DECISION SCIENCES
A JOURNAL OF THE DECISION SCIENCES INSTITUTE

Decision Sciences
Volume 45 Number 6
December 2014

Impact of Value-Added Service Features in e-Retailing Processes: An Econometric Analysis of Web Site Functions

Howard Hao-Chun Chuang
College of Commerce, National Chengchi University, Taipei, 11605, Taiwan, e-mail: chuang@nccu.edu.tw

Guanyi Lu
College of Business, Oregon State University, Corvallis, OR, e-mail: guanyi.lu@bus.oregonstate.edu

David Xiaosong Peng
Department of Decision and Information Sciences, C.T. Bauer College of Business, University of Houston, 334 Melcher Hall, Room 260C, Houston, TX, e-mail: xpeng@bauer.uh.edu

Gregory R. Heim†
Department of Information and Operations Management, Mays Business School, Texas A&M University, 320 Wehner Building, 4217 TAMU, College Station, TX 77843, e-mail: gheim@mays.tamu.edu

ABSTRACT

We examine the impact of three classes of Web site functions (*foundational*, *customer-centered*, and *value-added*) upon e-retailer performance. Using secondary panel data for 2007–2009 on operating characteristics of over 600 e-retailers, our econometric analysis finds that only the *value-added* service functions are positively associated with changes in e-retail sales revenues across time. We also observe a decreasing marginal impact of deploying additional value-added service features. To account for possible alternate explanations, we control for firm- and time-specific fixed effects, merchant types, merchandise categories, and order fulfillment strategies. By further decomposing e-retail sales revenues into Web site traffic, conversion rate, and average order value, we find that Web site functions affect e-retail sales revenues mainly through their impact on Web site traffic. Our investigation demonstrates the empirical research usefulness of the Voss conceptual e-service sand cone model. Our results identify for managers where to focus ongoing e-retailing system development efforts, yet suggest that focusing too many retailing capabilities on exploratory and experimental value-added service features may backfire, potentially leading to worsening e-retailer performance. [Submitted: September 25, 2012. Revised: April 30, 2013. Accepted: September 11, 2013.]

Subject Areas: E-Retailing, Econometrics, Q-Sort, "Sand Cone" Model, and Web Site Functions.

†Corresponding author.

INTRODUCTION

E-commerce Web sites enable customers to browse a variety of goods and services to identify the exact product they want and to find a retailer offering the prices they expect. Selling products and services over the Internet is believed to generate a massive potential for retail sales (Keeney, 1999). Such prospects came true in recent years as numerous e-retailers strove to offer unique value propositions to different customer segments (Grewal & Levy, 2009). According to the U.S. Census Bureau, online retail sales as a percent of total U.S. retail sales increased from 1.2% in 2002 to 4.2% in 2011. U.S. retail e-commerce sales reached $48.2 billion in the third quarter of 2011, a 13.7% increase from the same period of 2010, and $54.8 billion by the second quarter of 2012 (United States Census Bureau, 2012).

Modern online retailing systems enable customer service encounters that drive online as well as brick-and-mortar retail transactions. Retailers use many types of Internet e-commerce technologies to create service processes through which to sell either exclusively online, or through both online and offline channels (Chircu & Mahajan, 2006). Those e-commerce process technologies allow retailers to transact information-intensive sales, fulfill orders, and track delivery processes automatically. Having noted the emergence of e-retailing, scholars from several domains have been trying to understand the antecedents and consequences of successful Internet retailing (Grewal, Iyer, & Levy, 2004), including aspects arising from process technology (De, Hu, & Rahman, 2010).

Most findings on e-retailing to date focus on psychometric models of customer perceptions about service quality or their behavioral intentions (Janda, Trocchia, & Gwinner, 2002; Boyer & Hult, 2006). Studies on operational execution of e-retail stores mainly focus on order fulfillment (Rao, Griffis, & Goldsby, 2011; Rabinovich & Bailey, 2004) without paying much attention to how process characteristics arising from Web site functions enhance the delivery of services and the generation of sales. Much less literature examines the critical linkage between service process capabilities and e-retail performance at the firm level.

