Examining the Role of "Free" Product-Augmenting Online Services in Pricing and Customer Retention Strategies

RAMNATH K. CHELLAPPA AND K. RAVI KUMAR

RAMNATH K. CHELLAPPA is an Assistant Professor of Information Systems in the Department of Information and Operations Management, Marshall School of Business, University of Southern California. He is the Codirector of the Electronic Economy Research Lab at the Marshall School (ebizlab) and is also affiliated with the Center for Research in Electronic Commerce at the University of Texas at Austin. His primary interests and expertise are in the topical areas of digital product piracy, electronic commerce, technology standards, information security, and privacy. He applies economic modeling methods and social network analysis to analyze problems related to incentives, intellectual property rights, standards development, and public policy governance. His research papers have been published in leading journals and conferences on information systems. His recent paper on privacy won the best CIST-INFORMS conference theme paper award for the year 2003. He is also frequently cited in the practitioner and popular press on technology-related issues. Dr. Chellappa received his Ph.D. in Management Information Systems from the University of Texas at Austin in 1997.

K. RAVI KUMAR is a Professor in the Department of Information and Operations Management at the Marshall School of Business in the University of Southern California. He also serves as the Vice Dean for International Programs and is in charge of all of Marshall's distinctive experiential learning courses, such as PRIME, PM.GLOBE, and ExPORT. Dr. Kumar received his Ph.D. from the Industrial Engineering and Management Sciences Department at Northwestern University and, before joining USC in 1986, he taught at the University of Illinois at Urbana–Champaign. His research interests include the embedding of information systems within global physical operations as well as the development of sustainable information technology industries in developing countries (such as IT hardware in Taiwan and software in India). He is the author or coauthor of more than 40 articles, including publications in *Management Science, Marketing Science, Journal of Economic Theory, Production and Operations Management,* and *Journal of Operations Management.*

ABSTRACT: As products on the Web are continually enhanced through "free" Web-based services that add to the product purchase experience, it is important to understand how these free services may affect pricing and customer retention strategies of an online vendor. This paper argues that product competition on the Web is not for *generic* products but, rather, for *expected* and *augmented* product bundles. Our findings point out that even in the absence of price premiums, variance in the ability to offer online services can affect pricing strategies and possibly contribute to online

Journal of Management Information Systems / Summer 2005, Vol. 22, No. 1, pp. 355–377.

0742–1222 / 2005 $9.50 + 0.00.

price dispersion. We then go on to suggest that online services affect a vendor's customer retention strategy as they influence the design of the augmented product. We characterize an online vendor's selection of augmenting services as a knapsack problem, and recommend that the online vendor should not only periodically reevaluate the set of services offered to satisfy the expected product requirements, but also assess the customer retention ability of his augmented product. A service does not contribute to customer retention when it has either lost its value to the customer or become required as a part of the expected product. Our solution recommends that a vendor should include new services based on the cost-to-value ratio of each service so as to remain above the loyalty threshold of a consumer. The results from our model partially explain the variety in product offerings of many online vendors, whose competency in providing Web-based services allows them to vary the *generic* product.

KEY WORDS AND PHRASES: consumer loyalty, customer retention, knapsack problem, online pricing, online services, product augmentation, switching behavior.

THE WIDESPREAD ADOPTION OF THE INTERNET by both vendors and consumers alike has created a thriving electronic marketplace on the Web for many consumer goods. The characteristics of these markets have been studied extensively in information systems (IS) literature [1, 15, 20, 21]. In addition to those services that accompany product purchasing in the brick-and-mortar context, the online stores offer a plethora of Web-based services such as product comparison tools, expert/peer review of products, coupons, personalized shipping, and other services that are tailored to individual consumers. There are two important facets of these online services; first, online stores do not explicitly price—that is, charge for—these services, and, second, many of these services are common across different online stores. However, there is currently little academic research that has studied the role of these "free" online services.

In this paper, we propose that products on the Web are not just *generic products* but they are actually *augmented products* [18], and this augmentation is the result of services that envelop a product to create a consumer's product purchasing experience. For example, in an electronic market for used cars, such services may include user recommendations, instant access to Blue Book values, and reviews by known auto personalities. Therefore, a consumer's value from an online purchase is the aggregate value of the product and the purchase experience. Similarly, from a seller's perspective, the cost of online selling is the aggregate cost of the product being sold and the cost incurred in offering Web-based services that create the product purchase experience. This leads us to two questions: Can "free" augmentation services possibly play a role in a vendor's pricing strategies? What is the economic rationale behind offering online services if consumers are not being explicitly charged for services?

Our research posits that even if these services are free to the consumer and common across most online vendors, the ability (as dictated by technical and human factors) to offer the services may vary considerably across different vendors. Further, we also point out that although vendors may not directly extract a price for the online services, these services do contribute toward maintaining loyalty and thus serve as a barrier to switching. Based on this premise, we develop two models: Our first model analyzes pricing strategies of an online firm when competing firms also provide at least the *expected product* (defined as the product and the core set of services expected by the consumer). Our second model develops a service selection strategy with respect to a representative consumer, wherein the focal firm's choice of services to offer is illustrated through a numerical example. Our analyses show that even if services are "free," the differences in implementation abilities can be a source of variability in prices. Further, we introduce a construct called the *switching threshold* as a proxy for loyalty, and propose that although the services do not extract price premiums, they contribute to customer retention. We then cast a vendor's strategy of identifying his ideal set of Web-based services as a knapsack problem, and show that vendors can make their service selections by analyzing the cost-to-value ratio of individual services. We highlight our analysis through a numerical illustration and discuss the theoretical and managerial implications of our work.

Characterizing Regulated and Unregulated Electronic Markets

Markets or marketplaces provide a platform for transactions [3], and they typically match buyers and sellers; facilitate exchange of information, goods, and services; enable payments associated with the exchange; and provide an institutional infrastructure that allows for efficient trade. There are two kinds of *electronic* markets—one that is unregulated and built on open standards (e.g., technologies such as TCP/IP [transmission control protocol/Internet protocol] and the Internet as a whole) with no limitations on who can participate and a second that is regulated and built on a proprietary architecture. We refer to the former as Web-based electronic marketplaces and the latter as regulated electronic marketplaces.

Regulated electronic marketplaces, such as those for stock and commodities trading, require an entry fee and compliance with conditions set by a market regulator. Entities such as the NYSE or NASDAQ provide a regulated market where registered brokerages participate through an auctionlike mechanism. The firms that list themselves with NYSE/NASDAQ, as well as the brokerages that trade in stocks of these companies, need to satisfy rules and regulations set forth by regulators such as the Securities and Exchange Commission (SEC). Violations of these regulations could result in fines, penalties, and delisting for the violators. For example, in NASDAQ, market makers post bid and ask prices of stocks in SuperMontage to all market participants [4]. Electronic communications networks (ECNs) also bring buyers and sellers together for electronic execution of trades and play an important role in reducing transaction costs [5]. Not only are ECNs operating in U.S. securities markets regulated but they are also obligated by the SEC to provide the best execution of an order [4]. However, no such regulations govern the selling of books or CDs on Amazon.com or an auction setup such as eBay.com.

