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Risk profile and consumer shopping behavior in electronic and traditional channels

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Abstract

This paper develops an economic model that captures consumer shopping channel choices based on shopping channel characteristics and consumer risk profiles—risk-neutral or risk-averse. Analyses of results show that after making purchases through one channel, electronic or traditional, risk-averse consumers tend to be more loyal customers than risk-neutral consumers. Further, the two types of consumers may exhibit split channel behavior—risk-neutral consumers prefer one channel and risk-averse consumers prefer the other. However, risk-neutral consumers are not always more likely to prefer electronic channel than risk-averse consumers. Implications for retailer pricing strategies are discussed.

Keywords: Pricing; E-commerce; Retail channel switching; Consumer risk profile; Online shopping behavior

1. Introduction

E-commerce is growing rapidly and has penetrated almost all industries. This trend is amplified by the reduced cost of participation in e-commerce due to the establishment of standards for access and transactions. Given the enormous potential of e-commerce, the number of electronic stores has increased at an unprecedented rate during the last 5 years. Department of Commerce data (http://www.census.gov/mrts/www/mrts.html) shows that e-commerce retailing accounts for 1.2% of total retailing for the second quarter of 2002, 1.0% for second quarter of 2001, and 0.8% for the second quarter of 2000. These represent 25% increase from 2Q 2000 to 2Q 2001, and 20% increase from 2Q 2001 to 2Q 2002. Will online shopping keep rising and eventually exceed that of other direct marketing at 8%? Theory seems to support this prediction as online search engines and various intelligent agents can dramatically reduce search costs associated with purchase decisions [1,3,29]. In addition, online stores offer buyers the convenience of placing orders instantaneously from the comfort of their home. However, traditional retail outlets maintain an edge over online storefront in delivering products and services where experience and look-and-feel are very important [14,45]. Ultimately, the share of online shopping

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depends on how it compares with brick-and-mortar store shopping in satisfying consumers' shopping needs. In this paper, we develop an economic model of consumer shopping decision in order to understand different factors affecting a consumer's decision to either shop online or in-store. To be able to compare consumers who shop online with those who shop in a brick-and-mortar store, this model focuses on shopping for products that are available in both channels through different retailers. Our primary objectives are to explore the behavior of different types of consumers in online and traditional retail channels. In addition, we explore the strategies that retailers can pursue to segment consumers and to devise different strategies to attract different segments.

We explore these issues by modeling consumers as either risk-neutral or risk-averse and studying how these two types of consumer trade-off among factors such as price, product range offered, ease of product evaluation, and product acquisition time. An understanding of these trade-offs is important for retailers who want to avoid purely price-based competition. We start with a brief background of related research that provides justification for our segmenting consumers by their risk profiles and our consideration of factors mentioned above in the model. The rest of the paper is organized as follows: Section 2 investigates the literature and articulates how our work fits into the literature. Section 3 introduces the actual economic model. Section 4 develops propositions based on the model that explain consumer channel shopping behavior and discusses implications for retailers. In Section 5, we present numerical results that further explore consumer channel shopping behavior. Implications of our results and contributions of the paper are discussed in Section 6. Section 7 points out the limitations and future research topics.

2. Background

Consumers perceive risk in most store purchase decisions [11]. Consumer risk perception has long been shown to heavily influence a consumer's decision to modify, postpone, or avoid a purchase decision [11,50]. Research has also indicated that risk perceptions can be extended beyond products to the shopping medium itself [12,48]. In the online environment, studies found evidence that perceived risk associated with online shopping, arising from concerns for system security and difficulty in evaluating products online, is an important factor when consumers consider whether to purchase online or in a brick-and-mortar store [7,37]. Several recent industry and government-related studies [13,16–18] have also found consumer risk perceptions to be a primary obstacle to the growth of online shopping.

Risk perception notwithstanding, some consumers embrace online shopping while others shun away from it. Since a person's risk-taking behavior is determined by her perception of risk as well as her acceptance of risk [26,33,40,46], it follows that a consumer's risk profile (risk-neutral or risk-averse) would affect her shopping behavior online: Risk neutral consumers are more likely than risk-averse consumers to consummate a purchase transaction when faced with buying a product (or service) with uncertain outcomes or possible loss [26,50].

Search costs, evaluation costs, and price are factors consumers weigh when making a purchase decision according to marketing literature [15,27]. Based on that literature, a purchase process includes five stages: problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase support. The purchase process starts when a consumer recognizes a problem or need. Information search for desired products or services ensues, which incurs search costs. When a relevant product or service is identified, the consumer examines its product attributes and compares it to other products or services identified to determine whether the product suits her needs. Finally, a purchase decision is made. In a traditional shopping environment, most products are acquired immediately following the purchase. Where a later delivery is required or other post-purchase support is needed, consumers also evaluate the timeliness and quality of those services. In the consumer purchase process articulated above, the two shopping channels, online and in-store, differ dramatically in the levels of efforts consumers have to exert and the levels of uncertainty in each step: Online search engines and intelligent agents dramatically reduce search costs [1,3,29]; Online shopping lacks "look-and-feel" [14,45] for many physical products and hence evaluation of those products can be difficult [7]; Further, in an online environment, the acquisition of a purchased physical product is not immediate–products have to be delivered from the online retailer to the consumer, untimeliness of which can be a source of customer dissatisfaction [25]. On the other hand, evaluation and acquisition of digital products (such as software trial versions and music clips) can be easier in an online environment. Since consumers who buy online tend to be those who are time-starved [6] and online shopping tends to be goal-oriented or utilitarian, i.e., "task-oriented, efficient, rational, and deliberate" [52], search costs, evaluate costs, and delivery time will be important factors that consumers evaluate when considering buying online or in-store.

An understanding of how consumers trade off those factors mentioned above is important when a retailer is faced with devising a pricing strategy, determining product offerings, or designing online storefront, among others. An online retailer can choose to increase the range of product options offered for a particular product (such as different styles and colors of shoes), which may deter a consumer from searching for alternatives and later buying from elsewhere. This strategy may eventually reduce consumer price sensitivity by distracting consumers from focusing their purchase decisions on price alone. For example, Amazon.com does not have the lowest price [47], but consumers still regularly buy from it, which may due in part to its exhaustive list of carried titles of any particular subject, although its brand and service are also important. Although recent empirical studies have shown that the range of product offerings can create customer lock-in in the online brokerage industry [9], the issue has not been studied analytically.

An online retailer, as another strategy, can focus on enabling easy product quality evaluation by providing gigabytes of product demonstration data or virtual reality software. Note that for certain digital products, touch-and-feel in an online environment can even be better with the help of various virtual reality tools. This approach may attract those consumers who value and are willing to pay premium for services [20,32] and hence reduce price sensitivity for the segment of consumers the retailer intends to attract and keep.

Delivery of most categories of products purchased online has served as a deterrent for online shopping [45]. However, online channel can compete with traditional retailers along this dimension for many product categories and has an advantage for digital products such as news and information. Therefore, considering this dimension is extremely important for retailers who often need to take into account the relative strength or weakness of either channel in product delivery.

In sum, past and present research points at the importance of understanding consumer behavior with respect to shopping channel choices. Trade-offs between price, search costs, evaluation costs, and delivery time seem to be important factors highlighting consumer channel shopping behavior. Literature also supports the notion that considerations of these factors are influenced by consumer risk profile. In the next section, we introduce our economic model that takes into account these factors and consumer risk profile.

3. Model development

We assume that each product is offered in two retail channels: the traditional or physical channel, denoted by T, and the electronic channel through the Internet, denoted by E. Buyers make their decisions to purchase based on maximizing the net utility derived from buying a product. The net utility is the utility from consuming a product less the costs of efforts of product search and evaluation, dollar equivalent of delivery time, and the price paid to obtain the product. We assume that all consumers derive the same utility, denoted by V, from consuming one unit of the product, whether it is purchased from channel E or channel T. We only focus on the economic factors affecting a consumer's decision to purchase a product and do not take noneconomic factors, such as personal interest, satisfaction, habits, culture, social class, motivation, attitude and beliefs, into consideration. This is appropriate in the scope of this paper because, as mentioned before, online shoppers tend to be time-starved and use the Internet for shopping activities that are goal-oriented.

Conforming to search literature, the search cost, denoted as S, is modeled as a function of the number of products searched, a [3]. A consumer chooses how many products to search. We model the evaluation cost C as a function of quality certainty level, q. When comparing product attributes, quality is relatively hard to evaluate, especially for online shopping. Literature suggests that consumers may be apprehensive about buying something without touching or feeling it because of quality certainty issues [7,14]. Therefore, in our model, evaluation costs are modeled as a function of quality certainty level. Goods with a *higher* quality certainly level (due to reputation, for example) incur *lower* evaluation costs. When a product is associated with a known brand name or when a product is evaluated in-store where consumers can look-and-feel, consumers are more certain about whether or not a product will suite their needs [32,47]. In our model, we treat q as a decision variable, which allows us to investigate the implicit consumer trade-off; essentially, while quality is a product characteristic, quality certainty level is a perception-based issue. For example, a person might decide that quality level of a given product can be decided based on stores that carry it and hence limits its search to only the "universe" of a certain quality level (e.g., I will only search at Borders and Amazon). On the other hand, a consumer may decide to conduct a general search and decide on the product by looking at how many sites carry the same product. How a customer decides regarding the quality is what quality certainty level is about and hence it is modeled as a decision variable here. Collectively, we refer to search and evaluation costs as buyer effort, denoted by B. The framework of our consumer purchase decision model is presented in Fig. 1.

