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Consumer heterogeneity and online vs. offline retail spatial competition

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Abstract

This paper develops a game-theoretic spatial model featuring consumer heterogeneity in online vs. offline retailers' spatial competition. We find that consumers' browse-and-switch behavior intensifies the competition because both offline and online retailers' price and profit decline when the behavior occurs, but it is not necessarily a threat to offline retailers especially when the product relates more closely to experience. We consider six equilibrium scenarios for different combinations of consumer behaviors when considering a hybrid retailer. The analysis taking consumer heterogeneity into consideration shows that the hybrid retailer operating both online and offline is not always the winner. Particularly, the business opportunity for the offline retailer lies in consumers' willingness to pay in store, and whether the retailer launches an online store depends on the type of products and services provided.

Keywords: Spatial competition, Online retailing, Browse-and-switch behavior, Consumer heterogeneity, Consumer behavior, China, Circular city model

Introduction

Over the last two decades, technology-driven commerce innovation has transformed the retailing industry. In recent China, with the new trends of online and offline integration and collaboration, many new technology-driven retail formats have emerged, such as Ali's Hema Fresh, Ali's cooperation with Yintai department store, and JD's 7 fresh or JD's "to home service." These new retailing formats attempt to seize the market by enabling consumers to have more flexible purchasing choices. Online retailing is often valued for its convenience, effort savings, better selection and availability, search capabilities, increasingly accurate information, and the lack of lines and crowds (Wolfinbarger and Gilly 2001). Consumers' purchasing decisions are beyond the limits of time and place and have become diversified. For instance, consumers can purchase directly from an online retailer, or visit the offline store and then purchase the item online. In this paper, we call this new format which offers products in stores as well as supplying online sale and delivery services "the hybrid retailer." Hence the spatial competition becomes more complex across pure offline, online and hybrid retailers. At the same time, we can see that with the advance of the retail market today, consumer behaviors are also more complex.

The key questions analyzed in this paper are: By taking consumer heterogeneity into consideration, how will online retailing influence the spatial retailers' competition equilibrium? What strategies should pure offline retailers employ regarding the browse-and-switch behavior in which some consumers visit the offline retailer but subsequently purchase only from an online retailer? Will the hybrid retailer which operates both online and offline lead to a "winner-take-all" outcome? Does it lead the offline retailer to go online? All these issues are important for offline retailers to assess in order to decide whether they need to make a digital transformation.

This paper attempts to elucidate the competitive equilibrium of online and offline spatial competition based on Salop's (1979) circular city model under consumer heterogeneity. There is a growing body of research that studies online vs. offline spatial competition (Balasubramanian 1998; Cheng and Nault 2007; Jeffers and Nault 2011; Viswanathan 2005). Balasubramanian (1998) finds that the online retailer acts as a competitive wedge between offline retailers, and each offline retailer competes against the remotely-located Internet marketer, rather than against neighboring retailers. Jeffers and Nault (2011) extend Balasubramanian's circular market model by introducing a hybrid retailer and demonstrate that the entry of a hybrid retailer can lead to increased offline retailer prices and increased profits across the industry. Cheng and Nault (2007) assert that market coverage is critical for offline retailers' decision about launching an online store. The assumption of most literatures is based on homogeneous consumers and few of them consider consumer heterogeneity. Unlike previous studies, by taking consumer heterogeneity into account, our research defines different types of consumer behaviors according to their varying purchase costs and the likelihood of products satisfying their needs and preferences. In this research, consumers' switching behavior to another retailer is allowed; that is, consumers could first visit the offline retail store to examine a product and then buy the item from the online retailer, or at the offline store, or even forego the purchase. We then explore how consumers' choices influence equilibrium price and profit of the online and offline retailers under spatial competition. In each scenario, consumers' choices would influence equilibrium results differently. We find that consumers' switch option intensifies the competition because when it occurs, the price and profit of both offline and online retailers decrease. In this scenario, the offline retailer has no incentive to charge a lower price compared to its competitor.

Furthermore, extended model analysis focuses on the competition between the offline and the hybrid retailers. The hybrid retailer allows consumers to have more purchasing choices. Consumers can purchase from an offline retailer, or an offline store of the hybrid retailer, or an online store of the hybrid retailer, or they can even switch to another retailer at any step of their purchase process. To take all these choices into account, our comprehensive analysis encompasses six scenarios and five types of consumer behaviors. Results show that it is not inevitable for the hybrid retailer to derive more profit in all circumstances. Moreover, for either the hybrid retailer or the offline retailer, low price is not a critical factor to capture market share and high profit. This may indicate that the price strategy is not effective in all scenarios. The findings also highlight the important role of consumers' willingness to pay at offline retailers' stores, which may implicate that the type of products and services they provide are critical for their integration choices.

Our marginal contributions are reflected in the following three aspects. First, different from other research, we enrich the spatial competition model by introducing consumer heterogeneity and bridge the theoretical gap. This assumption is also closer to real consumer behavior and analysis results can give a more practical reference value for retailers. Second, apart from introducing different purchase costs to reflect consumer heterogeneity, we allow the switch option and assume that consumers' choices depend on their costs and the likelihood of the product meeting their needs. Under this circumstance, we enhance consumers' shopping strategies through different scenarios. Third, in addition to the assumption of consumer heterogeneity, we add a hybrid retailer into the model to study its influence and provide offline retailers with some managerial proposals regarding launching an online store. We find that the type of products and services they provide and whether they have strong offline brands may influence consumers' choices.

The rest of this paper is structured as follows. Section 2 elucidates the key consumer heterogeneity parameters that motivate the analytical models that follow. Section 3 describes the basic model of competition between pure offline retailers and online retailers. Building on the basic model in section 3, section 4 analyzes the impact of the entrance of a hybrid retailer on the equilibrium outcomes. Section 5 concludes with a discussion of managerial implications.

Consumer heterogeneity and spatial competition

Our analysis begins with consumers' different choices. Heterogeneous consumers have various online and offline purchase costs so that different retail formats provide distinct combinations of products and services to meet consumer needs. Consumers choose their destination according to diverse preferences and the real purchase cost which is comprised of price and transaction costs. They will take advantages of both online and offline retailers to fulfill their shopping strategies and maximum their surpluses. Offline transportation cost, online shopping disutility cost, and the price level of both retailers can be critical factors for consumers' choices. To be attractive for more consumers, some new retail formats, or "hybrid retailers" in this paper, offer more alternative combinations of products and services. For example, Ali's Hema Fresh launched its first store in Shanghai in 2017.This new format of fresh food supermarket allows consumers to purchase at the store or through an APP, and consumers can even have a meal at the store. Additionally, an online order within 3 km can be delivered within 30 min, providing consumers with greater convenience. Since it may be welcomed among several types of consumers, the emergence of Hema Fresh can pose a threat to other pure offline retailers in the area, and change the equilibrium of original spatial competition.

