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Price competition in e-tailing under service and recognition differentiation

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Abstract

The Internet has significantly increased the bargaining power of consumers. Many online shopping search engines allow consumers to find most retailers that sell a specific product, compare product prices, and review detailed store ratings. With competition just a click away, online retailers have little control over where consumers would shop. Offering the lowest price alone does not always guarantee that consumers will come and buy at your site. Other non-price attributes, such as service quality and a merchant's brand recognition, also play important roles in helping online retailers to build competitive advantages. In this paper, we present a model of price competition that assumes e-tailers can mainly differentiate themselves by providing different levels of service and by establishing a different online recognition. Closed-form equilibrium solutions are obtained for the different scenarios that may arise in this model. Based on such solutions, we give managerial insights on how e-tailers should position themselves when parameters such as service cost, service levels, and recognition are varied.

Keywords: E-service; Service quality; Price competition; Brand recognition

1. Introduction

The Internet is continuing to revolutionize the way business is conducted and to reshape how companies interact with their customers. In the early days of electronic commerce, many online retailers (e-tailers) believed in the first-mover advantage. As a result, firms spent a considerable amount of money on advertising and giveaways to attract customers to their Web sites, under the assumption that once customers came, they would be locked in to using the site. However, companies have come to realize that the challenge is not simply to attract customers to the site, but to actually convert visitors to purchasers and to retain customers. This challenge has been intensified by the advent of online comparison shopping search engines (such as BizRate), which provide users the capability to find most e-tailers that sell a specific product, compare product prices, and review detailed store ratings. With competition just a click away, little can be done to prevent consumers from switching and changing, where they would shop. Often times, offering the lowest price alone does not guarantee that consumers will come and buy at your site. Other non-price attributes, such as the quality of services provided online and the recognition levels of e-tailers, also play important roles in helping e-tailers to build competitive advantages ([9,13,22]).

Provision of business services over electronic networks (such as the Web) is generally referred to as e-service [13]. E-service may include several components such as personalization of web pages, order processing and fulfillment, responding to inquiries, status tracking and information security. These components together affect the quality of e-service, which is usually defined as consumers' overall

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evaluation and judgment of an e-tailer's service offerings along two-dimensions: how the service is delivered and what the customer receives [21]. Empirical research has shown that e-service quality is becoming an increasingly important factor influencing consumer's decision choices ([6,8,24]).

Establishing an (online) brand recognition is also important as providing good services [7]. In the online environment, brand recognition has been considered an important inducer of trust [10], which significantly influences consumers' online shopping behavior ([1,15,23]). Studies have also suggested that brand recognition and brand loyalty have direct positive impacts on consumers' Web site behavior ([17,18]). However, for most e-tailers, establishing online recognition is not only expensive but also difficult because of the lack of a physical presence. In this situation, retailers often engage in fierce price competition, hoping to influence the (price-sensitive) consumers' choice process. Smith and Brynjolfsson [14] and Baye et al. [4] find wide price dispersion for the same product being offered online. It is argued that price dispersion is largely due to retailer heterogeneity with respect to brand recognition, service, and trust.

Brand recognition also has different impacts on consumer decision making in the physical world and online. Research has found that highly familiar (or accessible) brands are more likely to be considered and chosen over less familiar brands ([3,12]). In the physical world, however, consumers are constrained by time and the geographical distance of a store. Therefore, stores that are well recognized but are far away (i.e., not easily accessible) do not necessarily attract certain consumers. In contrast, in the online environment, Internet shoppers have at their fingertips equal access to most stores (and a wealth of valuable information about those stores). Brand recognition, therefore, could very well determine which site the consumers would visit and buy from.

In this paper, we present a model of price competition that assumes e-tailers can mainly differentiate themselves by providing different levels of service and by establishing a different online recognition. We assume that the recognition and service are independent and can be controlled separately by the e-tailer. The independence assumption seems reasonable, as service quality is usually a post-purchase judgement by the consumer and recognition is not. Closed-form equilibrium solutions as well as managerial implications are obtained. We also give insights on how firms should try to influence and adjust the levels of service they provide and whether they should increase their level of recognition (e.g., by increasing advertising).

This research is a direct extension to the vertical (quality) differentiation model. Moorthy [11] and Tirole [19] study a two-stage game in which firms first compete in quality and then compete in price. They show that, in equilibrium, firms choose maximal differentiation. Many economists (for example, [5,20]) have subsequently studied this game under different settings and obtained similar findings (the principle of differentiation). In [20], Vandenbosch and Weinberg analyze a two-stage model in which firms compete in product and price, and product is characterized by any two attributes. The model, however, assumes the cost for all product positions is independent of the choice and is zero. A significant difference between our work and the previous ones is that we incorporate, in the competitive model, (i) a third dimension – merchant's recognition, and (ii) a variable cost that is dependent on a firm's choice. The inclusion of merchant's recognition allows firms to have more choices in differentiating themselves (for example, recognition differentiation or service differentiation or both recognition and service differentiation). The variable cost structure is a more realistic setting because high service-quality products generally cost more than low service-quality products. We also incorporate a fixed convex cost function, which increases with the levels of recognition.

The rest of this paper is organized as follows. Section 2 presents the theoretical model. Section 3 analyzes the short-term price equilibrium when firms are mainly service differentiated, and discusses the results, with an emphasis on managerial implications. Section 4 provides similar analyses when firms are mainly recognition differentiated. We conclude the paper and offer future research directions in Section 5.