Unregulated Web-based electronic markets are fundamentally different in that there is little or no barrier to entry for any firm that wants to establish a storefront on the Web, and the role of regulators such as the Federal Trade Commission (FTC), which now play an important role in privacy initiatives, is still being defined. Anyone can operate a business on the Web without the need for a centralized sanction other than a domain name from the Internet Corporation for Assigned Names and Numbers (ICANN), which approves Domain Name Servers (DNS). The cost for a business to establish a bare-bones Web presence is quite small, though a full-fledged online strategy may imply a significant investment, leading to a rapid increase in the number of retailers in a very short amount of time (see www.mediametrix.com for annual growth statistics). Although many of these e-tailers may not survive in the medium to long run, they do increase competition in Web-based markets. Our research proposes that an important consequence of this competition is the offering of "free" Web-based services along with many products sold on the Web.

Free Web-based services are used to enhance products, and can possibly lead to variability in vendors' pricing, even if a part of the market itself is regulated. To illustrate our point, consider the case of airline tickets offered on the Web. An online travel agency has two main operational parts—the Computerized Reservation System (CRS), which is regulated by the Federal Aviation Administration (FAA), and a Web-based front end. For the purpose of this research, we constructed an intelligent agent to retrieve prices for a selected segment between Los Angeles and New York for a specific time. An analysis of these results reveals that for a particular airline/flight combination, the ticket prices are exactly the same. Clearly, this result is not surprising, since all the online travel agents talk to the same set of CRSs, such as Sabre and Apollo. On the other hand, it has been shown that the prices of airline tickets vary as much as 20 percent across online travel agents [8]. This apparent anomaly can be explained if we look closely at the tools available through the Web-based user interface. One important reason for the variation in prices is that when a consumer selects a city pair, the result of his query greatly depends on how the online interface chooses to present the price listing. Not only can sorting mechanisms and the choice to add or leave out taxes affect the price that the consumer sees, but online travel sites also offer a variety of free comparison and recommender services along with a basic ticket.

An important question that emerges in the context of Web-based markets is: How do add-on services that are offered along with a product contribute to a vendor's pricing strategy, given that they are not being charged for! In physical markets, it is well known that with vanishing search costs, firms offering homogenous products in a market will have to charge the same price. Positive search costs, though, will lead to variable prices [28]. Given the belief that the Internet reduces search costs [2] and creates greater market transparency [1], it has been expected that all vendors will charge the same prices. However, empirical findings suggest otherwise; for example, prices of books have a variation of 33 percent and prices of CDs have 25 percent dispersion [6]. In this regard, Varian [30] suggests that the "law of one price" is no law at all, and, even if consumers behave rationally, vendors can set different prices. He suggests that vendors can randomly change prices such that consumers cannot learn from experience, thus allowing vendors to charge different prices for homogenous goods. More recently, Chen and Hitt [7] suggest that even in the online context, branded retailers can price products higher than unbranded retailers. Such an argument is also provided in the case of online travel agents, where a travel agency's market position and strategies can contribute to its pricing strategy [10]. Our paper argues that a *part* of the variability in prices can be explained by vendors' differences in implementing Web-based services.

Another important question that emerges in the context of free Web-based services is how vendors should select a set of services to offer, given that these services have differential costs of implementation. In order to be comparable to other competitors in a market, a vendor may be required to offer a basic set of services, implying that he has no choice in their selection. Our research suggests that there may be indirect benefits to offering more than the required set of services, even if no direct revenue is generated. We go on to propose that although the role of Web-based services in customer acquisition may be hard to assess, they play a very definitive role in customer retention, and hence a vendor's selection of an ideal basket of services is critical.

Expected and Augmented Products on the Web

Rose is a rose is a rose is a rose.

—Gertrude Stein

A PRODUCT ON THE WEB is not defined just by the core value it provides or its price; rather, it is defined by the bundle of services that accompanies its purchase, hence a bouquet of roses ordered from 1800flowers.com differs from those ordered through its rival ftd.com, even if the roses and prices themselves are indistinguishable. To this extent, Levitt observes the following about commodities in physical markets: "This [that commodities are only price dependent] is seldom true except in the imagined world of economics textbooks. In the actual world of markets, nothing is exempt from other considerations, even when price competition rages" [18, p. 3].

We adopt this view from Levitt [18] to define products sold on the Web, that a product is more than just its tangible features, but, rather, it is a combination of the tangible and the intangible, a complex bundle of attributes and perceived benefits. Levitt [18] argues that any product can be conceptualized to have a range of possibilities: (1) the *generic (or core) product,* which is the rudimentary, substantive "thing," sought by consumers; (2) the *expected (or actual) product,* which represents the customer minimal purchase conditions; (3) the *augmented product,* which is the addition of extra or unprompted augmentations or benefits to the expected product; and (4) the *potential product,* which refers to everything potentially feasible to attract and keep customers. Thus, a generic product may be upgraded to an augmented or potential product through a series of intangibles in the form of services.

Along these lines, a product on the Web consists of the product itself and the Web-based services that accompany the product purchase experience, as shown in Figure 1

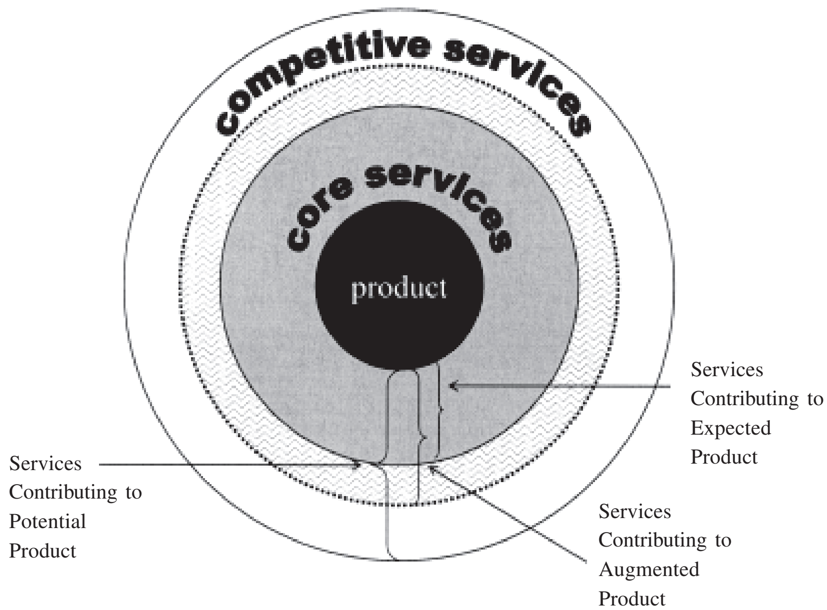

Figure 1. A Model of Products on the Web (product + product purchase experience)

(adapted from Levitt's model). Whereas digital product vendors can introduce augmentations to the product itself, augmentation to physical products is created by services that are part of the different phases of a product buying process, such as search, evaluation, and postpurchase interactions. Some of these services have been referred to as the "digital attributes" of a product and have been found to have a significant effect on online competition [16].