Many studies have explained that consumer heterogeneity can influence retailers' best response and the online vs. offline competition equilibrium. Balakrishnan et al. (2014) construct a stylized economic model that captures the heterogeneity among consumers in their inclination to purchase online and find that the option of consumers to browse-and-switch intensifies competition, reducing the profits for both retailers. Mahar and Wright (2017) focus on in-store pickup and return options provided by hybrid retailers and find that the location of the store is very important for retailers to substantially increase customer value while maintaining cost minimization. Mahar et al. (2014) also introduce a model including consumer behavior and its effect on the retailer's cost and emphasize the importance of the hybrid retailer. Druehl and Porteus (2010) assert consumer service experience and firm cost structure are two of the key differentiators in the competition between online and offline retailers. When further investigating hybrid retailer, Herhausen et al. (2015) find online and offline retailer integration leads to a competitive advantage and channel synergies rather than channel cannibalization, and the effects vary across customers with different levels of Internet shopping experience.

Since most of previous studies (e.g., Rui et al. 2015 Forman et al. 2009) highlight the influence of consumers' relative location to the nearest offline store on their purchase choice, in this paper, we are motivated to combine consumer heterogeneity and spatial competition. Viswanathan (2005) also studies the competition between online, offline, and hybrid retailers based on a spatial differentiation model as we do. However, he focuses more on channel differentiation such as differences in channel flexibility, network externalities, and switching costs, to examine their impact on competitive equilibrium. We consider six equilibrium scenarios for different combinations of consumer shopping behaviors, characterize the parameter ranges for each scenario, and demonstrate that consumers' location, the relative price of retailers and the likelihood of products satisfying consumer needs can influence consumers' shopping strategies and further exert an influence on equilibrium price and profit for retailers.

Our basic circular spatial model is based on the Salop (1979) model. Since Hotelling (1929) proposed the linear urban spatial competition model, the concept of spatial competition is usually used for market competition under oligopoly. By extending the Hotelling model, Salop (1979) proposes a circular city model and demonstrates the number of retailers in free competition will be greater than the number of retailers under an optimized situation. Then, Balasubramanian (1998) adjusts the circular city model to embrace an online retailer and provides a set of frameworks to analyze the multiple-channel environment. Bouckaert (2000) incorporates e-commerce into the Salop's (1979) model and analyzes the free competition between a traditional retailer and a mail order business. In previous models, the consumer's choice is a function of the price, the transportation cost and distance to the closest offline retailer, and a measure of the suitability of the product for the online retailer. Based on all parameters, a hybrid retailer and a return option are added into our model where consumer heterogeneity is highlighted by introducing different scenarios. Assumptions and parameter settings are detailed in the next section.

The basic model

We assume that there are two retailers: retailer a operating in the pure offline format and retailer b operating in the pure online format. Parameters p_a and p_b are prices set by retailer a and retailer b, respectively. According to Salop's standard model, consumers are uniformly distributed in a circular market with the length of 1, and the whole market capacity is N with each consumer's demand being a unit. As is depicted in Fig. 1, retailer a is situated diametrically opposite to retailer b, and x ($x < \frac{1}{2}$) is the distance between the location of a consumer and the offline retailer.

For an offline consumer, his/her expected utility is U_a and the consumer who buys the product online can obtain an expected utility U_b:

$$\begin{cases} U_a = \theta(V - p_a) - tx, \\ U_b = \theta(V - p_b) - (1-\theta)\delta p_b - m(\frac{1}{2} - x). \end{cases}$$

Different from Salop's model where high reservation prices are assumed to ensure consumers always purchase a product, in our analysis, consumers who are attracted by

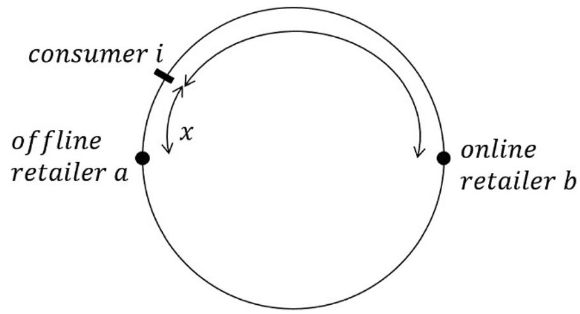

Fig. 1 Offline vs. online spatial competition

a product are initially unsure if this item will meet their needs and tastes. Thus, we assume that V which is in line with the reservation price captures the consumer perceived value from the product and $\theta \in (0, 1)$ denotes the probability that a consumer will like the product and purchase it.

No matter whether purchase online or offline, consumers always incur a positive cost. There is a distance-related transportation cost including the cost of travel, opportunity cost of time and so on when consumers visit the offline retailer, while the online distance-related cost can account for the distribution cost or waiting cost associated with delivery, concerns about the security and privacy, and other disutility costs. Thus, t and m are supposed as offline and online unit purchase cost respectively. Our model incorporates heterogeneity among consumers in terms of their distance-related costs of visiting the store and purchasing online. This variation among consumers leads to different consumer behaviors and permits us to fully capture various competition scenarios. In the ensuing analysis, we assume $m < t$ for three reasons: (a) Convenience is always a central reason for the patronage of direct online purchase (Eastlick and Feinberg 1999); (b) The online transportation cost is being reduced under the irreversible trend that scattered and small distribution centers allow for more efficient delivery (Wu 2010); and (c) Some online retailers offer free shipping fees, although this could potentially mean that they also adjust their online prices to compensate (Cavallo 2017).

Additionally, online retailers attract consumers and reduce their purchase risk by offering a return option. If consumers order the product directly from online retailers and find out that they do not like the item after receiving it, they can return the item at a cost, which we call the return fee. We assume that the return fee is a positive fraction $\delta \in (0, 1)$ of the price because it not only includes the logistics costs, but also relates to psychological cost associated with returning goods. For notational convenience, we define the parameter λ as $\lambda \triangleq \theta + (1-\theta)\delta$, thus, $U_b = \theta V - \lambda p_b - m(\frac{1}{2} - x)$. To simplify the analysis and focus on consumer heterogeneity, we also assume that the product cost is zero for both retailers.

Both retailers set respective prices to maximize their individual profits. Consumers have full information about their specific purchase cost m or t, the offline and online prices (p_a, p_b), and the other parameters (V, θ, δ and x). This information allows each consumer to select the strategy that provides him/her the highest utility. We assume that the expected value θV of the product is greater than the store visit cost tx; otherwise, no consumer will visit the store.

