Customer Efficiency

Concept and Its Impact on E-Business Management

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The continued development of e-business models has triggered a dramatic transition of customers' roles in a variety of service production and delivery processes. In the coproduction of service, the scale and scope of customers' participation have been significantly transformed and enhanced by new e-business models and technology. This transition calls for a new understanding of customers' roles in service delivery systems. The concept of customer efficiency *is crucial for the successful management of systems where customers are actively engaged in service production and delivery processes. This article presents the concept of customer efficiency management (CEM), studies its relationship with other key customer characteristics, and explores its potential impact on e-business management.*

A dramatic transition of customers' roles in many service industries (e.g., online retailing, auctions, banking, and brokerage) triggered by new e-business models and technologies is under way. Instead of being the traditional recipients of service, customers increasingly play active and even leading roles in service production and delivery processes enabled by the Internet. Traditional consumer theory has long recognized a customer's contribution to a service production and delivery process in terms of triggering the service, providing the necessary information, and assisting in the completion of the service. However, in many e-business situations, a customer's contribution is far greater than the above-mentioned level of involvement. Increasingly, customers are acting as if they were the "partial employees" of the firm and thus, the service production and delivery process can be viewed as a coproduction process between the customer and the firm.

This transition has many potential impacts on e-business management as it has brought new insights to some existing problems. For example, consider the recently reported declines in service quality as a result of the practice of customer segmentation based on profitability in customer relationship management (CRM) systems in a variety of service industries. Equipped with advanced information technologies, companies can now obtain and keep comprehensive records of their customers and use data mining to segment customers into profitability hierarchies. By cutting labor and other expenses used to serve average customers, many companies are able to increase profits at the expense of declining service quality for some of their less valuable (profitable) customers. The media and public have intensified their criticism of these practices, for example, "The result is more efficiencies for the companies—and more frustration for their less valuable customers"

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(Brady 2000, pp. 118-28). In reply to this criticism, many companies argue that some customers are just too expensive to serve. This issue has actually been an ongoing topic that has puzzled researchers in both marketing and operations management: Can there be a win-win scenario for both the company and the customer? Can a company cut costs without sacrificing the quality of the service provided to its customers?

The answers to these questions may be found in the idea of *customer efficiency*, a concept that has not yet been well defined nor studied. The fact that customer efficiency has been overlooked both by academics and practitioners is no surprise, because the traditional service production and delivery models regard customers' contributions to a service production and delivery process as minor and supplementary. However, as mentioned before, customers' contributions have significantly increased due to the Internet and other related technologies. They are true coproducers, not just recipients of service. Thus, the quality of the service delivered to a customer depends on not only the firm but also on the customer. That is, the efficient delivery of high-quality service requires consistently good performance by both the employees and the customer who uses the firm's infrastructure to participate in the production and delivery of the service. Therefore, customer efficiency management (CEM), a strategy focusing on customer efficiency, is crucial for a service firm's success in the short run and in the long run.

In the short run, a customer-efficient service delivery infrastructure is crucial for attracting and retaining customers. Many studies have shown that customer satisfaction depends to a great extent on the efficient delivery of a service. However, in terms of judging the efficiency of service delivery, a consumer often makes this judgment based not only on how long it takes the firm to complete its portion of the process but also on how efficient the consumer views the use of their resources, especially their time, to complete the service process. Ease of use of the infrastructure has also been shown to be a decisive factor in customer satisfaction when extensive self-service is involved in the process.

In the long run, an efficient customer base makes it possible for a firm to simultaneously lower its costs and maintain high quality of service. The ability to leverage customer efficiency by seamlessly integrating information technology and customer-efficiency-oriented process design, or to have customers serve themselves or other customers efficiently, has been shown to be the key to success of many new e-service business models such as e-banking, e-brokerage, and e-auctions. In addition, efficient customers may enhance their relationship with the firm and other customers and, consequently, increase their loyalty to the firm. Therefore, given the significant influence of customer efficiency on a firm's profitability, it is necessary to reemphasize the customer's implicit role as a coproducer in a service delivery process.

This article presents the concept of *customer efficiency* and a framework for CEM, investigates the potential customer-specific factors and Web site–specific factors relevant to customer efficiency, explores the relationships between customer efficiency and other important customer characteristics (e.g., customer loyalty), and discusses the potential managerial impacts of CEM. The article concludes by describing a large-scale empirical study of customer efficiency using a panel data set of more than 20,000 customers who visited 12 popular Internet companies' Web sites during October 1999 through March 2000.

The rest of the article is organized as follows. The second section provides a brief review of the relevant literature in marketing, service operations management, information systems, and productivity and efficiency analysis. The third section defines the concept of *customer efficiency*, presents a framework for CEM, and discusses the relationships of this concept with the standard CRM as well as the recently developed concept of customer equity. The fourth section presents the Data Envelopment Analysis (DEA) model used to measure customer efficiency in this empirical study and the results of this investigation. The article concludes with a discussion of the implications and limitations of the results, along with directions for future research.

LITERATURE REVIEW

There are several streams of literature related to this article: coproduction in service operations management, consumer behavior, CRM, customer equity theory in marketing, search theory in information systems, productivity and efficiency analysis theory in economics, and citizen participation in public policy management.

In the service operations management literature, there are several classical articles that focus on service operations strategy and a few recent articles about service supply chain design that have explicitly considered consumers' involvement. In Chase (1978), a customer's involvement and its potential influence on the service delivery process were first discussed. Lovelock and Young (1979) pointed out that customers were the potential source for increasing a service firm's productivity. The authors discussed the importance of taking consumers' needs into account when designing self-service technologies such as automated teller machines (ATMs). Mills and Morris (1986) mentioned that clients often play the role of "partial" employees of service organization. Bowen

(1986) suggested the use of human resource management techniques to manage on-site customers. Kelley, Donnelly, and Skinner (1990) proposed the use of organization socialization tools to manage customers as human resources in service organizations. Karmarkar and Pitbladdo (1995) provide a comprehensive literature review on "service markets and competition" and point out the value of exploring how a customer's engagement in service delivery processes will influence the design of the process as well as competition in the market. In Heskett, Sasser, and Schlesinger (1997), the authors noticed that by encouraging customers to share responsibility, the firms could not only reduce their costs but also improve service quality. Ha (1998) presents a GI/GI/1 queuing model with customer-chosen service rates and linear delay costs to solve the pricing problem of a service facility where the facility and the customers jointly produce services. Cachon and Harker (1999) consider three "service supply chain" design configurations: The firms perform the service, the firms outsource the service to a contractor, or the firms outsource the service to their customers (i.e., customers become coproducers of the service).