Based on the framework described above, we construct the consumer utility function with four parts, assuming additive separability:

$$U_{\text{total}}(a,q,w,p) = V + U_{\text{effort}}(S(a)+C(q)) + U_{\text{waiting}}(w) + U_{\text{price}}(p) \qquad (1)$$

where V is the utility derived from consuming one unit of a product, and U_{effort}, U_{waiting}, and U_{price} are utility loss from buyer effort, delivery time, and price, respectively. We have assumed separability of each of the components contributing to the total utility for the purpose of analytical tractability, as is common in the economics and marketing literature (e.g., Refs. [21,39]). As we mentioned previously, a consumer chooses the number of products to search and the quality certainty level to obtain by choosing a combination of a and q that maximizes her total utility.

We assume that consumers are heterogeneous in their risk preferences. We consider two types of consumers: risk-neutral, denoted by N, and risk-averse, denoted by A. Risk profiles of consumers reflect their attitude towards uncertainty and information asymmetry between channels, which in turn influence their shopping behavior [50]. Risk-averse buyers are more sensitive to uncertainty and are willing to pay premiums to reduce it. Consequently, they are more likely to

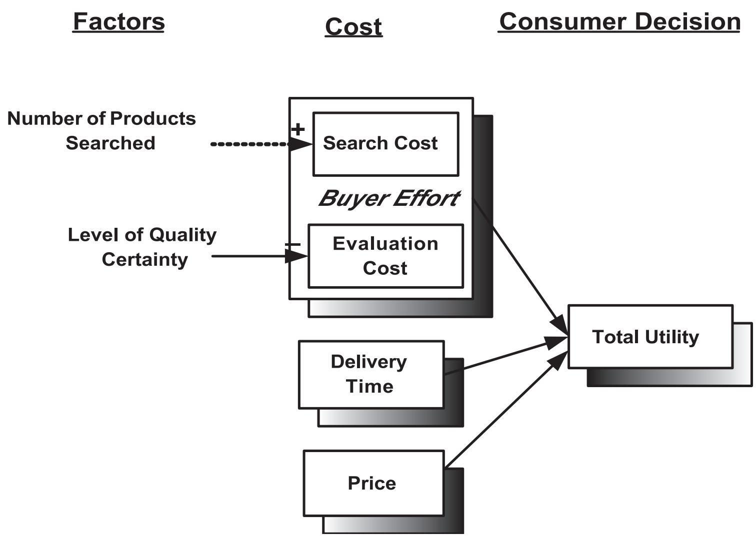

Fig. 1. A basic framework for consumer purchase decision.

be brand conscious. Ceteris paribus, risk-averse consumers are likely to evaluate more products in order to reduce the level of uncertainty associated with any one product. Consequently, in our model we assume that these two types of consumers realize differ amounts of disutility from the same level of effort, delivery time, or expenditure. This is dealt with in Section 3.1 where we choose different shapes of disutility functions for these two types of consumers.

The two shopping channels, E (online) and T (in-store), incur different search costs associated with searching for the same number of products. This is because online shopping allows consumers to search different products from one computer screen. The two shopping channels also incur different evaluation costs for a product with the same level of quality certainty because in-store shopping affords the consumers the advantage of look-and-feel. These differences are dealt with in Section 3.2 where we choose different disutility functions for the two channels. In sum, taking into account difference in risk profile and channels, Eq. (1) can be rewritten as Eq. (2):

$$U^{i,j}_{\text{total}}(a,q,w,p) = V + U^{i,j}_{\text{effort}}(S^i(a) + C^i(q)) + U^{i,j}_{\text{waiting}}(w) + U^{i,j}_{\text{price}}(p), \quad \forall\ i,j \tag{2}$$

where $j = \text{A}$ (risk-averse) or N (risk-neutral) indicates the type of consumers, and $i = \text{E}$ (electronic) or T (traditional) indicates the channel.

Next, we present the specific shapes of all utility components for the two types of consumers and the two shopping channels.

3.1. Different shapes of disutility functions for the two types of consumers

In this paper, we effectively assumed that all consumers perceive the same level of risk when faced with the same uncertain scenario. However, their behaviors can be different due to their different risk tolerance. We use a negative exponential function to model the perceived disutility by risk-averse consumers from efforts, delivery time, and price. This function has been widely used to model risk-aversion [4,8,10,34,44]. Consistent with the literature, we use a linear function to model the perceived disutility by risk-neutral consumers. The actual functions are represented as follows:

$$\begin{cases} U^{i,\text{A}}_k(x^i) = -V(e^{d_k x^i} - 1), x^i < \dfrac{\ln 2}{d_k} \\ U^{i,N}_k(x^i) = -\dfrac{V}{\bar{k}} x^i, x^i < \bar{k} \end{cases},$$

$$i = \text{E or T}, \ k = \text{effort, waiting, or price} \tag{3}$$

where x^i represents the level of effort, the length of wait, and the price, respectively, in each of the three associated disutility functions. Since $V - V(e^{d_k x^i} - 1) > 0$ implies $(\ln 2/d_k) > x^i$, when $x^i > (\ln 2/d_k)$, the price, length of waiting, or level of effort exceeds the maximum that a risk-averse consumer would tolerate. Consequently, the consumer will choose not to participate in the market, similarly for risk-neutral consumers when $x^i > \bar{k}$. This reflects the fact that consumers would stay out of the market if any *single* cost exceeds its upper bound even if there are no other costs. For example, the upper bound for effort, $\ln 2/d_1$, is interpreted as the maximum effort a risk-averse customer would be willing to make if the product is free and there is no delivery time delay.

d_{effort}, d_{waiting}, $d_{\text{price}} > 0$ are the risk parameters, measuring the level of risk-aversion towards buyer effort, delivery time and price, respectively. Higher d's indicate higher risk-aversion. In the exponential utility functions, the risk-aversion measure is constant [22], representing the constant risk-aversion towards costs. Increasing risk-aversion is not used because its response function has been shown to be quite similar to that obtained using constant risk-aversion [38]. However, the former function is more computationally complex.

3.2. Shapes of disutility functions for the two channels

Shopping online allows consumers to search product information from different vendors from one computer screen, therefore search costs, when shopping online, will increase more slowly with the number of products searched than shopping in-store. Hence, we assume that $(\partial S^i/\partial \alpha) > 0$, $i = \text{E}$ or T, but $(\partial^2 S^{\text{T}}/\partial \alpha^2) > 0$ and $(\partial^2 S^{\text{E}}/\partial \alpha^2) > 0$, i.e, in traditional channel, the marginal search cost increases with the number of products, and in electronic channel, it is constant. Both increasing and constant marginal search costs in the number of products searched are a common assumption in economics literature [3,38]. The actual functions chosen are quadratic for channel T and linear for channel E, as represented in Eq. (4). We choose these functions because they satisfy the criteria $(\partial S/\partial \alpha)>0$ and $(\partial^2 S/\partial \alpha^2)>0$, and they are relatively simple and easy to analyze.

Other functional forms could have been chosen and should not have affected analysis results. Note that k_2^{T} denotes the minimum effort required even when search does not take place. This cost can be interpreted, for example, as the cost incurred in locating the product on the shelf. Similarly, k_2^{E} denotes the minimum effort required for online shopping.

$$\begin{cases} S^{\mathrm{T}}(a) = k_0^{\mathrm{T}} a^2 + k_1^{\mathrm{T}} a + k_2^{\mathrm{T}}, k_0^{\mathrm{T}}, k_1^{\mathrm{T}}, k_2^{\mathrm{T}} > 0 \\ S^{\mathrm{E}}(a) = k_1^{\mathrm{E}} a + k_2^{\mathrm{E}}, k_1^{\mathrm{E}}, k_2^{\mathrm{E}} > 0 \end{cases} \tag{4}$$

In terms of evaluation costs, we assume decreasing evaluation costs when quality increases, i.e., $(\partial C^i/\partial q)<0$. In addition, we assume that marginal evaluation costs are decreasing in quality certainty level as well, i.e., $(\partial^2 C^i/\partial q^2)<0$, for both channels. The hyperbolic functions are chosen to represent evaluation costs for both the traditional and electronic channels with different function parameters for different channels, as represented in Eq. (5). Similar to Eq. (4), this functional form is chosen because it satisfies $(\partial C^i/\partial q)<0$ and $(\partial^2 C^i/\partial q^2)<0$, and it is relatively simple and easy to analyze. Other functional form could have been chosen and should not have changed analysis results.

$$C^i(q) = K_3^i + \frac{k_4^i}{q}, \text{ where } i = \mathrm{E} \text{ or } \mathrm{T}, \ k_3^i \geq 0, k_4^i > 0; \tag{5}$$

In sum, the two channels differ in buyer efforts for both the search costs and evaluation costs. The buyer effort functions can be represented as follows with first equation representing the buyer effort in traditional channel and the second equation representing the effort in electronic channel:

$$\begin{cases} B^{\mathrm{T}}(a,q) = S^{\mathrm{T}}(a) + C^{\mathrm{T}}(q) = k_0^{\mathrm{T}} a^2 + k_1^{\mathrm{T}} a + k_2^{\mathrm{T}} + k_3^{\mathrm{T}} + \dfrac{k_4^{\mathrm{T}}}{q} \\ B^{\mathrm{E}}(a,q) = S^{\mathrm{E}}(a) + C^{\mathrm{E}}(q) = k_1^{\mathrm{E}} a + k_2^{\mathrm{E}} + k_3^{\mathrm{E}} + \dfrac{k_4^{\mathrm{E}}}{q} \end{cases} \tag{6}$$