2. Theoretical model

We consider a situation, where two firms sell substitutable goods (for example, electronics or commodity type of products) online and assume that they acquire the products at the same constant marginal cost. Each firm sets its recognition level, service quality, and product price to maximize its profit. It has been shown that there is no pure-strategy equilibrium if both firms choose service quality and price simultaneously [16]. We model the firm's decision choice using a three-stage game, but in this paper only the last stage of price competition is explicitly analyzed. In the first stage, a firm has to decide how much to invest to achieve its desired recognition level. In the second stage, the firm decides on the quality of service it is going to provide. In the third stage, firms compete in price. The symmetric market structure, where both firms set the same recognition level, service quality and price, is trivial. We focus on the market segmentation, which arises when firms choose different price margins (i.e., the markup above the marginal product cost), service and recognition levels. Let p_j, S_j, and R_j represent the choice of firm j's ($j = 1, 2$) price margin,[1] service, and recognition level accordingly. We assume that a firm incurs a fixed cost for brand recognition (independent of quantity sold), and a total variable cost for

[1] If the marginal cost of the product is C, then the price choice of firm j is $p_j + C$.

service, which is an increasing function of quantity sold. The profit for firm j can therefore be expressed as:

$$\Pi_j(p_j, S_j, R_j, D_j) = (p_j - f(S_j))D_j - g(R_j)$$

where $f(S_j)$ is the cost of providing service at level S_j for one unit of good sold ($f(S_j)$ is assumed to be a strictly increasing function), D_j is the demand for e-tailer j and $g(R_j)$ is the cost of obtaining a recognition at level R_j. Since products from different firms are perfect substitutes, the demand for one firm's product is determined not only by its own price, service quality, and brand recognition, but also by its competitor's price, the service the competitor provides, and the recognition the competitor enjoys, hence $D_j(\mathbf{p}, \mathbf{S}, \mathbf{R})$.[2]

The cost function $g(R_j)$ is assumed to be an increasing and convex function. This is reasonable since it takes a firm (like Amazon) a considerable amount of time and money to build a brand name. For simplicity, we assume that it takes on a quadratic form, i.e., for a given recognition level R_j, a firm incurs a fixed cost of $g(R_j) = \beta R_j^2$, where β is a constant. On the other hand, service costs (including order processing, after-sales service, etc.) usually depend on the number of items sold. In order to make our model analytically tractable, we assume that the cost function $f(\cdot)$ for service provision is linear and $f(S_j) = \alpha S_j$, where α is the same across firms. Therefore, firm j's profit function can be written as:

$$\max_{p_j, S_j, R_j} \Pi_j(\mathbf{p}, \mathbf{S}, \mathbf{R}) = (p_j - \alpha S_j)D_j - \beta R_j^2. \quad (1)$$

2.1. Consumer behavior

In this paper, a consumer is characterized by two parameters: her recognition sensitivity γ and her service sensitivity θ. The recognition-sensitivity parameter γ measures how much utility a consumer derives per "unit of recognition", i.e., how much she is more willing to pay to buy from a firm with higher recognition as compared to one with lower recognition. Such utility for recognition may be related to a consumer's risk attitude; i.e., it may indicate how likely it is that a customer is willing to buy from an unknown firm, or how good a perception the customer has of a firm. We assume that γ takes on a value from the range $[\underline{\gamma}, \bar{\gamma}]$, with $\underline{\gamma} \geqslant 0$. The utility derived from a firm's recognition is assumed to be linear. In other words, if a firm's recognition level is R_j, then the value to the consumer is γR_j.

In addition to recognition sensitivity, consumers are also characterized by a service-sensitivity parameter θ, which denotes the utility that a consumer derives from per unit of service provided by a firm. The utility a consumer derives from service is also assumed to be linear in service quality; i.e., if the service quality is S_j, then the value of the service to the consumer is θS_j. We assume that θ takes on a value from the range $[\underline{\theta}, \bar{\theta}]$, and that $\underline{\theta} \geqslant 0$.

Since the products provided by the two firms are indistinguishable,[3] the two firms are differentiated by their product price, the service they provide, and the recognition they each enjoy. A consumer's preferences are then completely determined by $U = \theta S_j + \gamma R_j - p_j$. We assume that θ and γ are orthogonal and that the consumers are distributed uniformly over $[\underline{\theta}, \bar{\theta}] \times [\underline{\gamma}, \bar{\gamma}]$. Finally, we assume that $\underline{\theta}$ and $\underline{\gamma}$ are such that the market is covered, i.e., every consumer buys exactly one product from either firm 1 or 2. This means that the purchase decision has already been made and the consumer only faces the decision of which firm to choose.

2.2. Market segmentation

Again, the two firms are differentiated by the service they provide and the recognition they have. In the rest of the paper, we assume that firm 1 is the one with the highest recognition, i.e., $R_1 \geqslant R_2$. In what follows, the quantity $\varphi \equiv \frac{S_1 - S_2}{R_1 - R_2}$ will play an important role. The magnitude of φ measures the amount of service differentiation relative to the recognition differentiation of the two firms. The sign of φ indicates whether the high-recognition firm also provides the highest service level ($\varphi > 0$), or whether the low-recognition firm provides the highest service ($\varphi < 0$).