The study of CEM also involves a detailed look at the strategic design of electronic services. Xue, Harker, and Heim (2000) proposed a customer-focused model for the strategic design of electronic services. By focusing on customers, interactive self-service channels such as the Internet can serve as an effective means to migrate customers to lower cost channels and simultaneously improve customer efficiency, corporate efficiency, and customer satisfaction. In addition, process management techniques (Frei and Harker 1999a, 1999b; Harker and Hunter 1996; Harker and Zenios 2000) can also be applied to reengineer service production and delivery processes to stimulate and facilitate the improvement of customer efficiency.

In the marketing literature, classical consumer behavior theory has long recognized customers' contributions to the production and delivery of a service in terms of triggering the process, providing the necessary information and material, and aiding in the completion of the process in most cases (Lilien, Kotler, and Moorthy 1992). In particular, this work is closely related to the literature on CRM, including customer equity theory. There are numerous influential works in this area, and only a handful can be included herein due to space limitations. Some articles study the relationships between service quality, customer satisfaction, and customer loyalty and profitability. Understanding these relationships provides the theoretical and empirical ground for CRM: a customer-centric strategy. In Zeithaml, Parasuraman, and Berry (1990), the SERVQUAL model is used to define the quality of service as the gap between a customer's perception and expectation of the service quality. On the relationship between service quality and financial returns, Rust (1995); Rust and Keiningham (1994); and Anderson, Fornell, and Rust (1997) discussed the trade-offs between a company's quest for service quality and financial returns. Positive relationships between customer satisfaction, customer loyalty, and market share are reported in Rust and Zahorik (1993) and Anderson, Fornell, and Lehmann (1994). Other articles focus on the strategic implications of CRM and the organizational strategy to develop CRM competence (Day 1999) and explore the application of new Web technology and data-mining techniques that have enabled the prevalence of CRM in the past several years (Greenberg 2001). Customer equity theory (Rust, Zeithaml, and Lemon 2000) views the customer base as a valuable asset of the firm and defines the goal of CRM as "driving customer equity."

The concept of the *coproduction model* was used in the field of public policy management (Whitaker 1980), where a citizen's participation in public service delivery was studied. Whitaker (1980) pointed out that "co-production is essential in services which seek to change the client" (e.g., education). Later, in Chappell (1994), the coproduction model was applied to quality management in public education. Wilson (1994) concluded that coproduction of services is the key feature of government policy for providing care for senior citizens.

The definition and measurement of customer efficiency herein is related to search theory in economics, consumer theory in marketing, and productivity and efficiency analysis in operations management literature. Traditional search theory defines a buyer's search cost as "the cost incurred by the buyer to locate an appropriate seller and purchase a product" (Bakos 1997). Classical productivity and efficiency analysis in economics uses ratio of outputs and inputs as a measurement of productivity or efficiency (Charnes et al. 1994). The concept and measurement of customer efficiency presented herein are related to these two frameworks.

CUSTOMER EFFICIENCY AND CEM

Customer Efficiency

Classical consumer theory assumes that consumers go through five steps in the purchase cycle: need arousal, information search, evaluation, purchase, and postpurchase analysis (Lilien, Kotler, and Moorthy 1992). Using this framework, consider a simple example of purchasing a book on the Internet to illustrate how a consumer coproduces the service with an Internet bookseller (see Figure 1). Customers participate in almost all stages of the service production and delivery process except the back-

office operations such as shipping and handling of the goods. In fact, they trigger the service, search for product information, evaluate the search results to make a purchase decision, submit the order, and initiate the return process if a return is desired. In general, in other e-service industries such as e-banking, e-brokerage, and e-auctions, both the scope and the scale of customers' engagements in the service delivery processes are even more significant and often require more sophisticated intellectual efforts and hence, more time. Also, in these cases, customers' inputs are crucial for the efficient delivery of high-quality service.

It is well recognized that the quality of employees' performance in a service delivery system has a decisive influence on a firm's productivity and service quality (Heskett, Sasser, and Schlesinger 1997; Zeithaml, Parasuraman, and Berry 1990). Because customers are the coproducers and "partial employees," their efficiency and/or productivity should also influence the efficiency and qualities of the service delivery processes. Consequently, customer efficiency should also have certain impacts on marketing strategy and the design of a service supply chain. However, what is customer efficiency? Conceptually, customer efficiency has been involved in many previous discussions. However, to the best of our knowledge, there has been no specific definition devoted to this concept. In this article, the following definition will be used:

> *Customer efficiency:* Customer A is evaluated as more efficient than Customer B if Customer A consumes fewer inputs to produce at least the same amount of certain outputs as Customer B, or if Customer A produces more outputs using at most the same amount of certain inputs as Customer B.

This definition provides the general conceptual framework for customer efficiency. Accordingly, the precise definition of the inputs and outputs may vary depending on the specific application of this concept. In addition, the definitions can also change when viewed from the customer's perspective rather than the firm's perspective. In general, there are three types of customer efficiency:

Transaction efficiency: The outputs of the service are defined as the number of transactions accomplished, such as informational transactions, customer service transactions, and purchase transactions. The inputs are mainly the time expended by the customer and the firm in these transactions. Transaction efficiency is of interest when there exists a capacity constraint on the service facility and congestion is costly for the firm (e.g., due to the potential abandonment of service because of long waiting time or slow processing speed).

Value efficiency: Value efficiency is often measured by the value per unit of cost that the customer creates through coproduction with the firm. This value creation can either be tangible, such as financial value created though purchases, or intangible, such as the intellectual assets that consumers create but owned by the firm. Clearly, a customer who makes frequent purchases can be value efficient by directly contributing to the firm's profits. However, a customer can also be value efficient by creating valuable intellectual assets for the firm, which may in turn have significant financial potential. For example, the product reviews written by Amazon.com's customers have strong appeal to online shoppers and have become one of Amazon's brand advantages. Therefore, those customers who diligently write good product reviews are value-efficient customers for Amazon.com.