A consumer situated at a distance x from retailer a purchases in the offline format if

$$\begin{cases} \theta(V-p_a)-tx_a \geq \theta(V-p_b)-(1-\theta)\delta p_b - m(\frac{1}{2}-x) \\ \theta(V-p_a)-tx_a \geq 0, \end{cases},$$

or if $x \leq \frac{\lambda p_b - \theta p_a + \frac{m}{2}}{t+m}$. The total demand faced by retailer a in offline format is, therefore

$$q_a = 2N\theta x = \frac{2N\theta\lambda p_b - 2N\theta^2 p_a + N\theta m}{t+m}.$$

Similarly, the demand for retailer b in online format is

$$q_b = 2N\left(\frac{1}{2}-x\right) = N - \frac{2N\lambda p_b - 2N\theta p_a + Nm}{t+m},$$

Given the prices p_a and p_b, therefore, the profits for the two retailers are π_a and π_b:

$$\pi_a = p_a \cdot q_a = \frac{2N\theta}{t+m}\left[p_a p_b \lambda - \theta p_a^2 + \frac{mp_a}{2}\right],$$

$$\pi_b = p_b \cdot q_b = Np_b - \frac{1}{t+m}\left[2N\lambda p_b^2 - 2N\theta p_a p_b + Nmp_b\right].$$

At equilibrium, each retailer chooses a price to maximize its profits, given the price choices of the other retailer. Solving the profit functions by the first-order conditions yields the following price reaction functions:

$$p_a(p_b) = \frac{2\lambda p_b + m}{4\theta},$$

$$p_b(p_a) = \frac{2\theta p_a + t}{4\lambda}.$$

Proposition 1: *The optimal prices, demands and profits at equilibrium for the offline retailer (retailer a) and the online retailer (retailer b) are given by*

$$p_a{}^* = \frac{1}{6\theta}(t+2m);\;\; p_b{}^* = \frac{1}{6\lambda}(2t+m).$$

$$q_a{}^* = \frac{N\theta(t+2m)}{3(m+t)}; q_b{}^* = \frac{N(2t+m)}{3(m+t)}.$$

$$\pi_a{}^* = \frac{N(t+2m)^2}{18(m+t)}; \pi_b{}^* = \frac{N(m+2t)^2}{18\lambda(t+m)}.$$

The basic model considers the performance of online and offline retailers under spatial competition. The best response functions suggest that the prices of both retailers depend on each other and consumer characteristics (*m, θ or t*), and that the equilibrium price and profit illustrate the effect of consumer purchase cost. Intuitively, we expect that higher values of the store visit cost t will put the offline store at a disadvantage and force it to have a lower price and profit, while the situation will be the same with online purchase cost m and online retailer's price and profit. However, in the equilibrium, both retailers' prices have a positive correlation with m and t and the relationship between profits and the parameters are uncertain. We think that these unanticipated pricing and profit trends stem from competition. At higher values of t, stores are less attractive and online retailer can raise its price without losing consumers. In turn, the offline retailer reacts to competitor's price increase by raising its own price.

Proposition 2: *When* $1 > \frac{m}{t} > \frac{\theta}{\delta(1-\theta)} - 1$, *the equilibrium price of the offline retailer is higher than the price of the online retailer* ($p_a^* > p_b^*$). *Furtherly, if* $\theta < \frac{\delta}{1+\delta}$ (i.e., $\frac{\theta}{\delta(1-\theta)} < 1$), p_a^* *will always be higher than* p_b^*.

Proposition 2 indicates that when the relative online purchase cost is higher than a certain level, online shopping will be less attractive and the offline retailer can charge a higher price. Then if θ is low, which means consumers are uncertain about whether the product can satisfy their needs, most of them will visit the offline store to examine the product. In this circumstance, the offline retailer will be more attractive and has an incentive to set a higher price. We also find that the partial derivative of p_a^* on m is greater than that of p_b^*, which implies that offline retailer is even more sensitive to consumers' online purchase cost than online retailer. As for the profit, π_b^* is greater than π_a^* because of the larger market share of the online retailer.

Following this, we allow consumers to have a switch option. Sometimes, after gathering all the pertinent information from readily accessible sources, consumers are still unsure whether the item meets their needs. There are two possible ways for them to resolve the uncertainty: visiting a retail store or waiting for the package. Physical stores allow consumers to exam the product before purchasing it. On the other hand, if a consumer orders the product directly from the online retailer, he/she discovers whether he/she likes the product only after receiving the item and can then return the unsatisfying item at a cost. Hence, to buy a certain product, if tx is low and p_a is much greater than p_b, consumers will have an intention to experience the product offline and then purchase it from online retailer if they are satisfied with it. Thus, in the next stage, we allow the consumer to switch across the retailers and analyze the situation where the consumer switches to the online retailer b from the retailer a after completing a shopping trip at the offline retailer. This situation represents a shopper behavior prevalent in today's retail landscape. Many scholars have referred to this consumer behavior as browse-and-switch and explore its impact and reasons. Gupta et al. (2004) attribute this behavior to consumers' differences in purchase risk perceptions, price search intentions, evaluation effort, and waiting time between online and offline retailers. Gensler et al. (2017) find expected average price savings and the perceived dispersion in online prices to be positively associated with browse-and-switch behavior, while many other non-price factors such as perceived gains in the quality of the product and time pressure also play a key role. Most research considers browse-and-switch as a threat to offline retailers. However, guided by the theoretical lens of consumer experience, Sit et al. (2018) assert that this is a positive shopper behavior and it can provide potential opportunities for retailers.

In our model, a consumer who visits the offline retailer a to examine a product but later purchases it online from retailer b has an expected utility $U_s = \theta[V - p_b - m(\frac{1}{2} - x)] - tx_a$. Applying spatial competition indicates that the distance to the nearest offline retailer plays an important role in consumers' shopping strategy and in delineating their types. In the utility functions shown in Fig. 2, x_{AS} denotes the distance at which a consumer is indifferent between purchasing offline or adopting browse-and-switch behavior. Similarly, x_{AB} and x_{BS} denote the distance at which an online purchase yields the same utility as offline and browse-and-switch behaviors, respectively. These three indifference values can be expressed as:

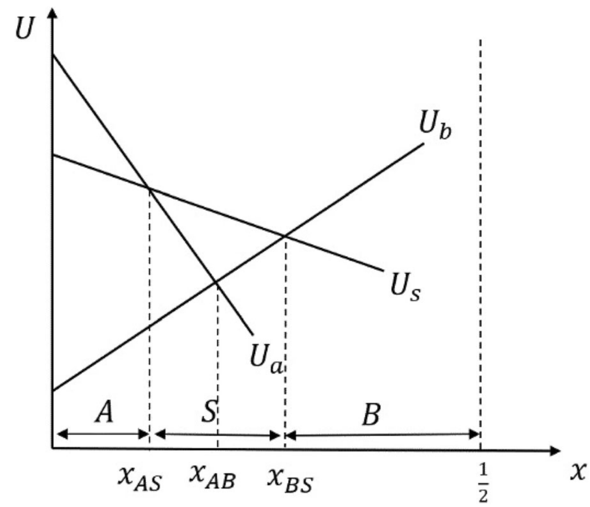

Fig. 2 Consumer utility functions

$$x_{AS} = \frac{p_b - p_a}{m} + \frac{1}{2};\ \ x_{AB} = \frac{2(\lambda p_b - \theta p_a) + m}{2(m+t)};\ \ x_{BS} = \frac{2(\lambda - \theta)p_b + m(1-\theta)}{2(t + m(1-\theta))}.$$

We can conclude from Fig. 2 that, for any given offline and online retail prices, consumers who select an offline purchase must have lower transportation costs than those that choose to switch to online retailers; similarly, people who prefer an online purchase must have higher transportation costs.

