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Online Personalization And Information Sharing Under Horizontal Relationship

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ABSTRACT

Customer preference information is of great importance for vendors to carry out price discrimination and targeted marketing. Advanced Internet technologies, especially web 2.0 and web-economy, have been provided accessibility and allowed vendors to acquire these information by the user-community and online personalization technologies. This study investigates an information market where the complementary firm pays to the vendor to indirectly acquire the customer preference information, which could be costly to acquire. We develop an economic model to examine vendor's optimal information acquisition and sharing strategies under horizontal relationship under different payment formats of the complementary firm (i.e. fixed-fee or service-rate payment). We show that both payment formats improve the basic personalization service, and the basic personalization service is equal under two payment cases, but the extra personalization service under fixed-fee payment is higher than that under the service-rate payment. Nevertheless, the vendor's equilibrium benefits are improved with information sharing under both payment formats. Moreover, although the complementary firm would get zero benefits under fixed-fee payment and positive benefits under service-rate payment, the customer preference information can be acquired under both cases. Our findings not only help researchers interpret why the vendors implement information sharing strategies, but also assist practitioners in developing better social commerce and cooperation strategy. The implications of this paper can shed light on how firms interact under horizontal relationship where a vendor possesses information superiority.

Keywords: personalization service, information sharing, complementary firm, horizontal relationship, privacy concerns

INTRODUCTION

Complementary products are those for which a customer's utility from using both of them together is greater than the sum of the utilities that he or she would have received from using each product separately [2] . Complementary relationships frequently arise in many industries. For example, the demands for home appliances are highly related to the home decorations. In fact, when customers buy the home appliances, the home decoration is also considered. This is because more utilities can be obtained from the combination of these two complementary products. Other examples of complementary products include the relationship between the iPhone and AT&T, computer hardware and software, etc.

It has been widely recognized that customer preference information (CPI) is of great importance for vendors. In fact, the importance of customer preference information can be reflected in two aspects. On the one hand, this customer preference information can be used to design, innovate and improve products characteristics among complementary vendors in reality and can also be applied to carry out price discrimination and targeted marketing. On the other hand, through sharing the acquired information, a vendor can strategically influence its complementary firm's behavior [16] under horizontal relationship.

Advanced Internet technologies, especially web 2.0 and web-economy, have provided an accessibility and allowed vendors to offer online personalization (e.g. toolbars, DIY, The build-in, etc) to interact with customers to acquire CPI. Personalization, as a key interactive marketing strategy, is widely used in marketing areas. Imagine a vendor who becomes better informed of customer preference information through advanced network, user communities, online recommendation services, text mining technologies and online personalization technologies, etc. [20] [27] [41] [44] [45] . When the vendor uses the personalization service to acquire CPI for his own products, because of negligible cost of acquiring information based on these technologies, he may have the ability to simultaneously acquire this information for its complementary firm. Nevertheless, corresponding complementary firm may lack the necessary expertise and resources, and because of building a social platforms or interactive-community may bear an enormous one-time investigate which cannot afford especially for many small and medium-sized emerging enterprises. Therefore, these firms may only use the traditional acquiring technologies (e.g. E-mail, Phone, fax, etc). For instance, Haier, as a famous household appliances vendor in China, sponsors the Casarte Community （www.casarte.cn/jzxjd.php） and interacts with customers. The other example is Siemens which constructs the Built-in community （diykitchen.siemens-home.cn） to acquire customer preference information. Both of communities simultaneously offer the services of home appliances and home decorations for customers. When customers participate in the community and use the personalization services, his or her preference information can be disclosed. This disclosed information includes not only the preference for household appliances （e.g. Haier or Siemens）, but housing-decoration which is most important for the complementary firms (e.g. housing-decoration firm or housing-design firm). In addition, many housing-decoration firms have realized that they are less informed about this preference information than the vendor （e.g. Haier or Siemens）. It is intuitive that if the vendor shares this information to its complementary firm, the extra payoff and higher satisfaction may be obtained from combination products, and that if these complementary firms acquire these preference information, R&D costs may be reduced and higher competitive advantage can be obtained. Consequently, it is wise for complementary firms to acquire this preference information shared by the vendor.

Considering the importance of customer preference information and the practice of information management under horizontal relationship, it is indispensable for firms to investigate the influence mechanism of information acquisition and sharing. However, to the best of our knowledge, few theoretical works have considered the possibility that there is an information market including a vendor who possesses information superiority and a complementary firm who lacks necessary customer preference information; that cooperation can exist between two firms under horizontal relationship; and that sharing modes may affect the firm's acquisition strategies and benefits. Our research bridges between the theoretical and practical gap by proposing a complementary-service model. In this model, the vendor offers online personalization service to acquire customer preference information. And the complementary firm pays to the vendor to share this information. Through this model, we investigate the economic effects and payoff implications of both the vendor and the complementary firm under horizontal relationship. We address several questions that have not been analyzed in the literatures.

RQ1: How many personalization services should be offered by the vendor?
RQ2: How do patterns of payment affect the vendor's acquisition strategies and benefits?
RQ3: Which patterns of payment should be adopted and implemented by complementary firm?

To answer these questions, we first consider two simple cases that each of firms acquires customer preference information alone. Taking these cases as the benchmark, we then investigate the case where the complementary firm pays to the vendor in two payment formats (fixed-fee or service-rate payment) to acquire preference information. In addition, under two payment formats, we respectively discuss how both payment formats affect the vendor's acquisition strategies, in other words, how many personalization services should be offered in equilibrium, and how the strategies of payment influence the firms' benefit. Moreover, we examine the equilibrium payoff for the complementary firm. Finally, through comparing the equilibrium results of two cases, we propose some interesting and optimal strategies for both firms.

This paper makes three main contributions. First, we have developed a simple micro-model of customer utility for personalization service and preference information. Second, we identify the information trade-off faced by a vendor and a complementary firm. Finally, we have used this model to demonstrate how the payment formats affect firm's optimal information acquisition strategies and equilibrium benefits.

The remainder of this study is organized as follows. In §2, we review and analyze the relevant literature. We describe the model to capture the interaction between the vendor and the complementary firm in §3. In §4, we present some preliminary results. The analysis of fixed-fee payment is addressed and the effects of service-rate payment case is further discussed in §5. In §6, we discuss the limitations and management implications. The last section concludes the paper and identifies potential directions for future research. All proofs of results are elaborated in the appendix.

LITERATURE REVIEW

This study is related to the research on personalization, which have been extensively studied in recent years. The related personalization literature examines effects such as interactive marketing [32] [34] [35] [42], Customer Relationship Management [23], consumer responses and behavior [25] [21], E-commerce [5] [24] [26], user communities [44] etc. A comprehensive review of online personalization can be found in [36], which presents a framework for personalization by taking an interdisciplinary approach in the management sciences and many interesting research directions in the interactions between a firm and other key players are proposed. Under the direction of this framework, [9] starts with an empirical study on personalization versus privacy. They pointed out that customers are willing to disclose their personal information in exchange for some economic or social benefits. Considering the privacy concerns, (Chellappa 2007) uses a formal economic model to demonstrate that the entire market is better off when both privacy contracts and usage enforcement are allowed by the regulator. [10] examines vendor strategies in a market where consumers have heterogeneous concerns about privacy. [33] demonstrate how cultural and generational influences on privacy concerns empirically. [37] propose a methodology that systematically considers privacy issues by using a step-by-step privacy impact assessment. By contrast to this stream of research on privacy concerns and personalization, this study extends the literature to a horizontal relationship between a vendor and a complementary firm and theoretically investigates effects of firms' information acquisition and sharing strategies.

This study is also closely related to the literature on information acquisition. Recently, the research of information acquisition mainly includes: economic perspective [3] [14] [15], operation research [12] [19] [30] [31], etc. Comparing these literatures of information acquisition, however, with the help of advanced network technologies (e.g. by using toolbar or sidebars to offer and design personalization services) to acquisition customer preference information is relatively new and important for management practice. Interacting with customers by effective personalization strategies, vendor not only increases its bargaining power [36], but also benefits itself through information sharing. Therefore, this study mainly focuses on online information acquisition through effective personalization technologies under horizontal relationship, to best of our knowledge, which is relatively new in the research of information acquisition.

