

# Strategic Choices of Implementing Personalization

Eric See-To\* and Xu Xin\*\*

*Facing increasingly sophisticated customers, firms are under the pressure to provide tailor-made products or services that better match customers' preferences. Hence, there has been heavy investment in personalization in recent years. However, very few firms get the expected business performances. Using a game theoretical approach, we analyze the impacts of implementation strategies (the platform strategy vs. the non-platform strategy) and customer heterogeneity on the potential of personalization as a source of competitive advantage. We find that the platform strategy is in general preferred. However, the non-platform strategy is socially optimal. We find that platform-based personalization has limited strategic value when customers are highly heterogeneous. Firms may capture the strategic value of platform only when customers are homogeneous enough. Personalization cannot be an effective tool of differentiation, but will be a competitive necessity, when the technology is mature and the implementation cost is negligible.*

Key Words: Personalization, Differentiation, Customer Heterogeneity, Platform vs. Application Strategy

## I. Introduction

Personalization is the process of collecting customer information, matching customer profile with the right solution (e.g., communication information, products, or services), and delivering the solution at the right time.

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\* Eric See-To, Department of Management Science, Lancaster University Management School, Lancaster, LA1 4YX, UK  
e.see-to@lancaster.ac.uk  
+44 01524 593868

\*\* Xu Xin, Department of Management and Marketing, Hong Kong Polytechnic University, Hong Kong  
xin.xu@polyu.edu.hk

In e-commerce, a customer mainly interacts with the web site to get the product information and make their purchase decisions, instead of communicating with a familiar sales representative to get good advice. Online personalization technologies such as cookies, click stream tracking, collaborative filtering, and web mining enable a firm to collect and analyze data about customer preferences and offer targeted recommendations or even customized solutions to different customers, which is expected to differentiate the firm from its competitors and gain competitive advantages, such as customer loyalty, greater market share, and higher revenue and profits.

Although business has embraced the idea of online personalization and begun to invest on related technologies since the middle of 1990s, the idea of providing users with the right information or recommendation can be traced back to 1950-60s, when the Library of Congress utilized “cross-references” to help readers find literature of related or synonyms topics (Kochen 1976, pp. 117-118). The advances in information technology, especially the Internet computing technologies, enable firms to deploy online personalization to target the right solution at the right customer. Typically, personalization is implemented at six levels (Jupiter Research 2003):

1. Customization—personalizing the layout, language, and content of a site,
2. Registration—gathering personalized data by requesting or requiring visitors to register,
3. Demographic branching—using demographic data gathered by registration or other user input to personalize content,
4. Pattern matching—delivering personalized content based on matching the preferences of one site visitor to other visitors with similar tastes, derived from either information the visitor provided or observation of the visitor’s online activity,
5. Situational—an enhanced form of pattern matching, personalizing based on predicting seasonal trends (such as suggesting holiday-related items regardless of a visitor’s demonstrated preferences), and
6. Sensitive—detecting real-time preference changes and delivering personalization based on these sensitivities.

Online business invested heavily on all these six levels. It was expected that global investment in personalization technologies would reach US\$ 2.1 billion by 2006, up from US\$ 500 million in 2001 [2]. So far most e-commerce focused firms have adopted certain personalization technologies. Prominent examples include *Amazon.com* (an online bookstore) and *My Yahoo!* (a web portal). Other cases involve companies such as *Barnes & Noble*, *Buy.com*, *1-800-Flowers.com*, and office supply vendors like *Staples* and *Office Depot*. Some of these firms have achieved significant improvement in business performance, such as *Amazon.com*, *1-800-Flowers.com*, *Staples*, and *Office Depot* [3]. And the development in wireless devices and interactive television may spur more demand for personalization technologies.

However, recent market research recognized two controversial aspects of online personalization. The first one is about how markets respond to personalization. Customers in different markets are heterogeneous in terms of their behavioral patterns toward personalization, i.e., whether or not they would use personalization technologies and the depth of their usage. For instance, in the Jupiter 2003 report “Beyond the Personalization Myth: Cost Effective Alternatives to Influence Intent”, it was found that only 14% of customers said that personalized offers or recommendations on shopping web sites lead them to buy more often from online stores, and only 8% said that personalization increased their repeat visits to content, news, or entertainment web sites [4]. An online travel agency found that personalization technologies had little impact on some customer who “only want to check miles, compare flights, and book passage” [4]. In the case of *My Yahoo!*. It was discovered that although some ‘*power users*’ did fully exploit the personalization features of *My Yahoo!*, most users just took what was given and never customized 3.[24].