Given prices p_a and p_b at which both retailers have positive profits, (i) some consumers adopt browse-and-switch behavior if and only if $p_a \geq p_b + \frac{m}{2} - \frac{m(1-\theta)(m+2\delta p_b)}{2m(1-\theta)+t}$, and (ii) some consumers purchase only directly if and only if $p_b \leq \frac{2(t+m)x-m}{2\delta(1-\theta)}$.

A consumer who visits a store and likes a product will switch to purchasing from the online retailer if the total cost of this purchase $p_b + m(\frac{1}{2} - x)$ is less than the offline price p_a. Since the lowest cost for consumers to switch to online is $m(\frac{1}{2} - X_{BS})$, some consumers will switch only if $p_a \geq p_b + m(\frac{1}{2} - X_{BS})$. Next, the expected return cost for the consumer who purchases online and finds he/she does not like the product is $\delta(1-\theta)p_b + m(\frac{1}{2} - x)$, whereas the cost of visiting the store is tx. Hence, if $\delta(1-\theta)p_b + m(\frac{1}{2} - x) > tx$, then even the consumer with the lowest (zero) online cost will not order directly online.

Like the previous method, when there is a switch option, we can get the optimal prices, demands and profits at equilibrium for retailer a and retailer b.

$$p_a^* = \frac{m}{3}; p_b^* = \frac{m}{6}.$$

$$q_a^* = \frac{2N\theta}{3}; q_b^* = \frac{N}{3}.$$

$$\pi_a{}^* = \frac{2Nm\theta}{9} \quad \pi_b{}^* = \frac{Nm}{18}.$$

Proposition 3A: *In the scenario where consumers can adopt browse-and-switch behavior, the offline retailer's price is higher than that of the online retailer and its demand and* *profit depend on θ. If* $\frac{1}{2} < \theta < 1$, *the demand of the offline retailer is greater than that of the online retailer and if* $\frac{1}{4} < \theta < 1$, *the profit of the offline retailer is higher.*

According to the previous analysis, browse-and-switch behavior can indeed exist in some circumstances. Intuitively, we expect that offline retailer will reduce the price to maintain customers when there is a browse-and-switch behavior. However, our equilibrium shows that the price of offline retailer is twice that of online retailer in this situation, and the offline retailer's demand and profit have a positive correlation with θ. This may implicate that the switch option is not necessarily a threat to offline retailer. If offline retailer can increase the probability that a consumer will like the product and purchase it at the store, especially for a product that requires being experienced, more profit can be derived. This outcome is consistent with Sit et al. (2018) which assert that browse-and-switch behavior is a positive consumer behavior and its potential opportunities can be better appreciated when retailer considers fully its experiential aspects, such as decision activities and emotions. For online retailers, they prefer to maintain their low price to attract switch consumers.

Proposition 3B: *When considering consumers' browse-and-switch behavior, both the offline retailer and the online retailer charge lower prices and gain lower profits compared to the prices and profits for the no-switching model.*

When comparing price and profit behavior with and without the switch option, we find that the presence of browse-and-switch behavior reduces profits for both retailers. This result is consistent with observations that the browse-and-switch phenomenon is partly responsible for the declining profits of offline retailers. Because of the asymmetric shopping cost assumption, in our model online retailer's price and profit also decline when there is a switch option. In the model where consumers are not allowed to adopt browse-and-switch behavior, consumers with low transportation cost will purchase from the offline retailer while others with higher offline purchase costs will order online. With the switch option, competition intensifies because the online retailer prefers to cut prices aggressively to compete with the offline retailer and attract informed consumers who have already incurred the offline visit costs. In this situation, consumers endowed with more choices will benefit from intense price competition.

Model extension

Consumer purchasing decisions (when considering the hybrid retailer)

In order to satisfy diversified demand of consumers and be attractive, both offline retailers and online retailers are updating their strategies and seek cooperation nowadays. In this part, a hybrid retailer operating in both offline and online spheres is involved in analyzing the impact of its presence on the equilibrium outcomes. We study only the case where the hybrid retailer competes with the offline retailer because it is a more practical one and can include more scenarios compared to the competition between the pure online retailer and the hybrid one. In accordance with the earlier model setup, the hybrid retailer h is located diametrically opposite to the offline retailer a (Fig. 3).

Distinguished from homogeneous consumers, here, heterogeneous consumers have different purchase costs and reservation prices for the product. Each consumer determines his/her purchasing strategy to maximize his/her utility. There are five types of consumer's shopping behavior (T) in the market. $T = A$ represents "brick-and-mortar" retail shoppers who visit and purchase from the offline retailer a if satisfied with the product. $T= H_1$ and $T= H_2$ are those who purchase the product on the Web and from the physical store of retailer h respectively. Specifically, online-direct consumers H_1 could return the product alternatively if they do not enjoy the goods. Then, there are two types of consumers who adopt browse-and-switch behaviors. Consumers of type S_1 are who browse in the offline retailer and then switch to the online store of the hybrid retailer for purchasing. Another type of "switch" behavior S_2 refers to the situation in which consumers visit the physical store of hybrid retailer h but prefer to purchase from the offline retailer a on account of shopping costs. The consumer types and their corresponding utility expressions are shown in Table 1.

Scenarios and equilibrium

Based on the heterogeneous consumer types, we derive six different equilibrium scenarios: $A- H_1$, $A- H_2$, $A- H_1- H_2$, $A- H_1- S_1$, $A- H_1- S_2$ and $A- H_2- S_1$, distinguished by the purchasing behaviors adopted by consumers.

In scenario $\boldsymbol{A- H_1}$, some consumers choose to purchase the product from the physical store of retailer a, while others order the item directly from the online store of retailer h. The outcome as follows is the same as the competition of pure offline and online retailers in the basic model.

$$p_a{}^* = \frac{1}{6\theta}(t+2m); \quad p_h{}^* = \frac{1}{6\lambda}(2t+m).$$

$$q_a{}^* = \frac{N\theta(t+2m)}{3(m+t)}; \quad q_h{}^* = \frac{N(2t+m)}{3(m+t)}.$$

$$\pi_a{}^* = \frac{N(t+2m)^2}{18(m+t)}; \quad \pi_h{}^* = \frac{N(m+2t)^2}{18\lambda(t+m)}.$$

In scenario $\boldsymbol{A\text{-}H_2}$, consumers will visit the offline retailer a or the physical store of the hybrid retailer and purchase the product if satisfied with it. Under this circumstance, the spatial competition between two pure offline stores is discussed. Given the expected utility isU_a and U_{h1} respectively, the consumer purchases from the retailer a only if $U_a \geq U_{h1}$ or if $x \leq \frac{\theta(p_h - p_a)}{4t} + \frac{1}{4}$. Thus, the demand functions of those two retailers are $q_a = 2N\theta x = \frac{N\theta(2\theta(p_h - p_a)+t)}{2t}$, $q_h = 2N\theta(\frac{1}{2} - x) = \frac{N\theta(2\theta(p_a - p_h)+t)}{2t}$ in this scenario. The optimal solutions at equilibrium are given as follows.