Product augmentation on the Web can be done in a variety of ways and at different times. For example, when a customer logs into an e-tailer such as Amazon.com, it provides him or her with a series of services such as recommendation, electronic coupons, complementary product sales, and information. In other words, even though the customer logs into the Web site to buy a book, a set of services are offered to enrich his or her buying experience. Note that consumers on the Web are usually not charged for these accompanying services, and, in fact, consumers today are getting used to more of these services without actually paying for them. Therefore, vendors are now faced with a situation in which consumers have begun to expect a default set of services during any product purchase. Thus, many services that might have been part of the *augmented product* are increasingly becoming part of the *expected product* today; for instance, not many customers may be willing to buy a CD without reviews or personalization services being offered by the e-tailer. The number of these services on the Web may be limitless, and an infinite number of new services can be introduced, therefore always extending the notion of the *potential product.* The extension of Levitt's characterization of an expected product to a competitive setting closely resembles the "strategic necessity" hypothesis proposed by Clemons and Row

[9] in that services that may have been introduced as a strategy by a leader have now become commonplace on the Web, and consumers de facto expect them to be offered. Therefore, in order to compete effectively, online e-tailers need to offer at least the number of services that constitute the expected product.

However, not every vendor is equally capable of offering every service that makes up the expected product, and, moreover, this capability is intrinsic to a firm and is dependent upon its technical human resources and ability to manage technology outsourcing. Even if the services do not generate revenue, online vendors will need to incorporate the costs incurred in creating the expected product in their pricing strategy. To analyze this pricing strategy, we develop our model of expected product pricing.

Model 1—Expected Product Pricing

We consider a stylized model of online vendors offering some homogenous good with some known demand function. Vendors offer Web-based services, but they do not charge for them even if they do incur a cost in providing the services. Consider the following profit maximization problem of vendors in the online marketplace:

$$\Pi(p,o,s) = pD(p) - c\big(D(p),o,s\big), \tag{1}$$

where p is the price of the product and $D(p)$ is the downward sloping, twice continuously differentiable demand, dependent only on prices (i.e., $D'(p) < 0$). $c(D(p), o, s)$ is the cost function, twice continuously differentiable, and increasing in o and s. $o \in [0, \infty]$ is some service-level parameter that depicts the number of Web services offered, where $o = 0$ implies no services and $o \to \infty$ represents all possible Web-based services (part of the potential product). We assume that there exists an $\bar{o}$, which is representative of the minimum number of services (core services) offered in order for a vendor to be a participant in the electronic market—that is, each vendor is able to provide at least the *expected product.* In our model, we refer to the smallest unit of any valued offering on the Web as a service, and complex services can be constituted by aggregating many of these atomic services. We denote the implementation ability or skills of the vendor in providing the Web-based services as $s \in [0, 1]$. This parameter is used to capture the varying costs to vendors in offering Web-based services. For example, technologically sophisticated firms that also have ready access to human resources would incur a lower cost of offering Web-based services, and hence would have a low value for s. Similarly, even the ability to manage information technology (IT) outsourcing is firm specific—for example, Dell is known for its strategic capability in managing outsourcing partners that far surpasses its competitors. We also assume that this ability to offer Web-based services is known only to the firm offering the service—that is, firms in the electronic market do not know each other's cost of providing Web-based services.

Consider a set of n competing firms whose implementation ability in providing Web-based services $s_{i=1,\ldots,n}$ is uniformly distributed in the bounds [0, 1]. The cumulative distribution function is common knowledge, and the hazard rate can be written as $h(s) = 1/(1 - s)$. We first wish to understand how firms on the Web will set prices for a given product, assuming that they all offer only $\bar{o}$ number of services (minimal services that a consumer expects when buying a product on the Web). To determine prices, we model this as a simple Nash game [27, p. 76]. Given that one firm does not know the other firms' cost of offering services, the firms will choose prices based on the expectations of the other firms' equilibrium strategies.

Proposition 1: When the costs of offering Web-based services vary and when vendors in the marketplace are not privy to each other's implementation abilities, there is an equilibrium where vendor prices do not converge to marginal cost pricing. At equilibrium, each vendor will offer the expected product at some price $p^*(s)$ strictly less than its monopoly price $p^m(s)$, which is given by the solution to

$$p'^*(s) = \frac{(n-1)\pi\left(p^*(s), s\right)}{(1-s)\pi'\left(p^*(s), s\right)},$$

with boundary condition $\pi(p^*(\bar{s}), \bar{s}) = 0$.

Proof: Let $\bar{s}$ be the service parameter of the firm with the highest cost of offering services $\bar{o}$ in the market that can still generate a nonnegative profit, and let $p^m(s)$ be the monopoly price for the profit function given in Equation (1). The profit function is concave in s. Given that the vendors do not know each other's costs of offering services, the cost parameter s_i is private information to a vendor i. Consider a market of n vendors with uniformly and independently distributed costs of offering services s. The probability that the value of this random s is the lowest—that is, represents the vendor with the lowest cost—is given by $(1 - s)^{n-1}$. Now recall that $p^*(s) \leq p^m(s)$, thus we need to show that $p^*(s) < p^m(s)\ \forall s$.

Suppose not—that is, suppose $p^*(s) = p^m(s)$ for some s. For a vendor with a cost of $\tilde{s}$, the expected profit can be represented as $\pi(\tilde{s}|s) = (1 - s)^{n-1}\pi(p^*(\tilde{s}), s)$, and from the first-order derivative, we have:

$$\pi'\left(\tilde{s}|s\right) = (1-s)^{n-1}\pi'\left(p^*(\tilde{s}), s\right)p^{*\prime}(\tilde{s}) - (n-2)(1-s)^{n-2}\pi\left(p^*(\tilde{s}), s\right).$$

Now, if $\tilde{s} = s$, then $p^*(s) = p^m(s)$ such that $\pi'(p^*(s), s) = 0$, and

$$\pi'\left(s|s\right) = -(n-2)(1-s)^{n-2}\pi\left(p^m(s), s\right) < 0.$$

In other words, the strategy $p^m(s)$ cannot maximize expected surplus, contradicting $p^*(s) = p^m(s)$. $\therefore p^*(s) < p^m(s)$. There is no closed-form solution for the equilibrium pricing strategy, but we can see that the boundary condition implies that only those firms that have a cost less than the parameter given above can successfully compete in the market. See Spulber [27, p. 76] and Maskin and Riley [23] for further discussions on the implications of pricing at this level, and for a generalized proof.