Quality efficiency: When the major content of the service product is provided by peer customers, or when the mutual direct service among customers constitutes the major part of the service, the quality of the service associated with a firm's brand name is actually in the control of its customers to a large extent. For example, at ebay.com, customers serve each other directly by posting product information, bidding, contacting each other after the auction ends, packing and shipping the merchandise, completing payment transactions, and writing reviews for each other as part of the credit supervision system. For ebay.com, a quality-efficient customer is a desirable customer because the high-quality services that he or she provides to other customers is crucial for ebay.com's success. As a market maker, ebay.com cannot succeed without attracting a significant number of consumers to continuously participate, and ebay.com cannot attract consumers to join the market without certain quality guarantees, which depend heavily on the willingness and ability of customers to serve each other well. In such cases, quality efficiency can be measured by the percentage of good credit reviews the customer has been given by other customers throughout his or her participation at ebay.com.

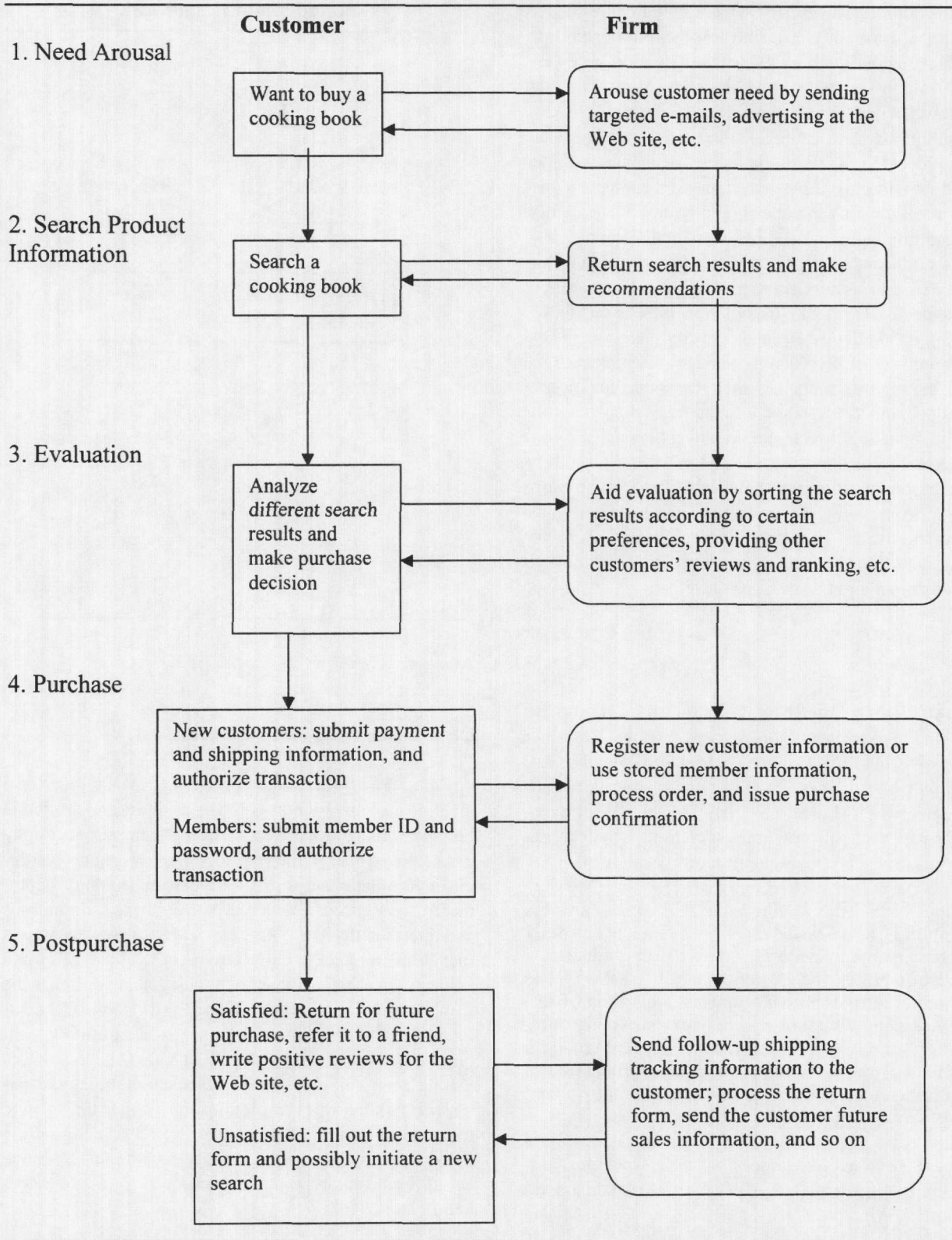
An efficient customer base, no matter whether the customers are transaction efficient, value efficient, or quality efficient, is valuable for the firm for a variety of reasons:

Cost-saving: A transaction-efficient customer base enables a firm to lower its costs by reducing its operational costs through shorter occupancy of the facility and reduced capacity congestion, as well as by consuming less employee labor and other resources in the service delivery process.

Value-adding: A value-efficient customer base creates financial value for the firm through both increased profitability and the intellectual contributions that enhance the brand equity of the firm.

Quality control: A quality-efficient customer base is critical when peer-to-peer service is a significant part of the

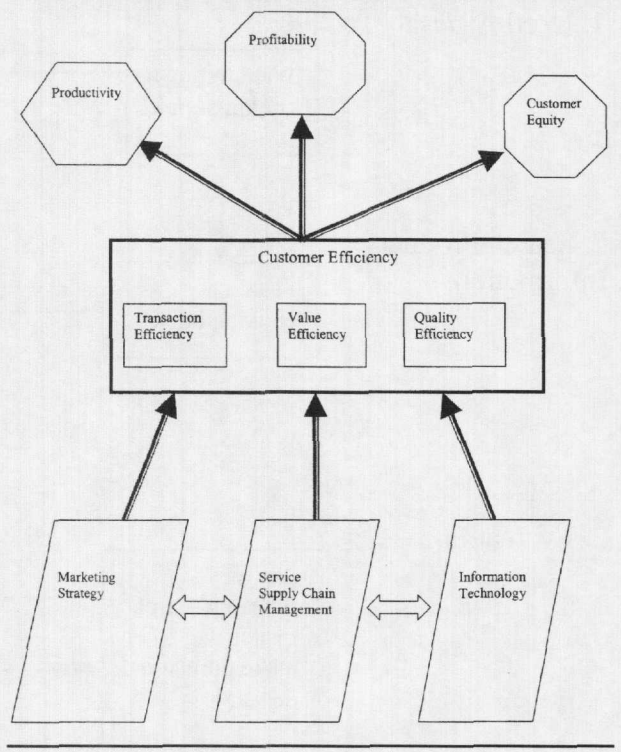
FIGURE 1
Customer Involvement in Buying a Book Online



service process. In such cases, the firm relies on a quality-efficient customer base to control the quality of the service. In addition, when self-service is a significant portion of the service, a quality-efficient customer is more likely to experience a high-quality service than a quality-inefficient customer, although both could blame the firm rather than themselves when there is a problem.