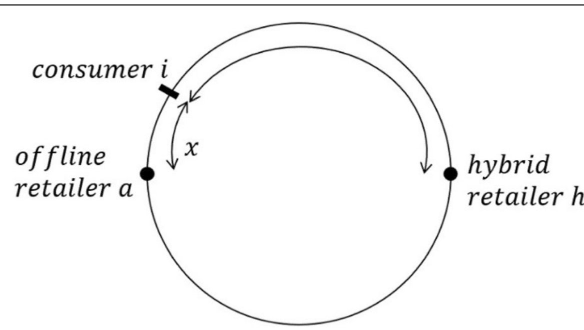

Fig. 3 Spatial competition of offline vs. hybrid retailers

Table 1 Consumer type and utility expression

Consumer type		Utility expression
A	Consumers who visit and purchase from the offline retailer if satisfied with the product	$U_a = \theta(V - p_a) - tx$
H_1	Consumers who purchase the product from online store of the hybrid retailer	$U_{h1} = \theta(V - p_h) - (1-\theta)\delta p_h - m(\frac{1}{2} - x)$
H_2	Consumers who purchase the product from physical store of the hybrid retailer	$U_{h2} = \theta(V - p_h) - t(\frac{1}{2} - x)$
S_1	Consumers who browse in the offline retailer and then switch to the online store for purchase	$U_{s1} = \theta(V - p_h - m(\frac{1}{2} - x)) - tx$
S_2	Consumers who browse in physical store of the hybrid retailer and then switch to the pure offline retailer for purchase	$U_{s2} = \theta(V - p_a - tx) - t(\frac{1}{2} - x)$

$$p_a{}^* = p_h{}^* = \frac{t}{2\theta}, q_a{}^* = q_h{}^* = \frac{N\theta}{2}, \pi_a{}^* = \pi_h{}^* = \frac{Nt}{4}.$$

It shows that if the equilibrium occurs in the interior of the $A-$ H_2 scenario, both retailers choose the same price which is positively related to offline distance-related cost t and divide the market equally. This equilibrium is expected because it is the standard model of price competition between two pure offline retailers.

In scenario $\boldsymbol{A-}$ $\boldsymbol{H_1-}$ $\boldsymbol{H_2}$, the competition becomes complex because more purchasing behaviors are encompassed within the spatial model. The consumer types H_1 and H_2 coexist in the market simultaneously, which means there are two alternative choices (online-store or offline-store) provided by the hybrid retailer. Each consumer selects, based on his/her position along the circular city, the shopping behavior to maximize utility function. Then depending on the retail price (p_a, p_h), one of the utility conditions may be greater than the other for a certain value of x. It also means that not all consumer types necessarily exist for every combination of prices and distances.

Like x_{AB} and x_{BS}, here, x_{AH_1}, x_{AH_2} and $x_{H_1H_2}$ are endowed with similar meanings. At the point of x_{AH_1}, a consumer is indifferent between purchasing from a physical store of retailer a or a website of retailer h. The consumer types A, H_1 and H_2 are characterized into three intervals by partitioning the range of possible values of x (Fig. 4). Specifically,

$$x_{AH_1} = \frac{2(\lambda p_h - \theta p_a) + m}{2(m+t)}, x_{AH_2} = \frac{2\theta(p_h - p_a) + t}{4t}, x_{H_1H_2} = \frac{(\lambda - \theta)p_h}{m - t} + \frac{1}{2}.$$

The demand functions of retailer a and retailer h are: $q_a = 2N\theta x_{AH_1}$ and $q_h = 2N(\frac{\theta}{2} + (1-\theta)x_{H_1H_2} - x_{AH_1})$, respectively. For simplified notation, let the parameter γ be $\gamma \triangleq (1-\theta)(\lambda-\theta)(m+t) + \lambda(t-m)$ $(\gamma \geq 0)$. The equilibrium prices and profits of offline retailer and hybrid retailer are given by

$$p_a{}^* = \frac{\lambda t^2 + m(2\gamma - \lambda t)}{2\theta(4\gamma - \lambda(t-m))}, p_h{}^* = \frac{2t^2 - m^2 - mt}{2(4\gamma - \lambda(t-m))}.$$

$$q_a{}^* = \frac{N\theta(\lambda t^2 + m(2\gamma - t\lambda))}{(m+t)(4\gamma - \lambda(t-m))}, q_h{}^* = \frac{N\gamma(2t^2 - m^2 - mt)}{(t^2 - m^2)(4\gamma - \lambda(t-m))}.$$

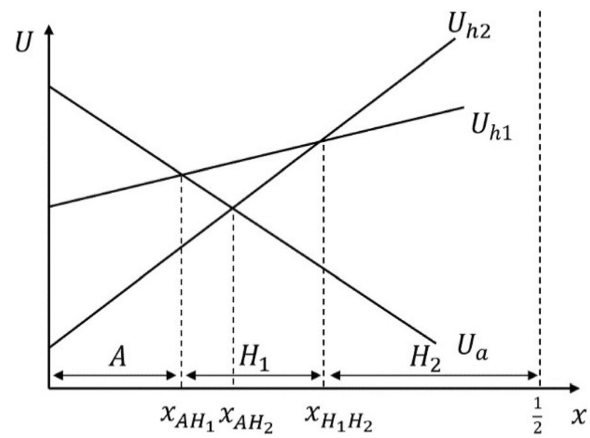

Fig. 4 Consumer utility functions for $A-H_1-H_2$ scenario

$$\pi_a^* = \frac{N\theta(\lambda t^2 + m(2\gamma - t\lambda))^2}{2\theta(m+t)(4\gamma - \lambda(t-m))^2}, \pi_h^* = \frac{N\gamma(2t^2 - m^2 - mt)^2}{2(t^2 - m^2)(4\gamma - \lambda(t-m))^2}.$$

To complete the equilibrium analysis, we need to apply the price validity conditions for each scenario. Intuitively, the scenario $A-H_1-H_2$ occurs when the consumer is far away from the pure offline retailer whose price is lower than that of the hybrid retailer. That is, $x_a > x_h$ (or $\frac{1}{4} < x < \frac{1}{2}$), and $p_a < p_h$. There is a tradeoff between the attractive price and the convenient trip. Under this circumstance, the hybrid retailer will probably satisfy more potential demand due to the integration of both channels. Moreover, if $p_h > p_a + tx_a$, the consumer may prefer to "browse" in the physical store of a hybrid retailer first and then switch to the store of retailer a to decide whether to buy the product. In other words, it is possible for the consumer to choose the purchasing behavior S_2. Thus, we have, $p_a < p_h < p_a + tx_a$.