Note that the monopoly price is not a restrictive upper bound, but is relevant to show that the resulting prices are neither monopolistic nor perfectly competitive. When the competitors have no knowledge of each other's capability of offering services, a seller in the electronic marketplace will not be able to charge the monopoly price, but at the same time, all vendors in the market will not sell at their marginal cost, as in the case of a full information Bertrand model. The market will exhibit a range of prices for a product, which is a function of each seller's capability of offering Web-based services, and the vendor with the highest capability in offering the services will charge the lowest price. Indeed, it is true that variability in the cost of any effort (marketing, logistics, production, etc.) will also lead to price dispersion as long as the cost information is private. Our model simply demonstrates how variability in "free" services can also partially explain price dispersion (we do not make the claim that it is the only source). Note that in this model, there is no specific demand for Web-based services other than a common threshold $\bar{o}$, as a vendor does not explicitly price for these services. As in other game-theoretic models, existence of Nash solutions requires the compactness of the strategy space, and hence we assume a nonzero minimum number of services that is consistent with reality, in that almost every retailer today at least accepts credit card payments.

Thus, if Web-based services add only to the costs of the seller, will all sellers offer only the core set of services $\bar{o}$ for a given market? The array of service offerings online clearly indicates that although there are common services across vendors, vendors may also offer more than the core set of services to their consumers. For example, existing customers of Amazon.com are privy to a "gold box" that consolidates the individual's preferences and offers personalized discount coupons. Note that such a service is not offered by other vendors and is available only to registered customers.

Model 2—Selecting Services to Create the Augmented Product

If vendors do not explicitly charge for the services, how do they choose the set of services to offer? We propose that these services contribute toward the loyalty (or, conversely, the switching) threshold of a consumer. Recent research in marketing [11, 17, 19] has shown that price sensitivity of an online consumer is no different from that in the offline context, and may actually be lower online than offline. But when all the nonprice attributes being considered are grouped together as product information, it has been found that it can affect consumer loyalty [26]. Similarly, we propose that the aggregate value of competitive services (those beyond the common set offered by all vendors) should be higher than a consumer's loyalty value, otherwise he or she might switch to another seller. Consider the loyalty programs, such as the frequent-flyer programs offered by many airlines. Consumers may switch from one airline to another if their value (from special fares, first-class upgrade) from their current program is not sufficient compared to potential gains from switching. When customers have access to a wide range of information about a product, they expect to be able to choose an item that offers them the maximum overall value [32]. Thus, electronic markets do not suddenly make consumers price sensitive, rather they may increase the perceived value of undertaking a price search [25]. So, how does a vendor choose the set of services beyond the core services ($> \bar{o}$) so as to be competitive? Let us now examine the consumer attitude toward the set of services beyond the core set $i \in (\bar{o}, \infty)$ that are being considered by the vendor; henceforth, we shall refer to this set as competitive services.

Standard microeconomic theory [31] dictates that the rational consumer will choose a bundle of services from those available so as to maximize his utility subject to a budget. If v_i is the value placed on the ith service, and if p_i is the price for that service (if services were being charged), then the consumer's decision function can be written as

$$\begin{aligned} &\max \sum U\left(v_i\right) a_i \\ &\text{s.t.} \sum p_i a_i \leq y, \end{aligned} \tag{2}$$

where $a_i = 1$ if service i is chosen and 0 otherwise, y is the income available to the consumer, and U is some utility operator. Note that Equation (2) refers only to utility from the services; the total utility from the entire product purchasing experience is discussed in Equation (6). For reasons of tractability, and in the absence of any known utility functions for Web-based services, we assume that the utilities are independent and additive in services. Indeed, it is possible that utilities of some services may be related, leading to super modularity in values; however, it is beyond the scope of our current research to examine these cases. As discussed earlier, online consumers are not being explicitly charged for services; for example, when Amazon incorporates a new service, such as an automatic reminder system for important anniversaries, it does not explicitly charge a price for that service. Hence, from the standard construction above, it would appear that a consumer may want an infinite number of services. Since the vendor incurs a cost in providing each service, he cannot offer an infinite level of services and will seek to determine an ideal set of services. Typically, a firm will offer a bundle of services from the available set so as to minimize its cost function subject to some technical efficiency frontier or a production function given by the standard microeconomic model:

$$\begin{aligned} &\min \sum c_i a_i \\ &\text{s.t.} \sum f\left(a_i\right) \geq z, \end{aligned} \tag{3}$$

where c_i is the cost of offering the ith service, and $f(a_i)$ is the corresponding production function for some desired level of output z. Just as the optimal solution for the standard form of the consumer model is infinite services when prices are zero, the optimal solution to the vendor's problem is zero services when there is no minimal output stipulation. Therefore, the classical approach to analyzing this problem fails to lend useful insights in our context. Whereas budgeting for technological services is a common practice for IT support services, in a competitive market a firm needs to take into account the consumer's valuation for these services. The optimal strategy for the firm will therefore be to offer a set of services that will maximize the consumer's utility while meeting the budget constraint *w*:

$$\begin{aligned} &\max \sum U\left(v_i\right) a_i \\ &\text{s.t.} \sum c_i a_i \leq w. \end{aligned} \tag{4}$$

However, in a competitive market, a vendor's decision on the number of competitive services cannot merely be a function of his own budget constraint, just as he will not seek to maximize the consumer's utility. Therefore, we develop the vendor's problem as a minimization-of-cost approach subject to some consumer-driven parameter—namely, a minimum consumer utility. We develop this construction in the following fashion.

We construct our vendor's problem as his decision to choose the optimal services at any point in time. The salient points of a seller's decision problem can be given as: (1) he cannot explicitly charge a consumer for a new service, (2) a representative consumer does not value all services equally, and (3) services may rise and fall in value over time. We incorporate a temporal dimension to the vendor's problem to capture the variation in consumers' valuation for certain services with time. For example, WAP (wireless access protocol; which is needed to offer Web services on personal digital assistants [PDAs]) services were important at one point in time when Web browsers on PDAs were unable to read regular Web pages, as opposed to current PDA browsers that can read Web pages directly. From our earlier discussions, we know that the product sold online is not just a *generic product;* rather, it is a bundle of the product and the online services that encompass the product purchase experience. Therefore, assuming a separable utility function over some utility operator *U*, the utility to a consumer from acquiring a product online at any point in time can be written as

$$U_{total}^{t} = U\left(V_{product}, V_{services}^{t}\right). \tag{5}$$

We can categorize services into the common or core services that are offered by all vendors in the electronic market and the new or competitive services that are specific to a vendor. The product, along with the core services, is the equivalent of Levitt's *expected product.* The vendor's decision is to find the optimal *augmented product* from a range of *potential products.* From a consumer valuation perspective, we could express this as

$$U_{total}^{t} = U\left(\underbrace{\overbrace{\underbrace{V_{product}}_{generic\ product}, V_{core\ services}^{t}}^{expected\ product}, V_{competitive\ services}^{t}}_{augmented\ product}\right), \tag{6}$$

where *core services* = $(\bar{o})$ and *competitive services* $\in (\bar{o}, \infty)$. In order to understand switching behavior, we need only consider the competitive services, as both the product and the core services are common across different sellers. A representative consumer's value for a service can change over time due to many exogenous factors; valuation of some services may increase and that of others may decrease. Similarly, some others may become part of the core services—that is, all sellers in the market begin to offer the service. For example, the valuation for mobile Web access may increase in value over time as mobile access technology matures, hence all consumers may demand mobile Web access as a service. On the other hand, with increasing broadband access, text-based services may decrease in value to a consumer. Thus, at any point in time t, the utility from competitive services to a consumer can be written as

$$U^t_{competitive\ services} = U\left(\alpha_{it} a_{it} \,|\, i = \bar{o} + 1, \ldots, \infty\right), \tag{7}$$

where α_{it} is a consumer's value for the ith online service, $a_{it} \in \{0, 1\}$ is a binary variable indicating whether a service is offered or not, and t refers to a time cross-section when the utility is evaluated. The vendor's cost of offering a service may also vary with time. For example, for any unit mobile service offered, a vendor would incur a relatively lesser cost of finding a WML (a mobile markup language) programmer today as compared to a year ago, when it was still an immature technology. Therefore the cost function of the vendor at time t can be written as

$$C^t_{competitive\ services} = C\left(c_{it} a_{it} \,|\, i = \bar{o} + 1, \ldots, \infty\right), \tag{8}$$

where c_{it} is the vendor's cost of offering the ith online service.