If a consumer characterized by (γ, θ) decides to buy from firm j at a price of p_j, her net value is $\gamma R_j + \theta S_j - p_j$. The consumer will buy from the firm that maximizes her net value. The consumer is indifferent between buying from either firm if and only if $\gamma R_1 + \theta S_1 - p_1 = \gamma R_2 + \theta S_2 - p_2$, or $\gamma = -\varphi\theta + \frac{p_1 - p_2}{R_1 - R_2}$. The indifference curve is a straight line in the consumer preference space $[\underline{\theta}, \bar{\theta}] \times [\underline{\gamma}, \bar{\gamma}]$. Fig. 1 shows the indifference curve and the consumer self-selection. For example, in Fig. 1a, consumers with a preference profile (θ, γ) in the lower left corner under the solid line will choose the product from firm 2, which is now seen serving the consumers that are the most price-sensitive, i.e., the ones who derive a (relatively) low utility from the service bundled with the product or the firm's recognition. Consumers in the upper right corner will choose the product from firm 1: they are willing to sacrifice price for better service and/or recognition levels. So, when the indifference curve is the solid line in Fig. 1a, the demand that firm 2 faces is the area to the left and below the solid line, firm 1 faces the demand to the right and above the solid line. Note that the value of φ determines the *slope* of the

[2] We use the shorthand notation $\mathbf{p}$, $\mathbf{S}$, $\mathbf{R}$ to mean the vectors (p_1, p_2), (S_1, S_2), (R_1, R_2).

[3] The substitutability between products comes from the fact that the utility function is additive in the service and recognition dimension. Such additive utility functions are common in models of vertical differentiation in the economics as well as the marketing literatures. When the nature of product substitutability changes, the form of the utility function changes. Hence, the results presented here may or may not hold.

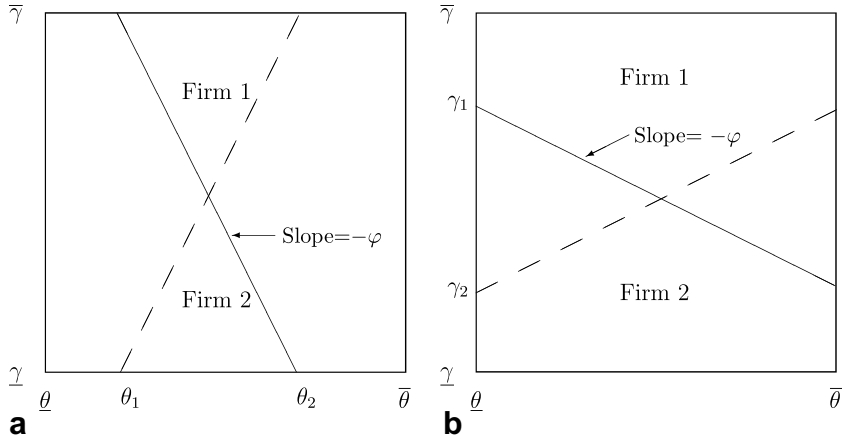

Fig. 1. Indifference curves and market segmentation: (a) service differentiation and (b) recognition differentiation.

indifference curve, whereas the price difference (weighed by the difference in recognition) determines the *location* of the indifference curve.

In Fig. 1a, the firms are mainly differentiated in the service dimension. The more vertical the indifference curve, the less the firms are differentiated in terms of recognition. When the indifference curve is completely vertical, there is no differentiation in the recognition dimension and the model reduces to a model of two-dimensional competition. Fig. 1b shows a market profile, where the firms are mainly differentiated in the recognition dimension. The flatter the indifference curve, the less the firms are differentiated in the service dimension. So, firms are mainly recognition differentiated when $|\varphi| < \frac{\bar{\gamma}-\underline{\gamma}}{\bar{\theta}-\underline{\theta}}$ and service-differentiated when $|\varphi| \geqslant \frac{\bar{\gamma}-\underline{\gamma}}{\bar{\theta}-\underline{\theta}}$. Solid lines display the case where the high-recognition firm also provides the highest service; dashed lines represent the case where the low-recognition firm provides the highest service. Note that in Fig. 1a, the demand for firm 1 falls on the left side and above the dashed curve; when the high recognition firm (firm 1) provides a low level of service, the consumers with a high value for service (high θ) and relatively low value for recognition (low γ) will choose the product from firm 2 which now provides the higher service.

Our equilibrium analysis of the three-stage model is based on the following assumptions:

Assumption 1. $\bar{\gamma} \geqslant 2\underline{\gamma}$. This assumption says that the amount of consumer heterogeneity in terms of recognition sensitivity is sufficiently high. Otherwise, recognition would not be a differentiating factor for the consumer's choice.

Assumption 2. $\min\{\alpha_1,\alpha_2\} \leqslant \alpha \leqslant \max\{\alpha_1,\alpha_2\}$ if $\varphi > 0$; or $\min\{\alpha_3,\alpha_4\} \leqslant \alpha \leqslant \max\{\alpha_3,\alpha_4\}$ if $\varphi \leqslant 0$, where the critical values of α are

$$\alpha_1 = -\bar{\theta} + 2\underline{\theta} + \frac{2\bar{\gamma}-\underline{\gamma}}{\varphi} \quad \text{and} \quad \alpha_2 = 2\bar{\theta} - \underline{\theta} + \frac{2\underline{\gamma}-\bar{\gamma}}{\varphi}, \qquad (2)$$

$$\alpha_3 = -\bar{\theta} + 2\underline{\theta} + \frac{2\underline{\gamma}-\bar{\gamma}}{\varphi} \quad \text{and} \quad \alpha_4 = 2\bar{\theta} - \underline{\theta} + \frac{2\bar{\gamma}-\underline{\gamma}}{\varphi}. \qquad (3)$$

Table 1
Key modeling assumptions and parameters

Key parameters	Modeling assumptions
Recognition cost: $g(R_j)$	$g(R_j)$ is fixed and quadratic
Service cost: $f(S_j)$	$f(S_j)$ is variable and linear
Per-unit service cost: α	α is not extreme
Consumer service sensitivity: θ	$\theta \in [\underline{\theta}, \bar{\theta}]$
Consumer recognition sensitivity: γ	$\gamma \in [\underline{\gamma}, \bar{\gamma}]$, $\bar{\gamma} \geqslant 2\underline{\gamma}$
Consumer distribution	Uniform over $[\underline{\theta}, \bar{\theta}] \times [\underline{\gamma}, \bar{\gamma}]$
Consumer utility: U	U is linear: $U = \theta S_j + \gamma R_j - p_j$

This assumption implies that the cost of providing service is not extreme. It ensures that in equilibrium neither firm has excessive market power.[4] In other words, the indifference curves cross both horizontal or vertical axes.