Based on Eqs. (2), (3), and (6), using d_1, d_2, d_3 to represent d_{effort}, d_{waiting}, d_{pricing}, respectively, and using $\bar{B}$, $\bar{w}$, and $\bar{p}$ to represent the upper bounds of effort, waiting time, and price, respectively, the consumer utility functions characterizing the purchasing decision for each type of consumers in each shopping channel are represented as follows:

$$\begin{cases} U_{\text{total}}^{\mathrm{E,N}}(a,q,w^{\mathrm{E}},p^{\mathrm{E}}) = V - \dfrac{V}{\bar{B}}\left(k_1^{\mathrm{E}} a + k_2^{\mathrm{E}} + k_3^{\mathrm{E}} + \dfrac{k_4^{\mathrm{E}}}{q}\right) - \dfrac{V}{\bar{w}} w^{\mathrm{E}} - \dfrac{V}{\bar{p}} p^{\mathrm{E}} \\ U_{\text{total}}^{\mathrm{E,A}}(a,q,w^{\mathrm{E}},p^{\mathrm{E}}) = V - V[\mathrm{e}^{d_1\left(k_1^{\mathrm{E}} a + k_2^{\mathrm{E}} + k_3^{\mathrm{E}} + \frac{k_4^{\mathrm{E}}}{q}\right)} - 1] - V(\mathrm{e}^{d_2 w^{\mathrm{E}}} - 1) - V(\mathrm{e}^{d_3 p^{\mathrm{E}}} - 1) \\ U_{\text{total}}^{\mathrm{T,N}}(a,q,w^{\mathrm{T}},p^{\mathrm{T}}) = V - \dfrac{V}{\bar{B}}\left(k_0^{\mathrm{T}} a^2 + k_1^{\mathrm{T}} a + k_2^{\mathrm{T}} + k_3^{\mathrm{T}} + \dfrac{k_4^{\mathrm{T}}}{q}\right) - \dfrac{V}{\bar{w}} w^{\mathrm{T}} - \dfrac{V}{\bar{p}} p^{\mathrm{T}} \\ U_{\text{total}}^{\mathrm{T,A}}(a,q,w^{\mathrm{T}},p^{\mathrm{T}}) = V - V[\mathrm{e}^{d_1\left(k_0^{\mathrm{T}} a^2 + k_1^{\mathrm{T}} a + k_2^{\mathrm{T}} + k_3^{\mathrm{T}} + \frac{k_4^{\mathrm{T}}}{q}\right)} - 1] - V(\mathrm{e}^{d_2 w^{\mathrm{T}}} - 1) - V(\mathrm{e}^{d_3 p^{\mathrm{T}}} - 1) \end{cases} \tag{7}$$

In this model, we incorporated V in the construction of each disutility function. This simple linear transformation allows us to easily calculate the bounds on the level of effort, price and wait time beyond which the total utility would be less than zero (holding other disutility to zero). Since in this model we only deal with consumer's decision concerning any one given product and do not deal with situations where consumers have to compare across products, this linear transformation allows us to study variable ranges without compromising the correctness of the model.

Simple algebra will show that these functions are quasi-concave (see Appendix B for proof) and hence satisfy all necessary properties of a utility function.

4. Model analysis

In this section, we derive propositions to characterize a utility-maximizing consumer's trade-off among different model parameters.

Proposition 1. *For both risk-neutral and risk-averse shoppers,* $(\partial a/\partial p^E)>0$, $(\partial a/\partial w^E)>0$, $(\partial a/\partial p^T)>0$, *and* $(\partial a/\partial w^T)>0$, *iff* $a^*>((k_1^E k_4^T - k_4^E k_1^T)/2k_4^E k_0^T)$.

Proof. See Appendix B. □

Condition $a^*>((k_1^E k_4^T - k_4^E k_1^T)/2k_4^E k_0^T)$ implies that for differentiated products, consumers will search more product options as price or delivery time goes up. This implies that, in order to charge a higher price, a vendor should reduce consumer search costs by carrying a larger variety of a product thereby reducing products searched across different sites, *a*, and consequently reducing consumer search costs because a consumer can evaluate his consideration set at a single source instead of searching for alternatives elsewhere. Note that a large variety of products here does not mean different, unrelated products such as bicycles, basketballs, and brooms, for example. It means varieties of a particular product such as different colors of materials and styles of shoes. To put it in another way, this proposition indicates that, due to ease of comparison-shopping online, consumers are likely to exhibit variety-seeking behavior for both low- and high-ticket products. This behavior deviates from that found in traditional channel where consumers show variety seeking behavior only for low-ticket products such as cereal and canned foods [5,19]. The practice of carrying large collection of varied products are found in reality in the prime example of Ashford.com—a leader in online luxury goods retailing—which charges more than its traditional counterparts, but carries altogether more than 15,000 styles of products from over 400 leading luxury brands [2].

Proposition 2. *Let* $w^d = w^T - w^E$, $p^d = p^T - p^E$, *and* $S^d = S^T - S^E$. *For both risk-neutral and risk-averse shoppers, if* $(\partial S^d/\partial a)>0$, *then* $(\partial a/\partial p^d)<0$ *and* $(\partial a/\partial w^d)<0$.

Proof. See Appendix B. □

It is generally true that, as a consumer searches more and more products, the search costs increase faster in traditional channel than in electronic channel (i.e., $(\partial S^d/\partial a)>0$). Therefore, Proposition 2 implies that if the difference in prices between the traditional channel and the electronic channels is higher, consumers tend to search less, similarly for the difference in waiting times between the two channels. Proposition 2 also implies that retailers can keep price or delivery time lower in electronic channel (i.e., increasing differences in price or deliver time between traditional and electronic channels) so as to discourage consumers from searching more. In the end, for products with

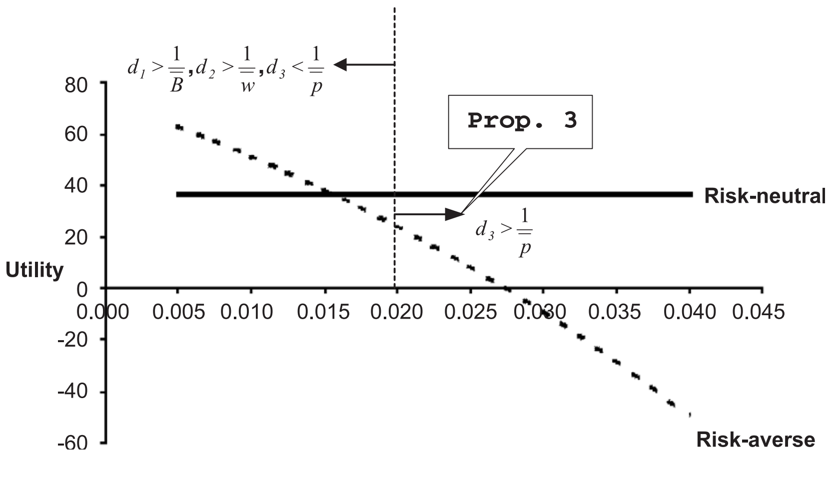

Fig. 2. Graphical illustration of Proposition 3 on the electronic channel.

fewer alternatives, price competition becomes the dominant form of competition for customers.

Proposition 3. *If $d_1>(1/\bar{B})$, $d_2>(1/\bar{w})$ and $d_3>(1/\bar{p})$, then the risk-neutral consumers derive more utility than risk-averse consumers from either the electronic or the traditional channel.*

Proof. See Appendix B. □

Fig. 2 illustrates Proposition 3 graphically for the electronic channel. The dotted line separates the region where the proposition holds ($d_1>(1/\bar{B})$, $d_2>(1/\bar{w})$ and $d_3>(1/\bar{p})$) from where it does not hold ($d_1>(1/\bar{B})$, $d_2>(1/\bar{w})$ but $d_3<(1/\bar{p})$). These parameter values are used in Fig. 2: $\bar{B}=30$, $\bar{w}=15$, $\bar{p}=50$, $d_1=0.035$ ($>1/\bar{B}$), $d_2=0.07$ ($>1/\bar{w}$), $B^E=5$, $w^E=1$, $p^E=25$ and $V=100$.

Although Proposition 3 does not indicate how consumers would make a channel choice, it is helpful in improving our understanding of the difference between the two types of consumers. To see this, let us look at a scenario where both types of customers prefer the same shopping channel. Here we assume that $B^T>B^E$, $w^T>w^E$, and $p^T>p^E$. Clearly, both types of consumers will choose electronic channel under these conditions. The issue of interest in Proposition 3 is not that both types of consumers have chosen electronic channel but whether one type of the consumers are more likely than the other type to switch from online shopping to in-store shopping when model parameters change, or equivalently, whether online retailers can build customer loyalty by targeting the customers that are less likely to switch. Consumer loyalty can represent either a consumer's desire to return to a particular Website (vendor loyalty) or his desire to purchase a particular product (product loyalty). Here, we are referring to vendor loyalty.