The second aspect is the choice of implementation strategies for personalization and the associated cost structure. One approach to personalization is the so-called “application strategy”, by which information goods are created and customized at the individual customer level, i.e., based on individual customers’ tastes and preferences. For instance, some online CRM applications create profiles of each individual customer and formulate targeted services and prices according based on. In this case, whenever a new customer comes or a significant amount of new information about an existing customer is found, a essentially new information goods needs to be created accordingly. Variable costs are the dominant component of the cost structure of this approach. That is, for each additional (marginal) information goods produced, an amount of cost is incurred.

Personalizing online offerings was considered less costly than customizing physical products because of the “digital” nature of information goods. That is, with advanced information technology, information goods can be manipulated easily to suit individual customers’ needs. Based on this assumption, many online firms strived to achieve personalization by the application strategy. However, the reality indicated that personalization at the individual level can be a significant part of the cost center. It was found that operating a personalized web site cost more than four times that operating a “comparative dynamic site” and most sites that deployed personalization have not realized adequate returns on their investments [4].

Under the cost pressure, online firms are forced to seek other approaches to cost-effective variety [4]. One widely discussed approach is the “platform strategy”. A platform is a set of subsystems and interfaces that form a common structure of an information goods, from which a stream of derivative applications (i.e. products / services) can be effectively developed and distributed 3.[25].

Sawhney pointed out that a well-defined product platform can server as the “underlying core technology” based on which a variety of applications (products / services) can be built cost-effectively to satisfy different consumer needs 3.[26]. With this approach, a online firm first built a common platform of its information goods, when a new customer comes, the platform will be modified or extended with little additional cost to produce a offering that suits the customer’s needs. A typical example of this approach is *My Yahoo!*, where a default portal page (the platform) is provided to each customer, and the structure and individual parts of the page can be modified based on each customer’s preferences. As the creators of *My Yahoo!* pointed out, the major cost component of this approach is the fixed part – R&D expenditures that are needed to create a well-defined platform – the default portal.

The market reveals both success and failures of either approach. The recommendation system of Amazon.com can be regarded as a success of the application approach while My Yahoo! implemented a successful platform. On the other hand, the report of many failures [4] indicated the contingent nature of the appropriateness of these two strategies. In this paper, we theorize that either of the two approaches – application or platform – can provide competitive advantages to online firms, depending on the nature of the market online firms face. The major theme of our paper is that the strategic value of personalization depends on the interaction between the two issues described above, i.e., the degree of consumer heterogeneity and the choice of implementation strategies. Our goal is to clarify market conditions when the platform / application strategy is preferred, and derive corresponding strategic implications for firms that adopt / will adopt online personalization. The rest of the paper is organized as follows. In Section II, we briefly review related studies in personalization literature and discuss the theoretical foundations for our modeling approach. Then in Section III we develop the model to address the research question. The strategic interactions among firms under different implementation strategies and customer heterogeneity are analyzed in section IV. In the final section, managerial implications and possible extensions to the research are discussed.

## **II. Literature Review and Theoretical Foundations**

The literature is rich with researches on personalization [7, 8, 9, 10, 11, 12]. A recent survey suggested that personalization was examined across several disciplines such as economics, marketing, and information technology in a relatively isolated manner [1]. In a broader sense, research on personalization fit into the agenda of research on electronic commerce customer relationship management (e-CRM), particularly the business model area, which involves a variety of issues such as customer loyalty, channel coordination, transformation of cost structure, customer interaction and profiling, mass customization and personalization, and so forth [13].

A particular type of the strategic value of personalization is differentiation, by which a firm can gain competitive advantages over its competitors. Personalization technologies can enable a firm to take advantages of two types of differentiation - horizontal differentiation and vertical differentiation [16]. Horizontal differentiation refers to customizing attributes of products / services according to different customer tastes. For instance, web news portal may provide news items about tennis to customers who are fans of this sport and news in financial markets to businessmen. By vertical differentiation firms differentiate their products or services in terms of quality level and customers have higher valuation of products or services of higher quality.

A number of papers have addressed the issue of how differentiation through personalization can provide firms with several types of competitive advantages. For example, Dewan et al. [17] demonstrates how horizontal differentiation and price discrimination by Internet-based product customization can provide a firm with first-mover advantage by both greater market share and higher profits. Ulph and Vulkan [18] also study horizontal differentiation and price discrimination by mass customization in the case of duopoly. They show that firms are strictly better off by first-degree of price discrimination and mass customization. Desai [19] examined both vertical (i.e. differences in product quality) and horizontal differentiation (i.e., differences in customers' tastes) in the context of firms' product-line strategies. He showed that when horizontal differentiation dominates vertical differentiation (i.e., the heterogeneity of tastes dominates the heterogeneity of quality valuation), the cannibalization effect between high- and low- quality products can be reduced and a firm can have higher profits by offering product variants. Shaffer and Zhang [20] also incorporate both horizontal and vertical differentiation in their model. They find that although personalized one-to-one promotion intensifies the competition, firms can benefit from greater market share that dominates the effect of lower prices.