Seamless e-retail operations rely on portfolios of Web site functions to enable and optimize consumer shopping experiences. Consequently, as consumer e-retailing expectations become more stringent, e-retailers are apt to keep expanding their Web site functions (Lightner, 2004). Ayanso and Yoogalingam (2009) report that some e-retailers increased their customer conversion rates and revenues by improving Web site functions. Heim and Field (2007) identify several Web site functions that may drive perceived service quality. Overall, although prior studies uncover the positive impact of customer perceptions of Web site functions on perceived customer satisfaction, researchers still need to investigate whether and what associations exist between specific investments in Web site functions and favorable business outcomes (Randall, Netessine, & Rudi, 2006). Thus, some important research questions are: What is the overall impact of e-service process capabilities (as represented by Web site functions) on e-retailer revenues? Does having a more comprehensive set of Web site functions enhance sales performance? Or, have certain subsets of Web site functions become more important today for driving revenue?

To examine these research questions, we capitalize on a previously proposed "sand cone" model for e-service (Voss, 2003) that explains why e-retailers need to invest in several categories of Web site technologies to provide better, broader sets of service features. This theoretical framework proposes three categories of e-service functions: *foundation of service*, *customer-centered*, and *value-added*. Customer-centered are proposed to rely upon foundations of service, whereas value-added build upon customer-centered functions. The conceptual model provides a theoretical foundation for our study and enables us to categorize Web site functions for further analysis. We test our research hypotheses pertaining to these categories using longitudinal data on top Internet retailers from the United States as ranked by their annual online sales. We hope to shed light on the issue because e-retailers should not invest in updating Web site functions simply for the sake of jumping on a bandwagon. Rather, gaining a better understanding of how Web site functions tend to affect sales should enable e-retail managers to make better decisions.

Utilizing a three-year panel data set for calendar years 2007–2009, we show that only the *value-added* Web site functions exhibit a direct and sizable effect on Web site sales. As hypothesized, we also observe that the effect of *value-added* functions can be characterized as an inverted U-shape, which is seemingly surprising but actually well-grounded on the social contagion literature and assimilation-contrast theory. We reflect on this counterintuitive finding and offer an additional *ex post* explanation for the implications of expanding value-added functions too much. The effects of *foundation of service* Web site functions and *customer-centered* Web site functions on e-retailer sales revenues appear to be nonsubstantial in our data. Our findings suggest that only the *value-added* Web site functions act as a particularly strong driver of Web site sales. In contrast, the other two categories are necessary, as e-retailers usually must implement them to facilitate customer transactions, but they are not significantly associated with achieving better sales performance.

Our work has three major contributions. First, although existing literature tends to evaluate e-service as an aggregate process, there is a limited understanding about how different types of individual functions affect online retail performance. We fill in the gap by assessing documented e-retailer process functions and revealing an inverted U-shaped association between value-added functions and Web site sales. The finding implies that too much is not necessarily a good thing in Internet retailing and suggests that *technology sophistication* needs to be optimized. Although the negative impact of overly pursuing technology sophistication has been identified for tangible products, how much those insights carry over to digital services remains largely unknown (Baird, 2012). The nonlinear association uncovered in our study is worth investigating and provides theoretical as well as practical implications for e-service operations.

Second, unlike service quality, e-retailing research seldom studies actual sales performance (Pentina & Hasty, 2009). Our study is distinct in that it adopts the Voss (2003) e-service sand cone model as the theoretical framework to examine drivers of this important yet understudied metric. Our findings for the impact of Web site functions on e-retail sales performance are robust in that we explicitly control for differences in fulfillment, merchant types, and merchandise categories, which also may affect e-retail sales. Third, in addition to assessing e-retail sales, we decompose Web site sales into three underlying components—Web site traffic, conversion rate, and average order value—to assess the impact of Web site functions on the three elements, respectively. We find that Web site functions affect e-retail sales revenues mainly through their impact on Web site traffic, which has a determinant effect on the success of e-retailing (Nikolaeva, 2005). Our finding sheds light on the essential reasons why Web site functions are critical to e-retailing and provide opportunities for managers to adjust Web site operations in order to boost performance.

Our study also carries two methodological implications. First, most prior studies on e-service operations use cross-sectional, primary customer survey data to measure consumer perceptions (Ba & Johansson, 2008). As such, actual service process attributes of e-retailers are evaluated mainly on a perceptual basis (Palmer, 2002), making their real-world implications comparatively under-researched. We take a different perspective and use multiyear panel data to examine the impact of e-service process. The use of panel data enables us to econometrically address unobserved heterogeneity across the e-retailers, an issue that cannot be overlooked because e-retailers are different in many ways (e.g., managerial decisions about policies, products, markets, business models). Second, we present an innovative use of both psychometric and econometric techniques. To operationalize the Voss (2003) conceptual model, we apply the Q-sorting procedure to classify individual Web site functions that cannot be appropriately categorized via ordinary factor analysis. We compare and contrast our Q-sorting results with an external group of experts to build confidence in using the constructed Web site function indices. After adopting the psychometric technique to operationalize key regressors, we carefully specify econometric models to make the best use of panel data. Specifically, we employ the Hausman–Taylor (HT) model to ensure consistent parameter estimation and to elicit more information from the data (Wooldridge, 2001). Our study provides a prototypical example for empirical researchers who intend to make complementary use of qualitative and quantitative methods.