Let $U^{d,A}=U^{E,A}_{total}$ and $U^{d,N}=U^{E,N}_{total}-U^{T,N}_{total}$. We derive the following related proposition characterizing the two types of consumers:

Proposition 4. *If $d_1>(1/\bar{B})$, $d_2>(1/\bar{w})$, $d_3>(1/\bar{p})$ and $B^T>B^E$, $w^T>w^E$, $p^T>p^E$, both types of consumers prefer electronic channel to traditional channel and risk-averse consumers will have a higher utility difference between electronic channel and traditional channel than risk-neutral consumers, i.e., $U^{d,A}>U^{d,N}$.*

Proof. See Appendix B. □

Fig. 3 illustrates Proposition 4 graphically. The dotted vertical line is $d_3>(1/\bar{p})$, which separates the region where the proposition holds (to the right) from

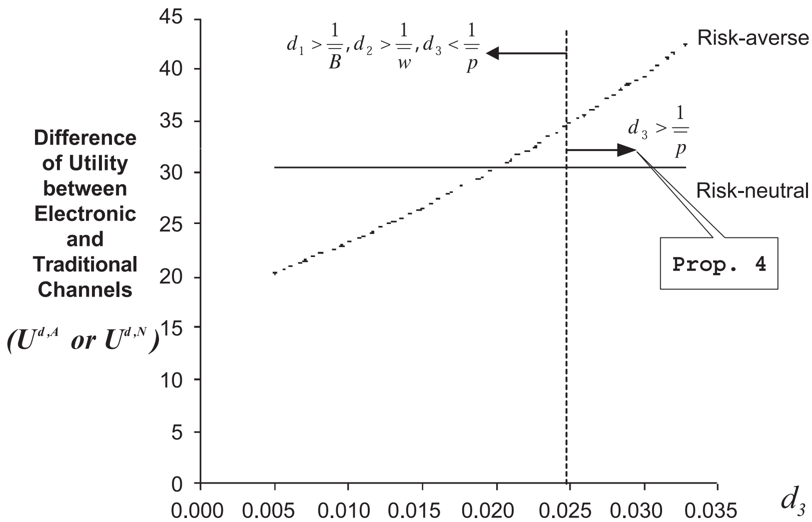

Fig. 3. Graphical illustration of Proposition 4.

where it does not hold (to the left). In both regions, $U^{d,N}$ and $U^{d,A}$ are positive, indicating that both types of buyers prefer the electronic channel. When the condition of the Proposition 4 holds (to the right), risk-averse consumers have a higher utility difference between electronic channel and traditional channel than risk-neutral consumers. These parameter values are used in Fig. 3: $\bar{B}$=30, $\bar{w}$=14, $\bar{p}$=40, d_1=0.035 (>1/$\bar{B}$), d_2=0.072 (>1/$\bar{w}$), B^T (=10)>B^I (=9), w^T (=2)>w^I (=1), p^T (=15)>p^I (=10) and V=100.

Propositions 3 and 4 together show that risk-averse consumers prefer the electronic channel in a stronger term than risk-neutral consumers under model parameter values specified in Proposition 4. Under these conditions, risk-averse consumers are more likely to develop loyalty to online retailers and are more likely to exhibit repeat buying behavior. This result seems to be counter-intuitive at first glance as commonsense seems to tell us that risks associated with online shopping should deter risk-averse consumers. However, a careful examination of risk-averse consumers reveals that they prefer a channel that is more familiar and offers more certainty. As a result, once risk-averse consumers are enticed to a channel, they tend to stay with that channel for longer time than risk neutral consumers because switching channels involves uncertainty.

Since most consumers are risk-averse to some degree, Proposition 4 indicates that consumers are more likely to be repeat shoppers at sites such as Amazon.com than at sites that operate purely based on price competition such as Priceline.com. Proposition 4 provides support for strategies of online retailers that focus on customer accounts maintenance, preference identification, and community building so that existing customers will feel an affinity to the online retailer and will be less likely to be enticed away by other retailers. Corollary 1 investigates consumer behavior under conditions specified by Proposition 4 but when parameter values change.

Corollary 1. *Under conditions specified by Proposition 4, as B^T, w^T or p^T increases, the gap, $U^{d,A} - U^{d,N}$, increases. As B^T, w^T or p^T decreases, the gap decreases.*

Proof. See Appendix B. □

Fig. 4 illustrates the corollary graphically and explores the impact of prices on the gap, $U^{d,A} - U^{d,N}$, which measures relative inclination of risk-averse customers to stay with the electronic channel compared with risk-neutral consumers. Clearly, as p^T increases, the gap increases because $U^{d,A}$ increases faster than $U^{d,N}$ does, which is due to the fact that an

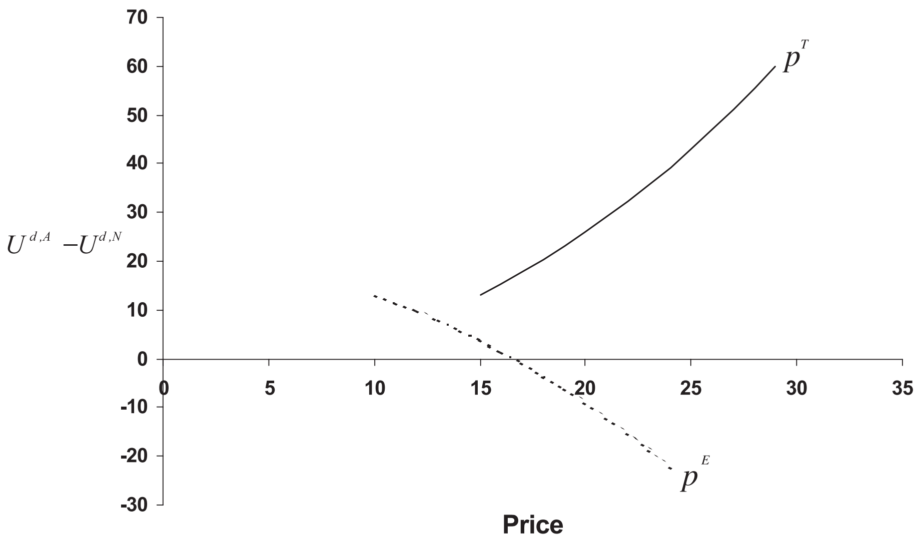

Fig. 4. Graphical illustration of Corollary 1 with respect to price.

increase in p^T draws more risk-aversion behavior from risk-averse consumers than from risk-neutral ones. Similarly, as p^E increases, $U^{d,A}$ decreases faster than $U^{d,N}$ does. Parameter values used are the same as in Fig. 3, plus $d_3 = 0.03$ ($>1/\bar{p}$).

For traditional channels, a similar proposition is derived in Proposition 5 after setting $U^{d,A} = U^{T,A} - U^{E,A}$ and $U^{d,N} = U^{T,N} - U^{E,N}$.

Proposition 5. *If $d_1 > (1/\bar{B})$, $d_2 > (1/\bar{w})$, $d_3 > (1/\bar{p})$ and $B^T < B^E$, $w^T < w^E$, $p^T < p^E$, both types of consumer prefer traditional channel to electronic channel. In addition, risk-averse consumers will have a higher utility difference between traditional and electronic channels than risk-neutral consumers, i.e., $U^{d,A} > U^{d,N}$.*

Proof. See Appendix B. □

Clearly, when $B^T < B^E$, $w^T < w^E$, and $p^T < p^E$, both types of consumers will choose traditional channel. This proposition shows that risk-averse consumers prefer the traditional channel in a stronger term than risk-neutral consumers under model parameter values of Proposition 5. Again, risk-averse consumers tend to be more loyal customers than risk-neutral consumers in the traditional channel as well. Online retailers wishing to entice consumers from traditional channels should target risk-neutral consumers first. This supports our perception that risk-neutral consumers will be the first to try online offerings.

Due to the complexity of the model, we next use some numerical examples to investigate behaviors of the two types of consumers studied here and to point out strategies for retailers.

5. Consumer channel-switching behavior

In the preceding section, we analyzed the scenarios in which both risk-neutral and risk-averse shoppers prefer the same shopping channel. In this section, we use numerical examples to analyze scenarios in which the two types of consumers prefer different shopping channels.

Often, retailers offer products through both electronic and traditional channels. Pricing strategies and other characteristics have to be carefully designed to avoid cannibalization of one channel over another. For consumers, choice of a channel depends largely on economic factors relevant to a consumer's channel choice, i.e., search cost, evaluation cost, delivery time, and price. In fact, most consumers are cross-shoppers and tend to shop in a channel for products suitable for that channel. For example, consumers may buy flowers online but shop at a local jeweler for expensive jewelry. A retailer may influence a consumer's channel choice by changing some or all of the economic factors modeled in this paper. For example, the retailer may consider raising price but at the same time reducing search cost through advertising and/or reducing evaluation cost by providing more product information and demonstration. A case in point is sites such as Amazon.com, which actively provides incentives for their customers to write reviews for the products they purchased before—a move that can be interpreted as trying to influence consumers, channel choice decisions by reducing evaluation costs for customers.

Observation 1. For certain values of $S^T > S^E$, $C^T < C^E$, and $w^T = w^E$, there exist prices $p^E > p^T$, such that risk-averse shoppers will choose traditional channel but risk-neutral shoppers will choose electronic channel.