In the current study, we extend previous research by focusing on strategic choices of implementing personalization. Firstly, we consider the function of personalization as an approach to vertical differentiation, which is different from most prior literature (e.g., Dewan et al. [17]). Moreover, we discuss two typical types of implementation strategies – the platform strategy and the application strategy – as vehicles for vertical differentiation. We show that these two strategies have different impacts on firms' cost structure, which in turn determines the strategic values of personalization under different market scenarios – relatively heterogeneous markets where customers have diverse tastes vs. relatively homogeneous markets where customers' preferences can be segmented. In short, we study the business value of personalization strategies contingent upon different consumer heterogeneity.

### **III. Model Specifications**

In this section we consider a market in which customers are heterogeneous in tastes. There are  $n$  firms each offering one particular personalized product.  $N$  customers are in the market and each buys exactly one product. In the discussion follows, firms are indexed by  $j=1\dots n$  and customers are indexed by  $i=1\dots N$ .

## A. Degree of Personalization and Costs

Firms can incorporate different degrees of personalization, into their products. The more personalized a product is (i.e. the higher the degree of the personalization), the better it fits with a customer's tastes and preferences. Consequently, the customer perceives the product as more valuable. We can observe how personalized a product is in practice. For instance, recommending the right product at the right time (Amazon.com recommends a gift to a customer who needs to buy the gift for a friend's birthday) is more personalized than simply recommending the right product (Amazon.com recommends some new book to a customer when one login).

To incorporate a higher degree of personalization into the product, higher costs will be incurred. Depending on the implementation strategy of the firm, costs are impacted differently. With the platform strategy, firms increase the degree of personalization of their products through fixed cost type investment, such as R&D investment. Hence, fixed costs are increasing in the degree of personalization chosen. Variable costs for each customization are relatively low and constant due to the cost-effectiveness of the platform strategy, and unaffected by the choice of the degree of personalization. If firms choose the application strategy, the initial investment will be relatively low and the fixed costs of the firms are not related to how personalized the products are. Instead, the variable costs will be increasing in the degree of personalization.

## B. Customer Preference and Demand Structure

We model customer preference using the random utility framework. Imagine there is a representative customer in the market. If this customer purchases the product of firm  $j$ , the utility obtained is  $V_j$  from the purchase for price  $p_j$ . The degree of personalization offered by the product of firm  $j$  is  $d_j$ . The customer gives a value of  $\theta > 0$  to this personalization. Hence, we have:

$$V_j = \theta d_j - p_j \quad (1)$$

The customer heterogeneity is represented by a random variable  $\varepsilon_{ij}$ . The utility of customer  $i$  buying the product of firm  $j$  is thus  $U_{ij} = V_j + \varepsilon_{ij}$ .  $\varepsilon_{ij}$  are i.i.d. and follow the double exponential distribution with mean zero and variance  $\mu^2 \pi^2 / 6$ :  $\Pr(\varepsilon_{ij} \leq x) = \exp[-\exp-(x/\mu + \gamma)]$ .  $\gamma$  is the Euler's constant ( $\approx 0.5772$ ). As the variance is strictly increasing in  $\mu$ ,  $\mu$  captures the degree of customer

heterogeneity in the market. By assuming a double exponential distribution for the random structure we are essentially adopting a discrete-choice model for the demand. We justify this specification with two points. First, discrete choice model has been widely applied in the study of consumer behavior and found to be a valid approach (e.g. Allenby et. al 2003, Akcura et. al 2004, Kim et. al 2002). Secondly, the discrete-choice framework fits well in the context of online personalization in that usually consumers face a choice among several different personalization technologies offered by different firms.

Summarizing the above, the utility of a customer  $i$  who buys product  $j$ , represented by the random utility framework, is as below:

$$U_{ij} = \theta d_j - p_j + \varepsilon_{ij} \quad (2)$$

With the distribution assumption of  $\varepsilon_{ij}$ , the probabilities that the product of firm  $j$  will be bought by a customer are:

$$P_j = \frac{\exp[(\theta d_j - p_j) / \mu]}{\sum_{k=1}^n \exp[(\theta d_k - p_k) / \mu]} \quad (3)$$

The demand for the product for firm  $j$  is then  $D_j = NP_j$ .

#### IV. Analysis and Results

In this section, we analyze the strategic value of personalization, in a market of heterogeneous customers, under three different implementation situations: 1) personalization technology is mature and implementation is considered “free”, i.e., the base model for extension; 2) the “application” strategy with variable cost influence by the degree of personalization; 3) the “platform” strategy with fixed cost influenced by the degree of personalization. Table 1. summarizes the model parameters and two decision variables – degree of personalization ( $d_j$ ) and price ( $p_j$ ).