In addition to the beneficial effects on the service operations process discussed so far, one expects that customer efficiency will have a positive impact on the firm's customer equity, which includes brand equity, value equity, and retention equity (Rust, Zeithaml, and Lemon 2000). That is, efficient customers may enhance their relationship with the firm and other customers over time. There are several factors that lead to this expectation. First, as customers efficiently and effectively engage in coproduction, the efficient delivery of high-quality services satisfies customers (value equity), enhances their favorable impression about the brand (brand equity), and attracts them to return for repeat purchases (retention equity). Second, the continuous involvement of customers helps to develop and enhance their relationships with both the firm and the entire customer community. As a result of such enhanced long-term relationships, customer satisfaction and customer loyalty may flourish, which in turn makes it possible to drive customer equity to a higher level.

FIGURE 2
The Customer Efficiency Management Framework



CEM

An efficient customer base is desirable for all the operational and marketing benefits discussed above. Customer efficiency is not only a source of productivity and profitability but also a driver of customer equity. As a necessary supplement to CRM, which has mainly focused on the customer's role as a patron with economic resources to expend, this article proposes the framework of CEM:

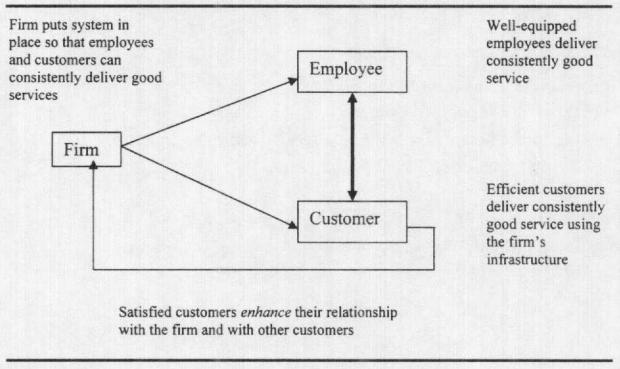
> *Customer efficiency management* (CEM) is a business strategy based on developing an efficient customer base to simultaneously improve firm productivity, profitability, and customer equity. This goal is achieved through the seamless integration of service supply chain management, marketing strategy, and information technology designed to actively engage customers in the coproduction of service to stimulate or facilitate the improvement of customer efficiency.

Figure 2 exhibits the conceptual framework of CEM, and Figure 3 illustrates the expected profit cycle associated with CEM.

CEM, CRM, AND CUSTOMER EQUITY

Although the recent emergence of CRM has received a great deal of attention in both the business and academic literature, the roots of this customer-centric philosophy can be traced back to the very personal one-to-one vendor-customer relationships that have existed as long as commerce has existed. There are many different definitions and interpretations of CRM. However, it is widely agreed that the centerpiece of CRM is to successfully develop and enhance the relationship with the customer to optimize the firm's long-term value (Greenberg 2001; Helm 2001). Although powerful database systems and data-mining techniques are the primary enablers of CRM, many authors emphasize that CRM is an overall business strategy, an enterprise culture, or even a philosophy rather than a pure technology solution. One of the desired outcomes from CRM is improved customer equity, which includes value equity, brand equity, and retention equity (Rust, Zeithaml, and Lemon 2000).

FIGURE 3
The Customer Efficiency Management Profit Cycle



Although both CRM and CEM aim at driving customer equity, the differences lie in their respective foci. The current research and practice of CRM have primarily focused only on one aspect of a customer's dual role in service coproduction: a patron with purchase potential that can be exploited. For example, one characteristic practice of CRM is to cross-sell or make product recommendations to the customer based on the results of data mining in the hope of extracting more sales from the customer. CEM takes a different perspective on customers: They are not just patrons but also coproducers with talents and labor resources indispensable for the successful delivery of high-quality service. CEM points to another way to nurture a successful long-term relationship with customers: to actively engage customers in the service coproduction processes. Thus, CRM focuses on a customer's identity as a patron, whereas CEM emphasizes his or her potential as a coproducer. Putting both concepts together provides a complete picture about who a customer really is and a comprehensive tool set to drive profitability, productivity, and customer equity, the ultimate goal for both CRM and CEM.

EMPIRICAL STUDY

Data

To empirically investigate the concept of customer efficiency and its potential impact on e-business management, a panel data set was assembled using data from Jupiter Media Metrix, an Internet marketing company (www.mediametrix.com). Through a research alliance, the Wharton Electronic Business Initiative (WeBI) (http://webi.wharton.upenn.edu/) obtains data from Jupiter Media Metrix on a monthly basis, which is collected directly from approximately 60,000 individual Web users' PCs. The data contain the 60,000 Web users' monthly Web log files, about 15 million records per month, and the users' demographic information.

In the assembled data set, there are more than 20,000 consumers who visited 12 popular Web sites during the period from October 1999 through March 2000. Among them, 4,836 customers made at least one purchase from 1 of the 12 Web sites. The data set consists of two parts. Part 1 includes the original monthly Web log files for each consumer from which one calculates each consumer's inputs and outputs used to measure his or her transaction efficiency. Part 2 includes the following demographic data of each consumer: gender, age, annual income level, education, household size, family status, race, and home region. See Table 1 for a description of these data and Table 2 for the summary statistics of this sample.

The 12 Web sites involved are among the most popular e-businesses Web sites, which include major Internet bookstores, travel agents, and e-retailers.

This investigation is designed to answer three strategic questions:

1. Who are the potentially efficient customers?
2. How can a firm help customers to become efficient?
3. Will customer efficiency influence customer loyalty and other key customer characteristics?

To address these questions, a means of measuring customer efficiency is required.