Another closely related literature stream is information sharing. Most literatures of information sharing appear in supply chain management. For example, value [22] [28] [46], competition [18] [29], trust [38], pricing and profits [13]. Many theoretical literatures of information acquisition demonstrate the benefits between upstream and downstream in supply chain management. [16] [17] show that the downstream retailer can be hurt by information sharing, but benefit the upstream vendor in a vertical

relationship. However, there are few studies that demonstrate the information sharing under horizontal relationship. Based on the product attribute and inter-enterprise cooperation, horizontal relationship is different from the vertical relationship in supply chain. In contrast, we examine information sharing from a vendor to its complementary firm under horizontal relationship. The complementary firm may prefer to acquire information, even if it is costly, because he cannot acquire the customer preference information by himself. Moreover, we examine how information sharing affects the vendor's information acquisition strategies and benefits.

THE MODEL

To explore the efficacy of information acquisition strategies and patterns of payment, we consider a stylized model with two players: a vendor *M* who provides two associated personalization services to acquire customer preference information, and a complementary firm *C* who pays to obtain the customer preference information from vendor's personalization service. We intend to investigate a three-period game where the complementary firm proposes a contract for information sharing modes, then the vendor observes the contract and accepts it and determines the personalization service to offer for customers, finally the CPI can be acquired and shared to the complementary firm. In this game, customers freely use the personalization service, disclosing his or her personal and preference information under privacy concerns. We assume that both of firms are risk neutral and maximize benefits. Therefore, there are three possible scenarios as detailed below and illustrated in Figure 1.

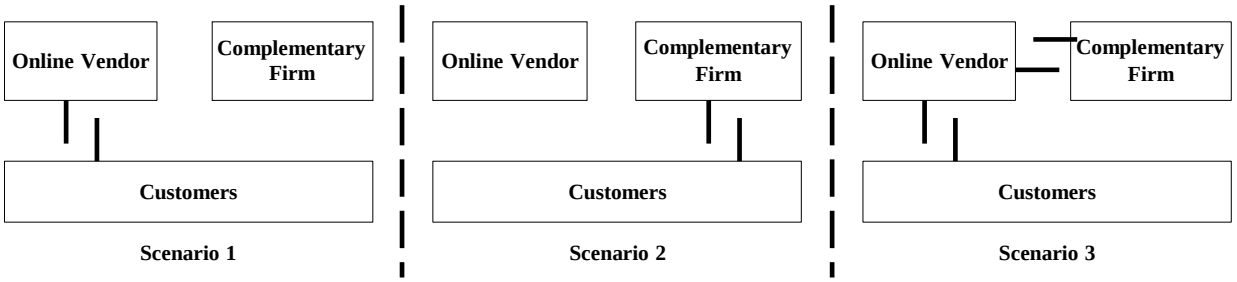

Figure 1. A model with one vendor and one complementary firm

Without loss of generality, we assume

1. Scenario 1 — Vendor offers online personalization service S_1 for customers to acquire CPI alone.
2. Scenario 2 — Complementary firm uses the traditional technologies or services S_2 to acquire CPI alone.
3. Scenario 3 — Vendor simultaneously offers personalization services $S_1 \& S_2$ to customers to acquire CPI. Complementary firm indirectly gets CPI from vendor offered online personalization service S_2.

Scenario 1 & 2 are similar to the advertiser-portal model in [8] in terms of personalization and privacy, but they differ in that we focus on efficacy of information acquisition strategies and patterns of payment for two players under horizontal relationship. Scenario 3 is relatively innovative to the literatures. Therefore, in order to reveal the trade-off between the vendor and complementary firm, we take the Scenario 1 & 2 as a benchmark model.

We assume Scenario 2 that is mainly based on the two considerations. On the one hand, firms build an online interactive platform , all the resources, service and management may be integrated in this huge systems and may need an enormous one-time investigate which cannot afford. On the other hand, based on the consideration of complementary relationship, the complementary firm (e.g. small software enterprise and housing-decoration firm or housing-design firm), especially for many small and medium-sized emerging enterprises, can use the brand influence of vendor (e.g. Dell and Haier) to increase its competitiveness.

To describe the customers' complementary preference, we adopt the framework of complementary products established by [11] [39]. This framework reveals quantity of demands. In our model, the vendor uses online personalization technologies to acquire CPI depending on how many such services can be offered and how much information is disclosed by customers. According to [7], this service-information mapping is given by $g^{-1}(I) = S$, where I is customer's preference information, S is the online personalization services and $g^{-1}(\cdot)$ is the current state of personalization technologies. To make the model and analysis simple, we assume a unit of information leads to a single unit service (i.e. $I = S$). Meanwhile, from [10], customer's utility submits to an inverted U-shaped function in personalization service. The vendor offers two online personalization services $S_1 \& S_2$ ($S_1 > 0, S_2 > 0$). Note that the basic personalization service S_1 is used to acquire CPI for vendor himself, and the extra personalization service S_2 for complementary firm. We assume that $P_C (P_C > 0)$ is the marginal value for personalization service and $r_C (r_C > 0)$ is the privacy cost coefficient of customer. Thus, a customer's utility function from using personalization service can be represented as

$$U_C(S_1, S_2) = P_C(S_1 + S_2) - r_C(S_1^2 - KS_1S_2 + S_2^2) \qquad (1)$$

Where $K(0 \le K \le 1)$ measures the degree to which personalization services are complement. If parameter $K = 0$, the two personalization services are independent to each another. If $K = 1$, the two personanlization services are perfect complements. This structure of customer utility function has been widely utilized in economics, marketing, and operations management literature e.g. [1] [4] [43]. It is worth noting that the cross product S_1S_2 represents the complementarity of two personalization services corresponding products. When vendor adds the associated personalization service into its basic service, there is spillover effect emerging from the cross-product term for the customers of combination of personalization services, which leads a higher utility for customers. This spillover effect, however, may also lead customers to disclose more customer preference information and thus induce higher privacy cost.

From the customer's utility function (1), we calculate its bordered Hessian, due to $0 < K < 1$, we have $H = r^2(2-K) > 0$, and $U_{S_1S_1} = -2r < 0$. Therefore, there is a local maximum value in this function. Moreover, the point (S_{1C}^*, S_{2C}^*) is a local maximum. Thereby, the customers' optimal service level would be $S_{iC}{}^* = \frac{P_{iC}}{r_{iC}(2-K)}(i = 1, 2)$, note that ratio $\frac{P_{iC}}{r_{iC}}$ which reveals a customer's characteristic using the online personalization service and is a quanlitiative repersentation of the behavioral construct privacy calculus(see Chellappa & Shivendu, 2006). We consider a market of customers whose two ratios $\frac{P_{iC}}{r_{iC}}$ for two kinds of personalization service $S_1 \& S_2$ are uniformly distributed, i.e. $\frac{P_{1C}}{r_{1C}} \approx U[0, a]$ and $\frac{P_{2C}}{r_{2C}} \approx U[0, b]$, respectively. Consequently, the two customers' optimal service levels are specifically distributed as $S_{1C}^* \approx U[0, \frac{a}{2-K}]$ and $S_{2C}^* \approx U[0, \frac{b}{2-K}]$, respectively. Due to privacy concerns, the online personalization service levels used by customers are not more than theirs optimal levels,（i.e. $S_{iC} \le S_{iC}^*$）. In a word, a rational vendor would never offer services greater than optimal service level S_{iC}^* as no customer would find it optimal to use services beyond this level.

This study deals with customer preference information, which the vendor can acquire through personalization services and share to its complementary firm. However, complementary firm should pay to the vendor to get this useful information. The complementary firm usually chooses between two payment formats (fixed-fee or service-rate) in reality. There are numerous examples of fixed-fee & service-rate pricing for information good e.g. long-distance telephone markets, advertising expense, anonymous text markets, internet services, etc. This represents situations where the vendor has superior access to service fit customer's preference, so the firms' ability for information acquisition is asymmetric.