Conditions in Observation 1 can occur with products such as durable goods where evaluation of the product is difficult in an online setting and the product requires professional delivery and installation. Needing delivery and installation results in the same delivery time whether the product is bought online or in-store. This numerical example illustrates the trade-off among three factors: evaluation effort, search effort, and price and how the two types of consumers can choose different channels for their

Table 1
Price of p^T and the corresponding range of p^E where risk-averse shoppers will choose traditional channel but risk-neutral shoppers will choose electronic channel

p^T	p^E
10	[11.89 – 13.44]
11	[12.85 – 14.44]
12	[13.80 – 15.44]
13	[14.76 – 16.44]
14	[15.72 – 17.44]
15	[16.67 – 18.44]

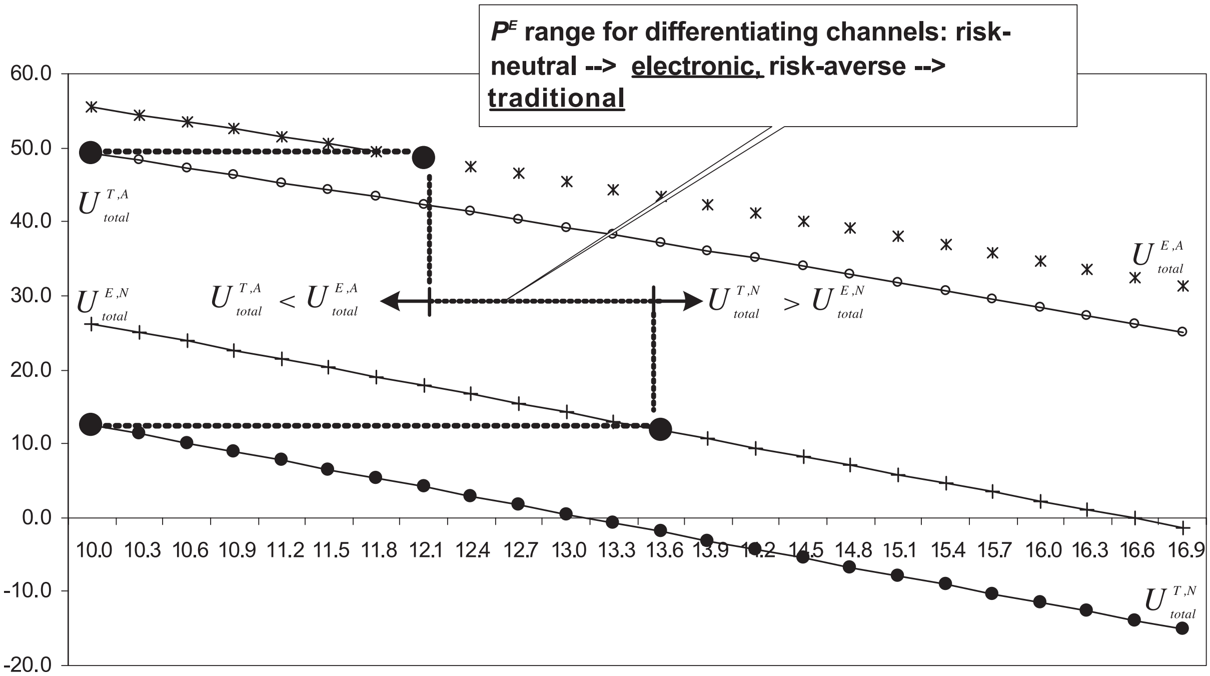

Fig. 5. Consumer utility and channel choices for example 1.

purchases. Let the parameter values be $\bar{B} = 40$, $\bar{w} = 10$, $\bar{p} = 25$, $d_1 = 0.01$, $d_2 = 0.06$, $d_3 = 0.025$, $S^T = 10$, $S^E = 2$, $C^T = 5$, $C^E = 7.5$, and $w^T = w^E = 1$. Table 1 gives prices, $p^E > p^T$, where risk-averse shoppers choose traditional channel but risk-neutral shoppers prefer electronic channel obtained by setting $U^{E,N}_{total} > U^{T,N}_{total}$ and $U^{T,A}_{total} > U^{E,A}_{total}$. Keeping p^T the same (e.g., $p^T = 10$) and reducing p^E to below the

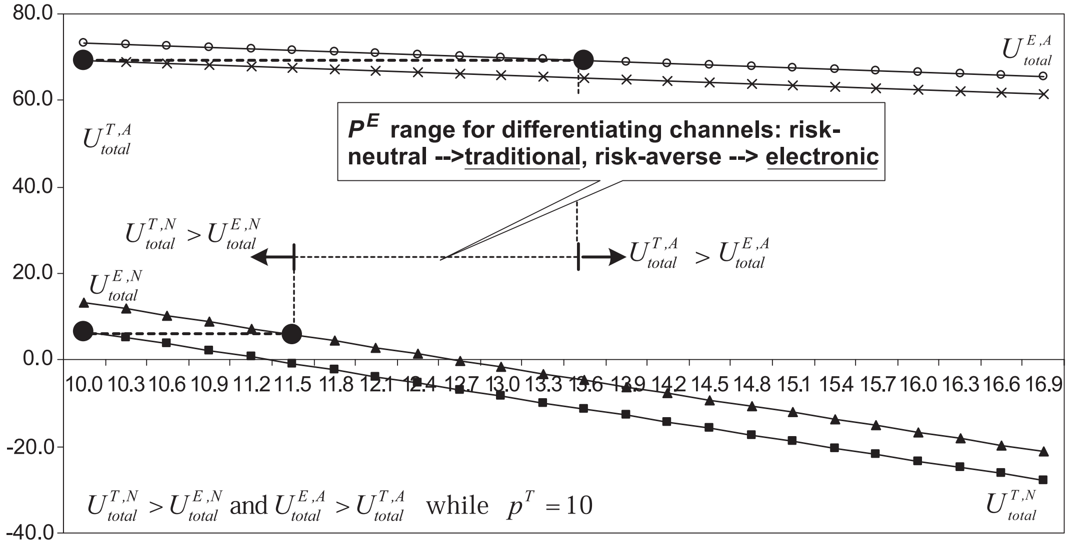

Fig. 6. Consumer utility and channel choice for example 2.

corresponding lower bound ($p^E < 11.89$), both types of consumers will prefer shopping online. Similarly, keeping p^T the same (e.g., $p^T = 10$) and raising p^E to beyond the corresponding upper bound ($p^E > 13.44$), both types of consumers will prefer shopping in-store (Fig. 5).

Observation 2. For certain values of $S^T > S^E$, $C^T > C^E$, and $w^T < w^E$, there exist price values of $p^E > p^T$, such that risk-neutral shoppers will choose traditional channel and risk-averse shoppers prefer electronic channel.

Conditions in Observation 2 can occur with products such as music CDs and videotapes for which search and evaluation is more difficult in a traditional environment than in an online setting: In a traditional environment, consumers may not be able to sample all music or video clips that they are interested in because of the capacity constraints of a physical store. In an online environment, the seller can choose to have clips of all CDs or videos. However, a music CD or a videotape purchased online still requires delivery. This numerical example illustrates the trade-off among four factors: evaluation effort, search effort, waiting time, and price and how the two types of consumers can choose different channels for their purchases. Observation 2 is illustrated with these parameter values in Fig. 6: $\bar{B} = 30$, $\bar{w} = 10$, $\bar{p} = 20$, $d_1 = 0.015$, $d_2 = 0.04$, $d_3 = 0.01$, $S^T = 5$, $S^E = 2.5$, $C^T = 5$, $C^E = 2.5$, and $w^T = 1$, $w^E = 2$. Table 2 gives prices, $p^E > p^T$, where risk-neutral shoppers choose traditional channel but risk-averse shoppers prefer electronic channel. Keeping p^T the same (e.g., $p^T = 10$) and reducing p^E to below the corresponding lower bound ($p^E < 11.33$), both types of consumers will prefer shopping online. Similarly, keeping p^T the same (e.g., $p^T = 10$) and raising p^E to beyond the corresponding upper bound (e.g., $p^E > 13.68$), both types of consumers will prefer shopping in-store.

Table 2
Price of p^T and the corresponding range of p^E so that risk-neutral shoppers will choose traditional channel but risk-averse shoppers will choose electronic channel

p^T	p^E
10	[11.33 – 13.68]
11	[12.33 – 14.65]
12	[13.33 – 15.61]
13	[14.33 – 16.58]
14	[15.33 – 17.54]
15	[16.33 – 18.51]

In the above two examples, the sufficient conditions specified in Proposition 3 can still be true, that is, risk-neutral consumers may be deriving more utility than risk-averse consumers from the same channel. However, since Proposition 3 is not concerned with channel choice of consumers, the above two examples illustrate how retailers can still influence consumers' channel choice decision. For example, a retailer can segment consumers by offering channel discriminatory-pricing so consumers would self-select their desired channel. The elements of this channel-based discriminatory-pricing include offering different combinations of product information and variety, search convenience, and delivery time. Since online shopping is conducive for price comparisons, online retailers that charge a premium should truly provide added benefits that competitors do not offer; otherwise, undifferentiated services will be bought on price alone. For example, the Wall Street Journal Online edition is charging a relatively high subscription rate for online access to its pages, which few print publications have managed to do. The Journal's success is due to its personalized search and archive features, along with 24-hour instant news alerts for online readers [31]. If online offerings cannot distinguish themselves from in-store offering, cannibalization of one channel over another can occur as is the case with many booksellers [35,51].