**Table 1a. Parameter Specification**

$n$	the number of firms
$N$	the number of consumers
$j$	the index number of firms
$i$	the index number of consumers
$U_{ij}$	the total utility of consumer $i$ from firm $j$ 's product
$V_j$	the deterministic structure of the total utility
$\varepsilon_{ij}$	the random structure of the total utility (capturing consumer heterogeneity in the market)
$\theta$	consumers' evaluation of personalization
$\mu$	$\mu^2 \pi^2 / 6$ is the variance of $\varepsilon_{ij}$ (capturing the degree of consumer heterogeneity in the market)
$P_j$	the probabilities that the product of firm $j$ will be bought
$D_j$	Demand for firm $j$ 's product
$F$	the fixed cost
$c_j$	the variable cost
$\pi_j$	firm $j$ 's profit
$s$	$s = \exp\{[(\theta d_j - p_j^*) - (\theta d - p^*)] / \mu\}$
$\hat{s}$	$\hat{s} = \exp\{[\theta(d_1 - d_2) - (p_1^* - p_2^*)] / \mu\}$
<b>Table 1b. Decision Variables</b>	
$d_j$	degree of personalization chosen by firm $j$
$p_j$	the price of firm $j$ 's personalized product / service

We first build a base model with zero cost of personalization. While being an extreme case in terms of cost assumptions, it is useful and relevant. As is widely observed, information technology advances rapidly and the costs of implementation are dropping exponentially. The same applies to personalization technology. It is likely that in the near future personalization technology advances to an extent such that implementation costs are low enough to be considered "free". In this case, the results from the base model can be of strategic importance to business.

When the cost of implementing personalization is not negligible, firms may adopt the "platform" or the "application" strategy. Either strategy could be dominant in different market contexts. We deal with both situations. The case of having both strategies in the market is not considered. In our model settings, if one strategy has advantages over the other, all firms will choose the better one. There is no incentive for firms operating in the same market to choose different strategies.

## A. Competition when Personalization does not affect Costs<sup>1</sup>

The market is modeled by a two-stage game. In stage one, firms simultaneously choose the degree of personalization,  $d_j$ , offered by their products. In stage two, firms choose their prices,  $p_j$ , at the same time. This game setting will be used throughout the paper. In this sub-section, we assume that marginal cost and fixed cost are independent of the degree of personalization to be offered. All firms face the same marginal cost and fixed cost. Without loss of generality, we set the marginal cost to zero and the fixed cost,  $F > 0$ . The profit function of a firm  $j$  is then given by:

$$\pi_j = p_j NP_j - F \quad (4)$$

The game is solved by backward induction. In stage two, firms choose prices given their personalization decision in stage one. From (3), we have two important derivatives:

$$\frac{\partial P_j}{\partial p_k} = \frac{P_j P_k}{\mu}, \quad j \neq k \quad (5)$$

$$\frac{\partial P_j}{\partial p_j} = \frac{P_j (P_j - 1)}{\mu} \quad (6)$$

Using (5) and (6), the first order condition and the second order conditions are:

$$\left. \frac{\partial \pi_j}{\partial p_j} \right|_{p_j=p_j^*} = p_j^* N \frac{P_j^* (P_j^* - 1)}{\mu} + NP_j^* = 0 \quad (7)$$

$$\left. \frac{\partial \pi_j}{\partial p_j} \right|_{p_j=p_j^*} = p_j^* N \frac{(2P_j^* - 1)P_j^* (P_j^* - 1)}{\mu^2} + 2N \frac{P_j^* (P_j^* - 1)}{\mu} \quad (8)$$

Note that by putting (7) into (8), the second order conditions equals to  $-NP_j^*/\mu < 0$ . Therefore, the profit function is quasi-concave and a solution exists. By (7), the equilibrium prices are given by:

$$p_j^* = \frac{\mu}{1 - P_j^*} \quad (9)$$

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<sup>1</sup> The analysis approach of this and the subsequent two sections borrows heavily from Anderson, Palma, and Thisse [22] section 7.5 since similar types of issues are studied.

Since all firms are identical in cost structure, only symmetric equilibrium is possible. Hence all firms will set the same price and have the same share of the market. That is,  $p_j^* = p^*$  and  $P_j^* = 1/n$ . The equilibrium price is thus;

$$p^* = \frac{n\mu}{n-1} \quad (10)$$

In stage one, firms choose degree of personalization offered given their anticipation of the equilibrium price given by (10). Again, due to symmetric cost structures among firms, the same degree of personalization will be chosen. As customers value personalization favorably ( $\theta > 0$ ) and it is costless for firms to deliver personalization, all firms will choose the highest possible degree of personalization.

We summarized the analysis in this section by the following proposition.