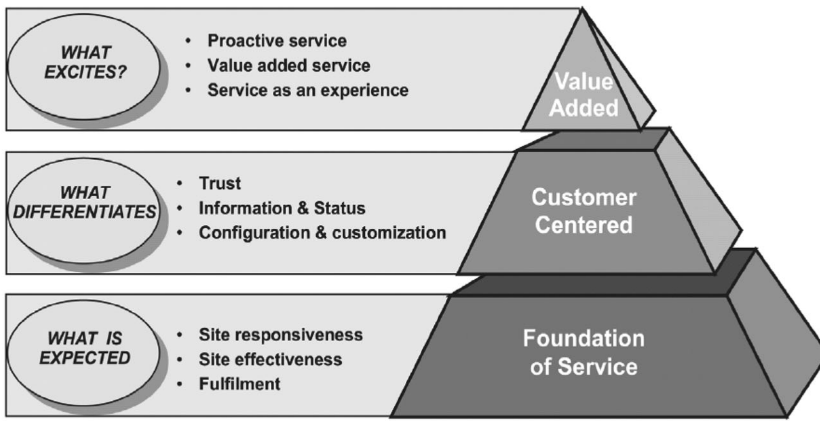
The article is organized as follows. The next section reviews literature, formulates a conceptual model, and puts forward three hypotheses. The following section describes the data, operationalization of variables, and estimation methodology. The empirical findings section presents results, discussion, and additional analyses. We conclude with research limitations and potential directions.

THEORY DEVELOPMENT

The E-Service Sand Cone Model

The original sand cone model for manufacturing has been widely applied to analyze firm capabilities. First introduced by Nakane (1986) and Ferdows and De Meyer (1990), the model asserts that firms may be able to develop multiple capabilities that build upon lower-level foundational capabilities (Ferdows & De Meyer, 1990). In the context of e-service operations, firm capabilities are primarily manifested through technology-based Web site functions (Piccoli, Brohman, Watson, & Parasuraman, 2004). Web site functions improve e-retail operations by facilitating front-end customer transactions and coordinating back-end order

Figure 1: A "sand cone" model of e-service (adapted from Voss, 2003, p. 100).



fulfillment and distribution activities. These functions are built to ensure reliable order-processing and order-fulfillment because most online customers desire to use their time efficiently and effectively (Randall et al., 2006). Thus, improving Web site functions is a relevant service management task in the e-retailing domain.

To support this argument, we adopt a "sand cone" model of e-service (Voss, 2003) as our theoretical foundation (Figure 1), to explain the necessity of enhancing e-retailer processes. The sand cone model of e-service suggests that e-retailers should develop their process functions following a certain sequence: *foundation of service* functions, *customer-centered* functions, and then *value-added* functions. The underlying logic of this model is similar to the operations concept of order qualifiers and order winners. That is, the model suggests advanced functions will not be fully effective until basic functions are in place. Expanding the model to the context of online retailing, we argue that the three categories of functions should affect e-retailer sales differently. For example, there are basic e-retail stores in which simple payment functions are sufficient to execute transactions. In contrast, there are also high-end e-retailers for which advanced payment and personalized services are necessary to close a sale.

Following the Voss (2003) e-service sand cone model, we categorize Web site functions into *foundational* functions, *customer-centered* functions, and *value-added* functions. *Foundational* functions must be in place before a retailer can sustain a presence (Voss, 2003). Essentially Web sites are supposed to be responsive and reliable so that they meet "what is expected" by customers. For example, basic search functions will be of great importance as they provide rudimentary ways to allow customers quickly to locate what they want. In addition to meeting the basic service requirements, e-retailers also need to increase *customer-centered* functions for the sake of maximizing customer efficiency (Xue & Harker, 2002) and delivering "what differentiates." Some e-retailers differentiate themselves by investing in advanced search technology to make customer navigation more intuitive and convenient (Srinivasan, Anderson, & Ponnavolu, 2002). Finally, the competitive environment may force e-retailers to provide *value-added* functions and to enhance these Web site functions in an ongoing manner in order to create "what excites" (Voss, 2003). For example, some firms noticed the rise of online social networking services and formed corporate pages within Facebook and Twitter to extend their consumer base and proactively announce their product and service updates.