> *Proposition 2: A seller's choice of his or her competitive services at any point in time is a function of the representative consumer's switching threshold, and it can be expressed as the solution to a discrete optimization problem.*

From a valuation perspective, a consumer will switch from one seller to another if the other seller offers a service that is of more value to him or her. Given that the consumer will incur a switching cost in the form of inconvenience caused by having to reenter shipping information, credit card details, and other inputs, it is reasonable to argue that a consumer will exhibit a certain inertia toward switching. This can be abstracted as a consumer's *switching threshold* value given by $V_{loyalty}$. This implies that if the vendor offers a set of services, which give utility greater than $V_{loyalty}$ to the consumer, then he or she will not switch. Thus $V_{loyalty}$ forms the constraint to the vendor's problem given in Equation (4), which can be written as

$$\sum U\left(\alpha_{it} a_{it}\right) \geq U\left(V_{loyalty}\right). \tag{9}$$

Note that our model represents the decisions of a single vendor and a representative consumer whose $V_{loyalty}$ is given exogenously. This parsimonious model is developed to analyze vendor decisions when certain consumer parameters vary and is not intended to explain when consumers are heterogeneous. We also assume that the loyalty factor induced by the services ensures that the customer buys the product from the same vendor whose services he or she has used. There may, of course, be cases to the contrary, such as when a consumer reads reviews of one vendor and buys the product from another. Our model does not capture such strategic behavior on the part of the consumer. We now rewrite this as an optimization problem for the vendor given by

$$\min_{a_{it}} C^t_{competitive\ services} = C\left(c_{it} a_{it} \,|\, i = \bar{o} + 1, \ldots, \infty\right)$$
$$\text{s.t.} \sum U\left(\alpha_{it} a_{it}\right) \geq U\left(V_{loyalty}\right). \quad (10)$$

Equation (10) is the dual problem of Equation (4), where the consumer's utility maximization subject to the vendor's budget constraint is now the vendor's cost minimization subject to the consumer's switching threshold. This setup provides us with a nonlinear programming problem, and, hence, for reasons of insights and tractability, we assume *U* and *C* to be linear operators. This assumption reduces the expression given by Equation (10) to a 0–1 knapsack problem [13], also known as the one-dimensional knapsack problem. As these problems are NP-hard, there are generally no efficient algorithms that can solve them optimally (for a full discussion, see [12]).

Techniques for developing solutions to these general integer programming problems are usually categorized into search methods and cutting methods, and several such methods have been studied to solve this problem [29]. Search methods include complete (or exhaustive) enumeration and branch-and-bound methods that search the solution space. Cutting methods include primal and dual methods that seek to generate constraints on the solution space that could make the integer solution become an extreme point of the constrained space. Since the knapsack problem has special properties (for example, all the parameters have positive values), there are specialized methods that have been investigated. The shortest-route method consists of viewing the knapsack problem as an acyclic directed network and uses the shortest-path method to generate the solution. Another method proposed to solve the knapsack problem is to convert it into a dynamic programming problem by defining the recursive equation and solving that equation—these have been proven to solve the problems in pseudopolynomial time. Enumeration methods search the feasible solution space by excluding infeasible points through the use of adjustable bounds on the variables. Finally, there are branch-and-bound ranking methods that search certain ranked extreme points of the continuous problem, ranking being done using bounds on the objective function [14, 22, 24]. These algorithms use the "greedy" heuristic (where one allocates services [variable] ranked with high c_i/α_i values to the knapsack) to obtain good bounds. In fact, it has been shown that this heuristic provides an extremely good approximation of the optimum itself when the services become more divisible. The heuristic solution to our problem is obtained by:

1. ordering the cost-to-value ratios of all services in a decreasing fashion, and
2. selecting such that the solution set S consisting of m services, satisfying:

$$S^t = \left\{ \frac{c_{1t}}{\alpha_{1t}}, \frac{c_{2t}}{\alpha_{2t}}, \frac{c_{3t}}{\alpha_{3t}}, \ldots, \frac{c_{mt}}{\alpha_{mt}} \right\}, \tag{11}$$

where

$$\frac{c_{1t}}{\alpha_{1t}} \leq \frac{c_{2t}}{\alpha_{2t}} \leq \frac{c_{3t}}{\alpha_{3t}} \leq \ldots \frac{c_{mt}}{\alpha_{mt}}$$
$$\sum_{1}^{m} (\alpha_{it}) \geq V_{loyalty} > \sum_{1}^{m-1} (\alpha_{it}).$$

In selecting the services for augmentation, the vendor has to keep in mind that core services that make up the *expected product* cannot be considered to be contributing to the consumer's switching threshold. So, at every instance t, when the vendor evaluates his basket of services, he has to first weed out those services that (1) have no value and (2) have now become part of the core offering. We illustrate the vendor's decision through a numerical example in the next subsection.

Numerical Example and Discussion of Results

We now provide a numerical example of a vendor's decision regarding the selection of his ideal set of services during a period given by $t_0 \rightarrow t_{100}$. Assume a basket of competitive services that vary in their value to the consumer over time and also differ in their cost of implementation to the vendor over time. Consider a consumer (or segment) whose loyalty threshold is 0.45, implying that at any point in time, the cumulative value from the competitive services to the consumer should be at least 0.45, otherwise he will switch to another vendor. Let us assume that the vendor is faced with the task of identifying services to offer at four distinct time periods. A temporal cross-section is representative of a new entrant's decision with respect to the set of services he should offer, or it could represent an incumbent's reevaluation of his service strategies when technological innovations have occurred or a new competitor has entered the market. The purpose of this exercise is to illustrate a vendor's choice of competitive services and changes to this service set over time when (1) services lose/gain in consumer valuation, (2) services increase/decrease in implementation costs, and (3) competitive services become core services.