Table 1 summarizes our key modeling assumptions and parameters.

3. Price equilibrium under service differentiation

In this section, we derive the equilibrium prices $\mathbf{p}^* = (p_1^*, p_2^*)$ when the service and recognition levels, hence φ, are fixed, and firms are mainly differentiated in service. A formal analysis is first presented. Comparative statics are then conducted to see how the equilibrium prices are going to change with different parameters, such as service costs, service levels, and recognition levels.

For notational purpose, let θ_1 be the intersection of the indifference curve with $\gamma = \bar{\gamma}$ and θ_2 be that with $\gamma = \underline{\gamma}$, i.e. $\theta_1 = \frac{p_1-p_2}{S_1-S_2} - \frac{\bar{\gamma}}{\varphi}$ and $\theta_2 = \frac{p_1-p_2}{S_1-S_2} - \frac{\underline{\gamma}}{\varphi}$. Similarly, let γ_1 be the intersection of the indifference curve with $\theta = \bar{\theta}$ and γ_2 be that with $\theta = \underline{\theta}$. Hence, $\gamma_1 = \frac{p_1-p_2}{R_1-R_2} - \bar{\theta}\varphi$ and $\gamma_2 = \frac{p_1-p_2}{R_1-R_2} - \underline{\theta}\varphi$.

[4] If the cost of providing service is too high or too low, one firm becomes a dominant player and will grab most of the market. The other firm acts as a niche player that serves customers with extreme preferences. The detailed analysis of this scenario is studied in [2].

3.1. Formal analysis

From Fig. 1a, we can see that when $\varphi > 0$ the demand for firm 2 is equal to the area of the left trapezoid, and the trapezoid on the right represents the demand for firm 1 (when $\varphi < 0$, the left trapezoid becomes the demand for firm 1 and the right trapezoid the demand for firm 2). Under service differentiation, the indifference curve intersects both horizontal axes, so $\underline{\theta} \leqslant \theta_1 \leqslant \bar{\theta}$ and $\underline{\theta} \leqslant \theta_2 \leqslant \bar{\theta}$, then the demand for $\varphi > 0$ is computed as the area of the trapezoid:

$$D_2 = \frac{\bar{\gamma} - \underline{\gamma}}{2}(\theta_1 + \theta_2 - 2\underline{\theta}) \quad \text{and} \quad D_1 = D - D_2,$$

where $D \equiv (\bar{\theta} - \underline{\theta})(\bar{\gamma} - \underline{\gamma})$ is the *total demand*. Similarly, when $\varphi < 0$, the demand becomes

$$D_1 = \frac{\bar{\gamma} - \underline{\gamma}}{2}(\theta_1 + \theta_2 - 2\underline{\theta}) \quad \text{and} \quad D_2 = D - D_1,$$

Substituting the above demand functions into the profit functions $\Pi_j(\mathbf{p}, \mathbf{S}, \mathbf{R}) = (p_j - \alpha S_j)D_j$ (since the R_js are assumed fixed, they are *sunk costs* at this point), and solving the reaction functions, we can obtain the equilibrium prices.

Proposition 1.

(i) *When* $\varphi \geqslant \frac{\bar{\gamma} - \underline{\gamma}}{\bar{\theta} - \underline{\theta}} > 0$, *the price equilibrium is given by*:

$$p_1^* = \alpha S_1 + \frac{1}{6}(R_1 - R_2)[(\bar{\gamma} + \underline{\gamma}) + 2\varphi(2\bar{\theta} - \underline{\theta} - \alpha)], \tag{4}$$

and

$$p_2^* = \alpha S_2 + \frac{1}{6}(R_1 - R_2)[-(\bar{\gamma} + \underline{\gamma}) + 2\varphi(\bar{\theta} - 2\underline{\theta} + \alpha)]. \tag{5}$$

(ii) *When* $\varphi \leqslant -\frac{\bar{\gamma} - \underline{\gamma}}{\bar{\theta} - \underline{\theta}} < 0$, *the price equilibrium is given by*:

$$p_1^* = \alpha S_1 + \frac{1}{6}(R_1 - R_2)[(\bar{\gamma} + \underline{\gamma}) + 2\varphi(2\underline{\theta} - \bar{\theta} - \alpha)], \tag{6}$$

and

$$p_2^* = \alpha S_2 + \frac{1}{6}(R_1 - R_2)[-(\bar{\gamma} + \underline{\gamma}) + 2\varphi(\underline{\theta} - 2\bar{\theta} + \alpha)]. \tag{7}$$

The equilibrium prices yield the following equilibrium demands. For $\varphi > 0$:

$$D_1(\mathbf{p}^*, \mathbf{S}, \mathbf{R}) = \frac{\bar{\gamma} - \underline{\gamma}}{6}\left[\frac{\bar{\gamma} + \underline{\gamma}}{\varphi} + 2(2\bar{\theta} - \alpha - \underline{\theta})\right]$$

and when $\varphi < 0$:

$$D_1(\mathbf{p}^*, \mathbf{S}, \mathbf{R}) = \frac{\bar{\gamma} - \underline{\gamma}}{6}\left[-\frac{\bar{\gamma} + \underline{\gamma}}{\varphi} + 2(\bar{\theta} + \alpha - 2\underline{\theta})\right],$$

and $D_2(\mathbf{p}^*, \mathbf{S}, \mathbf{R}) = D - D_1(\mathbf{p}^*, \mathbf{S}, \mathbf{R})$.