Theoretically, the effective exploitation of a set of functions is contingent on having another lower-level set of functions already in place (Voss, 2003). Those functions may even cross-fertilize each other and support Web site operations in a reinforcing manner. The sand cone model of e-services provides a concise way to group Web site functions. One must realize that, due to the fast evolving nature of Web technology, today's value-added functions can be tomorrow's foundational functions. Thus, the functions/capabilities embedded in each level of the model may vary over time (i.e., 1995 distinctive capabilities may differ from 2012 distinctive capabilities). The Voss (2003) model is flexible and conceptually well-grounded for hypothesis development, allowing researchers to capture the impact of these different levels of Web site functions.

A complementary theoretical explanation for the continuous improvement specified in the e-service sand cone model (i.e., from foundational to value-added) is grounded in the notion of *services* and *uncertainty* (Cusumano, Karl, & Suarez, 2009; Suarez, Cusumano, & Kahl, 2013). Theoretically, high market uncertainty will force companies to offer more and better services. Internet environments are changing rapidly and causing high uncertainty for e-retailers (Grewal & Levy, 2009). Internet retailers hence must update technological and operational capabilities to provide a higher level of service. Specifically, enhancing Web site functions provides a means to achieve continuous service improvement, because the outcomes of online shopping usually depend on the quality, interface, satisfaction, and experience provided by the Web site (Darley, Blankson, & Luethge, 2010). The uncertainty-driven viewpoint helps to clarify the bottom-up movement illustrated in the Voss (2003) e-service model.

Before presenting specific research hypotheses, we point out that the dependent variable used in this study measures sales revenue, which is a critical measure of e-retail performance. To the best of our knowledge, few existing studies have scrutinized the direct impact of Web site process functions on e-retailer sales revenues. Although sales revenue may also be affected by a number of factors, identifying Web site functions that significantly contribute to a marginal increase in sales revenue is still valuable to e-retailers (De et al., 2010). The breadth of potential alternative drivers of sales revenue also suggests the need for researchers to use econometric methods that can carefully control for such factors in order to reliably estimate the individual contributions of the three classes of Web site functions.

Research Hypotheses

Foundational functions

Foundational functions include basic attributes involved in the shopping process, ease of ordering attributes, and order fulfillment attributes. Functions such as gift certificates and online coupons/rebates have become foundational in Internet retailing because of intense price/channel competition. As for ordering activities, most retailers design certain Web site features to streamline the ordering process. For example, nearly all catalog retailers now allow customers to place orders by entering the item number online instead of asking customers to fill out and mail a paper order form back to the company. Regarding fulfillment, numerous retailers provide reliable delivery service features such as precisely estimated shipment and arrival dates and allowing customers to buy items online and pick them up in-store.

Although these Web site functions often correlate positively with customer satisfaction, a "crisis of dilution" may still occur (Piccoli et al., 2004). That is, customers may begin to take these Web site functions for granted. As a result, the ability of those functions to attract customers and drive additional sales becomes weaker. Consequently, those foundational Web site functions are seen as an "order qualifier" (Hill, 1989)—a necessary feature to do business, but not one that wins the customer order. Eventually, e-retailers would have to equip themselves with those very basic functions simply to be considered by customers as a reasonable place to shop. From an e-service standpoint, foundational functions mainly support the initial stage of online experience that leaves customers with the impression that "the site works well" (Forbes, Kelley, & Hoffman, 2005). Although those functions can mitigate the risks of losing online shoppers due to unsatisfied basic requirements (Voss, 2003), over the long-run they are not likely to substantially increase sales. Although foundational Web site functions provide the basic core of e-retailing processes, the above reasoning leads us to hypothesize:

H1: Foundational functions will have a nonnegative impact on sales revenues.