Measuring Customer Efficiency

During holiday seasons, popular retailing Web sites run the risk of congestion or, even worse, a Web site crash, which is very costly for the e-retailers because of the potential to lose customers to competitors who are just a couple of clicks or several minutes drive away. Although technology investment can help to control such risks by adding capacity, it is also desirable to have transaction-efficient customers who help to reduce the risk of congestion and thus lower an e-retailer's required capacity and operational costs. Transaction efficiency is important not only because of operational concerns but also for its effect on customer relationships. Long waiting time, slow processing of transactions, and broken connections (i.e., the dreaded "Web site cannot be found" message when you were just there) cause a high level of anxiety and can be fatal in establishing a trust relationship. Thus, this empirical study will focus on customer transaction efficiency be-

TABLE 1
Description of the Demographic Data

Variable	*Code Description*
Gender	1 = male, 2 = female
Age	1 = younger than 25 years, 2 = 25-45 years, 3 = 45-55 years, 4 = older than 55 years
Annual income	1 = less than $35,000, 2 = $35,000-$75,000, 3 = $75,000-$100,000, 4 = more than $100,000
Education	1 = high school, 2 = college, 3 = graduate school, 4 = postgraduate school, 5 = others
Household size	1 = with 2 people or less in the house, 2 = with 3 to 4 people in the house, 3 = with 5 or more people in the house
Family status	1 = having one or more children living in the house, 2 = having no children living in the house
Race	1 = majority, 2 = minority
Region	1 = East North Central or West North Central, 2 = East South Central or West South Central, 3 = Middle Atlantic and New England region, 4 = Mountain, 5 = Pacific, 6 = South Atlantic

TABLE 2
Summary Statistics of the Sample

Variable	*Distribution*
Gender	Male = 45%, female = 55%
Age	Younger than 25 years = 7.6%, 25-45 years = 45.3%, 45-55 years = 24.2%, older than 55 years = 22.9%
Annual income	Less than $35,000 = 25%, $35,000-$75,000 = 48%, $75,000-$100,000 = 14%, more than $100,000 = 13%
Education	High school = 13%, college = 25%, graduate school = 33%, postgraduate school = 18%, others = 10%
Household size	2 people or less in the house = 54.5%, 3 to 4 people in the house = 36.6%, 5 people or more in the house = 8.9%
Family status	No children in the house = 67%, one or more children in the house = 33%
Race	Majority = 86%, minority = 14%
Region	East North Central or West North Central = 23%, East South Central or West South Central = 13%, Middle Atlantic and New England region = 21%, Mountain = 8%, Pacific = 15%, South Atlantic = 20%

cause of its importance to e-retailers and the availability of data. However, the other two types of efficiency are clearly important; future empirical research will be devoted to measuring and understanding their roles in CEM.

To measure customers' transaction efficiency, one must first identify customers' inputs and outputs in the specific case of the online retailing. Traditional search theory defines a buyer's search cost as "the cost incurred by the buyer to locate an appropriate seller and purchase a product" (Bakos 1997). In e-retailing, the depth and breadth of a customer's participation in the service production and delivery process is clearly greater than just product information search activities. In addition, customers participate through a variety of activities such as customer service interactions, placing an order, and entering billing and shipping information. However, similar to product information search, all of these activities are mainly intellectual activities and have time opportunity costs associated with them. They are intangible inputs and can be classified into two types: the financial cost measured by the time spent on the activity (e.g., opportunity cost) and the psychological cost including the fatigue and irritation incurred after a long period of self-service. Therefore, a customer's major inputs into the online service production and delivery process can basically be measured by the time that he or she contributes to the process.

The direct outputs of a customer's coproduction activity in e-retailing include informational transactions, service transactions, and purchase transactions. Informational transactions fulfill customers' needs for information browsing or searching. Service transactions include activities such as reviewing account history, changing customer profiles, and tracking shipments. Purchase transactions are those associated with the actual completion of an online purchase. The definition of *transaction* in this model is based on the definition of *session*. According to standard methods of measuring Internet usage, a *session* is defined as a 30-minute time-out between two consecutive clicks of a user. That is, when the time interval between two clicks by a user exceeds 30 minutes, a new session is said to have started (Cooley, Mobasher, and Srivastava 1999). A purchase is identified when a user visits a secure https mode and a purchase confirmation page is issued. A purchase transaction is a session with a purchase actually completed by the user. Service transactions involve customer service activities such as checking account history, tracking ship-

ping, and changing customer information profile. A session is identified as a service transaction when a user logs into secured https mode but no purchase confirmation page is issued. The term *informational transaction* refers to a session where the user only visits the common unsecured http Web site for informational browsing or other general purposes but does not visit a secured https mode.

DEA (Charnes et al. 1994; Xue and Harker 1999a, 1999b), a popular tool for productivity and efficiency analysis based on mathematical programming, is used herein to measure customer efficiency. The value of the DEA efficiency score reflects a customer's relative efficiency by comparing it with that of his or her peers. In an input-oriented DEA model, a higher DEA efficiency score indicates higher relative efficiency.

There are two inputs in these DEA models: (a) purchase activity time and (b) nonpurchase activity time. Purchase activity time refers to a customer's online activity time directly related to making a purchase (checking out), including the time used for specifying the product and its quantity, registering customer information, providing payment and shipping information, and authorizing the transactions. Nonpurchase activity time refers to a customer's online activity that is not directly related to a purchase. It includes activities such as information browsing and other customer service–type activities such as reviewing account history, changing customer profile, and tracking shipments.

There are three outputs in these DEA models:

1. Number of informational transactions
2. Number of service transactions
3. Number of purchase transactions

From a customer's perspective, all the three types of transactions fulfill his or her different needs and therefore, are all necessary and important. However, from a company's perspective, the three different types of transactions are not equally important. In most cases, when factors such as profit margin and customer affiliation are taken into account, a manager often evaluates purchase transactions as more valuable compared with service transactions and service transactions more valuable than informational transactions. Thus, two different constant-returns-to-scale (CRS) DEA models are used in this analysis to reflect the different perspectives of the customers and the company:

Model 1: Input-Oriented CRS DEA Dual Model (Customer View)

$$\max \omega_O = \mu^T Y_O \tag{1}$$

subject to

$$v^T X_O = 1 \tag{2}$$

$$\mu^T Y - v^T X \le 0 \tag{3}$$

$$\mu^T \ge \varepsilon \vec{1} \tag{4}$$

$$V^T \ge \varepsilon \vec{1} \tag{5}$$

Linear programs like the one shown above are calculated for each customer in the observation set to obtain their DEA efficiency scores (i.e., this linear program needs to be solved to obtain the efficiency score for customer O). In this linear program, X_O denotes the input vector of customer O, Y_O denotes the output vector of customer O, X denotes the input matrix of all customers, Y denotes the output matrix of all customers, ε is a non-Archimedean (infinitesimal) constant, v^T is the vector of the shadow prices of the two inputs, and μ^T is the vector of the shadow prices of the three outputs.