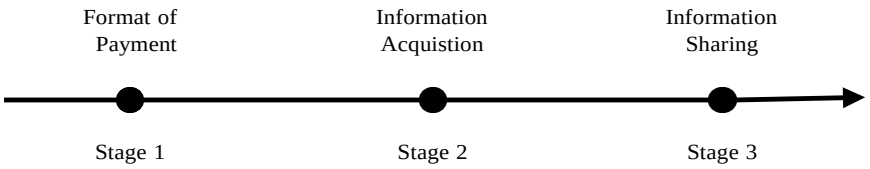

Figure 2. Timing of the Model

The timing of the game for a decision cycle is shown in Figure 2. In the first stage, the complementary firm provides a contract to the vendor about the formats of payment and expenses of information sharing (i.e. fixed-fee T or service-rate α). Namely, the format of payment is adopted by complementary firm to get the useful CPI through the personalization service S_2 offered by the vendor. Observing the payment contract (i.e. fixed-fee & service rate) in the second stage, the vendor determines whether or not to accept the contract. If the complementary firm proposes a contract and the vendor accepts it, then the vendor should decide how many personalization services S_2 to offer to acquire the CPI for the complementary firm. Note that the vendor, on the one hand, should balance the benefit from the basic services and extra services and the cost for offering $S_1 \& S_2$. On the other hand, considering the complementarities of customer demands, the vendor should coordinate the two associated personalization service $S_1 \& S_2$ to maximize its benefit. In other words, the vendor would like to get more information disclosed by customers. Therefore, the vendor should balance both his own interests and complementary firm's

interests in this stage and simultaneously decide the optimal personalization service level S_1 & S_2 . Both firms' benefit function will be provided in Preliminaries section. In the third stage, the vendor would share the acquired information with the complementary firm according to the contract signed in the first stage, and then the trade-off is achieved. The complementary firm may then update its belief about the customer's demand and assess the value of acquired information. To solve the game, we use backward induction to insure sub-game perfection. A summary of the model notation is presented in Table 1.

Table 1. Summary of Model Notations

Notation	Explanation
P_C	Customer's marginal value for personalization services
K	Complementarities of two personalization service
S_{iC}^{*}	Optimal service level used by customers(*i=1,2*)
r_C	Customer privacy cost coefficient
$U_C(S_1, S_2)$	Customers' utility from personalization service
S_1	The basic personalization service which can be used to acquire CPI for the vendor
S_2	The complementary personalization service which can be offered by the vendor and used to acquire CPI for complementary firm
C	Acquiring cost for the complementary firm by itself
T	Fixed-fee payment for the complementary firm
α	Service-rate payment for the complementary firm
β	The vendor's cost coefficient offering personalization service
$f(S_{iC}^{*})$	The customer's marginal distribution density
S_1^N	The personalization service level without information sharing
π_M^N	The vendor's benefit without information sharing
S_i^F	The personalization service level under the fixed-fee payment(*i=1,2*)
Π_j^F	The firm's benefits under the fixed-fee payment(*j=M,C*)
S_i^V	The personalization service level under service rate payment(*i=1,2*)
Π_j^V	The firm's benefits under the service rate payment(*j=M,C*)

BENCHMARK MODELS

Before we begin the main analysis, let us consider two benchmark cases. The first one presented in Scenario 1 is that vendor offers online personalization service S_1 to customers to acquire CPI alone. The customer's utility function is reduced as $U(S_1, P) = PS_1 - rS_1^2$. In absence of personalization service S_2 (i.e. $S_2 = 0$), since $\frac{P_{1C}}{r_{1C}} \approx U[0, a]$, the optimal personalization service level used by the customer would be $S_{1C}^* = \frac{P_{1C}}{2r_{1C}}$. Therefore, we have $S_{1C}^* \approx U[0, \frac{a}{2}]$ and distribution density $f(S_{1C}^*) = \frac{2}{a}$. The vendor's benefit function can be expressed as $\pi_M^N = R_1(\int_0^{S_1} S_{1C}^* f(S_{1C}^*) dS_{1C}^* + \int_{S_1}^{\frac{a}{2}} S_1 f(S_{1C}^*) dS_{1C}^*) - \beta S_1^2$, where β represents vendor's cost coefficient offering personalization service. The optimal personalization service offered by vendor would be $S_1^N = \frac{aR_1}{2R_1 + 2a\beta}$. Thus, there is no information sharing and in equilibrium the vendor's benefit is given by $\pi_M^N = \frac{aR_1^2}{4(R_1 + a\beta)}$.

The second benchmark case presented in Scenario 2 arises when the complementary firm acquires information through traditional service technologies S_2 (e.g. marketing surveys, purchase, developing data-mining or scientific management software packages, etc), because of building a social platforms or interactive-community may bear an enormous one-time investigate which cannot afford especially for many small and medium-sized emerging enterprises. There are two realistic and interesting awkward situations faced by between customers and the complementary firm. From a customer perspective, following the privacy calculus theory, if the utility obtained from S_2 is less than or equal to the privacy cost in this information exchange (i.e. $U \leq 0$), none of customer would like to disclose the preference information to the complementary firm. Therefore, the information-service trade-off would not be arisen.

From a complementary firm perspective, if the complementary firm wants to acquire information by himself, a number of expenses should be entailed. Therefore, even though the customer preference information is very significant, the complementary firm would have to be forced to abandon acquiring information under the exorbitant costs C .

As a result, we assume no information would be also acquired by the complementary firm in Scenario 2. It is also clear that from these perspectives the information value is zero for the complementary firm (i.e. $\pi^N = 0$). It is wise for the complementary firm to develop new channels to acquire CPI. For example, many customers would be reluctant to disclose their preference information to one firm in real estate industries, but be willing to disclose preference information to other real estate mediums. As a consequence, considering the complementarities of products or services and the limitation of resources, the complementary firm turns to information superiority of the vendor to acquire information indirectly. This Scenario will serve as the benchmark against which compare the acquiring cost to the complementary firm's payments (i.e. $C > T$ & $C > \alpha S_2$) to acquire customer preference information in Scenario 3.

ANALYSIS AND RESULTS

Vendor and Complementary Firm Benefits

In our model, there are no direct monetary payments from the customers. However, when customers use the personalization service offered by the vendor and disclose their preference information, the firms can derive value from this information. According to the previous studies (see Chellappa & Shivendu, 2007, 2010), customer information is acquired from two segments, the privacy seekers who are the most privacy-sensitive customers and the convenience seekers who are the least privacy-sensitive customers. To get the CPI from the vendor, the complementary firm may choose to simply pay the vendor the deterministic, pre-specified price T ($T > 0$) or pay the vendor according to service-rate α ($\alpha > 0$). We use the superscripts *F* and *V* to denote the corresponding fixed-fee payment and service-rate payment, respectively, throughout this paper. We assume that other coefficients are common knowledge for firms.

If the vendor offers personalization service S_1 & S_2 to customers, we model the vendor and complementary firm's benefits function in these two different cases. Under the fixed-fee payment, the vendor's benefit can be expressed as

$$\Pi_M^F = R_1(\int_0^{S_1} S_{1C}^* f(S_{1C}^*) dS_{1C}^* + \int_{S_1}^{\frac{a}{2-K}} S_1 f(S_{1C}^*) dS_{1C}^*) - \beta\left(S_1^2 + S_2^2\right) + T \quad (2),$$

and the complementary firm's benefit can be expressed as

$$\Pi_C^F = R_2(\int_0^{S_2} S_{2C}^* f(S_{2C}^*) dS_{2C}^* + \int_{S_2}^{\frac{b}{2-K}} S_2 f(S_{2C}^*) dS_{2C}^*) - T \quad (3).$$

Under the service-rate payment, the vendor's benefit can be expressed as

$$\Pi_M^V = R_1(\int_0^{S_1} S_{1C}^* f(S_{1C}^*) dS_{1C}^* + \int_{S_1}^{\frac{a}{2-K}} S_1 f(S_{1C}^*) dS_{1C}^*) - \beta\left(S_1^2 + S_2^2\right) + \alpha S_2 \quad (4),$$

and the complementary firm's benefit can be expressed as

$$\Pi_C^V = R_2(\int_0^{S_2} S_{2C}^* f(S_{2C}^*) dS_{2C}^* + \int_{S_2}^{\frac{b}{2-K}} S_2 f(S_{2C}^*) dS_{2C}^*) - \alpha S_2 \quad (5).$$

Where R_1 & R_2 represent the vendor and complementary firm's marginal value for customer preference information, respectively; function $f(S_{iC}^*)$ represents the customers' marginal distribution density. Note that the two customers' optimal service levels are uniformly distributed as $S_{1C}^* \approx U[0, \frac{a}{2-K}]$ and $S_{2C}^* \approx U[0, \frac{b}{2-K}]$, we have distribution density given by $f(S_{1C}^*) = \frac{2-K}{a}$, and $f(S_{2C}^*) = \frac{2-K}{b}$, respectively. Based on [40] which observes a unique feature of information goods, namely near-zero or zero marginal production cost, we assume that the vendor's production cost for offering online personalization service is zero and β represents the vendor's cost coefficient such that the net costs are quadratic convex in the total amount of services offered. These costs reveal the vendor's cost for collecting, storing, protecting, and transmitting the information. Noting that (2) & (4), the first term represents the value the vendor derives from the information obtained collectively from the customers, where the first integral formula indicates the amount of information disclosed by the privacy-seekers and the second integral formula for convenience-seekers. The second term represents the total cost for offering the personalization service S_1 & S_2. The third term represents the extra income from the complementary firm's payment.