*Proposition 1: When it is costless for firms to deliver personalization and all firms share the same cost structure, the highest possible degree of personalization will be offered and the equilibrium price set is proportional to the customer heterogeneity in the market. In the next two sections we will discuss two extensions of the base model where the implementation strategy of personalization will influence the cost structure of online firms. We summarize the two situations in Figure 1 below.*

		<u>Implementation Strategy</u>	
		<u>Platform</u>	<u>Application</u>
<u>Cost Structure</u>	<u>Fixed</u>	$F(d_j)$	$F$ is a constant
	<u>Marginal</u>	$c$ is a constant	$c(d_j)$

**Figure 1. Cost Structures of Platform vs. Application Strategies**

## B. Personalization using the Application Strategy

In this sub-section we consider competition among firms when the “Buy” strategy is the dominant way to offer personalization. By using “Buy” strategies in producing and delivering personalization, the fixed cost of a firm is independent of the degree of personalization while the variable cost of production will be dependent on how much personalization is offered to the market. Therefore, firm  $j$  face a variable cost,  $c_j = c(d_j)$  and a fixed cost,  $F$ . We assume that the cost function is increasing and strictly convex, i.e.,  $c'(\cdot) > 0$  and  $c''(\cdot) > 0$ . Denote the lowest possible and highest possible degrees of personalization by  $\underline{d}$  and  $\bar{d}$

respectively. It is assumed that  $c'(d) < \theta < c'(\bar{d})$ . The valuation of personalization by customers is in between the marginal costs of producing the lowest and highest possible degrees of personalization. Denote the price vector  $(p_1, p_2, \dots, p_n)$  by  $\bar{p}$  and the personalization vector  $(d_1, d_2, \dots, d_n)$  by  $\bar{d}$ . The profit function of firm  $j$  is given by:

$$\pi_j(\bar{p}, \bar{d}) = [p_j - c(d_j)]NP_j - F \quad (11)$$

The game is solved by backward induction and we first consider the case of symmetric equilibrium. Suppose in stage one, firm  $j$  has chosen  $d_j$  and all other firms have chosen  $d$ . In the stage two sub-game, with non-zero marginal cost, it can be shown that the equilibrium prices are given by the following using (3) and (4):

$$p_j^* = c(d_j) + \frac{\mu}{1 - \exp[(\theta d_j - p_j^*)/\mu]/S} \quad (12)$$

and for  $k \neq j$ ,  $p_k^* = p^*$

$$p^* = c(d) + \frac{\mu}{1 - \exp[(\theta d - p^*)/\mu]/S} \quad (13)$$

where  $S = \exp[(\theta d_j - p_j^*)/\mu] + (n-1)\exp[(\theta d - p^*)/\mu]$

Putting (12) into (11), we get the profit function of firm  $j$  for the stage one of the game:

$$\pi_j = \frac{\mu N s}{n-1} - F \quad (14)$$

where  $s = \exp\{[(\theta d_j - p_j^*) - (\theta d - p^*)]/\mu\}$  is the ratio of the market share of firm  $j$  to that of one of the other firm.

In stage one, firm  $j$  makes decision on  $d_j$ . The first order condition is given by:

$$\frac{\partial \pi_j}{\partial d_j} = \frac{\mu N}{n-1} \frac{\partial s}{\partial d_j} = \frac{N s}{n-1} \left[ \theta + \frac{\partial}{\partial d_j} (p^* - p_j^*) \right] = 0 \quad (15)$$

Subtracting (12) from (13) gives:

$$\frac{p^* - p_j^*}{\mu} = \frac{c(d) - c(d_j)}{\mu} + \frac{1}{n-2-s} - \frac{s}{n-1} \quad (16)$$

Differentiating (16) with respect to  $d_j$  and using the fact that  $\partial s / \partial d_j = 0$  inferred by (15),

$$\frac{\partial}{\partial d_j}(p^* - p_j^*) = -c'(d_j) \quad (17)$$

Putting (17) into (15), we have the following solution:

$$c'(d_j) = \theta \quad (18)$$

The second order condition is:

$$\frac{\partial^2 \pi_j}{\partial d_j^2} = \frac{N\mu}{n-1} \frac{\partial^2 s}{\partial d_j^2} = \frac{Ns}{n-1} \frac{\partial^2}{\partial d_j^2} (p^* - p_j^*) < 0 \quad (19)$$

From (19), we can readily derived  $\partial^2 s / \partial d_j^2 = (s/\mu) \partial^2 (p^* - p_j^*) / \partial d_j^2$ . Together with the fact that  $\partial s / \partial d_j = 0$  and differentiating (16) twice, the following is got:

$$\frac{\partial^2}{\partial d_j^2} (p^* - p_j^*) = \frac{-c''(d_j)}{1 + s[1/(n-1) + 1/(n-2+s)^2]} < 0 \quad (20)$$

Therefore, the second order condition is satisfied and a solution exists. In the symmetric equilibrium, the degrees of personalization chosen by all firms are the same, i.e.,  $d_j^* = d^*$  for all  $j$ . Hence the equilibrium prices in the second stage of the game are the same for all firms and each firm share the market equally. From (12), the equilibrium price is:

$$p^* = c(d^*) + \frac{n\mu}{n-1} \quad (21)$$

Note that at the symmetric equilibrium, the marginal cost of providing personalization is the same as the marginal benefit as shown in (18). This implies that the symmetric equilibrium is socially optimal and the only sub-game perfect Nash equilibrium.