To ensure the interval of H_1 is not empty, the value of intersection $x_{H_1H_2}$ cannot be less than x_{AH_1}. Hence, there is a minimum threshold price PhH1 for the hybrid retailer, $p_h^{H_1} \triangleq \frac{2\theta(t-m)p_a + t^2 - mt}{2(2\lambda t - \theta(m+t))}$, which means that the consumer's purchasing behavior H_1 coincides with H_2 only if $p_h > p_h^{H_1}$. Conclusively, $p_h \in (\max\{p_a, p_h^{H_1}\}, p_a + tx_a)$.

In scenario $\boldsymbol{A-H_1-S_1}$, three types of consumers—A (offline consumers), H_1 (online-direct consumers) and S_1 (consumers who browse in the offline retailer and then switch to the online store of the hybrid retailer) —exist. This is similar to the situation discussed in the basic model in which there was a switch option.

When a hybrid retailer is considered, it is probable that the scenario arises only when $x_a < x_h$ (or $0 < x < \frac{1}{4}$), and $p_a > p_h$, which means that the consumer is close to the offline retailer a whose price is relatively higher. Furthermore, if the utility function $U_{h2} = \theta(V - p_h) - t(\frac{1}{2} - x)$ of the consumer who examines the product at the physical store of retailer h exceeds $U_{h1} = \theta(V - p_h) - (1-\theta)\delta p_h - m(\frac{1}{2} - x)$ of an online-direct consumer (who orders directly from the Web), he/she would likely visit the physical store of the hybrid retailer first rather than adopt an online-direct shopping strategy. Hence, the value of distance $x > \max[\frac{1}{4}, \frac{1}{2} - \frac{(1-\theta)\delta p_h}{t-m}]$. Then, $0 < x_{AS_1} < x_{H_1S_1}$ is the premise of switch behavior, so we have: $p_h + \frac{mt}{2(t+m(1-\theta))} < p_a < p_h + \frac{m}{2}$. In equilibrium, we can get the range of parameters: $\frac{m}{t} > \frac{1}{2(1-\theta)}$ (Fig. 5).

In scenario ***A***– ***H***$_1$– ***S***$_2$, the purchasing choice S_2 is initially introduced into the competition model, with A and H_1. As is defined in the previous section, S_2 refers to the consumers visiting the physical store of hybrid retailer before ultimately purchasing from a pure offline retailer. Therefore, the respective demand for the offline and hybrid retailer are: $q_a = 2N\theta x_{H_1S_2}$ and $q_h = 2N(\frac{1}{2} - x_{H_1S_2})$, where $x_{AS_2} = \frac{1}{4-2\theta}, x_{H_1S_2} = \frac{2(\lambda p_h - \theta p_a)+m-t}{2(m+(\theta-1)t)}$. According to the principle of maximizing profits, we see the following price reaction functions of the two retailers: $p_a(p_h) = \frac{2\lambda p_h+m-t}{4\theta}$, $p_h(p_a) = \frac{2\theta p_a+\theta t}{4\lambda}$. Correspondingly the equilibrium forms can be found as follows.

$$p_a{}^* = \frac{\theta t + 2m - 2t}{6\theta}, p_h{}^* = \frac{2\theta t + m - t}{6\lambda}.$$

$$q_a{}^* = \frac{N\theta(\theta t + 2m - 2t)}{3(m + (\theta-1)t)}, q_h{}^* = \frac{N(2\theta t + m - t)}{3(m + (\theta-1)t)}.$$

$$\pi_a{}^* = \frac{N(\theta t + 2m - 2t)^2}{18(m + (\theta-1)t)}, \pi_h{}^* = \frac{N(2\theta t + m - t)^2}{18\lambda(m + (\theta-1)t)}.$$

Regardless of where the consumer is located, the scenario A– H_1– S_2 takes place under the condition of $p_h > p_a + tx_a$, which indicates that the price of the hybrid retailer is much higher than that of the offline retailer. Since it will require time, assets and resources for the online retailer to build an offline physical store, it is difficult for the hybrid retailer to gain advantages in pricing. Thus, if the consumer's real purchase cost at the offline retailer is lower than that of the hybrid retailer, he/she will benefit from adopting "switch" behavior S_2. In addition, the utility that consumer type S_2 occupies is positive only if $x_{H_1S_2} > x_{AS_2}$. We define $p_h{}^{S_2} \triangleq \frac{\theta}{\lambda}p_a + \frac{t+mt+\theta m-2m}{(4-2\theta)\lambda}$ as the minimum p_h

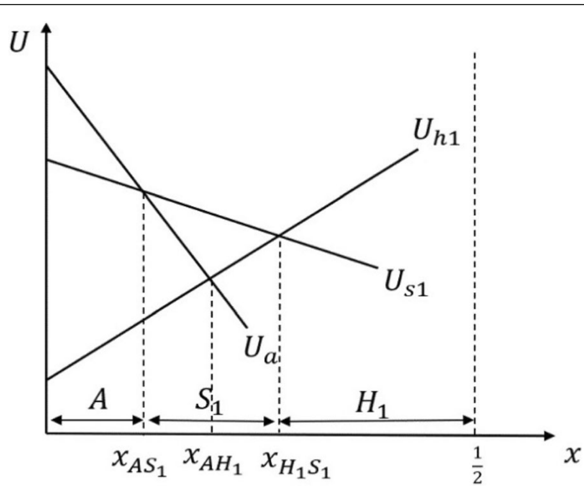

Fig. 5 Consumer utility functions for A– H_1– S_1 scenario

which ensures that the purchasing behavior S_2 exists with H_1. For the price p_h below this value, no consumer would switch to the offline retailer after browsing in the hybrid retailer. In equilibrium, the range of parameters is derived from the above conditions: $3m-4\frac{m}{t}+2\theta\frac{m}{t}<\theta(1-\theta)+1$ (Fig. 6).

Proposition 4: *If equilibrium occurs in the interior of the* $\boldsymbol{A-H_1-S_2}$, *the effects of changes in parameter values are as follows.*

a. *At higher values of the offline purchase cost t, the offline retailer sets a lower price and it realizes higher profit if and only if* $\theta<2-\sqrt{2+\frac{2m}{t}}$.
b. *At higher values of the offline purchase cost t, the hybrid retailer sets a higher price if and only if* $\theta>\frac{1}{2}$ *and it realizes higher profit.*
c. *At higher values of the online purchase cost m, both the hybrid retailer and the offline retailer set a higher price and gain lower profit.*

In the scenario $\boldsymbol{A-H_1}$, the prices of the offline and hybrid retailer are positively related to t and m. However, with higher t the offline retailer will set a lower price to attract consumers who are inclined to browse in the physical store of the hybrid retailer and then purchase from the offline retailer in the scenario $\boldsymbol{A-H_1-S_2}$. Only when θ is lower than a certain value, which means consumers are more likely to visit the offline retailer, the profit of the offline retailer can be higher with higher t. If the offline purchase cost is high, purchasing online can be more attractive especially when consumers are more certain about the product's fit (θ is high). Thus, the hybrid retailer can set a higher price and derive higher profit with higher t.