We investigate how the vendor's equilibrium acquiring strategies (i.e. S_1 & S_2) and information benefits are influenced by the complementary firm's payment strategies (i.e. T & α). We start with the fixed-fee payment when the complementary firm pays to acquire information from the vendor. Then, we derive the vendor's equilibrium effects under service-rate payment. In each case, we also investigate how the complementarity K and cost coefficient β affect the vendor and complementary firm's benefits and the vendor's acquiring strategies.

Fixed-Fee Payment

We first start analysis with the scenario 3 when the fixed-fee payment is adopted by the complementary firm to indirectly acquire CPI through the personalization service S_2 offered by the vendor. If the vendor decides to accept to acquire information for the complementary firm, how does the payment strategy (i.e. fixed-fee payment) affect the vendor's equilibrium personalization service level and the benefits? Moreover, how are the complementary firm's benefits and payment affected by the complementarity K ? We now characterize the manufacturing and complementary firm's optimal strategies and benefits in equilibrium as the following lemma.

LEMMA 1. Under the fixed-fee payment, the optimal one-time fixed-fee paid by complementary firm will be $T^* = \frac{bR_2^2[(2-K)R_2 + 4b\beta]}{2[(2-K)R_2 + 2b\beta]^2}$, meanwhile, the corresponding optimal service level offered by the vendor will be

$S_1^F = \frac{aR_1}{(2-K)R_1 + 2a\beta}$, $S_2^F = \frac{bR_2}{(2-K)R_2 + 2b\beta}$, respectively. The vendor's equilibrium benefit will be given as $\Pi_M^F = \frac{1}{2}\left(\frac{aR_1^2}{(2-K)R_1 + 2a\beta} + \frac{bR_2^2}{(2-K)R_2 + 2b\beta} \right)$.

Lemma 1 gives us the optimal decisions of the vendor and the complementary firm under the fixed-fee payment. As the complementary firm determines the fixed-fee payment contract, the vendor observes the contract and maximizes his own profit. Therefore, on the one hand, to get the information benefit, the vendor strategically offers the basic personalization service S_1 to customers to acquire preference information; on the other hand, the vendor attempts to extract more surplus value by information sharing from the complementary firm's payment. If the complementary firm earns negative profits from the information (i.e. $\Pi_C^F < 0$), the trade-off would be ceased. Given the participation constraint, the complementary firm will set optimal fixed-fee T^* in equilibrium to indirectly acquire the CPI from the vendor.

We now turn our attention to the efficiency of acquiring strategies and two firm's benefits under the fixed-fee payment. Comparing the benefits and personalization service level to the benchmark yields the following results.

PROPOSITION 1. If the fixed-fee payment can be adopted by the complementary firm, in equilibrium:

(1) The personalization service S_1^F offered by the vendor is higher than that non-information sharing (i.e. $S_1^F > S_1^N$) and increasing in complementarity K and decreasing in cost coefficient β .

(2) The personalization service S_2^F offered by the vendor is increasing in complementarity K and decreasing in cost coefficient β.

(3) The vendor's benefit Π_M^F is positive, increasing in the complementarity K and decreasing in cost coefficient β .

(4) The vendor is better off with information sharing（i.e. $\Pi_M^F > \pi_M^N$）.

This proposition suggests that the fixed-fee payment positively affect the vendor's basic personalization service S_1^F . This is because that to extract more fixed-fee from the complementary firm, the vendor increase S_1^F which leads to higher spillover effects and more information can be disclosed by customers. Thus the vendor can grab more surplus value from the complementary firm's payment by information sharing. Moreover, if the vendor can motivate to increase two associated personalization service, it would influence customers to be more of convenience seekers rather privacy seekers in this customer market. In addition, the complementary firm pays fixed-fee *T* to the vendor for acquiring information, nevertheless, this information only stems from the personalization service S_2^F offered by the vendor and the spillover effect from the personalization service S_1^F . Furthermore, the cost β for offering the personalization service increases, which leads both of service levels decrease. As the complementarities *K* of two personalization service increases, customers' service demand also increases. Based on this observation, the vendor has a motivation to increase the two personalization service that spills over for both personalization services. Therefore, this spillover efficiency effect can be strengthened by the higher complementarity *K*.

Proposition 1 also suggests that the vendor can benefit from information sharing. This is indicated by the difference in the complementary firm's equilibrium fixed-fee payment between the sharing and non-sharing cases (i.e. $\Pi_M^F > \pi_M^N$). Without information sharing, the vendor obtains the benefits from the information value of basic personalization service S_1^F . When the vendor shares the information to the complementary firm, the fixed-fee *T* can be paid by the complementary firm; meanwhile, the extra personalization service S_2^F can lead to spillover effect. On the contrary, the complementary firm cannot acquire the customer preference information by itself due to high cost or limited resources showed in Scenario 2. When the complementary firm pays to the vendor and indirectly acquires information, both of firms can achieve win-win. That is, the vendor improves the benefits, and the complementary firm gets the important preference information. Therefore, we get another important result as following.

PROPOSITION 2. If the fixed-fee payment can be adopted by the complementary firm and the acquiring cost $C > T^*$, in equilibrium:

(1) The complementary firm's benefit from the value of information is zero, but the customer preference information can be

acquired from the vendor.

(2) The one-time fixed-fee T^* paid by the complementary firm is increasing in complementarity K.

When the complementary firm determines to pay the fixed-fee to the vendor for acquiring customer preference information, in equilibrium, the vendor can grab all the surplus value. That is, the complementary firm gets zero economic profits. In the game, the complementary firm, as a leader, would realize that the vendor could make a strategic decision to extract all surplus value. However, in order to acquire the information, it is inevitable that the complementary firm has to pay to the manufacture. It is because that the customer preference information, in reality, is costly to acquire. Even if spending more extra for the firms, some customers would be reluctant to disclose their preference information to firms. For example, in real estate industries, many customers would be reluctant to disclose their preference information to real estate developer, but be willing to disclose preference information to other real estate mediums. Therefore, although the information benefits are zero in this game, the complementary firm would use this preference information to design and improve its products or services, reduce R&D cost, and to carry out target marketing, etc. Compared with the benchmark, the complementary firm will obtain the customer preference information through the fixed-fee payment.

The second point of this proposition is that the fixed-fee *T* paid by the complementary firm to acquire information is increasing with complementarities *K* of two personalization services. That is because the extra personalization service S_2^F offered by the vendor can be spilled over the basic personalization service S_1^F. When customers have more complementary demands for the two services, because of the mutual spillover effect, more preference information can be disclosed by customers, and thus the complementary firm should pay more to obtain this information. Therefore, the complementary firm's fixed-fee is increasing in complementarity K.

Service-Rate Payment

In this section, we investigate how the service-rate payment may influence the manufacturing and complementary firm's equilibrium behaviors and benefits. Similarly, we first provide the firm's equilibrium strategies under the service-rate payment.

LEMMA 2. Under the service-rate payment, the optimal service-rate paid by complementary firm will be $\alpha^* = \frac{2b\beta R_2}{(2-K)R_2 + 4b\beta}$ .Meanwhile, corresponding optimal service levels offered by the vendor will be $S_1^V = \frac{aR_1}{(2-K)R_1 + 2a\beta}$, and $S_2^V = \frac{bR_2}{(2-K)R_2 + 4b\beta}$ respectively. The firm's equilibrium benefit will be given as $\Pi_C^V = \frac{bR_2^2[(2-K)R_2 + 6b\beta]}{2[(2-K)R_2 + 4b\beta]^2}$ and $\Pi_M^V = \frac{aR_1^2}{2[(2-K)R_1 + 2a\beta]} + \frac{b^2\beta R_2^2}{[(2-K)R_2 + 4b\beta]^2}$, respectively.