3.2. Model implications

This section derives implications and gives insights on the results of our price equilibrium. We are mainly interested in the comparative statics, i.e., how do the model results change when some of the parameters are varied? The managerial implications of such variations are discussed. Table 2 lists the effects investigated and the respective figures.

Table 2
Comparative statics under service differentiation

Change	Effects on	Figure
Service cost (α)	Prices (p^*) and profit margins (np^*)	Fig. 2
Service differentiation (ΔS)	Profits (Π^*)	Fig. 3
Service differentiation (ΔS)	Demands (D^*)	Fig. 4
Service differentiation (ΔS)	Prices (p^*)	Fig. 5
Low service level (S_2)	Prices (p^*) and profit margins (np^*)	Fig. 6
Low service level (S_2)	Demands (D^*)	Fig. 7
Recognition differentiation (ΔR)	Profits (Π^*)	Fig. 8
Recognition differentiation (ΔR)	Demands (D^*)	Fig. 9

3.2.1. Effects of service cost

It can be seen from the above proposition that $\frac{\partial p_i^*}{\partial \alpha} > 0$; i.e., the optimal price increases with α. This is intuitive because as the cost of providing services increases, firms need to increase prices to recover the high cost. Fig. 2 shows this effect, where $S_1 = 9.6, S_2 = 1.8, R_1 = 9, R_2 = 5$, $\underline{\gamma} = 0.5, \bar{\gamma} = 2, \underline{\theta} = 1$, and $\bar{\theta} = 5$.

However, it is also worth looking at the unit profit margins $p_j - \alpha S_j$ when the service cost increases. For the high service provider (in our example this is firm 1), the net profit margin per unit denoted in the graph by np_1 is *decreasing*, whereas for firm 2 it is increasing. Firm 1 still has the higher net profit margin per unit (even under high service cost), but the extra premium it charges for the high service is slowly being eroded. The same phenomenon would occur when firm 2 is the high service provider ($\varphi < 0$). In that case, the net unit profit margin for firm 2 decreases under the high service cost, whereas firm 1's margin will increase. So, we conclude that it is always better to be the high service provider: per unit profit margin is high and (as we will demonstrate below) market share is higher as well. However, the advantage of being the high service provider decreases when service costs go up.

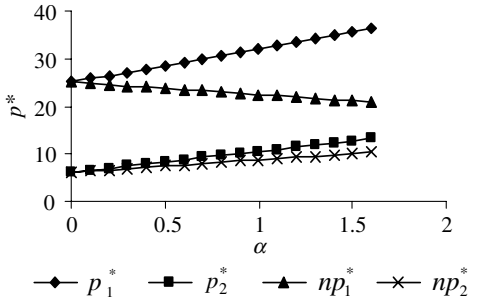

Fig. 2. Effects of service cost on prices.

3.2.2. Effects of service differentiation

Let us now investigate how profits, prices and market shares change under varying degrees of differentiation. It can be seen from the expressions of equilibrium prices and demands that a firm's optimal price and market share depend upon the difference in service levels (i.e. $\Delta S \equiv S_1 - S_2$) and the difference in recognition levels (i.e. $\Delta R \equiv R_1 - R_2$). Figs. 3–5 show how such quantities change under varying degrees of service differentiation ΔS.

Both profit functions are increasing with increasing service differentiation. It can be proven that both will increase monotonically. In fact, if we allow both firms to change their service levels, we would see that *in equilibrium* maximal differentiation would result: firm 1 chooses the highest possible service level and firm 2 chooses the lowest possible (but under the condition that $U = \underline{\theta} S_2 + \underline{\gamma} R_2 - p_2 \geqslant 0$, lest the market is not covered). This is consistent with the previous literature in vertical differentiation (see [11,19]). When the service differentiation decreases, the products of the two firms look more similar and the price competition increases, resulting in less profit for both. Figs. 4 and 5 disaggregate the profits into market shares and the price charged.

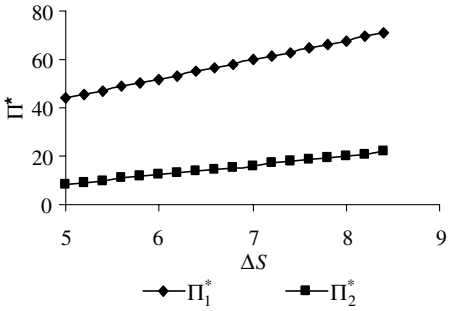

Fig. 3. Effects of service differentiation on profits.

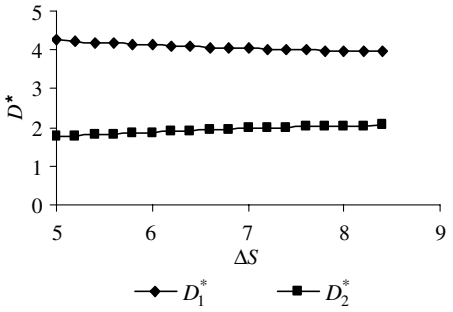

Fig. 4. Effects of service differentiation on demands.

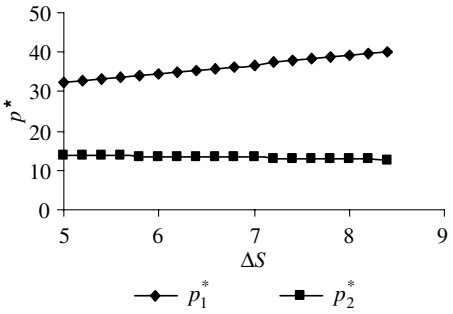

Fig. 5. Effects of service differentiation on prices.