For the purpose of our example, we denote these time periods as t_{15}, t_{31}, t_{51}, and t_{76}. From a consumer valuation perspective, we consider two different types of services: those that increase and decline in value over the period in consideration, and those that only increase in value during the whole time period. Note that although some services are not of value to the customer segment at the beginning, they may begin to acquire value over time. We model 10 such services with valuations ranging from

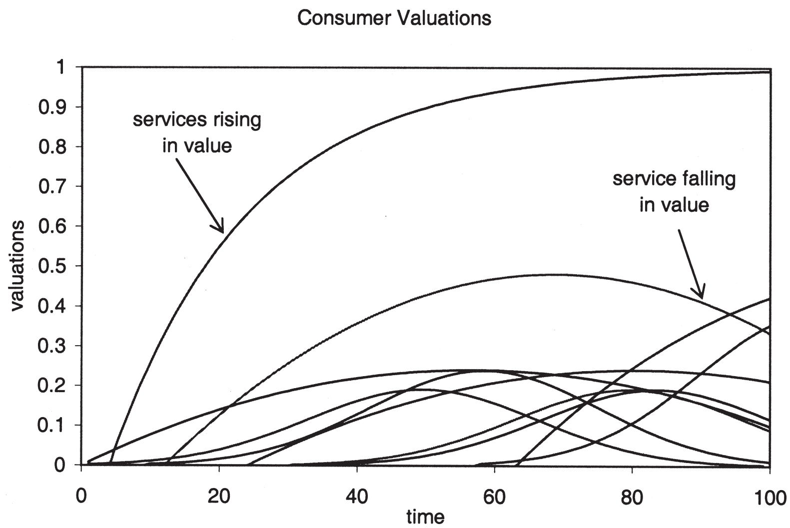

Figure 2. Changing Consumer Valuations of Services

0–1, drawn from quadratic, normal, and exponential distributions with initial positive valuations at differing times (Figure 2). From the vendor's cost perspective, we assume that the costs of introducing odd-numbered services are increasing (linear function) and those of even-numbered services are decreasing (exponential decay) over the given time period (Figure 3). The parameters (means and standard deviations) of both valuation and cost distributions were chosen so as to capture changes in the vendor's services set over time. It is important to note that, even though the consumer valuations may change in a continuous fashion over time, the vendor's decision problem is being analyzed at discrete times as in Model 2.

Consider the vendor's decision problem at t_{15}; at this time, all services in consideration are competitive services—that is, consumers do not expect these services to be offered by all vendors and hence vendors may use them to prevent consumers from switching. Note from Table 1 that at this time services 6–10 are of no value at all to the consumer. Using the knapsack heuristic from Model 2, we compute the cost-to-value ratio of all the services and rank them in a decreasing order. We see that services S5 and S2 cumulatively produce a consumer valuation of $0.4727 > V_{loyalty} = 0.45$, and hence the vendor would select these services to offer at t_{15}. If the vendor were revisiting his selection problem at t_{31}, we see that now service S5, by itself, is greater than the consumer's switching threshold ($V_{loyalty}$), implying that the service is so important that a consumer would switch if it were not offered. Such a service becomes part of the core services and is no longer part of the competitive services basket; for example, a secure credit card processing capability is now virtually offered by every online book vendor, making it a core service. As the vendor cannot consider S5 for the switching threshold anymore, he now selects S1 and S2 to be offered (Table 2).

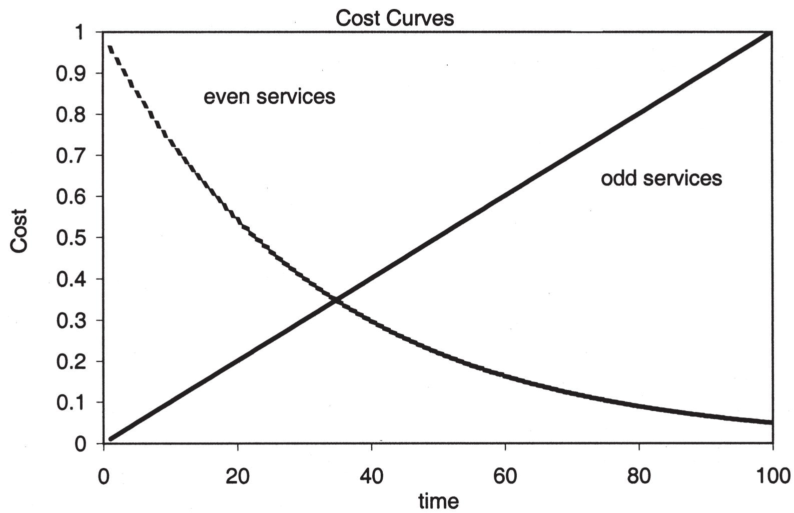

Figure 3. Changing Costs of Services

Along the same lines, S2 moves into the core set of services in period t_{76}, as at that time its value goes above the threshold value of 0.45. Even though it is apparent that its valuation peaks and begins to decline in the future time periods, given that all sellers in the market are forced to offer a service when it crosses the threshold value, S2 may continue to be offered as a core service in the product purchase experience. However, new entrants to the market may not choose to offer this service as a part of their core experience. This is commonly observed on the Internet, where firms that have been in operation for a longer time period continue to support older technologies (AOL supporting BBS [bulletin board system], support of low-bandwidth Web pages for older browser technologies, etc.), even if these services are losing their value among consumers.

Other reasons for vendors to consider moving competitive services to the core may be pure production efficiencies, such as S1. While not reaching high individual valuations, S1 appears consistently in all later time periods, hence a vendor may find it ideal to push this service into his core set, forcing all others to do the same. Similarly, S5 also displays production efficiency (low cost/value ratio) throughout the time period in consideration, and hence is sure to be a candidate for being part of the core service set. Finally, we see that services such as S3 come into the competitive service offering and then disappear over time. Obvious reasons may be that the consumer valuations diminish over time or the costs of offering these services become prohibitive.

Discussion and Implications for Practice

MANY STUDIES ON ONLINE PRICING have consistently found price dispersion for a wide range of products and services on the Internet [4, 6, 10], and this variance in prices has been attributed to factors such as trust, reputation, branding, and awareness.