When the complementary firm adopts service-rate payment to acquire customer preference information, as a leader, he knows that given an announced service-rate α , the vendor will strategically maximize her own profits. Under the service-rate payment, on the contrary, the complementary firm strategically decides on the service-rate α to be paid to the vendor. However, the vendor would not only consider benefits from the service-rate payment, but also the spillover effect. Based on these characteristics, the optimal personalization service levels can be offered to customers by the vendor. From the Lemma 2, there are several important results given as follows.

PROPOSITION 3. If the service-rate payment can be adopted by the complementary firm, in equilibrium,

(1) The personalization service S_1^V offered by the vendor is also higher than that non-information sharing (i.e. $S_1^V > S_1^N$), and increasing in complementarity K and decreasing in cost coefficient β.

(2) The personalization service S_2^V offered by the vendor is increasing in complementarity K and decreasing in cost coefficient β.

(3) The vendor's benefit Π_M^V is positive, increasing in the complementarity K and decreasing in cost coefficient β.

(4) The vendor is better off with information sharing（i.e. $\Pi_M^V > \pi_M^N$）.

Similar to the case with fixed-fee payment, the basic personalization service level S_1^V offered by the vendor is higher than that

non-information sharing case. This proposition further confirms that the payment formats can positively affect the basic personalization service level. In addition, the personalization service levels in equilibrium are increasing in the complementarity K and decreasing in cost coefficient β . This is because as the acquiring cost *C* increases, the vendor's benefits decrease. Therefore, the vendor is willing to reduce the service levels.

Proposition 3 also suggests that the vendor is better off with information sharing. This is because that the extra benefits can be paid by the complementary firm. Therefore, the rational vendor can influence its complementary firm's behaviors by information sharing and extract its surplus value. On the contrary, there is no other way for the complementary firm to pay to obtain customer preference information. The same as the case under the fixed-fee payment, the vendor's equilibrium benefits Π_M^V is related to the complementarity *K* and the cost coefficient β . As the complementarity *K* increases, the vendor's benefits increases. Meanwhile, as the acquiring cost increase, the vendor's benefits decrease. Finally, comparing the vendor's equilibrium benefits to the benchmark case, it is easy to confirm that the vendor's equilibrium benefits under the service-rate payment are higher than the non-information sharing case（i.e. $\Pi_M^V > \pi_M^N$ ）. That is the vendor is better off with information sharing.

PROPOSITION 4. If the service-rate payment can be adopted by the complementary firm and the acquiring cost $C > \alpha^* S_2^V$, in equilibrium:

(1) The service-rate α^* paid by the complementary firm is increasing in complementarity K .

(2) The complementary firm's benefit Π_C^V from the value of information is positive, increasing in complementarity K; and the customer preference information can be also acquired from the vendor.

Compared with the fixed-fee payment case, two results pertaining to the effect of service-rate in information sharing emerge from this proposition. First, in contrast to the fixed-fee payment case, service-rate is also positively related to the complementarity *K*. This is because that higher complementarity *K* leads to higher spillover effect and thus higher payment. As a result, the complementary firm would pay more, and get more information. Second, with the motivation of acquiring more information from

the customers, it is wise to increase the service levels for the vendor and further to extract more payoff. Therefore, higher personalization service level leads to higher service-rate.

When the service-rate payment would be chosen to acquire customer preference information, the complementary firm's equilibrium information benefits are positive and increasing in complementarity *K*. If the complementary firm's acquiring cost $C > \alpha^* S_2^V$, he adopts the service-rate payment α to indirectly acquire customer preference information from the personalization service offered by the vendor; compared with the benchmark case, the complementary firm can obtain this information as well. At the same time, the complementary firm can get positive value of information through the information sharing.

Finally, compared with the equilibrium service levels offered by the vendor and equilibrium benefit across the different payment formats cases yields the following proposition:

PROPOSITION 5. (1) The equilibrium personalization service level S_1^V offered by the vendor under the service-rate payment is equal to S_1^F under the fixed-fee payment (i.e. $S_1^V = S_1^F > S_1^N$).

(2) The equilibrium personalization service level S_2^V offered by the vendor under the service-rate payment is lower than that S_2^F under the fixed-fee payment (i.e. $S_2^V < S_2^F$).

(3) The vendor's equilibrium benefit under the service-rate payment is lower than that under the fixed-fee payment (i.e. $\pi_M^N < \Pi_M^V < \Pi_M^F$); moreover, the equilibrium fixed-fee T^* paid by the complementary firm is higher than that under the service-rate payment (i.e. $T^* > \alpha^* S_2^V$).

(4) The channel's total equilibrium benefit under the service-rate payment is higher than that under the fixed-fee payment (i.e. $\pi_M^N + \pi_C^N < \Pi_M^F + \Pi_C^F < \Pi_M^V + \Pi_C^V$).

Proposition 5 suggests that through comparing the two payment formats, the basic personalization service level under the service-

rate payment is equal to the fixed-fee payment case (i.e. $S_1^V = S_1^F$). This is because that the basic personalization service is used to acquire information for the vendor, but the extra personalization service for the complementary firm. Thus the payment formats cannot affect the basic personalization service levels. Note that the vendor should pay more attentions on the extra personalization service, and coordinate two associated personalization services. However, the extra personalization service level under the service-rate payment is lower than that under the fixed-fee payment (i.e. $S_2^V < S_2^F$). This is because that the basic personalization services may be only used to acquire CPI for the vendor and the extra personalization service for the complementary firm. In order to extract all surplus value of information, the vendor strategically determines the optimal extra personalization service level. Furthermore, the vendor increases benefit through adding extra personalization service into the basic personalization service, which leads spillover effects, and extracting more payoff from the complementary firm. On the contrary, the complementary firm realizes the vendor strategic behaviors and has a motivation to reduce the payment; the personalization service level offered by the vendor is decreased.

In addition, the vendor's equilibrium benefit under the service-rate payment is lower than that under the fixed-fee payment. This is because that under the fixed-fee payment, the vendor may strategically grab all surplus value of information from the complementary firm. Moreover, the complementary firm under the fixed-fee payment should pay more than that under the service-rate payment (i.e. $T^* > \alpha^* S_2^V$). That is why many complementary firms widely adopt the service-rate or utility-based payment to acquire information (e.g. advertising industries) in reality. Therefore, the complementary firm chooses which format of payment depending on not only the importance of CPI for producing and designing to satisfy customer's tastes, but also the value of customer preference information for increasing benefit.

Proposition 5 further confirms that although the extra personalization service level under the fixed-fee payment is higher than that under the service-rate payment, the complementary firm under the service-rate payment not only acquires the customer preference information from the vendor's information sharing, but also obtains a positive value of information. Consequently, the channel's total equilibrium benefit is higher than that under the fixed-fee payment case.

DISCUSSION AND IMPLICATIONS

A central assumption in our model is that the complementary firm pays to the vendor to acquire customer preference information indirectly. In fact, purchasing information is wildly used by firms in reality. In this paper, we just adopt two universal payments (i.e. fixed-fee or service-rate payment) to investigate impacts of information acquisition strategies and information sharing between a vendor and a complementary firm. However, we present the acquiring cost first appeared in

benchmark model which is just used to explain why the complementary firm adopts an indirect way of acquiring customer preference information from vendor. For example, in reality, because of high cost of information acquisition, many real estate developers cannot get customer preference information from customers themselves, but so many customers are willing to disclose their preference information to the real estate medium.

One implicit assumption in our model is that the preference information acquired from the extra personalization service offered by the vendor is truly and completely shared to the complementary firm. In fact, this information is usually shared depended on the trust and risk assessment in reality, the sharing modes in this paper cannot be realistic. However, although it is worth noting that the purpose of this assumption is only to simplify and streamline the mathematical analysis, it would not affect the qualitative insights. Moreover, our analysis focuses on online environments, but the model cannot be only restricted to online personalization service. In addition, in our model we propose the privacy concerns which is beyond our main analysis. On the contrary, our focus is on the impact of payment formats on the vendor's information acquisition and information sharing strategies and the impact on the firms' equilibrium benefits under horizontal relationship.