We see from Fig. 5 that the high-service firm can charge a higher price when there is a bigger difference in service level between the two firms, but Fig. 4 indicates that its market share is falling, although profit is increasing. This means that firm 1 will increasingly concentrate on the less price sensitive customers who value service highly; firm 1's price increases but it is losing its most price sensitive customers to firm 2. With increasing service differentiation, firm 2 responds by *lowering* its price, thereby attracting firm 1's most price sensitive customers. Firm 2's increase in market share more than makes up its decrease in price, resulting in an overall increase in profits.

3.2.3. The adverse price effect of service

Now, let's assume that $\varphi > 0$. Holding the service of firm 2 (S_2) constant, we can show that $\frac{\partial p_1^*}{\partial S_1} > 0$, i.e., when firm 1 increases its service, its price *always* increases. But, an interesting phenomenon can occur when we look at what results when the low-service firm 2 increases its service, holding S_1 constant. At first sight it would seem that if a "better product" is being provided, the firm should be able to charge more for it. Under certain conditions, however, the *opposite* of this is true: providing better service may result in a *lower* price. Indeed, if we compute $\frac{\partial p_2^*}{\partial S_2}$, it turns out that

$$\frac{\partial p_2^*}{\partial S_2} = \frac{1}{3}(2\alpha - \bar{\theta} + 2\underline{\theta}).$$

The right-hand side of the above equation becomes negative when $2\alpha < \bar{\theta} - 2\underline{\theta}$, i.e. when the consumer heterogeneity with respect to service is relatively high compared to the cost of providing service. We call this the *adverse price effect*, and the reason for its existence is as follows. We know from Fig. 3 that when S_2 increases while S_1 remains fixed, profits for both firms will decrease as the price competition intensifies. But with high customer heterogeneity, when firm 2 increases its service, it will try to capture market share from firm 1, to wit firm 1's least service sensitive customers. In return, firm 1 will respond by aggressively cutting its price to retain those customers, thereby even gaining some new customers. Since firm 1's unit profit margin is (much) higher than firm 2's (see Fig. 2), firm 1 has more room to cut prices than firm 2. The only response firm 2 has against this aggressive price cut is to cut prices itself. This phenomenon occurs in our example when $\alpha < 2$. Figs. 6 and 7 show how the optimal prices and market shares change when the low service firm increases its service level. We used a value of $\alpha = 0.5$ for both figures, the other parameters retain the same values as before.

It can be checked that the same phenomenon occurs when $\varphi < 0$, but in this case firm 1 is the low service provider and with high customer heterogeneity firm 1's price

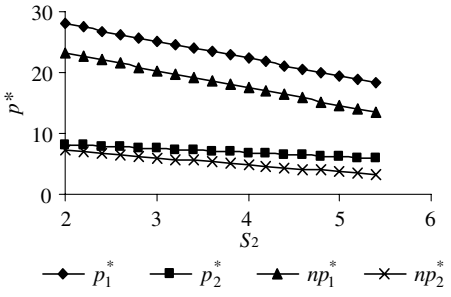

Fig. 6. The *adverse price effect* of service.

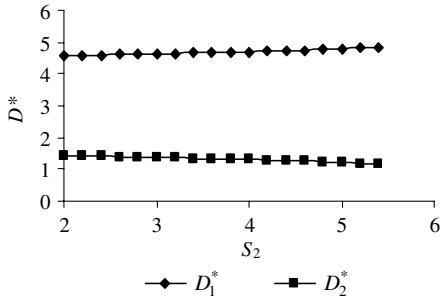

Fig. 7. Demands under the *adverse price effect*.

will decrease when it increases its service level. Note that this result holds about the *price*, not the per unit profit margin $(p_j - \alpha S_j)$, which will always decrease for an increase in service by the low service firm.

3.2.4. Effects of recognition differentiation

The effects of different degrees of differentiation in recognition when firms are mainly service-differentiated (i.e., $|\varphi| \geqslant \frac{\bar{\gamma}-\underline{\gamma}}{\bar{\theta}-\underline{\theta}}$) are displayed in Figs. 8 and 9.

Holding the service differentiation ΔS constant, Fig. 8 shows how the profits of both firms change when the difference in recognition changes. When compared to Fig. 3, we see that profits for both firms are increasing for small ΔR, but then top off and start going down. In other words, the principle of maximum differentiation will no longer hold in the recognition dimension: there is an optimal level of differentiation beyond which both firms will see a decrease in profits. In Fig. 8, such optimal level seems to occur for $\Delta R \approx 6$.

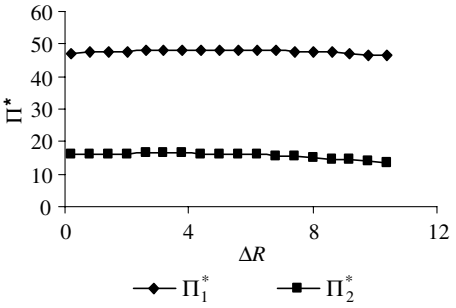

Fig. 8. Effects of recognition differentiation on profits when $|\varphi|$ is big.

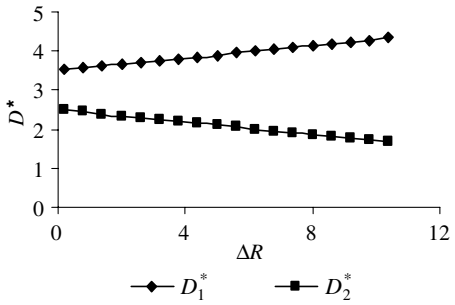

Fig. 9. Effects of recognition differentiation on demand when $|\varphi|$ is big.

