying its positioning decision only when the size of the new market is sufficiently large. What we need to show is that the leader's profit in equilibrium is higher in simultaneous positioning than in sequential positioning when μ is sufficiently large. Denote as π_a^{diff} the leader's profit difference in equilibrium between the simultaneous and sequential positioning game. From Tables 1 and 2, we get $\pi_a^{diff} = \frac{(9+18\mu+10\mu^2)^2}{108(1+\mu)} - \frac{8(\mu+1)^3}{9} + 1$. What we need to show is that there exists an $\widehat{\mu}$ such that $\frac{d(\pi_a^{diff})}{d\mu} > 0$ when $\mu > \widehat{\mu}$ and $\pi_a^{diff} < 0$ when evaluated at $\widehat{\mu}$. Let $d\pi = \frac{d(\pi_a^{diff})}{d\mu}$ and then we have $d\pi = \frac{12\mu^4 - 32\mu^3 - 144\mu^2 - 144\mu - 45}{108(1+\mu)^2}$. It is straightforward to verify that $d\pi$ is convex in μ since its second derivative (with respect to μ) $\frac{4\mu^4+16\mu^3+24\mu^2+16\mu+3}{18(1+\mu)^4}$ is strictly positive for all possible values of μ. By solving the first-order condition of $d\pi$, we obtain the minimum value of $d\pi$ as -1.01 at critical point $\mu = 2.33$. Furthermore, when $\mu = 5.35$, we have $d\pi = 0$. Since $d\pi$ is convex in μ, we know that $d\pi$ is strictly increasing when $\mu > 2.33$ and hence $d\pi > 0$ when $\mu > 5.35$. When evaluated at $\mu = 5.35$, we get $\pi_a^{diff} = -3.08$. Therefore, we have shown that there exists an $\widehat{\mu} = 5.35$ such that $\frac{d(\pi_a^{diff})}{d\mu} > 0$ when $\mu > \widehat{N}$ and $\pi_a^{diff} < 0$ when evaluated at $\widehat{\mu}$. This concludes the proof. $\square$

Figures

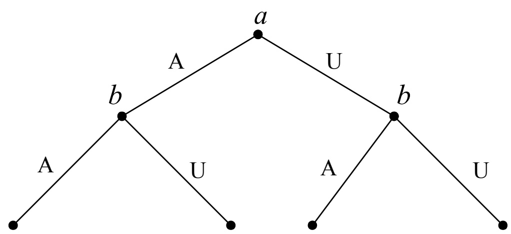

Figure 1: Sequential information acquisition.

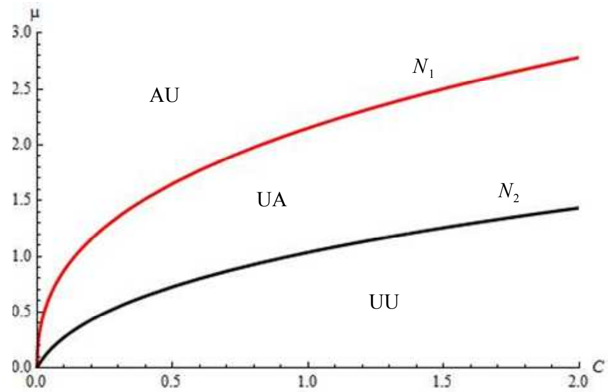

Figure 2: Information acquisition in equilibrium ($t = 1$).

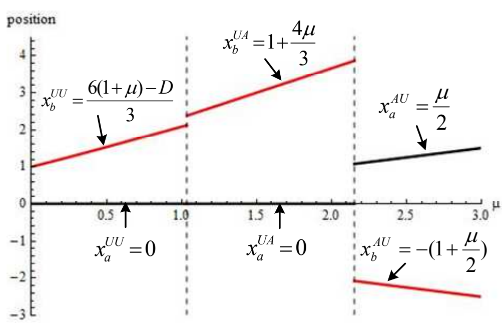

Figure 3: Equilibrium positions vs. new market size.

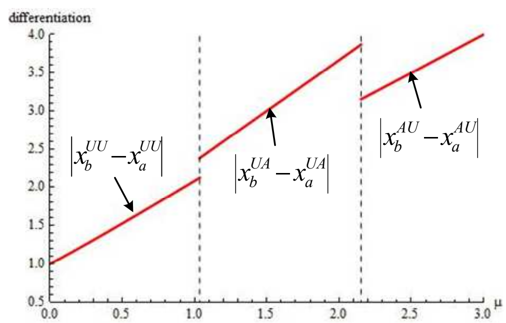

Figure 4: Differentiation vs. new market size.

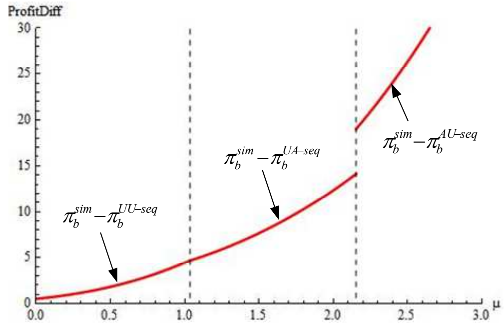

Figure 5: Retailer b profit difference vs. new market size.

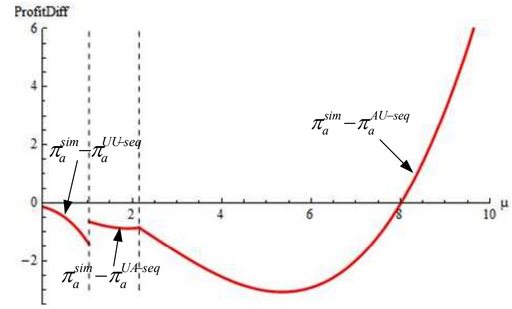

Figure 6: Retailer a profit difference vs. new market size.