6. Discussions and conclusions

In this paper, we develop an economic model of consumer shopping decision that takes into account consumer risk profiles and the substitution effects of economic factors such as prices, product range, ease of product evaluation, and product acquisition time. An examination of these substitution effects highlights the importance of quick delivery for online shopping, especially when the product in question requires long lead-time, as is the case with customized or rare items. For commodity items, the substitution effects suggest that a higher premium can be charged by providing a wide range of choices and comparison mechanisms so consumers incur lower search and evaluation costs. By modeling consumers as either risk-neutral or risk-averse, we are able to explain why consumers repeatedly buy from retailers such as Amazon.com who do not have the lowest price: once attracted to a site, risk-aversion keeps consumers there. Aversion to risk also explains why there is price dispersion in the cyberspace even though some predicted that ease of price search online would result in uniform pricing across retailers.

By focusing on substitution effects of various economic factors and consumers' risk-aversion in online shopping environments, we propose that retailers wishing to attract customers should develop strategies that segment consumers into two types: risk-neutral or risk-averse. We predict that risk-neutral consumers will be the first ones who can be enticed away from traditional retailers. In order to obtain them as customers, retailer should focus on providing valued-added service enabled by online shopping (e.g., search engines, impressive storefront design, and evaluation tools such as virtual reality). To retain customers, retailers should build virtual communities or engage in other relationship building techniques so risk-aversion will play a role in creating customer lock-in.

Our model also provides insights into consumer variety-seeking behavior online. As we mentioned before, existing marketing literature indicates that, in traditional channels, consumers engage in variety-seeking behavior mostly for low-ticket items while high-ticket item retailers are able to lock-in customers. However, in online environment, due to dramatically reduced search costs, consumers are likely to engage in variety-seeking behavior for both low- and high-ticket items. From retailers' point of view, even though consumer risk-aversion can be used to create lock-in, a more successful strategy would include offering a variety of products in order to discourage their customers from searching elsewhere.

Our analytical model draws from the economic literature on utility functions and risk profiles and from the marketing literature on consumer behavior. Most of the marketing research on online shopping has focused on analysis of empirical data [23,24,28,30,36,41–43,49]. Our theoretical model is the first attempt in trying to explain and predict consumer online shopping behavior, which in turn provides guidance to multi-channel retailers in designing their channel-specific strategies.

7. Limitations and future research

Our results are inherently tied to the assumptions we made about our models and hence assume their limitations. First of all, we have assumed separability of each of the components contributing to total utility. Although it is common in the economics and marketing literature (e.g., Refs. [21,39]) to assume such separability, it is important to be aware that some relevant joint effects of multiple factors may be lost in the analysis. These effects may not be dominant but can exist nevertheless. For example, disutility of search effort related to the number of product searched, a, may have interaction effects with the currently observed product price, p. If the observed price is very low, a consumer may see very little value in searching additional products, and vice versa. Second, we have assumed increasing marginal search costs in the number of products searched, a. This may not hold for all values of a. For example, in a physical search of alternatives, the start-up cost, i.e., the marginal cost of searching for the first item, may be quite high (since the consumer has to get out of the house and drive to the first shopping center). Several subsequent searches may incur a lot lower search costs until the consumer has to drive to a different shopping center. Third, our model is limited to scenarios where consumers either search and purchase from the traditional channel or the electronic channel. Our model does not deal with situations where a consumer can search in one channel and purchase in another. Fourth, since our model develops from the consumer preference and transaction based theory, it is subject to limitation inherent to such theories because a utility model cannot possibly include all potential factors influencing consumes' preferences and their choices. For example, retailer branding and trust may take on a heightened importance in electronic marketplaces. As we mentioned earlier, this paper focuses on only the economic factors relevant to consumer purchase decision process, the model does not incorporate non-economic factors, such as brand beliefs, personal interest, habits, culture, social class, motivation, religion, and attitude.

For future work, there remain important issues to be explored. One of such issues is the role of different types of intermediaries in the purchasing process. Some intermediaries operate by reducing consumers' search and evaluation costs. Others can play a new role by aggregating buyers with similar needs and by conducting collective bargaining with potential sellers. For instance, iVillage.com is the women's network and is formed as a virtual community. Subscribers of iVillage.com possess similar needs and have bargaining power for discounts. The underlying motivational factors are scale economies and risk pooling.

From online retailer's perspective, product bundling can be a strategy used to aggregate products and to further reduce search and evaluation costs for consumers. For long-term success, electronic channels have to be integrated with the traditional channels. For example, to purchase a TV set, a customer would prefer browsing and searching through the online store but would rather drive to a brick-and-mortar store to avoid paying shipping and delivery. Incorporating the integration of both channels would dramatically enhance our model.

Appendix A. Notations

a	number of products searched
q	level of quality certainty
B^i	buyer effort in channel i, where i=E (electronic) or T (traditional) and $B^i=S^i+C^i$, where S^i=search cost at channel i and C^i=evaluation cost at channel i
w^i	delivery time from the channel i, where i=E or T; for example, w^E=delivery time over the Internet shopping
p^i	product or service price in channel i, where i=E or T; for example, p^E=product or service price over the Internet shopping
k_0^T, k_1^T, k_2^T	parameters associated with the functional form of S^T
k_1^E, k_2^E	parameters associated with the functional form of S^E
k_3^i, k_4^i	parameters associated with the functional form of E^i, where i=E or T
$U_{total}^{i,j}$	total utility for a type j consumer derived from purchasing a product through channel i, i.e., $U_{total}^{i,j}=V+U_{effort}^{i,j}+U_{waiting}^{i,j}+U_{price}^{i,j}$, where i=E, T and j=A (risk-averse) or N (risk-neutral); for example, $U_{total}^{E,N}$=total utility for a risk-neutral buyer derived from purchasing a product online
V	reservation utility or the maximum valuation of a product
$U_{cost}^{i,j}$	disutility loss for a type j consumer derived from purchasing a product through channel i, where i=E or T, j=A or N, and cost=effort (for purchasing effort), waiting (for delivery time), or price (for product or service price); for example, $U_{effort}^{E,A}$= disutility from purchasing effort for a risk-averse buyer derived from purchasing over the Internet

Appendix B. Proofs

Proof of Quasi-concavity of utility function. When a, q are endogenous variables decided by the consumers and w^i, p^i are exogenous variables controlled by sellers, the utility functions $U_{total}^{i,j}$, i=E or T, j=A or N satisfy the consumer preference theory and the ordinal properties that are required by utility functions to make consumer preferences consistency. See proof below:. The determinants of the bordered Hessian matrixes for $U_{total}^{E,N}$, $U_{total}^{E,A}$, $U_{total}^{T,N}$, and $U_{total}^{T,A}$ are

$$\mathrm{Det}\begin{vmatrix} 0 & \dfrac{\partial U_{total}^{E,N}}{\partial a} & \dfrac{\partial U_{total}^{E,N}}{\partial q} \\ \dfrac{\partial U_{total}^{E,N}}{\partial a} & \dfrac{\partial^2 U_{total}^{E,N}}{\partial a^2} & \dfrac{\partial^2 U_{total}^{E,N}}{\partial aq} \\ \dfrac{\partial U_{total}^{E,N}}{\partial q} & \dfrac{\partial^2 U_{total}^{E,N}}{\partial qa} & \dfrac{\partial^2 U_{total}^{E,N}}{\partial q^2} \end{vmatrix} = \frac{2V^3(k_1^E)^2 k_4^E}{q^3\bar{B}^3} > 0,$$

$$\mathrm{Det}\begin{vmatrix} 0 & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial a} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial a^2} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial aq} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial qa} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q^2} \end{vmatrix} = \frac{2V^3 d_1^3 (k_1^{\mathrm{E}})^2 k_4^{\mathrm{E}} \mathrm{e}^{3d_1\left(k_1^{\mathrm{E}}a+k_2^{\mathrm{E}}+k_3^{\mathrm{E}}+\frac{k_4^{\mathrm{E}}}{q}\right)}}{q^3} > 0,$$

$$\mathrm{Det}\begin{vmatrix} 0 & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a^2} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial aq} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial qa} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q^2} \end{vmatrix} = \frac{2V^3 k_4^{\mathrm{T}}[4a^2 q (k_0^{\mathrm{T}})^2 + q(k_1^{\mathrm{T}})^2 + 4aqk_0^{\mathrm{T}}k_1^{\mathrm{T}} + k_0^{\mathrm{T}}k_4^{\mathrm{T}}]}{q^4 \bar{B}^3} > 0, \text{ and}$$

$$\mathrm{Det}\begin{vmatrix} 0 & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial a} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial a^2} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial aq} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial qa} & \frac{\partial^2 U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q^2} \end{vmatrix} = \frac{2V^3 d_1^3 k_4^{\mathrm{T}}[4a^2 q (k_0^{\mathrm{T}})^2 + q(k_1^{\mathrm{T}})^2 + 4aqk_0^{\mathrm{T}}k_1^{\mathrm{T}} + k_0^{\mathrm{T}}k_4^{\mathrm{T}}] \cdot \mathrm{e}^{3d_1\left(k_0^{\mathrm{T}}a^2+k_1^{\mathrm{T}}a+k_2^{\mathrm{T}}+k_3^{\mathrm{T}}+\frac{k_4^{\mathrm{T}}}{q}\right)}}{q^4}$$

$$> 0, \text{ respectively}$$

Therefore, $U_{\mathrm{total}}^{\mathrm{E,N}}$, $U_{\mathrm{total}}^{\mathrm{E,A}}$, $U_{\mathrm{total}}^{\mathrm{T,N}}$, and $U_{\mathrm{total}}^{\mathrm{T,A}}$ are all quasi-concave functions in a q. □