Customer-centered functions

Customer-centered functions are mainly about providing tailored services and needed information (Khalifa & Limayem, 2003). Information content is extremely important because when retail Web sites provide bad and confusing information it can make shopping experiences frustrating (Forbes et al., 2005). The customer-centered functions help increase ease of navigation and save customer time because navigation efficiency affects transaction efficiency and customer contact interactivity (Ba & Johansson, 2008). Customer-centered functions such as product comparisons and lists of top sellers can help customers make more-informed decisions. Additionally, reviews provided by prior customers will digitize word-of-mouth comments that can drive future customer purchasing on many occasions (Dellarocas, 2003). While providing abundant product and service information to customers may be helpful, such an act will not be sufficient without having features that ensure convenient and effective interactions with customers (Piccoli et al., 2004). In short, customization at this level of the e-service sand cone model offers a better sense of personalization. From an e-service perspective, these Web site functions can transition customers from the impression that "this site works well" into "this site understands me" and "it is part of me" (Forbes et al., 2005). This intimacy and internalization eventually should increase the chance of a customer buying, which directly contributes to sales revenue. Hence, we propose:

> *H2: Customer-centered functions will have a positive impact on sales revenues.*

Value-added functions

Value-added functions help e-retailing systems to be proactive and optimize online customer experiences. These functions need to be innovative to maximize service effectiveness (Voss, 2003). For instance, the rise of online social networking and the increasing use of Internet-enabled mobile devices today provide great opportunities for e-retailers to step in and expand their value-added functions. Web stores connect with social networking services such as Facebook and Twitter to seek customer and revenue growth through relationships, which is an advanced phase of evolution in Web site functions (Piccoli et al., 2004). These Web site features are considered value-added because they facilitate value coproduction in e-services (Xue & Harker, 2002) and help e-retailers to build a positive image for themselves in the minds of customers (Srinivasan et al., 2002). Therefore, we expect value-added functions to contribute positively to customer purchase interactions and thus to sales revenues.

However, we also expect the relationship between value-added functions and Web site sales to exhibit decreasing marginal returns past some point of deployment. The social cognition literature suggests that the positive image of e-retailers will reach a turning point beyond which any further efforts to improve Web site functions do not further generate customer attention (Starbuck & Milliken, 1988; Fiske & Taylor, 1991). In addition, the degree to which customers will use an attribute depends on its utility, which is mainly determined by the function's nonredundancy as compared with other functions (Anderson, 1981). The potential redundancy may not be salient for foundational functions or customer-centered functions, which are considered necessary to close a sale. However, redundancy can be a major concern for the value-added functions. For example, social networking enables customers to generate and share product reviews quickly and effectively. The benefits derived from this value-added function, however, may decrease with the use of other similar value-added functions, which potentially contribute to Web site sales in an overlapping manner. Such functional redundancy leads to a "utility decrement," diminishing the effect of additional value-added functions.

Moreover, some value-added functions are arguably somewhat "self-tailored" to customers. For example, consumer-specific preorders favor only individuals who presume to have an overflowing enthusiasm to own new products at the first moment those products become available. As a result, the effects of adding these value-added functions may benefit a reduced customer base and thus generate diminishing gains on Web site sales revenues. Also, some advanced functions may be beyond the technological readiness of certain customers and offset the intended advantages offered by these functions. One such example is that offering sophisticated decision aids does not lead to increased purchases (Sismeiro & Bucklin, 2004). This example can be rationalized by the *assimilation-contrast theory*, which posits that within a given context consumers assimilate toward products/services that are deemed useful/positive and contrast away from products/services that are deemed unnecessary/negative (Meyers-Levy & Sternthal, 1993). In our case, moderate levels of value-added functions may contribute to customers' perceived usefulness of these Web site functions whereas extreme levels of value-added functions may increase customers' perceived complexity of the e-retail store and eventually compromise online sales performance. Taken together, we hypothesize:

> *H3: Value-added functions will have a positive yet diminishing impact on sales revenues.*

DATA AND MODEL SPECIFICATION

Data

We collected data about Web site functions, online sales, and other metrics (e.g., conversion rate, Web site traffic) pertaining to e-retailers from a data service company (*Internet Retailer*, 2011). The company gathers detailed information about Web site features and operating performance of the top e-retailers in North America, as ranked by their annual online sales. The data set we have is a three-year panel (2007–2009). The panel is unbalanced because some retailers drop out of the top 500 sales ranking during that period. Missing data problems occur due to a decline in sales performance as opposed to random reasons. The missing data results in a potential attrition issue that ideally should be remediated (Wooldridge, 2001). Ignoring the effects of attrition may bias the statistical analysis. We discuss how we address this issue in the methodology section.