It can be easily checked from Eqs. (4) and (5) that $\frac{\partial p_1^*}{\partial(\Delta R)} = -\frac{\partial p_2^*}{\partial(\Delta R)} = \bar{\gamma} + \underline{\gamma}$. In addition, there is no adverse price effect for recognition, i.e., if firm j increases its recognition level while the other firm's is kept constant, there always results a price increase.

4. Price equilibrium under recognition differentiation

Instead of service differentiation, firms can also choose to differentiate along the recognition dimension. When firms are mainly recognition differentiated, the indifference curve cuts across the recognition dimension twice, as shown in Fig. 1b.

4.1. Formal analysis

Since $\underline{\gamma} \leqslant \gamma_1 \leqslant \bar{\gamma}$ and $\underline{\gamma} \leqslant \gamma_2 \leqslant \bar{\gamma}$, $D_2 = \frac{\bar{\theta}-\underline{\theta}}{2}(\gamma_1 + \gamma_2 - 2\underline{\gamma})$ and $D_1 = D - D_2$. The equilibrium prices are summarized in the following proposition.

Proposition 2. *When* $-\frac{\bar{\gamma}-\underline{\gamma}}{\bar{\theta}-\underline{\theta}} \leqslant \varphi \leqslant \frac{\bar{\gamma}-\underline{\gamma}}{\bar{\theta}-\underline{\theta}}$, *the price equilibrium is given by*:

$$p_1^* = \alpha S_1 + \frac{1}{6}(R_1 - R_2)[2(2\bar{\gamma} - \underline{\gamma}) + \varphi(\bar{\theta} + \underline{\theta} - 2\alpha)] \tag{8}$$

and

$$p_2^* = \alpha S_2 + \frac{1}{6}(R_1 - R_2)[2(\bar{\gamma} - 2\underline{\gamma}) + \varphi(2\alpha - \bar{\theta} - \underline{\theta})] \tag{9}$$

The equilibrium demands in this scenario are given by:

$$D_1(\mathbf{p}^*, \mathbf{S}, \mathbf{R}) = \frac{\bar{\theta} - \underline{\theta}}{6}[2(2\bar{\gamma} - \underline{\gamma}) + \varphi(\bar{\theta} + \underline{\theta} - 2\alpha)]$$

and

$$D_2(\mathbf{p}^*, \mathbf{S}, \mathbf{R}) = \frac{\bar{\theta} - \underline{\theta}}{6}[2(\bar{\gamma} - 2\underline{\gamma}) - \varphi(\bar{\theta} + \underline{\theta} - 2\alpha)].$$

4.2. Model implications

Most of the results discussed under the scenario of service differentiation hold true for the recognition differentiation with two important exceptions. First, Fig. 10 displays the profits of the firms under increasing service differentiation. It is clear that profits *decrease* for both firms, which

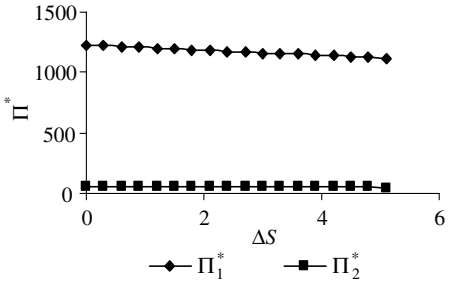

Fig. 10. Effects of service differentiation on profits when $|\varphi|$ is small.

means that in equilibrium the result will be *minimum differentiation* in service, i.e. $S_1 = S_2$. This does not mean that firms will not differentiate, but that they have decided to differentiate in the recognition dimension rather than in the service dimension. Again, this result is consistent with the previous literature on vertical differentiation (see [20]).

Another important distinction is that the *adverse price effect of service* is no longer present. Mathematically, it can be easily checked that $\frac{\partial p_j^*}{\partial S_j} > 0$, so an increase in service provided always translates into a higher price (but not necessarily a higher unit net profit margin $p_j - \alpha S_j$). However, the adverse price effect of recognition is now *always* present: an increase in recognition for the low recognition firm (firm 2) *always* translates into a price reduction. Indeed, it can be checked that $\frac{\partial p_1^*}{\partial R_1} > 0$, but $\frac{\partial p_2^*}{\partial R_2} < 0$. The reason is that now the firms mainly differentiate in recognition, so when the lower recognition firm tries to "invade" the higher recognition territory, the high recognition firm retaliates with an aggressive price cut (of magnitude $2(2\bar{\gamma} - \underline{\gamma})$).

For the rest, it can be checked that the following hold:

- Both prices increase when the difference in recognition levels increases;
- An increase in per unit service costs (α) results in higher prices; and
- An increase in customer heterogeneity in the recognition dimension increases the market share of the high recognition firm more than the market share for the low recognition firm.

In the e-tailing industry, prices are easy to adjust. However, it takes time before the (perception of) increased service levels take hold. Recognition building, e.g., by advertising, takes time as well. A complete model would take the decision of service and recognition levels as endogenous, and we think that this is a promising avenue for future research. Nevertheless, when e-tailers are faced with a constant service and recognition level, our analysis should provide them with the necessary tools to support their pricing decisions in the short term.

5. Managerial implications and conclusion

Online shopping search engines have awarded consumers the capability to find most e-tailers that sell a specified product, compare product prices, and review detailed store ratings. In this context, it is difficult for online retailers to attract and retain customers. Price as well as non-price factors such as e-service quality and brand recognition together contribute to the decision of making an online purchase. In this paper, we develop a game-theoretic model in which two firms compete in recognition, service quality, and price. We solve the model analytically and obtain closed-form equilibrium solutions. To the best of our knowledge, this is the first attempt to extend the vertical differentiation model to a three-dimensional setting.