Model 2: Assurance Region (AR) Input-Oriented CRS DEA Dual Model (Company View)

$$\max \omega_O = \mu^T Y_O \tag{6}$$

subject to

$$v^T X_O = 1 \tag{7}$$

$$\mu^T Y - v^T X \le 0 \tag{8}$$

$$\mu^T \ge \varepsilon \vec{1} \tag{9}$$

$$v^T \ge \varepsilon \vec{1} \tag{10}$$

$$\mu_1 \le \mu_2 \le \mu_3 \tag{11}$$

Here μ_1, μ_2, and μ_3 are, respectively, the shadow prices of the three outputs: μ_1 is the shadow price of informational transactions, μ_2 is the shadow price of service transactions, and μ_3 is the shadow price of purchase transactions. In this AR DEA model, Constraint (11) captures the relative importance of the three outputs as viewed by the company.

In this study, both the DEA model and the AR DEA model are used to ascertain how the difference between the customers' and company's view may change the results of the analysis.

Phase 1: Who Are the Potentially Efficient Customers?

As companies' human resource departments often use certain indices to evaluate potential job candidates, it is desirable to find some signs that can be used to find the customers with the potential to be efficient. For example, as education is often used as a predictor for a job candidate's productivity potential, will it also be a predictor for a consumer's efficiency potential? In addition, it is well established in the marketing literature that consumer demographics such as gender, age, income, education, household size, family status, ethnic group, and geographic locations often influence consumer behaviors (Solomon 2001). Previous studies have uncovered relationships between consumer demographics and consumer behavior. Kraut, Kiesler, et al. (1998); Kraut, Patterson, et al. (1998); Kehoe, Pitkow, and Rogers (1998); and Lohse, Bellman, and Johnson (2000) all found that demographics were important indicators of who is on the Internet in the first place. Lohse, Bellman, and Johnson (2000) found that two major categories of variables predicted online buying and spending: time starvation and a "wired" lifestyle. They also found that household income explains a significant portion of the variance in annual online spending. Because customer efficiency is a measurement and a result of consumer behavior, will consumer demographics predict who are more likely to be efficient?

Phase 1 of this empirical study focused on looking for the possible links between customer demographics and customer efficiency. A sample of 4,836 consumers who made at least one purchase at 1 of the 12 Web sites during the period from October 1999 through March 2000 is taken from the pool of more than 20,000 consumers who visited the 12 Web sites during that period. This analysis includes two steps. First, the DEA model and the AR DEA model are applied individually to calculate the DEA efficiency scores for the 4,836 customers. The summary statistics of the resulting DEA and AR DEA efficiency scores are shown in Table 3.

All the customers are classified into five groups based on their efficiency scores. Group 1 has an efficiency score from 0 to 0.2, Group 2 from 0.2 to 0.4, Group 3 from 0.4 to 0.6, Group 4 from 0.6 to 0.8, and Group 5 from 0.8 to 1.0.

In Step 2, a contingency table analysis is conducted to test the following (null) hypotheses relating customer efficiency and customer demographics:

Hypothesis 1: Customer efficiency is independent of gender.
Hypothesis 2: Customer efficiency is independent of age.
Hypothesis 3: Customer efficiency is independent of annual income level.

TABLE 3
Summary Statistics for Customer DEA and AR DEA Efficiency Scores

	DEA Score	*AR DEA Score*
Minimum	0.0700	0.0700
First quartile	0.2500	0.2500
Mean	0.3542	0.3511
Median	0.3300	0.3300
Third quartile	0.4300	0.4300
Maximum	1.0000	1.0000
Total *N*	4,836	4,836
SD	0.1515	0.1481

NOTE: DEA = Data Envelopment Analysis; AR = Assurance Region.

Hypothesis 4: Customer efficiency is independent of education level.
Hypothesis 5: Customer efficiency is independent of household size.
Hypothesis 6: Customer efficiency is independent of the fact whether or not the customer's family has any children.
Hypothesis 7: Customer efficiency is independent of race.
Hypothesis 8: Customer efficiency is independent of region.

The results of contingency table analysis using the efficiency scores from both the DEA model and the AR DEA model are shown in Table 4.

Based on the results in Table 4, the null Hypotheses 2, 3, 6, and 7 are rejected at a .05 significance level. Thus, customer efficiency is correlated with demographic factors such as age, income, children, and race based on these two models. As the younger generation generally has more exposures to the Internet, it is possible for them to accomplish transactions more efficiently compared with older generations. Lohse, Bellman, and Johnson (2000) found that household income explains a large portion of the variance of online spending. Consistent with their finding, the results herein show that household income is associated with the variations in customer efficiency. The fact that households with a higher income tend to spend more online, and thus conduct more online shopping transactions, may explain this relationship. It is interesting that there exists an efficiency gap between families with children living at home and families without children living at home. There are two possible reasons for this relationship. First, married couples with children living at home are often more "time starved:" under more time pressure and with less leisure time. As a result, they may use online purchase channels more often to save time, and when they use it, they try to finish the transactions more quickly for the same reason. Second, teenage children are usually Internet

TABLE 4
Results of Tests of Independence of Demographic Factors for Models 1 and 2

Factor	χ	p *Value*	*Conclusion*
	Model 1		
Gender	6.5051	0.1645	Independent
Age	26.5983	0.0088	Associated
Income	21.2359	0.0470	Associated
Education	20.3435	0.2051	Independent
Household size	13.5079	0.0955	Independent
Children	10.3994	0.0342	Associated
Race	10.3003	0.0357	Associated
Region	29.1706	0.0845	Independent
	Model 2		
Gender	6.7252	0.1511	Independent
Age	29.4177	0.0034	Associated
Income	25.8581	0.0112	Associated
Education	20.6250	0.1934	Independent
Household size	13.6533	0.0913	Independent
Children	9.6065	0.0476	Associated
Race	11.0272	0.0263	Associated
Region	32.3728	0.0395	Associated

savvy. Their participation in the family's online purchase activities may also help to improve efficiency. Race itself does not constitute a factor that causes efficiency variations. The finding that efficiency variations are not independent of race only reflects some of the existing gaps, for example, household income. According to Table 4, the null Hypotheses 1, 4, and 5 are acceptable at a .05 significance level; that is, customer efficiency is independent of demographic factors such as gender, education level, and household size. According to Table 4, null Hypothesis 8 is acceptable for Model 1 but rejected for Model 2. This change results from the changes in efficiency scores for individual customers when prior constraints on the shadow prices of the three outputs are added in the AR DEA model. It shows that customer efficiency is independent of region when a company's prior judgments about the importance of the three outputs are not taken into account; however, it becomes associated with region when such prior judgments are taken into account. This might suggest that there are some significant differences in the proportion of purchase transactions accomplished by consumers from different regions.