Proof of Proposition 1. When a, q are endogenous variables decided by the consumers and w, p are exogenous variables controlled by sellers, given the system of the implicit functions for risk-neutral consumers in a, q as,

$$\begin{cases} U_{\mathrm{total}}^{\mathrm{E,N}}(a,q,w^{\mathrm{E}},p^{\mathrm{E}}) = V - \frac{V}{\bar{B}}\left(k_1^{\mathrm{E}}a + k_2^{\mathrm{E}} + k_3^{\mathrm{E}} + \frac{k_4^{\mathrm{E}}}{q}\right) - \frac{V}{\bar{w}}w^{\mathrm{E}} - \frac{V}{\bar{p}}p^{\mathrm{E}} \\ U_{\mathrm{total}}^{\mathrm{T,N}}(a,q,w^{\mathrm{T}},p^{\mathrm{T}}) = V - \frac{V}{\bar{B}}\left(k_0^{\mathrm{T}}a^2 + k_1^{\mathrm{T}}a + k_2^{\mathrm{T}} + k_3^{\mathrm{T}} + \frac{k_4^{\mathrm{T}}}{q}\right) - \frac{V}{\bar{w}}w^{\mathrm{T}} - \frac{V}{\bar{p}}p^{\mathrm{T}} \end{cases}$$

and by the implicit function theorem and Cramer's rule,we have

$$\frac{\partial a}{\partial p^{\mathrm{E}}} = -\frac{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial p^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q} \\ \frac{\partial U_{total}^{\mathrm{E,N}}}{\partial p^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q} \end{vmatrix}}{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q} \\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q} \end{vmatrix}} = \frac{k_4^{\mathrm{T}}\bar{B}}{\bar{p}(2k_4^{\mathrm{E}}k_0^{T}a + k_4^{\mathrm{E}}k_1^{\mathrm{T}} - k_1^{\mathrm{E}}k_4^{\mathrm{T}})} > 0 \text{ iff } a > \frac{k_1^{\mathrm{E}}k_4^{\mathrm{T}} - k_4^{\mathrm{E}}k_1^{\mathrm{T}}}{2k_4^{\mathrm{E}}k_0^{\mathrm{T}}}.$$

$$\frac{\partial a}{\partial w^{E}} = -\frac{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial w^{E}} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial w^{E}} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}}{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial a} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial a} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}} = \frac{k_4^T \bar{B}}{\bar{w}(2k_4^E k_0^T a + k_4^E k_1^T - k_1^E k_4^T)} > 0 \text{ iff } a > \frac{k_1^E k_4^T - k_4^E k_1^T}{2k_4^E k_0^T}.$$

$$\frac{\partial a}{\partial p^{T}} = -\frac{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial p^{T}} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial p^{T}} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}}{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial a} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial a} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}} = \frac{k_4^E \bar{B}}{\bar{p}(2k_4^E k_0^T a + k_4^E k_1^T - k_1^E k_4^T)} > 0 \text{ iff } a > \frac{k_1^E k_4^T - k_4^E k_1^T}{2k_4^E k_0^T}.$$

$$\frac{\partial a}{\partial w^{T}} = -\frac{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial w^{T}} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial w^{T}} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}}{\mathrm{Det}\begin{vmatrix} \frac{\partial U_{total}^{T,N}}{\partial a} & \frac{\partial U_{total}^{T,N}}{\partial q} \\ \frac{\partial U_{total}^{E,N}}{\partial a} & \frac{\partial U_{total}^{E,N}}{\partial q} \end{vmatrix}} = \frac{k_4^E \bar{B}}{\bar{w}(2k_4^E k_0^T a + k_4^E k_1^T - k_1^E k_4^T)} > 0 \text{ iff } a > \frac{k_1^E k_4^T - k_4^E k_1^T}{2k_4^E k_0^T}.$$

Similarly for risk-averse consumers, given the system of the implicit functions for risk-neutral consumers in a, q as

$$\begin{cases} U_{total}^{E,A}(a,q,w^E,p^E) = V - V[e^{d_1\left(k_1^E a + k_2^E + k_3^E + \frac{k_4^E}{q}\right)} - 1] - V(e^{d_2 w^E} - 1) - V(e^{d_3 p^E} - 1)^T \\ U_{total}^{T,A}(a,q,w^T,p^T) = V - V[e^{d_1\left(k_0^T a^2 + k_1^T a + k_2^T + k_3^T + \frac{k_4^T}{q}\right)} - 1] - V(e^{d_2 w^T} - 1) - V(e^{d_3 p^T} - 1) \end{cases}$$

we have

$$\frac{\partial a}{\partial p^{\mathrm{E}}}=-\frac{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial p^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial p^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q}\end{vmatrix}}{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q}\end{vmatrix}}=\frac{d_3k_4^{\mathrm{T}}\cdot \mathrm{e}^{d_3p^{\mathrm{E}}-d_1\left(k_1^{\mathrm{E}}a+k_2^{\mathrm{E}}+k_3^{\mathrm{E}}+\frac{k_4^{\mathrm{E}}}{q}\right)}}{d_1(2k_4^{\mathrm{E}}k_0^{\mathrm{T}}a+k_4^{\mathrm{E}}k_1^{\mathrm{T}}-k_1^{\mathrm{E}}k_4^{\mathrm{T}})}>0 \text{ iff } a>\frac{k_1^{\mathrm{E}}k_4^{\mathrm{T}}-k_4^{\mathrm{E}}k_1^{\mathrm{T}}}{2k_4^{\mathrm{E}}k_0^{\mathrm{T}}}.$$

$$\frac{\partial a}{\partial w^{\mathrm{E}}}=-\frac{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial w^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial w^{\mathrm{E}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q}\end{vmatrix}}{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,A}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,A}}}{\partial q}\end{vmatrix}}=\frac{d_2k_4^{\mathrm{T}}\cdot \mathrm{e}^{d_2w^{\mathrm{E}}-d_1\left(k_1^{\mathrm{E}}a+k_2^{\mathrm{E}}+k_3^{\mathrm{E}}+\frac{k_4^{\mathrm{E}}}{q}\right)}}{d_1(2k_4^{\mathrm{E}}k_0^{\mathrm{T}}a+k_4^{\mathrm{E}}k_1^{\mathrm{T}}-k_1^{\mathrm{E}}k_4^{\mathrm{T}})}>0 \text{ iff } a>\frac{k_1^{\mathrm{E}}k_4^{\mathrm{T}}-k_4^{\mathrm{E}}k_1^{\mathrm{T}}}{2k_4^{\mathrm{E}}k_0^{\mathrm{T}}}.$$

$$\frac{\partial a}{\partial p^{\mathrm{T}}}=-\frac{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial p^{\mathrm{T}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial p^{\mathrm{T}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q}\end{vmatrix}}{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q}\end{vmatrix}}=\frac{d_3k_4^{\mathrm{E}}\cdot \mathrm{e}^{d_2p^{\mathrm{T}}-d_1\left(k_0^{\mathrm{T}}a^2+k_1^{\mathrm{T}}a+k_2^{\mathrm{T}}+k_3^{\mathrm{T}}+\frac{k_4^{\mathrm{T}}}{q}\right)}}{d_1(2k_4^{\mathrm{E}}k_0^{\mathrm{T}}a+k_4^{\mathrm{E}}k_1^{\mathrm{T}}-k_1^{\mathrm{E}}k_4^{\mathrm{T}})}>0 \text{ iff } a>\frac{k_1^{\mathrm{E}}k_4^{\mathrm{T}}-k_4^{\mathrm{E}}k_1^{\mathrm{T}}}{2k_4^{\mathrm{E}}k_0^{\mathrm{T}}}.$$

$$\frac{\partial a}{\partial w^{\mathrm{T}}}=-\frac{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial w^{\mathrm{T}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial w^{\mathrm{T}}} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q}\end{vmatrix}}{\mathrm{Det}\begin{vmatrix}\frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{T,N}}}{\partial q}\\ \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial a} & \frac{\partial U_{\mathrm{total}}^{\mathrm{E,N}}}{\partial q}\end{vmatrix}}=\frac{d_2k_4^{\mathrm{E}}\cdot \mathrm{e}^{d_2w^{\mathrm{T}}-d_1\left(k_0^{\mathrm{T}}a^2+k_1^{\mathrm{T}}a+k_2^{\mathrm{T}}+k_3^{\mathrm{T}}+\frac{k_4^{\mathrm{T}}}{q}\right)}}{d_1(2k_4^{\mathrm{E}}k_0^{\mathrm{T}}a+k_4^{\mathrm{E}}k_1^{\mathrm{T}}-k_1^{\mathrm{E}}k_4^{\mathrm{T}})}>0 \text{ iff } a>\frac{k_1^{\mathrm{E}}k_4^{\mathrm{T}}-k_4^{\mathrm{E}}k_1^{\mathrm{T}}}{2k_4^{\mathrm{E}}k_0^{\mathrm{T}}}. \qquad \square$$