The *Internet Retailer* data includes 96 Web site functions. However, it is neither reasonable nor practical to include all of the functions in our analysis. First, some Web site functions are designed for specific products (e.g., *videocasts* designed for high-value or high-complexity products) and thus are not representative across all e-retailers. Second, a number of Web site functions perform the same task but are called by different names (e.g., *enlarged product view* and *zoom*). Finally, some of the Web site functions are not collected in every year. Based on a thorough review of e-retailing literature, we adopt Ayanso and Yoogalingam's (2009) approach and study a subset of attributes that cover multiple Web site dimensions such as account maintenance, product recommendation, Web site search, and so forth. Each attribute can take on two possible values (0 = not implemented/1 = implemented) and represents a state-of-the-art Web site function that facilitates online shopping. We aim to use a comprehensive list of relevant functions, yet one should realize that any such list is by no means exhaustive.

We initially performed exploratory factor analyses (EFA) to relate the Web site function indicators to the three Voss (2003) categories. We analyzed the binary Web site function variables using several different extraction methods and estimators that are robust to binary variables but obtained numerous trivial factors. Moreover, most variables exhibited weak loadings or cross loadings that were hard to interpret. Although those findings are not surprising as we noted previously that a set of functions may build on other functions, they did motivate us to rethink the appropriateness of using EFA. We realized that, theoretically, Web site functions should be better modeled as formative indicators mainly because each selected Web site function performs a unique task, and thus they are not interchangeable (Damantopoulos & Winklhofer, 2001). With formative indicators, researchers can neither expect that the indicators exhibit high correlation with each other, nor require these indicators to hold together as a single factor. As such, we opt to construct three aggregated indices (Bollen & Lennox, 1991; Diamantopoulos & Winklhofer, 2001) that map the functions to the three levels of the e-service sand cone model.

To ensure the validity of the three aggregated indices, we employed the Q-sort method (Stephenson, 1953) to determine the "content domain" of each class of Web site functions. The Q-sort method is appropriate because it can capture the extent of agreement between people in how they employ concepts (Block, 1961), in our case whether people view a Web site function as *foundational*, *customer-centered*, or *value-added*. The use of ranking, rather than rating numerically in Q-sorting, is meant to capture the point that people think about ideas in relation to other ideas, rather than in isolation. More importantly, this way of encoding subjective rankings can make a rich but complicated information resource fruitful for research (Block, 1961). The key concern with this method is that the Q-sorter may frequently experience doubt, indecision, or despair over the actions requested of him. Nevertheless, Frank (1956) shows that the behavior of the Q-sorter is highly repeatable.

We use forced Q-sorting (i.e., we constrained the number of groups for classifying Web site functions to be three) because (i) unforced Q-sorting provides fewer discriminations and may suffer from the Barnum effect (Meehl, 1956), (ii) the unforced procedure is not more reliable than the forced (Block, 1961), and (iii) the three-group setting is consistent with the e-service sand cone model. A panel consisting of the four authors, each having sufficient experience in operations management and cognizant of the e-retailing market, ranked the dichotomous variables into three groups based on the extent to which a Web site function may affect the online customer shopping experience. If disagreements existed among the panel members concerning a Web site function, a discussion followed, and panel members re-ranked the functions after discussion. The process went through two iterations until consensus was achieved for the Web site functions belonging to the three groups. Note that a Q method study requires only a limited number of Q-sorters. The reason for this is that increasing the number of Q-sorters will introduce unnecessary variation and potentially taint the Q-sorting results in some cases. As Brown put it, "... all that is required are enough subjects to establish the existence of a factor for purposes of comparing one factor with another" (Brown 1980, p. 192). In addition, the Q-sorters must be knowledgeable about the research context which limits the potential candidates who can serve as a Q-sorter. Therefore, it is not uncommon that the authors serve as the Q-sorters for their studies (e.g., McKenzie et al., 2011).

The second column of Table 1 shows the Q-sorting results reached by the four authors specializing in operations management. The objectivity of the Q-sorting process should not be a concern as Q-sorting results are highly replicable (Brown, 1980; Thomas & Baas, 1992). Nevertheless, in order to build confidence in using the constructed indices, we invited an external group of Q-sorters to perform Q-sorting under the same condition of instruction. The group includes five Management Information Systems (MIS) professors who are familiar with the

Table 1: Q-sorting result of Web site functions.