Phase 2: How to Help the Customers to Become Efficient?

Both customer-specific factors and external factors are expected to influence customer efficiency. As the customer-specific factors may be related to a customer's demographic background, the external factors may include the functionality of the infrastructure of the firm (e.g., the design of the firm's Web site) and other factors determined by structure and capacity of the service supply chain. As was indicated before, congestion can both cause, and result in, low customer efficiency, which suggests a negative relationship between Web site traffic and customer efficiency:

Hypothesis 9: Given certain Web site traffic capacity, there is a negative relationship between Web site traffic and customer efficiency.

To test this hypothesis, consider the customer efficiencies of two major Internet Bookstores A and B. The so-called DEA window analysis (Charnes et al. 1994) was applied to a panel data set of 2,514 customers who made at least one purchase from one of the two Web sites during October 1999 to March 2000. In window analysis, each customer in each month is considered as a different decision-making unit, and his or her efficiency is evaluated by comparing it with that of all the other customers during a 6-month period. The average efficiency of customers per Web site for each month from the two analyses using Model 1 are shown in Table 5. The changes of the average customer efficiency at the two Web sites over time are shown in Figure 4, and the distribution of the efficient and inefficient customers at the two Web sites is presented in Figure 5.

From Figures 4 and 5, it is clear that there is a seasonal effect due to the Christmas holiday. At both Web sites, the total numbers of customers who made purchases reached the highest level in December 1999, whereas the average customer efficiency reached the lowest level at the same time. After the peak season of December 1999, as the number of customers who made purchases at the two Web sites decreased, the average customer efficiency at both Web sites started to increase. This phenomenon suggests a negative correlation between the number of customers and the average customer efficiency at the Web site as stated in Hypothesis 9.

To test Hypothesis 9, a correlation analysis of two variables, the number of customers who made purchases at the Web site during each month and the average customer efficiency, for each of the two Internet bookstores was conducted. The results of this analysis are shown in Table 6.

The results of the correlation analysis strongly support Hypothesis 9 as they show that there is a significant negative correlation between the number of customers, which reflects the amount of Web site traffic, and the average customer efficiency at both Web sites. The AR DEA model formulated as Model 2 was applied, and the analysis was redone with the efficiency scores from the AR DEA

TABLE 5
Results of the Analysis for Internet Bookstores A and B (Model 1)

	October 1999	*November 1999*	*December 1999*	*January 2000*	*February 2000*	*March 2000*
			Internet Bookstore A			
Number of efficient customers	6	4	5	2	5	11
Number of inefficient customers	246	375	438	241	224	270
Total number of customers	252	379	443	243	229	281
Average efficiency score	0.5300	0.5049	0.4968	0.5167	0.5516	0.5301
Minimum efficiency score	0.06	0.08	0.06	0.09	0.11	0.1
Maximum efficiency score	1.00	1.00	1.00	1.00	1.00	1.00
			Internet Bookstore B			
Number of efficient customers	7	14	13	16	19	11
Number of inefficient customers	81	112	171	81	78	84
Total number of customers	88	126	184	97	97	95
Average efficiency score	0.5500	0.5302	0.4801	0.5859	0.5873	0.5243
Minimum efficiency score	0.09	0.09	0.04	0.18	0.09	0.11
Maximum efficiency score	1.00	1.00	1.00	1.00	1.00	1.00

FIGURE 4
Change of Average Customer Efficiency at Internet Bookstores A and B (Model 1)

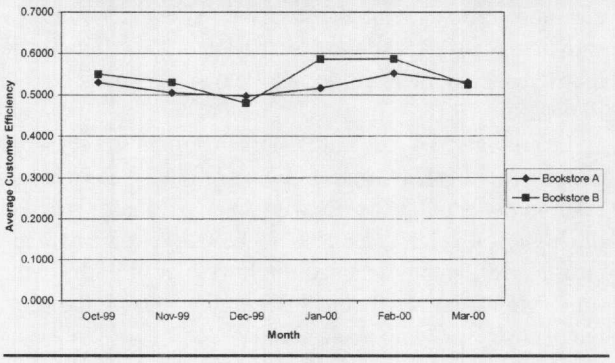
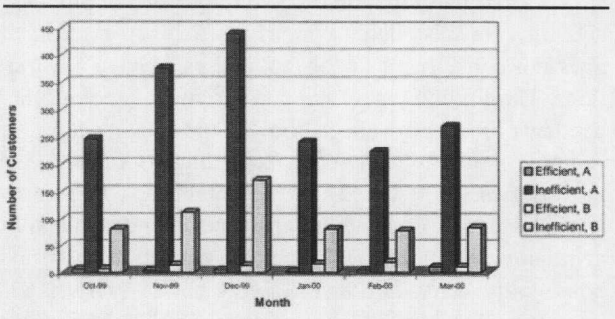


FIGURE 5
Distribution of Customers of Internet Bookstores A and B (Model 1)



model. The results are not substantially different from those of Model 1 and thus are not included herein.

Therefore, to improve customer efficiency, managers can invest in their Web site by increasing its capacity. They can also improve their Web site infrastructure through optimizing the portfolio of Web site attributes (Xue, Harker, and Heim 2000).

Phase 3: How Does Customer Efficiency Affect Customer Loyalty?