This study only considers the case that vendor and complementary firm are two different kinds of firms, and the vendor also has ability to acquire customer preference information through the effective personalization technologies. Therefore, another interesting issues is when the two kinds of firms have the same or different capability in acquiring customer preference information by online personalization service, whether the results showed in this paper may be different under this condition or not. This is our next step work to examine.

Implications for Theory

From a theoretical point of view, this study contributes to research in information sharing under horizontal relationship. Chellappa & Shivendu (2006) consider representative of portals (e.g. AOL &Yahoo) possess vast advertising and customer profiling abilities. These portals use the acquired customer preference information either to get income from advertisers or to develop online tools for targeted advertising and one-to-one marketing. Galbreth, Ghosh, & Shor (2012) examine the effect of social sharing for information goods. They point out that a firm can benefit from increased social sharing if the level of sharing is already high. Different from these literatures, we focus on the customer's complementary demands in reality, which results in the possibilities for cooperation. Our results show that if the vendor shares the acquired information to the complementary firm, extra benefits can be obtained. Moreover, the complementary firm can get the customer preference information. The intuition supporting this solution is that no prices can be charged for personalization service, firms derive value from customer preference information.

Furthermore, this work enriches and extends the privacy calculus theory (PCT) in IS research. The broadest and most important contribution of this work is integrating customer's privacy concerns into firm's information acquisition decision. Such integration is a key contribution and way to advance secience. Li (2012) reviews fifteen established theories in online information privacy research. Smith & Dinev (2011) review the information privacy research by an interdisciplinary perspective. Pavlou (2011) evaluates the current state of the IS literature on information privacy (where are we now?) and identifies promising research directions for advancing IS research on information privacy (where should we go?). These researches point out that information privacy refers to the concept of controlling how one's personal information is acquired and used. When customers disclose information to the firms, an individual's intention is based on a calculus of behavior which is the risk-benefit analysis, where the trade-offs between expected risks and expected benefits are considered within a specific information-disclosure context. Based on the privacy calculus theory, we build a simple micro-model of customer utility for personalization service and preference information, which can be used to reveal benefit-risk relationship between customers' information disclosure and privacy concerns. Our study shows that the vendor may balance and coordinate the two associated personalization services to lead customers disclosing more information. The customer, however, would strategically use the personalization service offered by the vendor and disclose information under privacy concerns.

In sum, this study examines the benefits of information sharing under horizontal relationship and demonstrates the importance of PCT in IS research, increases our understanding of sharing strategies and user-adoption and behaviors, and contributes to the growing body of research on online personalization and privacy concerns.

Implications for Practice

Several managerial implications result from our analyses. Firstly, our findings show that the vendor is better off with information sharing under two payment formats. Because of the complementary demands, the customer disclosed information is important for both the vendor and its complementary firms. If the vendor, as an only information superiority side, shares partial information to its complementary firm, she can obtain extra payment and thus increase benefits. Therefore，the economic force underlying this result conveys that the vendor has a motivation to share information acquired from customers to the complementary firm. Secondly, the vendor can strategically influence the complementary firm's behavior (e.g. free-riding). Through information sharing, the vendor may filtrate cooperative partner, and thus extract economic payoff from the complementary firms. In the contrary, in order to get competitiveness and reduce market uncertainty, it is wise for the complementary firm to acquire information indirectly from its partner. Thirdly, this study points out that the service-rate payment is an optimal strategy for the complementary firm. That is because the complementary firm not only obtains the customer preference information, but also gets a positive benefits from this information. This result is consistent with Sundararajan (2004), which points out that if the marginal cost component does not exist, then a fully revealing, purely usage-

based contract becomes optimal. Therefore, this result also provides a basis for the complementary firm who chooses the format of payment.

CONCLISIONS AND FUTURE WORK

In this paper, we theoretically investigate the impact of modes of information sharing on the firm's equilibrium acquisition strategies and benefits under horizontal relationship. Two payment formats (i.e. fixed-fee or service-rate payment) for information sharing are identified. We present several interesting results that provide management insights into information interaction between the complementary firms in markets characterized by complementary demands, strategies of information acquisition, and information sharing.

First, this paper demonstrates that although both personalization services, in equilibrium, are higher than that in benchmark case, basic personalization service level is equal to that under two payment formats. Moreover, the extra personalization service level under the fixed-fee payment is higher than that under the service-rate payment case. This suggests that the vendor should be more cautious in balancing two levels of personalization service and make efforts to coordinate the extra personalization service for acquiring more information disclosed by customers and thus extract more payoffs from the complementary firm. In other words, in order to ensure to acquire a given amount of information from the basic personalization service, the vendor should balance the extra personalization service level to acquire information for the complementary firm and extract payoff to improve its benefits.

In addition, this study shows that the vendor is better off with information sharing under two payment formats. The economic force underlying this result conveys that the vendor has a motivation to share information acquired from customers to the complementary firm. It is important to emphasize that, on the one hand, the vendor's benefits can be increased by information sharing; on the other hand, the vendor can strategically influence the complementary firm's behavior (e.g. free-riding) [16]. For example, because of the complementarity of preference, many complementary firms have the opportunistic behaviors to reduce cost. As a result, although our focus here is the observability of the benefits of information sharing, the conceptual insights of this paper can be extended to more general situations when the cost and risk of information sharing cannot be neglected under horizontal relationship.

The above insights provide prescriptions on how vendor should respond to changes in information acquisition and in information sharing arrangement. Under the fixed-fee payment, although all the value of information can be extracted by the vendor, the preference information would be acquired. Under the service-rate payment, the complementary firm can get the positive value of

information and obtain the customer preference information. Such theoretical insights suggest that to obtain the customer preference information, the complementary firm may find new channels and cooperative partners. With the help of cooperative partners' information superiority, the complementary firm can get useful information and increase competitiveness.

One direction for future research would be to consider other coordination mechanism that could be used to coordinate two personalization services offered by the vendor; meanwhile, other information sharing mechanism that the vendor decides when and how much information would share to the complementary firm. Another direction in which our study could be extended would be to relax the assumption that the characteristic of customers are uniformly distributed. Any other general distribution would be investegated, which would be more ture under the reality circumstances.

APPENDIX.
PROOFS OF LEMMAS AND PROPOSITIONS

Simplifying equation (2)-(5), we get

$$\Pi_M^F = R_1\left(S_1 - \frac{(2-K)S_1^2}{2a}\right) - \beta\left(S_1^2 + S_2^2\right) + T \qquad (6)$$

$$\Pi_C^F = R_2\left(S_2 - \frac{(2-K)S_2^2}{2b}\right) - T \qquad (7)$$

$$\Pi_M^V = R_1\left(S_1 - \frac{(2-K)S_1^2}{2a}\right) - \beta\left(S_1^2 + S_2^2\right) + \alpha S_2 \qquad (8)$$

$$\Pi_C^V = R_2\left(S_2 - \frac{(2-K)S_2^2}{2b}\right) - \alpha S_2 \qquad (9)$$

Proof of Lemma 1: Due to the complementary firm proposes a contract, if the vendor accepts it and thus has a motivation of extracting all surplus value from complementary firm. Therefore, in equilibrium, the value of information obtained by the complementary firm is zero. That is, the fixed-fee is equal to the value of information. Otherwise, note that complementary firm's profit function satisfies $\Pi_C^F \geq 0$, if the vendor wants to grab more surplus profit，complementary firm would discontinue the trade-off. We substitute the value of information (i.e. fixed-fee) in the vendor's benefit function given by (6). Differentiating equation (6) and getting the FOC equal to zero, we get the two optimal personalization service level of the vendor under fixed-fee payment $S_1^F = \frac{aR_1}{(2-K)R_1 + 2a\beta}$, $S_2^F = \frac{bR_2}{(2-K)R_2 + 2b\beta}$, respectively. Substituting these optimal personalization service levels in the complementary firm profit function given by equation (7), we get the optimal fixed-fee of the complementary firm $T^* = \frac{bR_2^2[(2-K)R_2 + 4b\beta]}{2[(2-K)R_2 + 2b\beta]^2}$. Then, substituting these optimal values in equation (6), we get the vendor's optimal profits as $\Pi_M^F = \frac{1}{2}\left(\frac{aR_1^2}{(2-K)R_1 + 2a\beta} + \frac{bR_2^2}{(2-K)R_2 + 2b\beta}\right)$.□