Table 1. Simulated Costs and Valuations at Four Time Periods

Services $t = 15$	α_{i15}	c_{i15}/α_{i15}	Cum α_{i15}	Cum c_{i15}	Services $t = 31$	α_{i31}	c_{i31}/α_{i31}	Cum α_{i31}	Cum c_{i31}
5	0.42305	1.492144	0.423050	0.631252	5		Moved to core services		
2	0.04965	3.041289	0.472700	0.782252	2	0.2688	1.1567	0.268850	0.311
1	0.110625	5.706232	0.583325	1.413504	1	0.1914	2.0405	0.460275	0.701608
4	0.007947	19.00078	0.591272	1.564504	3	0.1034	3.7767	0.563698	1.092216
3	0.022486	28.07323	0.613758	2.195756	4	0.0613	5.0672	0.625073	1.403216
6	NA				6	0.0558	5.5709	0.680898	1.714216
7	NA				7	0.0027	140.5825	0.683677	2.104825
8	NA				8	NA			
9	NA				9	NA			
10	NA				10	NA			
Services $t = 51$	α_{i51}	c_{i51}/α_{i51}	Cum α_{i51}	Cum c_{i51}	**Services $t = 76$**	α_{i76}	c_{i76}/α_{i76}	Cum α_{i76}	Cum c_{i76}
5		Moved to core services			5		Moved to core services		
1	0.238425	0.89911	0.238425	0.214370	2		Moved to core services		
3	0.19069	1.124184	0.429115	0.428741	1	0.2128	0.475852	0.21280	0.101261
2	0.43485	1.175118	0.863965	0.939741	9	0.19565	0.517564	0.408450	0.202523
4	0.216291	2.362562	1.080255	1.450741	7	0.187289	0.540669	0.595739	0.303784
6	0.174825	2.922923	1.255080	1.961741	3	0.054111	1.871379	0.649849	0.405045
7	0.044393	4.828887	1.299474	2.176111	6	0.2392	3.181438	0.889049	1.166045
8	0.028617	17.85621	1.328091	2.687111	8	0.173032	4.398018	1.062082	1.927045
9	NA				4	0.137931	5.517244	1.200013	2.688045
10	NA				10	0.071801	10.59873	1.271814	3.449045

Table 2. Optimal Competitive Services Set for Consumer Switching Threshold of 0.45

Time periods	$t = 15$	$t = 31$	$t = 51$	$t = 76$
Services moved to core		S5	S5	S5, S2
Optimal competitive services set	S5, S2	S1, S2	S1, S2, S3	S1, S7, S9

More recently, Chen and Hitt [7] present a formal model of price dispersion on the Web, where they show that when retailers do not know exact values for consumers' brand sensitivity, they randomize their prices, leading to price dispersion across all retailers. Most explanations of price dispersion have focused only on the consumer characteristics. We add to this literature by presenting a model of price dispersion that is based on vendor characteristics and also takes online consumer behavior into account. We extend Levitt's [18] concept of product differentiation and propose that online sellers do not merely sell a *generic product* on the Web; rather, in order to be competitive in the electronic market, they offer at least the *expected product.* We conceptualize that a product's augmentation is done by encasing the product with Web-based services that form the product purchase experience. We then point out that these services may not be explicitly priced on the Web, since products on the Web could be more costly than their offline counterparts [6]. We argue that even if all online sellers provide the same product with the same set of services (defined as core services), there is a distinct possibility of price dispersion.

We identify one possible cause of price dispersion to be the variability in the sellers' capacity to offer these Web-based services. Of course, if the sellers were aware of each other's variability, then the seller with the lowest cost of offering Web-based services would undercut all others and offer a price just less than the seller with the second lowest cost of offering these services. We introduce information asymmetry to this context and analyze a scenario where sellers may not be aware of each other's capacity to offer these services. This is representative of Web-based markets where, even if one may be aware of a superstore's ability to manage its physical warehouse and employees, it would be difficult to hazard a guess on its ability to offer online services. This market is relatively nascent, hence not enough information may be available on different sellers' technological competencies. Through our model, we show that sellers do not set their monopoly price—that is, they are aware of the competition that the electronic market has created. At the same time, they do not price at marginal cost, as they do not believe everyone has incurred this same cost. We find that sellers will actually set some intermediate price that is based on their expectations vis-à-vis others' cost of providing Web-based services. We then analyze the strategy of a single vendor in this market with regard to his goal of identifying the optimal set of services so that a consumer does not switch to another vendor. We model this as a vendor's decision problem at any given cross section of time when he is evaluating the set of services to offer in order to remain competitive. Due to the discrete nature of the valuations at any given time, we characterize the optimization problem as a knapsack problem and provide heuristic solutions and a numerical illustration.

The managerial implications of this work point toward a focus on the nonprice attributes. This work suggests that even in the presence of price bots and other intermediaries, Web-based electronic markets offer the potential for product discrimination through services. However, we also point that these differentiation services are focused toward customer retention rather than acquisition. Our work may help in understanding the evolution of pure e-business firms such as Amazon.com and Priceline.com. In Table 3, we present a list of firms that currently offer a wide range of products for sale. One can observe that many of these product categories are completely unrelated; for example, Amazon.com offers products such as books as well as kitchen appliances. However, if we trace the history of Amazon.com, we see that it began as a bookstore and not as a retailer of electronics or kitchen appliances. Although kitchen appliances and books may have little in common as products, on a product purchase level there are many similarities. For example, just as you would expect book reviews to be available when you log onto a book site, a consumer could also expect reviews of electronic items by actual users. At a core level, the technological investments required for these services are virtually identical; therefore, we could make the case that Amazon.com is suitable to sell all products that offer the review service. Indeed, we see this trend only in the online store and not in the offline context; physical bookstores do not offer drugs, electronics, or kitchen appliances. Similar strategies have also been adopted by e-business firms such as Priceline.com. Priceline.com began as a reverse-auction for surplus airline tickets, and as it realized that the Web-based name-your-price scheme and associated online services can be applicable to other products as well, it began offering a wide range of products from new cars to groceries and gasoline. Although it does not offer groceries and gasoline for sale anymore, it still offers many products unrelated to its original business of airline tickets, such as long-distance services and home financing. Therefore, we could argue that when a vendor develops competence in offering services that accompany a product, then the vendor may have a potential to enter into a second product market even if the two products are unrelated.

Another important managerial implication can be derived from the identification of services to offer from the knapsack solution. On the Web, firms are innovating constantly, and this often forces competing firms to duplicate their innovation. The ease of duplication of technology therefore not only creates a short-lived first-mover advantage but also offers no advantage to the firm that is copying the leader. Through our model, we can claim that instead of merely copying technological services as they emerge, vendors can strategically identify those that matter to their customers and prevent them from switching to their competitor. At this point, we should emphasize two aspects. First, this paper does not advocate or verify that offering unrelated products (such as in Table 3) is a successful strategy; rather, it helps us understand how seemingly impossible combination of products in physical markets are actually a viable proposition on the Web. Second, it is important to note that a seller's entry into a new product market is dependent not only on the front-end capabilities but also

Table 3. Firms Competing on the Basis of Web-Based Services

Company	Concept and initial product	Current products	Common Web-based services for all products
Priceline.com	Selling surplus airline tickets online. Ticket buyers post the price they will pay for a seat on one of the major national airlines to travel between two cities on a specific day, providing a credit card number for the nonrefundable fare. Participating airlines then decide whether to sell a seat at that price for any flight on that date.	The airline ticketing concept that was used earlier has been extended to other products such as gasoline, home finance, new cars, rental cars, hotel rooms, long-distance calls.	Online bidding, e-mail notification of the bid result, "My Profile" for easy transactions.
eBay.com	An online auction site that enables individuals to buy or sell online.	Diversified into customer service related to their product area such as insurance, authentication, dispute resolution, investigation, escrow services. It also enables professionals to bid for posted projects.	E-mail notification of the bid result, "My eBay" for personalized eBay transactions record and to view all bidding and selling activities, customer reviews of products and sellers, chat groups for community building.