In scenario $\boldsymbol{A-H_2-S_1}$, the shopping strategy H_2 (consumers who prefer to purchase from the physical store of hybrid retailer) occurs together with A and S_1. According to the consumer utility functions, the value of three intersections is given by

$$x_{AS_1}=\frac{p_h-p_a}{m}+\frac{1}{2},x_{AH_2}=\frac{2\theta(p_h-p_a)+t}{4t},x_{H_2S_1}=\frac{t-\theta m}{2(2t-\theta m)}.$$

Thus, $q_a=2N\theta x_{AS_1}$ and $q_h=2N(\frac{\theta}{2}+(1-\theta)x_{H_2S_1}-x_{AS_1})$ refer to demands of the offline retailer and the hybrid retailer respectively. As with the scenario $A-H_1-S_1$, $A-H_2-S_1$

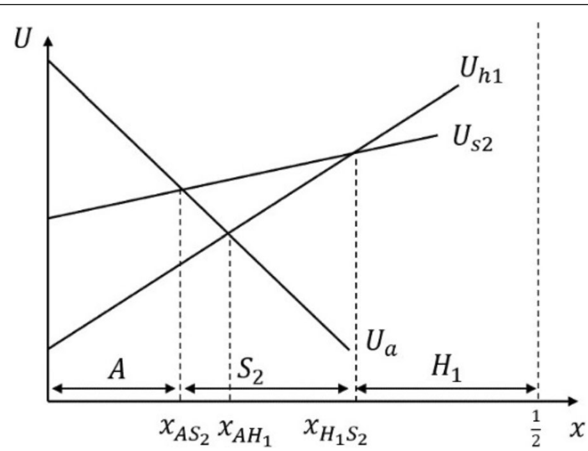

Fig. 6 Consumer utility functions for $A-H_1-S_2$ scenario

arises only when the consumer is close to the pure offline retailer whose price is relatively higher. That is, $x_a < x_h$ (or $0 < x < \frac{1}{4}$), and $p_a > p_h$. However, when p_a is too high, consumers no longer choose to visit the physical store of the offline retailer, so the upper limit of p_a is $(p_h + \frac{m}{2})$ in this scenario. In equilibrium, the range of parameters is derived from the above condition: $\frac{m}{t} < \frac{1}{2} + \frac{3}{2\theta}$. Opposite to the scenario $A–\ H_2–\ S_1$, if $(1–\theta)\delta p_h + m(\frac{1}{2}–x) > t(\frac{1}{2}–x)$, consumers prefer to purchase online directly instead of visiting the physical store of the hybrid retailer first, so the value of distance $x \in (\frac{1}{2} - \frac{(1-\theta)\delta p_h}{t-m}, \frac{1}{4})$ (Fig. 7).

Proposition 5: In scenario $A–H_2–S_1$ the offline retailer sets a higher price and derives higher profit and the solution of equilibrium prices, demands and profits for the offline retailer a and the hybrid retailer h are:

$$p_a{}^* = \frac{m(3t + t\theta–2\theta m)}{6(2t–\theta m)}, p_h{}^* = \frac{m\theta(2t–m)}{6(2t–\theta m)}.$$

$$q_a{}^* = \frac{N\theta(3t + t\theta–2\theta m)}{3(2t–\theta m)}, q_h{}^* = \frac{N\theta(2t–m)}{3(2t–\theta m)}.$$

$$\pi_a{}^* = \frac{Nm\theta(3t + t\theta–2\theta m)^2}{18(2t–\theta m)^2}, \pi_h{}^* = \frac{Nm\theta^2(2t–m)^2}{18(2t–\theta m)^2}.$$

At equilibrium, for offline retailers, the higher price and profit imply the strong position and absolute advantage over their competitors. In this scenario, no one purchases directly online and every consumer will go to a store to examine the product. Thus, consumers' relevant costs for selecting the offline retailer do not include the store visit cost and the offline retailer can charge a higher price and obtain greater profit while the online retailer does not charge as much to attract "switch" consumers. The high price and high demand of offline retailers may also indicate that for the commodity that requires more experience, the target consumer's price sensitivity is lower.

Table 2 shows all the equilibrium prices, demands and profits in each scenario.

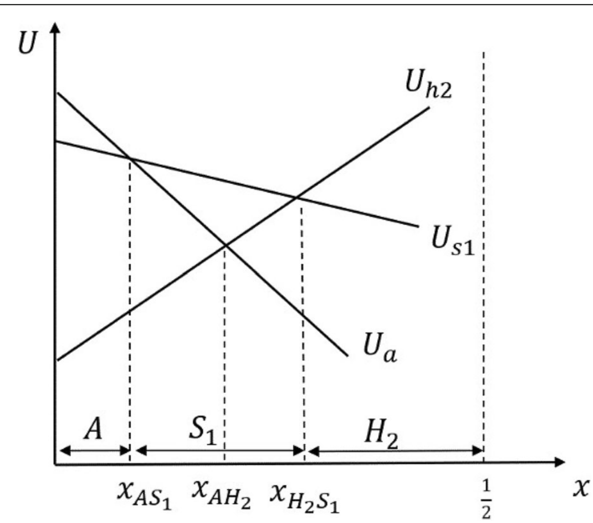

Fig. 7 Consumer utility functions for $A–\ H_2–\ S_1$ scenario

Proposition 6: *The hybrid retailer does not inevitably derive more profit in all possible scenarios. For either the offline retailer or the hybrid retailer, lower price cannot guarantee a larger market share or higher profit.*

Table 2 shows that in scenarios $A\text{–}\ H_1$, $A\text{–}\ H_1\text{–}\ H_2$ and $A\text{–}\ H_2\text{–}\ S_1$ the hybrid retailer gains higher profits with larger market share, while in scenario $A\text{–}\ H_2\text{–}\ S_1$ the offline retailer is the winner even with a higher price. The relative market share and profit of the offline retailer compared to its competitor depend on parameter θ in scenario $A\text{–}\ H_1\text{–}\ S_1$. We think that the hybrid retailer can benefit from network effect and serve a larger market so that a "winner-take-all" outcome may be induced. However, our results indicate that the hybrid retailer is not always the winner. Since consumers choose their shopping strategies according to their different purchase costs concerning location under a certain circumstance, there are still opportunities for offline retailer especially when the product needs to be experienced in person. The outcome highlights the importance of increasing consumers' willingness to pay at the store. We also find that decreasing the price cannot be implemented as an effective strategy to deal with competition, for either the pure offline retailer or the hybrid retailer. In nearly all scenarios, the retailer with the lower price does not have a larger market share or profit. As Gensler et al. (2017) assert, the browse-and-switch phenomenon is about more than merely price; this result may implicate that other shopping strategies of today's consumers also regard more than solely price and that price itself is no longer a key factor to victory.