Proof of Proposition 1: (1) Note that $S_1^F - S_1^N = \frac{aR_1}{(2-K)R_1 + 2a\beta} - \frac{aR_1}{2R_1 + 2a\beta} > 0$, we can get $S_1^F > S_1^N$. By differentiating S_1^F with respect to K and β, we have $\frac{\partial S_1^F}{\partial K} = \frac{aR_1^2}{[(2-K)R_1 + 2a\beta]^2} > 0$, and $\frac{\partial S_1^F}{\partial \beta} = -\frac{2a^2R_1}{[(2-K)R_1 + 2a\beta]^2} < 0$. We can prove that S_1^F is increasing in *K* and decreasing in β. (2) Similarly, by differentiating S_2^F with respect to K and β, respectively, $\frac{\partial S_2^F}{\partial K} = \frac{bR_2^2}{[(2-K)R_2 + 2b\beta]^2} > 0$, and $\frac{\partial S_2^F}{\partial \beta} = -\frac{2b^2R_2}{[(2-K)R_2 + 2b\beta]^2} < 0$, we can verified that S_2^F is increasing in K and decreasing in β. (3) By differentiating Π_M^F with respect to K and β, respectively, it is easy to confirm that the vendor's benefits is increasing in K and decreasing in

β. (4) Comparing the benchmark, it is easy to verify $\Pi_M^F - \pi_M^N > 0$.□

Proof of Proposition 2: By differentiating equation T^* respect to K, we get $\frac{\partial T^*}{\partial K} = -\frac{bR_2^3[(2-K)R_2 + 6b\beta]}{[(2-K)R_2 + 2b\beta]^2} < 0$. We have that the fixed-fee T^* paid by the complementary firm is decreasing in complementarity K. From the Lemma 1, it is easy to indicate that in equilibrium the complementary firm gets zero profit or surplus. It is because that all surplus value can be grabbed by the vendor. □

Proof of Lemma 2: By differentiating equation (8) with respect to S_1 and S_2, respectively, and letting the first-order condition equal to zero, we get the reaction function of the vendor for a paid service rate α by the complementary firm $S_1^V = \frac{aR_1}{(2-K)R_1 + 2a\beta}$ and $S_2^V(\alpha) = \frac{\alpha}{2\beta}$, respectively. Then, substituting $S_2^V(\alpha)$ in equation (9) and differentiating with respect to α, we set the first-order condition equal to zero, we get optimal service rate as $\alpha^* = \frac{2b\beta R_2}{(2-K)R_2 + 4b\beta}$. We substitute this optimal service rate in the reaction function, the optimal personalization service level can be $S_2^V = \frac{bR_2}{(2-K)R_2 + 4b\beta}$. Therefore, the vendor's and the complementary firm's optimal benefits can be given by $\Pi_C^V = \frac{bR_2^2[(2-K)R_2 + 6b\beta]}{2[(2-K)R_2 + 4b\beta]^2}$, and $\Pi_M^V = \frac{aR_1^2}{2[(2-K)R_1 + 2a\beta]} + \frac{b^2\beta R_2^2}{[(2-K)R_2 + 4b\beta]^2}$.□

Proof of Proposition 3: (1) Comparing the Lemma 2 and benchmark, $S_1^V - S_1^N = \frac{aR_1}{(2-K)R_1 + 2a\beta} - \frac{aR_1}{2R_1 + 2a\beta} > 0$, it is clear that in equilibrium S_1^V is higher that S_1^N. Similar as Proposition1, it is clear that S_1^V is increasing in *K* and decreasing in β. (2) Differentiating S_2^V w.r.t. K & β, we have that $\frac{\partial S_2^V}{\partial K} = \frac{bR_2^2}{[(2-K)R_2 + 4b\beta]^2} > 0$, $\frac{\partial S_2^V}{\partial \beta} = -\frac{4b^2R_2}{[(2-K)R_2 + 4b\beta]^2} < 0$. (3) It is obvious that $\Pi_M^V > 0$, and Π_M^V is increasing in K and decreasing in cost coefficient β. (4) Comparing the benchmark, we have that $\Pi_M^V - \pi_M^N = \frac{aR_1^2}{2[(2-K)R_1 + 2a\beta]} + \frac{b^2\beta R_2^2}{[(2-K)R_2 + 4b\beta]^2} - \frac{aR_1^2}{4(R_1 + a\beta)} > 0$.□

Proof of Proposition 4: (1) Differentiating α^* with respect to K, we have that $\frac{\partial \alpha^*}{\partial K} = \frac{2b\beta R_2^2}{[(2-K)R_2 + 4b\beta]^2} > 0$. (2) From the Lemma 2, by differentiating Π_C^V w.r.t. K, we get that $\frac{\partial \Pi_C^V}{\partial K} = -\frac{bR_2^3[(2-K)R_2 + 8b\beta]}{[(2-K)R_2 + 4b\beta]^2} < 0$.□

Proof of Proposition 5: From the Lemma 1 and Lemma 2, we can easily verify that

$$S_2^F - S_2^V = \frac{bR_2}{(2-K)R_2 + 2b\beta} - \frac{bR_2}{(2-K)R_2 + 4b\beta} > 0,$$

$$\Pi_M^F - \Pi_M^V = \frac{bR_2^2}{2[(2-K)R_2 + 2b\beta]} - \frac{b^2\beta R_2^2}{[(2-K)R_2 + 4b\beta]^2}$$

$$> \frac{bR_2^2[(2-K)R_2 + 4b\beta] - 2b^2\beta R_2^2}{2[(2-K)R_2 + 4b\beta]^2} = \frac{(2-K)bR_2^3 + 2b^2\beta R_2^2}{2[(2-K)R_2 + 4b\beta]^2} > 0$$

$$T^* - \alpha^* S_2^V = \frac{bR_2^2[(2-K)R_2 + 4b\beta]}{2[(2-K)R_2 + 2b\beta]^2} - \frac{4b^2\beta R_2^2}{2[(2-K)R_2 + 4b\beta]^2},$$

$$> \frac{(2-K)bR_2^3}{2[(2-K)R_2 + 4b\beta]^2} > 0$$

$$\Pi_M^V + \Pi_C^V - \Pi_M^F - \Pi_C^F = \frac{bR_2^2[(2-K)R_2 + 8b\beta]}{2[(2-K)R_2 + 4b\beta]^2} - \frac{bR_2^2}{(2-K)R_2 + 2b\beta}$$

$$= \frac{b^2\beta R_2^2}{2(2-K)R_2 + 2b\beta[(2-K)R_2 + 4b\beta]^2} > 0$$

$$\Pi_M^F + \Pi_C^F - \pi_M^N - \pi_C^N = \frac{1}{2}\left(\frac{aR_1^2}{(2-K)R_1 + 2a\beta} + \frac{bR_2^2}{(2-K)R_2 + 2b\beta}\right)$$

$$-\frac{aR_1^2}{4(R_1 + a\beta)} > \frac{aR_1^2}{2[(2-K)R_1 + 2a\beta]} - \frac{aR_1^2}{4(R_1 + a\beta)} > 0$$

Therefore, we have $\pi_M^N + \pi_C^N < \Pi_M^F + \Pi_C^F < \Pi_M^V + \Pi_C^V$.□

REFERENCES

[1] Bárcena-Ruiz, Juan Carlos (2007) 'Endogenous timing in a mixed duopoly: Price competition', *Journal of Economics,* Vol. 91, No. 3, pp. 263-72.

[2] Bhaskaran, Sreekumar R. & Stephen M. Gilbert (2005) 'Selling and leasing strategies for durable goods with complementary products', *Management Science,* Vol. 51, No. 8, pp. 1278-90.

[3] Bikhchandani, Sushil (2010) 'Information acquisition and full surplus extraction', *Journal of Economic Theory,* Vol. 145, No. 6, pp. 2282-308.

[4] Cai, Gangshu, Yue Dai, & Sean X. Zhou (2012) 'Exclusive channels and revenue sharing in a complementary goods market', *Marketing Science,* Vol. 31, No. 1, pp. 172-87.

[5] Chang, Shuchih Ernest, S. Wesley Changchien, & Ru-Hui Huang (2006) 'Assessing users' product-specific knowledge for personalization in electronic commerce', *Expert Systems with Applications,* Vol. 30, No. 4, pp. 682-93.