Web Site Functions	Four Authors in Operations/Supply Chain Management	Five Management Information Systems Professors
Value-added (V)	Affiliate program, auction, frequent buyer program, live-chat, mobile commerce, preorders, social networking, syndicated content.	Frequent buyer program (V→C)
Customer-centered (C)	Advanced search, customer reviews, daily/seasonal specials, e-mail a friend, enlarged product view, product comparisons, product customization, registry, site personalization, top sellers, videocasts, what's new, wish list.	Customer reviews (C→F)
Foundation of service (F)	Buy online/pickup in-store, catalog quick order, coupons/rebates, keyword, outlet center, online circular, online gift certificates.	Online circular (F→C)

Notes: These variables are dichotomous (0 = implemented; 1 = not implemented). ($x \rightarrow y$) means that a Web site function categorized into the x group by the four authors is classified as one of the y groups by the external Q-sorters.

e-retailing market. A short briefing of the e-service sand cone model was provided to the MIS professors. The third column of Table 1 shows their Q-sorting results. Although the sorting outcomes are not totally identical, they are fairly consistent and stable. The majority of Web site functions in each category remain unchanged. Moreover, we find that results of hypothesis testing stay the same when using the extra Q-sorting results to construct the three indices. This robustness check ensures the results are not dependent upon one Q-sort group or sensitive to minor pairwise exchanges in Web site functions between the categories, as prior literature recommends (Angst, Devaraj, Queenan, & Greenwood, 2011)

We thus constructed three index variables based on these groupings. A simplistic approach is to construct each index as an unweighted sum of several binary variables (0/1). This approach is adopted by several e-retailing studies (e.g., Spiller & Lohse, 1997; Ayanso & Yoogalingam, 2009; Pentina & Hasty, 2009), which devise an aggregate feature score by summing binary variables for Web site functions. However, such a rudimentary aggregation implicitly assumes that all Web site functions are equally critical, which may not be a reasonable assumption because some functions may be more important/rare than others. To address the deficiency, we adopt the adjustment approach proposed by Chou (2013) and Tsai, Raghu, and Shao (2013). Specifically, for each binary Web site function we first take the ratio of 1 (if the firm has the feature) over the total number of firms that have the same function in a particular year. Such an adjustment assigns more weights to less-adopted Web site functions because they may create scarcity effects. Then according to the groupings shown in Table 1, we sum up those ratios by year to create an index for each of the three groups, that is, *foundational*, *customer-centered*, and *value-added*. This ratio sum index is then transformed into a *Z* score to show firms' relative advancement compared with their peers. Note that even though using the unweighted sum of dichotomous variables does not change results of hypothesis testing, we posit that the weighted adjustment is more appropriate because each of the three Web site function indices takes into account average and variation of peers.

We approximated the sales performance of Internet retailers using annual Web site sales. For pure e-retailers, Web site sales are their total annual sales. For multichannel retailers, Web site sales are the proportion of total sales gained from the Internet outlet. As mentioned earlier, e-retailer sales are comparatively understudied. Most past findings on e-service/e-retail performance are derived from survey-based research, which primarily focuses on metrics regarding customer satisfaction, loyalty, and other perceptual metrics. Xia and Zhang (2010) argue that due to the self-reporting nature of the survey approach, the obtained measures may lack objectivity. In response to their call for using objective measures, we assess sales revenue using public data to better understand the financial impact of Web site functions.

In addition to the three key index variables of interest, we devised several control variables. E-retailer sales performance is largely affected by business models, product characteristics, and order fulfillment. Because Web site functions alone cannot determine sales revenue, omitting other relevant factors that contribute to sales revenues may inflate the impact of Web site functions (Serrano-Cinca, Fuertes-Callen, & Mar-Molinero, 2005). Regarding business models, we applied the taxonomy devised by the data service company to classify e-retailers into four merchant types: *Catalog/Call Center* (e.g., CDW Corp., Avon Inc.), *Brand Manufacturer* (e.g., Dell.com, Apple.com), *Retail Chain* (e.g., Macys.com, Sears.com), and *Web-Only* (e.g., Amazon.com, Rakuten.com). We construct three merchant dummies where Web-only serves as the base. Using the *Merchant Type* as a control is necessary because the type reflects a retailer's choice of business model and correlates with the scale and scope of its operations.

Product characteristics are also a major determinant of Web site sales. Hence, we need to control for *Merchandise Category* based on each firm's major product market. In line with the data source (*Internet Retailer*, 2011), we specify 15 merchandise categories: apparel/accessories, automotive parts/accessories, books/music/video, computers/electronics, flowers/gifts, food/drug, hardware/home improvement, health/beauty, housewares/home furnishings, jewelry, mass merchant, office supplies, specialty/nonapparel, sporting goods, and toys/hobbies. We construct 14 merchandise dummies where the toys/hobbies category serves as the base. On the one hand, controlling for merchandise category accommodates the fact that a virtual assortment can be very different among online retailers who sell diversified products. On the other hand, including the merchandise control can partially account for the effects of price on sales because some product types are likely to be more expensive than others. In a nutshell, we find it essential to control for merchant type and merchandise category because customer requirements differ across e-retail segments (Piccoli et al., 2004).