Conclusions and implications

The emergence of online retailing has given consumers more diversified choices through the new transaction model. This has made it possible for heterogeneous consumers to adopt different purchasing strategies, which also exerts an influence on competitive environment of the retail industry. In this paper, consumer heterogeneity is reflected in the different purchase costs and the likelihood of the product satisfying

Table 2 Equilibrium prices, demands, and profits in each scenario

Scenario	Retailer	Equilibrium price	Equilibrium demand	Equilibrium profit
$A\text{–}\ H_1$	*a*	$\frac{t+2m}{6\theta}$	$\frac{N\theta(t+2m)}{3(m+t)}$	$\frac{N(t+2m)^2}{18(m+t)}$
	h	$\frac{2t+m}{6\lambda}$	$\frac{N(2t+m)}{3(m+t)}$	$\frac{N(2t+m)^2}{18\lambda(m+t)}$
$A\text{–}\ H_2$	*a*	$\frac{t}{2\theta}$	$\frac{N\theta}{2}$	$\frac{Nt}{4}$
	h	$\frac{t}{2\theta}$	$\frac{N\theta}{2}$	$\frac{Nt}{4}$
$A\text{–}\ H_1\text{–}\ H_2$	*a*	$\frac{\lambda t^2+m(2\gamma-\lambda t)}{2\theta(4\gamma-\lambda(t-m))}$	$\frac{N\theta(\lambda t^2+m(2\gamma-t\lambda))}{(m+t)(4\gamma-\lambda(t-m))}$	$\frac{N(\lambda t^2+m(2\gamma-t\lambda))^2}{2(m+t)(4\gamma-\lambda(t-m))^2}$
	h	$\frac{2t^2-m^2-mt}{2(4\gamma-\lambda(t-m))}$	$\frac{N\gamma(2t^2-m^2-mt)}{(t^2-m^2)(4\gamma-\lambda(t-m))}$	$\frac{N\gamma(2t^2-m^2-mt)^2}{2(t^2-m^2)(4\gamma-\lambda(t-m))^2}$
$A\text{–}\ H_1\text{–}\ S_1$	*a*	$\frac{m}{3}$	$\frac{2N\theta}{3}$	$\frac{2Nm\theta}{9}$
	h	$\frac{m}{6}$	$\frac{N}{3}$	$\frac{Nm}{18}$
$A\text{–}\ H_1\text{–}\ S_2$	*a*	$\frac{\theta t+2m-2t}{6\theta}$	$\frac{N\theta(\theta t+2m-2t)}{3(m+(\theta-1)t)}$	$\frac{N(\theta t+2m-2t)^2}{18(m+(\theta-1)t)}$
	h	$\frac{2\theta t+m-t}{6\lambda}$	$\frac{N(2\theta t+m-t)}{3(m+(\theta-1)t)}$	$\frac{N(2\theta t+m-t)^2}{18\lambda(m+(\theta-1)t)}$
$A\text{–}\ H_2\text{–}\ S_1$	*a*	$\frac{m(3t+t\theta-2\theta m)}{6(2t-\theta m)}$	$\frac{N\theta(3t+t\theta-2\theta m)}{3(2t-\theta m)}$	$\frac{Nm\theta(3t+t\theta-2\theta m)^2}{18(2t-\theta m)^2}$
	h	$\frac{m\theta(2t-m)}{6(2t-\theta m)}$	$\frac{N\theta(2t-m)}{3(2t-\theta m)}$	$\frac{Nm\theta^2(2t-m)^2}{18(2t-\theta m)^2}$

consumer needs. These two factors in addition to the price will influence consumer behaviors to different extents and in turn, different consumer behaviors will change the competition scenario and the price and profit of retailers. We propose a spatial competition model with consumer heterogeneity to study online vs. offline competition. In this process, we focus on two factors: One is the consumer's browse-and-switch behavior which is an important and prevalent purchasing behavior when online retailer enter the market, and the other is the influence of a hybrid retailer since channel integration is a significant issue for the offline retailer.

We consider consumers' switch options when we analyze the competition between the offline and online retailers in the basic model. Traditionally we hold the view that the offline retailer prefers to "eliminate" browse-and-switch behavior by reducing its price so that consumers who visit the store are more likely to purchase the item at the store rather than subsequently ordering it online. However, our results show that when there is a switch option, reducing prices is not the only strategy for offline retailers. They can maintain a high price while the opportunity lies in how to increase consumers' willingness to purchase in store. The result supports the findings of Sit et al. (2018) who assert that browse-and-switch behavior can be understood from a positive standpoint and be harnessed as a positive consumer behavior for offline retailers. Consumers choose to visit a store because they are not sure whether the product will meet their needs. When they experience the product, the offline retailers' task is to keep them in the store by utilizing their decision activities, especially for people who intend to adopt browse-and-switch behavior. This result may be more significant for department stores or shopping malls when competing with online retailers because this strategy is more suitable for the product with high value uncertainty. Otherwise, if consumers already possess complete information about the product, or the likelihood for them to purchase the product is very high from the very beginning, they may purchase online directly. We also find that browse-and-switch behavior intensifies the competition because it decreases both retailers' price and profit compared to a non-switch situation.

Our extended model further analyzes the impact of a hybrid retailer. We focus on the competition between an offline retailer and a hybrid retailer. Our comprehensive analysis encompasses five consumer behaviors and six different competition scenarios. The results indicate the fact that because of its convenience, service or other advantages, the hybrid retailer with higher prices can derive a larger market share and profit in some scenarios. However, gaining more profit is not inevitable in all circumstances. Operating both online and offline cannot guarantee high profit, so hybrid retailers may adopt new business models to seek alternate revenue streams such as advertising revenue, in addition to revenue from direct sale of products and services. For offline retailers, when competing with hybrid retailers, reducing prices is not an effective way to be attractive. Instead, improving the shopping experience should play a critical role.

These findings can also be of significance to offline retailers' decisions on channel integration. The type of products and services they provide and whether they have strong offline brands may influence their choices. When selling a product with high value uncertainty such as clothes, the offline retailer can make effort to improve consumers' experience and lessen their price sensitivity in stores, especially with a strong brand. Thus, in this situation, it is not necessary for the offline retailer to launch an online store. When consumers are more likely to have sufficient information about the product and the probability of liking the product is high (e.g., books or CDs or food), they may purchase online directly and do not need to examine the product at the offline store. In this circumstance, operating online should be an option for the offline retailer. Therefore, the offline retailer needs to carefully balance between the benefits of extending operations online and the costs of adopting integrated strategies.

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Authors' contributions
MS carried out the theoretical studies, participated in the model analysis and drafted the manuscript. JZ and ZJ carried out the literature review and helped to draft the manuscript and give conclusions. All authors read and approved the final manuscript.

Ethics approval and consent to participate
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