[6] Chellappa, R. K. & S. Shivendu (2007) 'An economic model of privacy a property rights approach to regulatory choices for online personalization', *Journal of Management Information System,* Vol. 24,No. 3, pp. 193-225.

[7] Chellappa, Ramnath K & Shivendu Shivendu (2007) 'An economic model of privacy: A property rights approach to regulatory choices for online personalization', *Journal of Management Information Systems*, Vol. 24, No .3, pp. 193-225.

[8] Chellappa, Ramnath K & Shivendu Shivendu (2006) 'A model of advertiser—portal contracts: Personalization strategies under privacyconcerns', *Information Technology and Management*, Vol. 7, No. 1, pp. 7-19.

[9] Chellappa, Ramnath K & Raymond G Sin (2005) 'Personalization versus privacy: An empirical examination of the online consumer's dilemma', *Information Technology and Management,* Vol. 6, No. 2-3, pp. 181-202.

[10] Chellappa, Ramnath K. & Shivendu Shivendu (2010) 'Mechanism design for "free" but "no free disposal" services: The economics of personalization under privacy concerns', *Management Science,* Vol. 56, No. 10, pp. 1766-80.

[11] Dixit, Avinash (1979) 'Model of duopoly suggesting a theory of entry Barriers, A.', *J. Reprints Antitrust L. & Econ,* Vol. 10, pp. 399.

[12] Fu, Qi & Kaijie Zhu (2010) 'Endogenous information acquisition in supply chain management', *European Journal of Operational Research,* Vol. 201, No. 2, pp. 454-62.

[13] Galbreth, M. R., B. Ghosh, & M. Shor (2012) 'Social sharing of information goods: Implications for pricing and profits', *Marketing Science,* Vol. 31, No. 4, pp. 603-20.

[14] García, Diego & Joel M. Vanden (2009) 'Information acquisition and mutual funds', *Journal of Economic Theory,* Vol. 144, No. 5, pp. 1965-95.

[15] Gerardi, Dino & Leeat Yariv (2008) 'Information acquisition in committees', *Games and Economic Behavior,* Vol. 62, No. 2, pp. 436-59.

[16] Guo, L. & G. Iyer (2010) 'Information acquisition and sharing in a vertical relationship', *Marketing Science,* Vol. 29, No. 3, pp. 483-506.

[17] Guo, Liang (2009) 'The benefits of downstream information acquisition', *Marketing Science,* Vol. 28, No. 3, pp. 457-71. [18] Ha, A. Y. & S. Tong (2008) 'Contracting and information sharing under supply chain competition', *Management Science,* Vol. 54, No. 4, pp. 701-15.

[18] Ha, A. Y. & S. Tong (2008) 'Contracting and information sharing under supply chain competition', *Management Science,*Vol. 54, No. 4, pp. 701-15.

[19] Hernando-Veciana, Á ngel (2009) 'Information acquisition in auctions: Sealed bids Vs. open Bids', *Games and Economic Behavior*, Vol. 65, No. 2, pp. 372-405.
[20] Ho, Shuk Ying (2012) 'The effects of location personalization on individuals' intention to use mobile services', *Decision Support Systems*, Vol. 53, No. 4, pp. 802-12.
[21] Ho, Shuk Ying, David Bodoff, & Kar Yan Tam (2011) 'Timing of adaptive web personalization and its effects on online consumer behavior', *Information Systems Research*, Vol. 22, No. 3, pp. 660-79.
[22] Iyer, Ananth. V. & Jianming Ye (2000) 'Assessing the value of information sharing in a promotional retail environment', *Manufacturing & Service Operations Management*, Vol. 2, No. 2, pp. 128-43.
[23] Jackson, Tyrone W. (2007) 'Personalisation and crm', *Journal of Database Marketing & Customer Strategy Management*, Vol. 15, No. 1, pp. 24-36.
[24] Kim, Eunjin & Byungtae Lee (2009) 'E-service quality competition through personalization under consumer privacy concerns', *Electronic Commerce Research and Applications*, Vol. 8, No. 4, pp. 182-90.
[25] Kramer, Thomas, Suri Spolter-Weisfeld, & Maneesh Thakkar (2007) 'The effect of cultural orientation on consumer responses to personalization', *Marketing Science*, Vol. 26, No. 2, pp. 246-58.
[26] Kwon, Kwiseok, Jinhyung Cho, & Yongtae Park (2010) 'How to best characterize the personalization construct for e-services', *Expert Systems with Applications*, Vol. 37, No. 3, pp. 2232-40.
[27] Lee, Gyudong & Won Jun Lee (2009) 'Psychological reactance to online recommendation services', *Information & Management*, Vol. 46, No. 8, pp. 448-52.
[28] Lee, Hau L., Kut C. So, & Christopher S. Tang (2000) 'The value of information sharing in a two-level supply chain', *Management Science*, Vol. 46, No. 5, pp. 626-43.
[29] Li, Lode (2002) 'Information sharing in a supply chain with horizontal competition', *Management Science*, Vol. 48, No. 9, pp. 1196-212.
[30] Li, Yongquan & Kaijie Zhu (2009) 'Information acquisition in new product introduction', *European Journal of Operational Research*, Vol. 198, No. 2, pp. 618-25.
[31] Lindset, Snorre, Arne-Christian Lund, & Egil Matsen (2009) 'Optimal information acquisition for a linear quadratic control problem', *European Journal of Operational Research*, Vol. 199, No. 2, pp. 435-41.
[32] Miceli, Gaetano "Nino", Francesco Ricotta, & Michele Costabile (2007) 'Customizing customization: A conceptual framework for interactive personalization', *Journal of Interactive Marketing*, Vol. 21, No. 2, pp. 6-25.
[33] Miltgen, Caroline Lancelot & Dominique Peyrat-Guillard (2013) 'Cultural and generational influences on privacy concerns: A qualitative study in seven European countries', *European Journal of Information Systems*.
[34] Montgomery, Alan L. & Michael D. Smith (2009) 'Prospects for personalization on the internet', *Journal of Interactive Marketing*,Vol. 23, No. 2, pp. 130-37.
[35] Murray, Kyle B. & Gerald Häubl (2009) 'Personalization without interrogation: Towards more effective interactions between consumers and feature-based recommendation agents', *Journal of Interactive Marketing*, Vol. 23, No. 2, pp. 138-46.
[36] Murthi, B. P. S. & Sumit Sarkar (2003) 'The role of the management sciences in research on personalization', *Management Science*,Vol. 49, No. 10, pp. 1344-62.
[37] Oetzel, Marie Caroline & Sarah Spiekermann (2013) 'A systematic methodology for privacy impact assessments: A design science approach, *European Journal of Information Systems*.
[38] Ozer, O., Y. Zheng, & K. Y. Chen (2011) 'Trust in forecast information sharing', *Management Science*, Vol. 57, No. 6, pp. 1111-37.
[39] Spence, Michael (1976) 'Product differentiation and welfare', *The American Economic Review*, Vol. 66, No. 2, pp. 407-14.
[40] Sundararajan, Arun (2004) 'Nonlinear pricing of information goods', *Management Science*, Vol. 50, No. 12, pp. 1660-73.
[41] Sunikka, Anne & Johanna Bragge (2012) 'Applying text-mining to personalization and customization research literature – who, what and where?', *Expert Systems with Applications*, Vol. 39, No. 11, pp. 10049-58.
[42] Vesanen, Jari & Mika Raulas (2006) 'Building bridges for personalization: A process model for marketing', *Journal of Interactive Marketing*, Vol. 20, No. 1, pp. 5-20.
[43] Vives, Xavier (1984) 'Duopoly information equilibrium: Cournot and bertrand', *Journal of Economic Theory*, Vol. 34, No. 1, pp. 71-94.
[44] Wang, Yonggui & Dahui Li (2013) 'Testing the moderating effects of toolkits and user communities in personalization: The case of social networking service', *Decision Support Systems*, Vol. 55, No. 1, pp. 31-42.
[45] Xu, Heng, Xin Luo, John M. Carroll, & Mary Beth Rosson (2011) 'The personalization privacy paradox: An exploratory study of decision making process for location-aware marketing', *Decision Support Systems*, Vol. 51, No. 1, pp. 42-52.
[46] Zhu, Kaijie & Ulrich W. Thonemann (2004) 'Modeling the benefits of sharing future demand information', *Operations Research*, Vol. 52, No. 1, pp. 136-47.