Proof of Proposition 2. Let

$$U^{\mathrm{d,N}}_{\mathrm{total}} = U^{\mathrm{E,N}}_{\mathrm{total}} - U^{\mathrm{T,N}}_{\mathrm{total}} = \frac{V}{\bar{B}}\left[k_0^{\mathrm{T}}a^2 + (k_1^{\mathrm{T}} - k_1^{\mathrm{E}})a + k_2^{\mathrm{T}} \quad + k_3^{\mathrm{T}} - k_2^{\mathrm{E}} - k_3^{\mathrm{E}} + \frac{k_4^{\mathrm{T}} - k_4^{\mathrm{E}}}{q}\right] + \frac{V}{\bar{w}}w^{\mathrm{d}} + \frac{V}{\bar{p}}p^{\mathrm{d}},$$

where $w^{\mathrm{d}} = w^{\mathrm{T}} - w^{\mathrm{E}}$ and $p^{\mathrm{d}} = p^{\mathrm{T}} - p^{\mathrm{E}}$. By the implicit function theorem,

$$\frac{\partial a}{\partial p^{\mathrm{d}}} = -\frac{\dfrac{\partial U^{\mathrm{d,N}}_{\mathrm{total}}}{\partial p^{\mathrm{d}}}}{\dfrac{\partial U^{\mathrm{d,N}}_{\mathrm{total}}}{\partial a}} = -\frac{\bar{B}}{\bar{p}} \cdot \frac{\partial S^{\mathrm{d}}\ (= S^{\mathrm{T}} - S^{\mathrm{E}})}{\partial a} \quad < 0 \Leftarrow \frac{\partial S^{\mathrm{d}}}{\partial a} > 0.$$

Similarly,

$$\frac{\partial a}{\partial w^{\mathrm{d}}} = -\frac{\dfrac{\partial U^{\mathrm{d,N}}_{\mathrm{total}}}{\partial w^{\mathrm{d}}}}{\dfrac{\partial U^{\mathrm{d,N}}_{\mathrm{total}}}{\partial a}} = -\frac{\bar{B}}{\bar{W}} \cdot \frac{\partial S^{\mathrm{d}}\ (= S^{\mathrm{T}} - S^{\mathrm{E}})}{\partial a} < 0 \Leftarrow \frac{\partial S^{\mathrm{d}}}{\partial a} > 0$$

□

Proof of Proposition 3. Let $f = p^{\mathrm{E}}/\bar{p}$. Since $p^{\mathrm{E}} \le \bar{p}$ we have $0 \le f \le 1$.

Since

$$\mathrm{e}^{d_3 p^{\mathrm{E}}} > \frac{p^{\mathrm{E}}}{\bar{p}} + 1 \Leftrightarrow \mathrm{e}^{d_3 f \bar{p}} > f + 1 \Leftrightarrow d_3 > \frac{\ln(f+1)}{f\bar{p}}, \forall f \Leftarrow d_3 > \frac{1}{\bar{p}} \lim_{f \to 0^+} \frac{\ln(f+1)}{f} \Leftarrow d_3 > \frac{1}{\bar{p}} \lim_{f \to 0^+} \frac{\dfrac{\partial \ln(f+1)}{\partial f}}{\dfrac{\partial f}{\partial f}}$$

$$\times\ (\text{by L}'\text{Hôpital}'\text{s rule}) \Leftarrow d_3 > \frac{1}{\bar{p}}.$$

We obtain $d_3 > (1/\bar{p}) \Rightarrow \mathrm{e}^{d_3 p^{\mathrm{E}}} > ((p^{\mathrm{E}}/\bar{p}) + 1)$. Similarly, we have $d_1 > (1/\bar{B}) \Rightarrow \mathrm{e}^{d_1 B^{\mathrm{E}}} > ((B^{\mathrm{E}}/\bar{B}) + 1)$ and $d_2 > (1/\bar{w}) \Rightarrow \mathrm{e}^{d_2 w^{\mathrm{E}}} > ((w^{\mathrm{E}}/\bar{w}) + 1)$.

Therefore,

$$d_1 > (1/\bar{B} >),\ d_2 > (1/\bar{w}),\ d_3 > (1/\bar{p}) \Rightarrow \mathrm{e}^{d_1 B^{\mathrm{E}}} > \frac{B^{\mathrm{E}}}{\bar{B}} + 1, \mathrm{e}^{d_2 w^{\mathrm{E}}} > \frac{w^{\mathrm{E}}}{\bar{w}} + 1, \mathrm{e}^{d_3 p^{\mathrm{E}}} > \frac{p^{\mathrm{E}}}{\bar{p}} + 1 \Rightarrow U^{\mathrm{E,N}}_{\mathrm{total}} - U^{\mathrm{E,A}}_{\mathrm{total}}$$

$$= V\left[\left(\mathrm{e}^{d_1 B^{\mathrm{E}}} - \frac{B^{\mathrm{E}}}{\bar{B}}\right) + \left(\mathrm{e}^{d_2 w^{\mathrm{E}}} - \frac{w^{\mathrm{E}}}{\bar{w}}\right) + \left(\mathrm{e}^{d_3 p^{\mathrm{E}}} - \frac{p^{\mathrm{E}}}{\bar{p}}\right)\right] > 0.$$

Similar analysis with respect to the traditional channel yields:

$$d_1 > \frac{1}{\bar{B}},\ d_2 > \frac{1}{\bar{w}},\ d_3 > \frac{1}{\bar{w}} \Rightarrow U^{\mathrm{T,N}}_{\mathrm{total}} - U^{\mathrm{T,A}}_{\mathrm{total}} > 0,\ d_3 > \frac{1}{\bar{w}}.$$

□

Proof of Proposition 4. Let:

$$F = U^{\mathrm{d,A}} - U^{\mathrm{d,N}} = V\left\{\left[\left(\mathrm{e}^{d_1 B^{\mathrm{T}}} - \frac{B^{\mathrm{T}}}{\bar{B}}\right) - \left(\mathrm{e}^{d_1 B^{\mathrm{E}}} - \frac{B^{\mathrm{E}}}{\bar{B}}\right)\right] + \left[\left(\mathrm{e}^{d_2 w^{\mathrm{T}}} - \frac{w^{\mathrm{T}}}{\bar{w}}\right) - \left(\mathrm{e}^{d_2 w^{\mathrm{E}}} - \frac{w^{\mathrm{E}}}{\bar{w}}\right)\right] + \left[\left(\mathrm{e}^{d_3 p^{\mathrm{T}}} - \frac{p^{\mathrm{T}}}{\bar{p}}\right) - \left(\mathrm{e}^{d_3 p^{\mathrm{E}}} - \frac{p^{\mathrm{E}}}{\bar{p}}\right)\right]\right\}.$$

and $g=\mathrm{e}^{dx}-(x/\bar{x})$. We aim to prove that g is a strictly increasing function with $(\partial g/\partial x)=d\mathrm{e}^{dx}-(1/\bar{x})>0$.

In Proposition 3, $d>\frac{1}{\bar{x}}\Rightarrow \mathrm{e}^{dx}>\frac{x}{\bar{x}}+1 \Leftrightarrow d\mathrm{e}^{dx}>\frac{dx}{\bar{x}}+d$. It follows that $d>\frac{1}{\bar{x}}\Rightarrow\frac{dx}{\bar{x}}+d-\frac{1}{\bar{x}}=\frac{d(x+\bar{x})-1}{\bar{x}}>0$, then $d\mathrm{e}^{dx}>(dx/\bar{x})+d>(1/\bar{x})$ and $(\partial g/\partial x)=d\mathrm{e}^{dx}-(1/\bar{x})>0$.

Therefore, g is a strictly increasing function with respect x, if $d>(1/\bar{x})$. When $B^{\mathrm{T}}>B^{\mathrm{E}}$, $w^{\mathrm{T}}>w^{\mathrm{E}}$, $p^{\mathrm{T}}>p^{\mathrm{E}}$, we have $F>0$ and show the Proposition 4. □

Proof of Proposition 5. Similar to that of Proposition 4. □

Proof of Corollary 1

$$\frac{\partial F}{\partial B^{\mathrm{T}}} = V\left(d_1\mathrm{e}^{d_1 B^{\mathrm{T}}} - \frac{1}{\bar{B}}\right) > 0,$$
$$\frac{\partial F}{\partial w^{\mathrm{T}}} = V\left(d_2\mathrm{e}^{d_2 w^{\mathrm{T}}} - \frac{1}{\bar{w}}\right) > 0 \text{ and}$$
$$\frac{\partial F}{\partial p^{\mathrm{T}}} = V\left(d_3\mathrm{e}^{d_3 p^{\mathrm{T}}} - \frac{1}{\bar{p}}\right) > 0.$$
$$\frac{\partial F}{\partial B^{\mathrm{E}}} = V\left(\frac{1}{\bar{B}} - d_1\mathrm{e}^{d_1 B^{\mathrm{E}}}\right) < 0,$$
$$\frac{\partial F}{\partial w^{\mathrm{E}}} = V\left(\frac{1}{\bar{w}} - d_2\mathrm{e}^{d_2 w^{\mathrm{E}}}\right) < 0 \text{ and}$$
$$\frac{\partial F}{\partial p^{\mathrm{E}}} = V\left(\frac{1}{\bar{p}} - d_3\mathrm{e}^{d_3 p^{\mathrm{E}}}\right) < 0.$$

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