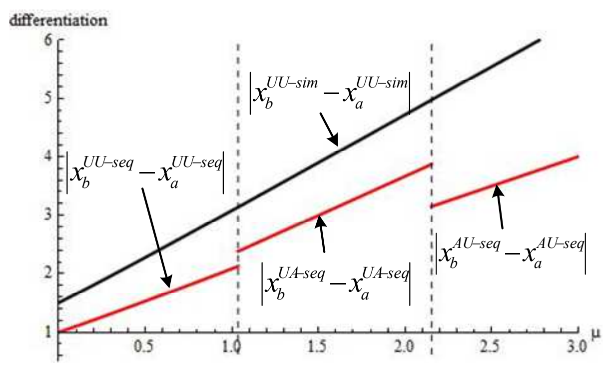

Figure 7: Differentiation versus new market size.

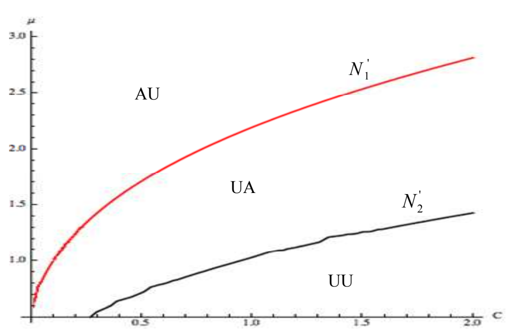

Figure 8: Information acquisition in equilibrium ($\sigma = 0.125$).

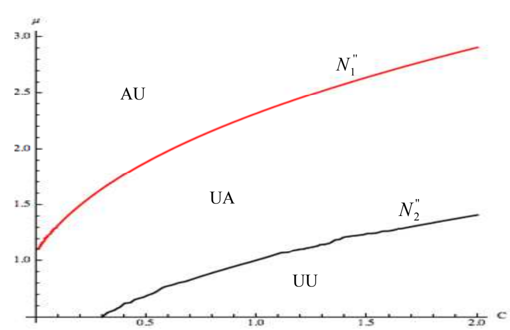

Figure 9: Information acquisition in equilibrium ($\sigma = 0.25$).

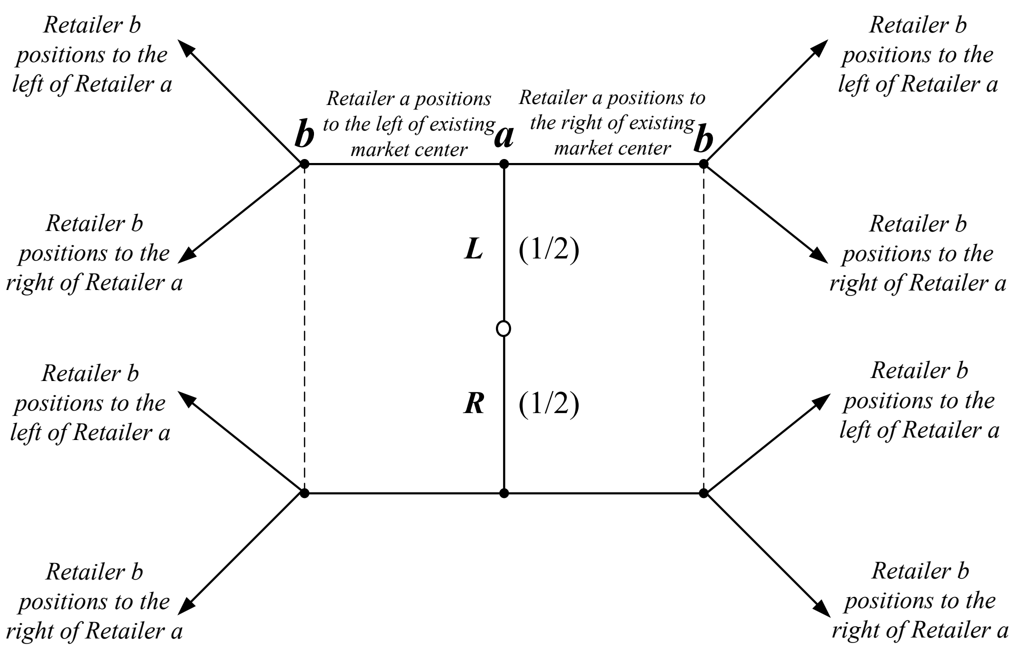

Figure 10: The sequential positioning game in AU.

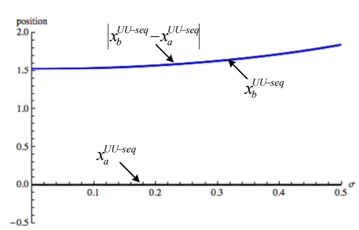

Figure 11: Equilibrium positions and differentiation versus σ ($\mu = 0.5$).

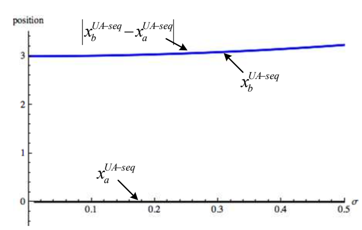

Figure 12: Equilibrium positions and differentiation versus σ ($\mu = 1.5$).

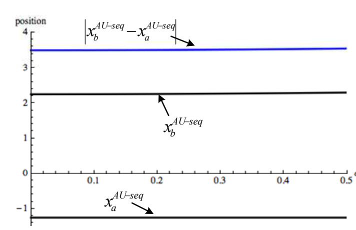

Figure 13: Equilibrium positions and differentiation versus σ ($\mu = 2.5$).