We summarized the analysis of this section by the following proposition.

*Proposition 2: When the degree of personalization affects only marginal cost:*

1. All firms choose the same degree of personalization, which in general is not the highest possible one.
2. The equilibrium is socially optimal.
3. Equilibrium degree of personalization is independent of number of firms in the market and hence unaffected by competition.
4. The equilibrium price exceeds marginal cost due to customer heterogeneity (by an amount proportional to  $\mu$ ).
5. If marginal cost increases by a fixed amount independent of degree of personalization, all such cost increases will be passed to customers.

### C. Personalization through the Platform Strategy

In this section, we deal with the duopoly case ( $n=2$ ) where the dominant strategy to produce and deliver personalization by firms is the “platform” strategy. To achieve a higher degree of personalization, the fixed cost is increased and the marginal cost is unaffected. The fixed cost is represented by a function in degree of personalization,  $F(d_j) = \exp(d_j)$  and the marginal cost is denoted by a constant  $c$ . The exponential functional form for fixed cost is chosen for two reasons. First, it makes the analysis tractable. Second, it captures well the fact that it will be increasingly difficult to produce a platform with higher and higher personalization power.

For any given choice of personalization in stage one, the price equilibrium of the stage two game is specified by (12) and (13). Denoting the ratio of firm 1’s output to firm 2’s output by  $\hat{s} = \exp\{\theta(d_1 - d_2) - (p_1^* - p_2^*)/\mu\}$ , the equilibrium prices of the stage two sub-game are:

$$p_1^* = c + \mu(1 + \hat{s}) \quad (22)$$

$$p_2^* = c + \mu(1 + \frac{1}{\hat{s}}) \quad (23)$$

By (22) and (23), the ratio can be found implicitly by:

$$\hat{s} = \exp\left[\frac{\theta(d_1 - d_2)}{\mu} - \hat{s} + \frac{1}{\hat{s}}\right] \quad (24)$$

In stage one, the profit functions of the two firms are:

$$\pi_j = (p_j^* - c)NP_j^* - F(d_j) \quad j = 1, 2 \quad (25)$$

Using (22) and (23), and the facts that  $P_1^* = \hat{s}/(1 + \hat{s})$ ,  $P_2^* = 1/(1 + \hat{s})$ , and  $F(d_j) = \exp(d_j)$ , we have:

$$\pi_1 = N\mu\hat{s} - \exp(d_1) \quad (26)$$

$$\pi_2 = N\frac{\mu}{\hat{s}} - \exp(d_2) \quad (27)$$

Using the first derivatives of (24) with respect to  $d_1$  and  $d_2$ , the first order conditions are:

$$\frac{\partial \pi_1}{\partial d_1} = \frac{N\theta\hat{s}^2}{\hat{s}^2 + \hat{s} + 1} - \exp(d_1) = 0 \quad (28)$$

$$\frac{\partial \pi_2}{\partial d_2} = \frac{N\theta}{\hat{s}^2 + \hat{s} + 1} - \exp(d_2) = 0 \quad (29)$$

Taking ratios of (28) and (29) yields the following condition:

$$\hat{s}^2 = \exp(d_1 - d_2) \quad (30)$$

Putting (30) into (24) gets the following equation,

$$\left(1 - \frac{2\theta}{\mu}\right) \ln(\hat{s}) + \hat{s} - \frac{1}{\hat{s}} = 0 \quad (31)$$

The solution of (31) describes the sub-game perfect Nash equilibrium.

One obvious solution for (31) is  $\hat{s} = 1$ . In this case, the resulting equilibrium is a symmetric one with the following optimal degrees of personalization and prices:

$$d_1^* = d_2^* = \ln\left(\frac{N\theta}{3}\right) \quad (32)$$

$$p_1^* = p_2^* = c + 2\mu \quad (33)$$

Note that the optimal degree of personalization is increasing in the market size  $N$ . From (28) and (29), we can see that this is true for any equilibrium. With the fixed cost being dependent on the degree of personalization offered, the larger the market size, the greater the economies of scale are available. As a result, firms will choose to provide more personalized products to large markets.