In the e-tailing industry, firms can mainly compete in price, service and recognition. Our analysis shows that when the e-tailers are mainly differentiated in service, then the firm(s) providing the highest service is in the best position: per unit profit margins, demands and overall profits are better than for the low service firm. However, an important lesson from our analysis is that if a firm is not in this enviable position, it is best *not* to try to join the other firms. Not only will the heightened price competition result in lower profits for both firms, but the low service firm will be hurt most. We outline that in conditions, where the cost of providing service is relatively low compared to the customer's heterogeneity for service, even an adverse price effect may result, i.e. the same product bundled with an improved service level may result in a lower sales price! This may be particularly relevant for the e-tailing industry, where the costs of providing service are relatively low and when the product for sale is a specialty item, i.e., when both price-sensitive as well as price-insensitive (or service-sensitive) customers are present, this adverse price effect may occur.

If the firms are not very much differentiated in the service dimension, but differ a lot in recognition, then it is not worthwhile to attempt to increase the differentiation in service. Our analysis suggests that it would be better to have *minimum service differentiation* in that case, and it would be best for both firms to retain a big difference in recognition. The low-recognition firm will then get the most price sensitive customers and the high-recognition will get the most recognition-sensitive customers. Again, the most enviable position is to be the high-recognition firm, since profits, demands and prices are higher than for the low-recognition firm. In addition, it would be self-destructive for the low-recognition firm to invest its money in attracting higher recognition. The resulting increase in price competition would be detrimental to both firms, but the low-recognition firm will be hurt more than proportionally. The reader may recall our assumption of independence between recognition and service, but our analysis shows how the e-tailers' *optimal decisions* in the two-dimensions become *interdependent*.

We think that in the e-tailing industry, it is easier to adjust service than recognition. When providing higher service, it will not take long before this would translate in improved customer feedback which can be used by potential customers to make a purchase decision. However,

increasing recognition will take longer, since it involves advertising, etc. to attract increased traffic to your Web site. Hence, when service decisions are shorter term than recognition decisions, our analysis would prescribe that:

- When currently faced with higher service differentiation than recognition differentiation, firms should continue to differentiate in the service dimension. When no more differentiation is possible, they should switch to recognition differentiation, but only to a certain extent. This follows from Figs. 3 and 8, where it is clear that the increase in service differentiation has a bigger impact on profits than an increase in recognition differentiation.
- When currently faced with higher recognition differentiation, firms should forget about service differentiation and just attempt to mimic the other's service level. Firms get most out of their investment if they continue to differentiate in the recognition dimension (see Fig. 10 for an illustration).

There are several possible directions for future research. The assumption of non-extreme service cost may be limiting. If this is not the case, the indifference curve will cut both the horizontal and the vertical line. The demand for each firm will become a triangular area, and equilibrium results may be significantly altered. Second, we have considered only the duopoly competition. It would be an interesting exercise to extend the analysis to an oligopolistic setting under quality and recognition differentiation. Finally, equilibrium results from our model need to be validated by collecting field data using online shopping search engines.

Appendix A

The appendix provides proofs of propositions.

Proof of Proposition 1. We can simplify the first-order conditions to obtain the following reaction functions

$$p_1(p_2,\mathbf{S},\mathbf{R}) = \frac{1}{4}[2p_2 + 2\alpha S_1 + 2(S_1 - S_2)\hat{\theta} + (R_1 - R_2)(\bar{\gamma} + \underline{\gamma})],$$

and

$$p_2(p_1,\mathbf{S},\mathbf{R}) = \frac{1}{4}[2p_1 + 2\alpha S_2 - 2(S_1 - S_2)\check{\theta} - (R_1 - R_2)(\bar{\gamma} + \underline{\gamma})],$$

where $\hat{\theta} = \bar{\theta}$ and $\check{\theta} = \underline{\theta}$ when $\varphi > 0$; or $\hat{\theta} = \underline{\theta}$ and $\check{\theta} = \bar{\theta}$ otherwise. The equilibrium prices can be obtained by solving the linear equations of the reaction functions. The expression to compute the demand assumes that the area is a trapezoid, so it is required that $\underline{\theta} \leqslant \theta_i \leqslant \bar{\theta}$, $i = 1,2$, which, after some algebra, reduces to: $\alpha_1 \leqslant \alpha \leqslant \alpha_2$ if $\varphi > 0$ or $\alpha_3 \leqslant \alpha \leqslant \alpha_4$ if $\varphi < 0$. □

Proof of Proposition 2. Substituting the demand functions into the objective and simplifying the first order conditions, we get the reaction functions:

$$p_1(p_2,\mathbf{S},\mathbf{R}) = \frac{1}{4}[2p_2 + 2\alpha S_1 + 2(R_1 - R_2)\bar{\gamma} + (S_1 - S_2)(\bar{\theta} + \underline{\theta})],$$

and

$$p_2(p_1,\mathbf{S},\mathbf{R}) = \frac{1}{4}[2p_1 + 2\alpha S_2 - 2(R_1 - R_2)\underline{\gamma} - (S_1 - S_2)(\bar{\theta} + \underline{\theta})].$$

Equilibrium prices are obtained by solving the above equations simultaneously. Finally $\underline{\gamma} \leqslant \gamma_i \leqslant \bar{\gamma}$, $i = 1, 2$, imply $\alpha_2 \leqslant \alpha \leqslant \alpha_1$ if $\varphi > 0$ or $\alpha_4 \leqslant \alpha \leqslant \alpha_3$ if $\varphi < 0$. □

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