As discussed previously, customer efficiency has an impact on customer attraction and retention. One of the major reasons for the high percentage of incomplete transactions on the Internet may be the frustration of customers with inefficient Web sites. In addition, one would expect that customer efficiency has a long-term influence on a firm's profitability by enhancing customer loyalty. On one

TABLE 6
Correlation Between Customer Efficiency and the Number of Customers for Internet Bookstores A and B

	Number of Customers	*Average Customer Efficiency*
	Internet Bookstore A	
Number of customers	1	
Average customer efficiency	–0.8494	1
	Internet Bookstore B	
Number of customers	1	
Average customer efficiency	–0.7881	1

TABLE 7
Repeat Purchase Ratio of Internet Bookstores A and B

	October 1999	*November 1999*	*December 1999*	*January 2000*	*February 2000*	*March 2000*
			Internet Bookstore A			
Repeat buyers	NA	44	100	88	78	99
Total buyers	252	379	443	243	229	281
Repeat purchase ratio (%)	NA	11.6	22.6	36.2	34.1	35.2
			Internet Bookstore B			
Repeat buyers	NA	12	32	25	25	39
Total buyers	88	126	184	97	97	95
Repeat purchase ratio (%)	NA	9.5	17.4	25.8	25.8	41.1

NOTE: NA = not available.

hand, efficient delivery of consistently high-quality service depends on efficient performance of customers at the Web site. After experiencing high-quality service, customers will enhance their relationship with the Web site and, possibly, with other customers. As a result, customers show increasing loyalty to the Web site by repeatedly returning to the site. On the other hand, as a loyal customer repeatedly visits the same Web site, it is possible for his or her efficiency to improve as a result of climbing a classical learning curve. Therefore, one expects that a positive relationship exists between customer loyalty and customer efficiency.

One measure of customer loyalty at a Web site is the repeat purchase ratio, which is calculated according to the following equation:

$$r_t = \frac{m_t}{n_t}, t = 1, \ldots, 5, \qquad (12)$$

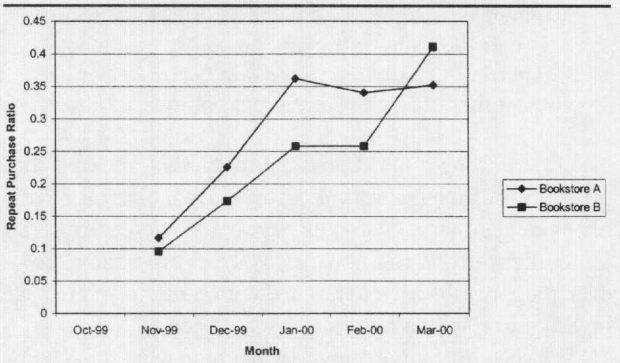
where r_t is the repeat purchase ration for month t (from November 1999 to March 2000, whereas October 1999 is the base period), m_t is the number of returning customers during month t, and n_t is the total number of customers in month t. The statistics of returning customers and the Web site repeat purchase ratio per month during October 1999 to March 2000 at the two Web sites are shown in Table 7, and in Figure 6.

Based on the above analysis, the following hypothesis is of interest:

Hypothesis 10: There exists a positive correlation between average customer efficiency and customer repeat purchase ratio.

To test this hypothesis, a correlation analysis per Web site is conducted to test the relationship between average efficiency and the repeat purchase ratio; the results of this analysis are shown in Table 8.

FIGURE 6
Customer Repeat Purchase Ratio of Internet Bookstores A and B



This correlation analysis was redone using the customer efficiency scores calculated from Model 2, and the results are again similar: The correlation coefficient for Internet Bookstore A is .6595 and the correlation coefficient for Internet Bookstore B is .2020. Thus, the results of the analysis using Model 1 and Model 2 support Hypothesis 10, that is, a positive relationship exists between customer efficiency and the repeat purchase ratio. Notice that there are substantial differences with correlation coefficients for Bookstore A and Bookstore B. The difference may be due to other firm-specific factors that contribute to repeat purchases other than customer efficiency.

SUMMARY AND DISCUSSIONS

This study of customer efficiency in the context of online retailing has led to three major conclusions:

1. There is a relationship between customer efficiency and certain customer demographic vari-

TABLE 8
Correlation of Average Customer Efficiency Versus Repeat Purchase Ratio for Internet Bookstores A and B

	Repeat Purchase Ratio	*Average Customer Efficiency*
	Internet Bookstore A	
Repeat purchase ratio	1	
Average customer efficiency	0.6611	1
	Internet Bookstore B	
Repeat purchase ratio	1	
Average customer efficiency	0.2044	1

ables such as age, income, race, family status, and possibly region.
2. There is a significant negative relationship between Web site traffic and customer efficiency.
3. There is a positive relationship between average customer efficiency and repeat purchase ratios.

The first finding hints at possible methods for identifying potentially efficient customer groups. By looking for a priori evidence that a customer may be efficient, firms can target their efforts to improve customer efficiency. However, these results need to be used with caution, and further investigation with a larger data set is needed.

The second finding suggests that managers must carefully consider the design and operations of their service supply chain (e.g., Web site infrastructure) to help their customers to become efficient. One solution is to improve their Web infrastructure by focusing on user-friendly, efficiency-focus Web site design (Xue, Harker, and Heim 2000). More fundamentally, they can consider redesigning and/or reengineering the service processes to become much more customer efficiency oriented.

The third finding implies that there are long-term advantages for focusing on customer efficiency by creating a more loyal customer base. By creating more loyal customers who also are willing and able to undertake a significant portion of the labor to serve their needs, long-term profitability is sure to follow.

All of these finding are, of course, dependent on the data used in the analysis, and there are certain limitations with this investigation. For example, a data set across a longer time span and with seasonal effect controlled for is necessary for further testing of Hypothesis 9.

The purpose of this article was not to provide definitive proof of these relationships; this will be left for future work. The goal was simply to (a) illustrate that the concept of customer efficiency seems to have great relevance for today's managers struggling to make their e-business operations successful and (b) present the framework of CEM as a necessary and important supplement to CRM that can drive customer equity to a higher level. By providing a measure of customer efficiency, firms can focus attention on the changes in their service delivery processes and infrastructure that are required to improve efficiency and, ultimately, loyalty and profitability. As the old adage says, if you can't measure it, you can't manage it. This article has made the first step in managing customer efficiency by providing a methodology for its measurement along with evidence that it is worth measuring. The CEM framework proposed herein calls attention to the important role that consumers play in service coproduction. Issues related to leveraging customer efficiency and incorporating CEM into a company's overall business strategy involving marketing strategy, service supply chain management, and the management of information systems (specifically, how to combine CEM with CRM to develop a long-term relationship with the customer, drive customer equity, and achieve high productivity and profitability at the same time) are the topics for future research.

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