The corresponding second order condition is:

$$\frac{\partial^2 \pi_2}{\partial d_2^2} \Big|_{(d_1^*, d_2^*)} = \frac{N\theta}{3} \left( \frac{\theta}{3\mu} - 1 \right) < 0 \quad (34)$$

which requires  $\mu > \theta/3$ . Therefore, the symmetric equilibrium only exists when  $\mu$  is large enough. The derivative of (31) with respect to  $\hat{s}$ , we get the following:

$$\hat{s}^2 + \left(1 - \frac{2\theta}{\mu}\right)\hat{s} + 1 = 0 \quad (35)$$

The quadratic form of (35) suggest that (31) has at most three roots. When  $\mu \geq 2\theta/3$ ,  $\hat{s} = 1$  is the only solution. Hence, the symmetric equilibrium is the unique sub-game perfect Nash equilibrium when  $\mu$  is sufficiently large. When  $\mu < 2\theta/3$ , equation (31) has exactly three roots. For immediate values of  $\mu$  ( $\theta/3 < \mu < 2\theta/3$ ), both symmetric and asymmetric equilibrium are possible. When  $\mu$  is small enough ( $\mu \leq \theta/3$ ), the only possible sub-game perfect Nash equilibrium is asymmetric.

We summarized the analysis in this section with the following proposition:

*Proposition 3: When the degree of personalization affects only fixed cost:*

1. *When the market is heterogeneous (i.e., consumers have diverse tastes), firms select the same degree of personalization.*
2. *When the market is homogeneous (i.e., consumers can be segmented into groups with similar tastes), firms select different degrees of personalization.*
3. *The larger the market is, the more personalized the products offered will be.*

## V. Discussions and Conclusion

Using a parsimonious model incorporating personalization as vertical differentiation, we analyze the strategic values of personalization under different implementation strategies and different degrees of consumer heterogeneity. Our results demonstrate both theoretical insights and important managerial

implications for using personalization as a source of competitive advantages in online markets.

## A. Theoretical Insights

Using a game theoretical approach in the current study, we analyze the impacts of implementation strategies and customer heterogeneity on the potential of personalization as a source of competitive advantage. Our paper extends research on personalization in three aspects. First, although horizontal differentiation by product variants and price discrimination has been extensively studied, the strategic value of vertical differentiation alone is less examined. However, in the real world multiple versions of products or services are not as pervasive as in the IT industry. One possible reason is the costly nature of versioning physical products – this is why Dewan et al. assume quadratic form of the cost function for the product variation strategy. In fact, in some industry sectors such as online bookstore, personalization provides strategic value mainly as a tool of vertical differentiation – customers shop at Amazon.com not because it offers books of greater variety, but because it offers the right and timely recommendations that greatly simplify customers' decision making process and save their search cost. Thus overall service at Amazon.com (i.e., selling books or selling knowledge) with personalization embedded is perceived by customers as more valuable or of higher quality than that offered by other online bookstores. With the more fierce online competition in markets of relatively homogeneous products or services, personalization may play a more important role in strategic differentiation. As discussed in the introduction part, although there are several prominent online bookstores (e.g., *Amazon.com*, *Barnes & Noble* and *Buy.com*), their business performances are quite different with Amazon.com leading the market even the other two mimic its personalization strategy. Can personalization differentiate a firm from its competitors in such case, and why? In this paper we focus on vertical differentiation and the strategic value of mere personalization – that is, different degree of personalization can induce different expected value of products or service perceived by customers. Thus, unlike personalization research of horizontal differentiation that assumes personalization away as a prerequisite of the research models, we incorporate degree of personalization directly into our model as an IT artifact [21].

Secondly, we incorporate different degrees of consumer heterogeneity in our research model. In the models where horizontal differentiation is considered, customer preferences are usually assumed to follow Hotelling's framework, where customer preferences are assumed to distribute along either a segment [20] or a circle [17]. And different customers have different valuations of the same product or service. As discussed above, these assumptions are appropriate when horizontal differentiation and price discrimination is the primary concern. However, when the personalization is directly modeled in vertical differentiation, different degree of personalization should result in different level of valuation of products or services – generally customers should have higher valuation of a

recommendation that exactly match his / her preferences than another one which is partial match. The degree of match depends on the degree of personalization. On the other hand, customer may still possess heterogeneous preferences toward the psychical product or services independent of the degree of personalization. And this heterogeneity of preference differs across various product / service types. For instance, without considering different degrees of personalization, customers have relatively homogeneous preferences toward the service provided by online bookstores. On the other hand, customer may have different valuation of services provided by online travel agencies or online health care institutions due to the nature of the services. Is personalization also important in such cases? The two cases reported by the Jupiter 2003 report cast doubts on this question and a formal analysis is needed. In the current research, we adopt a random utility framework to model customer preference, where the utility level of a customer deriving from a product or service depends on both the degree of personalization and a random factor. Customers are assumed to have higher utility of a product with higher degree of personalization (vertical differentiation), but the total utility also depends on a random variable (heterogeneity). The degree of customer heterogeneity is modeled as the variance of the distribution of the random factor. In this way, both vertical differentiation and customer heterogeneity are captured in our model.