Davenporthouse .com	Selling English Country furniture online.	Diversified into related areas. Started with furniture and later introduced related furniture accessories—English Country furniture, museum pieces, tea accessories, British food, kitchen, gift baskets, wedding-related accessories, English and French furniture-related books, and corporate gifts.	Personalized customer service, fast order processing and tracking, customer reviews, interactive (for search) services, e-mail notification about the order.
Amazon.com	Online bookstore.	Diversified into a lot of products such as electronics, hardware, housewares, toys, cars, auctions, and so on.	Personalized recommendations, customer reviews of products, one-click setting for easy transaction, e-mail confirmation of all orders, online order tracking, e-mail notification of order status.
InternationalMale .com	Providing clothing for men.	Diversified into other various products such as clothing, jewelry, bath, shoes for men, furniture, bedding, rugs, carpets, fit guides, and newsletters.	Interactive (for search) services, International Male Advantage Club Card applicable across a variety of products.

on the back-end requirements concerning inventory management and other activities. For example, although books and large appliances need virtually the same set of Web-based front-end services, the supplier sides of these two product categories are vastly different. Thus, in order to enter into new product markets on the strength of Web-based services, sellers also need to take into consideration their supply chain process capabilities.

Limitations and Future Research

A primary assumption of our model is that we know the consumer's valuation of a service at any time. Based on this, the study has focused on the nonprice attributes of products on the Internet and how they contribute to the consumer's switching behavior. The primary goal has been to identify methods by which the vendors can choose an optimal service set at any time. This research does not address long-term vendor strategies taking into account any increase or decrease in valuation of a particular service over time; it provides only a cross-sectional analysis. Further, we have also not taken into account the complementarity among services in terms of both their submodularity of cost and supermodularity of value. Finally, it may be beneficial to extend this research to identify specific characteristics of services that influence the consumer's switching behavior. This could shed further light on the influence of personalization on switching behavior. Additional factors such as privacy concerns of using Web-based services can also be studied in the context of switching threshold.

References

1. Bakos, Y. A strategic analysis of electronic marketplaces. *MIS Quarterly, 15,* 3 (1991), 295–310.

2. Bakos, Y. Reducing buyer search costs: Implications for the electronic marketplaces. *Management Science, 43,* 12 (1997), 1676–1692.

3. Bakos, Y. The emerging role of electronic marketplaces on the Internet. *Communications of the ACM, 41,* 8 (1998), 35–42.

4. Bakos, Y.; Lucas, H.C., Jr.; Oh, W.; Simon, G.; Viswanathan, S.; and Weber, B. The impact of electronic commerce on the retail brokerage industry. Working Paper, New York University, 2000.

5. Barclay, M.J., and Hendershott, T. Price discovery and trading costs after hours. Working Paper FR 00–03, Simon School, University of Rochester, New York, January 2000.

6. Brynjolfsson, E., and Smith, M. Frictionless commerce? A comparison of Internet and conventional retailers. *Management Science, 46,* 4 (2000), 563–585.

7. Chen, P.-Y., and Hitt, L.M. Measuring switching costs and the determinants of customers retention in Internet-enabled businesses: A study of the online brokerage industry. *Information Systems Research, 13,* 3 (2002), 255–274.

8. Clemons, E.K., and Hann, I.-H. Rosenbluth International: Strategic transformation of a successful enterprise. *Journal of Management Information Systems, 16,* 2 (Fall 1999), 9–27.

9. Clemons, E.K., and Row, M.C. Sustaining IT advantage: The role of structural differences. *MIS Quarterly, 15,* 3 (1991), 275–292.

10. Clemons, E.K.; Hann, I.-H.; and Hitt, L.M. Price dispersion and differentiation in online travel: An empirical investigation. *Management Science, 48,* 4 (2002), 534–549.

11. Degeratu, A.M.; Rangaswamy, A.; and Wu, J. Consumer choice behavior in online and traditional supermarkets: The effects of brand name, price, and other search attributes. Working Paper, eBusiness Research Center, Pennsylvania State University, March 2000.

12. Garey, M.R., and Johnson, D.S. *Computers and Intractability.* San Francisco: W.H. Freeman, 1979.

13. Glover, F. New results for reducing integer linear programs to knapsack problems. Management Science Report, University of Colorado, Boulder, 1972.

14. Horowitz, E., and Sahni, S. Computing partitions with applications to the knapsack problem. *Journal of the ACM, 21,* 2 (April 1974), 277–292.

15. Kambil, A., and van Heck, E. Reengineering the Dutch flower auctions: A framework for analyzing exchange organizations. *Information Systems Research, 9,* 1 (1998), 1–19.

16. Lal, R., and Sarvary, M. When and how is the Internet likely to decrease price competition? *Marketing Science, 18,* 4 (1999), 485–503.

17. Lee, H.G. Do electronic marketplaces lower the price of goods? *Communications of the ACM, 41,* 1 (1998), 73–80.

18. Levitt, T. Marketing success through differentiation—Of anything. *Harvard Business Review, 58,* 1 (1980), 83–90.

19. Lynch, J., and Ariely, D. Interactive home shopping: Effects of search costs for price and quality information on price sensitivity, satisfaction with merchandise and retention. Working Paper, Fuqua School of Business, Duke University, Durham, 1998.

20. Malone, T.W.; Yates, J.; and Benjamin, R.I. Electronic markets and electronic hierarchies. *Communications of the ACM, 30,* 6 (1987), 484–497.

21. Malone, T.W.; Yates, J.; and Benjamin, R.I. The logic of electronic markets. *Harvard Business Review, 67,* 3 (1989), 166–170.

22. Martello, S., and Toth, P. A new algorithm for the 0–1 knapsack problem. *Management Science, 34,* 5 (May 1988), 633–644.

23. Maskin, E., and Riley, J. Optimal auctions with risk averse buyers. *Econometrica, 52,* 6 (1984), 1473–1518.

24. Nauss, R.M. An efficient algorithm for the 0–1 knapsack problem. *Management Science, 23,* 1 (1976), 27–31.

25. Shankar, V.; Rangaswamy, A.; and Pusateri, M. The online medium and customer price sensitivity. Working Paper, eBusiness Research Center, Pennsylvania State University, 1999.

26. Shankar, V.; Smith, A.K.; and Rangaswamy, A. The relationship between customer satisfaction and loyalty in online and offline environments. Working Paper, eBusiness Research Center, Pennsylvania State University, 2000.

27. Spulber, D.F. *Market Microstructure.* Cambridge: Cambridge University Press, 1999.

28. Stigler, G.J. The economics of information. *Journal of Political Economy, 69,* 3 (1961), 213–225.

29. Taha, H.A. *Integer Programming: Theory, Applications, and Computations.* New York: Academic Press, 1975.

30. Varian, H.R. A model of sales. *American Economic Review, 70,* 4 (1980), 651–659.

31. Varian, H.R. *Intermediate Microeconomics: A Modern Approach,* 4th ed. New York: W.W. Norton, 1996.

32. Wigand, R., and Benjamin, R. Electronic markets and virtual value chains on the information superhighway. *Sloan Management Review, 36,* 2 (1995), 62–72.