Finally and most important, in contrast to the extensive studies of personalization benefits, the implementation strategy (platform vs. application) and the associated cost structure of personalization is less emphasized in the literature. Usually the cost of personalization is assumed to be a fixed amount or of a specific functional form. For example, Shaffer and Zhang [20] assumed a fixed cost of “targeting” in one-to-one promotions. Ulph and Vulkan [18] assumed a constant marginal cost of mass customization. Dewan et al. [17] assumed a variable cost of customization by a quadratic function form – mainly to capture the increasing marginal cost of diversification. However, as discussed in the introduction part, the Jupiter 2003 report indicated that the magnitude of personalization cost is significant and the structure is far more complicated – the total cost consists of both a fixed part (investment on software purchase or development and hardware equipments) and a variable part (human capital required to maintain and enhance the system) and the cost structure directly depends on the implementation strategy of personalization – platform vs. application. Under competition and customer heterogeneity, how does the implementation strategy influence the degree of personalization? And will the influence change under different degree of customer heterogeneity? Our analytic model provides insights into these issues. We find that the platform strategy is in general preferred. However, adopting the application strategy is socially optimal. Particularly, personalization based on the platform strategy has limited strategic value when customers are highly heterogeneous – firms may capture the strategic value of a platform only when customers are homogeneous enough. Personalization cannot be an effective tool of differentiation, but will be a

competitive necessity, when the technology is mature and the implementation cost is negligible.

## B. Strategic Implications

As noted by Porter [23], a differentiation strategy is valuable only if it can make the product or service of a firm *different* from others. Personalization, as a differentiation tool, can deliver little strategic value when all firms personalized their products to the same extent (e.g. a symmetric equilibrium). The strategic value of personalization can only be realized in markets where firms behave differently (e.g. an asymmetric equilibrium). In markets where the platform strategy is dominant, there is an important role played by the market size and the extent of customer heterogeneity in capturing the strategic value of personalization. The optimal degree of personalization chosen by firms is increasing in market size, due to the presence of economies of scale. When customers are highly heterogeneous in tastes and preferences, there is little strategic value that personalization can provide. In such markets, personalization is a competitive necessity. On the other hand, when customers are very homogeneous in tastes and preferences, firms can use personalization as a source of competitive advantage.

When the application strategy is dominating the market, all firms will offer personalization at the socially optimal level. Though this is desirable from a government policy point of view, personalization cannot be an effective tool of differentiation. The optimal level of personalization offered is independent of competition and market size. In case there are any fixed increases to the marginal cost of producing and delivering personalization, it is optimal for firms to pass them to the customers.

<u>Competitive Advantages</u>		<u>Implementation Strategy</u>	
		<u>Platform</u>	<u>Application</u>
<u>Consumer Heterogeneity</u>	<u>High</u>	No	No
	<u>Medium</u>	Maybe	No
	<u>Low</u>	Yes	No

**Figure 2. The Strategic Interaction between Consumer Heterogeneity of Personalization**

The results are supported by anecdotal evidence. Early adopters like *Amazon.com*, *Staples*, and *Office Depot* implemented similar platforms supporting its personalization needs. In the market of books and office supplies, customers' preference and demands are well defined and quite homogeneous in

terms of the online services they want (reviews, recommendations, transaction records, etc.). In such markets, personalization through the platform strategy could be a source of strategic values. As discussed earlier, *Amazon.com*, *Staples*, and *Office Depot* are all enjoying significant returns from their personalization investment. In the travel and health care industry, customers are highly heterogeneous in tastes and preferences of online services. Our results suggest that the strategic value of personalization is limited in such markets, no matter which implementation strategy is employed, and this is supported by the two cases reported by the Jupiter 2003 report.

In light of the possibility of creating competitive advantages by personalization, managers may consider favorably towards the platform strategy when both strategies are equally attractive in all other aspects. When personalization technology is so mature that the cost of implementing it is negligible, all firms will be offering the same degree of personalization. As such, there is little strategic value that personalization can offer to firms. However, firms should all provide as much personalization as possible. Personalization, instead of being a possible way to create competitive advantage, is a competitive necessity.

### **C. Limitations and Future Directions**

Our model takes a first step in investigating the realization of strategic value of personalization with the two basic implementation strategies: platform vs. application. As technology advances and firms get more experience in implementing personalization, it is possible that new types of implementation strategies will be used. For example, firms may choose a mixed strategy to reach both the majority of consumers with platform and other power users with special preferences. More complicated strategies with both fixed and variable costs dependent on the implementation of personalization may have significant impacts on market outcomes.

In additions, besides personalization, the simultaneous presence of other dimensions of differentiation for products is also an interesting area to look at. The value of personalization for products with different level of differentiation in other aspects is not very well understood. We have shown that customer heterogeneity on the demand side does have significant impacts on the use of personalization as a strategy. On the supply side, product differentiation in other aspects coexisting with personalization could play an important role too.

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