Finally, we control for fulfillment strategy because Voss (2003) puts a strong emphasis on fulfillment in the e-service sand cone model. Several papers (e.g., Rabinovich & Bailey, 2004; Boyer & Hult, 2006) demonstrate that reliable order fulfillment is critical to the success of e-retailers. Due to the inherent complexity of physical distribution, some e-retailers tend to fully outsource order fulfillment and seek assistance from logistics service providers (Xia & Zhang, 2010). Contrary to these outsourcing initiatives, Randall et al. (2006) find that keeping order fulfillment in-house ensures the inventory ownership and has a positive impact on firm revenues. Pentina and Hasty (2009) also report that many e-retailers like to handle fulfillment in-house. Therefore, it is not uncommon to see e-retailers take charge of order fulfillment themselves. Interestingly, instead of completely outsourcing or operating in-house, we observe some firms that choose to adopt a mixed fulfillment strategy, using both internal and outsourced fulfillment. Seeing the diversity in fulfillment initiatives, we construct two dummy variables (*Outsourced Fulfillment* and *Mixed Fulfillment*) to isolate the impacts of distribution on sales from Web site functions while assessing whether those strategies do make a difference in Web site sales revenues.

Table 2 reports the summary statistics and correlation coefficients of the key continuous variables. Table 3 presents frequencies of categorical variables—*Merchant Type*, *Merchandise Category*, and *Fulfillment Strategy*—by year.

Model Specification

Performing an econometric panel data analysis enables researchers to tackle unobserved individual observational unit heterogeneity, which can greatly enhance validity of findings. The standard econometric model is specified as $y_{it} = \mathbf{x}_{\mathbf{it}}^{/}\boldsymbol{\beta} + \alpha_i + \varepsilon_{it}$ in which α_i is the intrinsic ability/heterogeneity of each e-retailer. The fixed effects (FE) model assumes corr($\mathbf{x}_{\mathbf{it}}, \alpha_i$) $\neq 0$ whereas the random effects (RE) model assumes corr($\mathbf{x}_{\mathbf{it}}, \alpha_i$) $= 0$. Arguably the assumption of the RE model may be too strong, as the distinct characteristic (α_i) of each firm should affect its decisions about time-variant Web site functions (x_{it}). Therefore, we performed a Hausman test (Cameron & Trivedi, 2009), which suggests the FE model to be more appropriate. The advantage of the FE method is that it solves the omitted variable bias and gives consistent estimates in the presence of endogenous heterogeneity (i.e., corr($\mathbf{x}_{\mathbf{it}}, \alpha_i$) $\neq 0$; Wooldridge, 2001). The drawback of the FE method is that all time-invariant regressors along with the heterogeneity are cancelled out due to the time-demeaning "within" transformation, which results in a tremendous loss of information. If one wants to see the effects of time-invariant merchant types and product categories, the basic FE estimation will not be a reasonable technique. Therefore, we use the HT model (Wooldridge, 2001):

$$y_{it} = \boldsymbol{x}_{1it}^{/}\boldsymbol{\beta}_1 + \boldsymbol{x}_{2it}^{/}\boldsymbol{\beta}_2 + \boldsymbol{w}_{1it}^{/}\boldsymbol{\gamma}_1 + \boldsymbol{w}_{2it}^{/}\boldsymbol{\gamma}_2 + \alpha_i + \varepsilon_{it},$$

$\boldsymbol{x}_{1it}$ are time-variant exogenous regressors, corr($\boldsymbol{x}_{1it}, \alpha_i$) $= 0$

$\boldsymbol{x}_{2it}$ are time-variant endogenous regressors, corr($\boldsymbol{x}_{2it}, \alpha_i$) $\neq 0$

$\boldsymbol{w}_{1it}$ are time-invariant exogenous regressors, corr($\boldsymbol{w}_{1it}, \alpha_i$) $= 0$

$\boldsymbol{w}_{2it}$ are time-invariant endogenous regressors, corr($\boldsymbol{w}_{2it}, \alpha_i$) $\neq 0$

Table 2: Summary statistics and Pearson correlation coefficients.

	N	Mean	SD	1	2	3	4	5	6
1. Value-added index	1,432	−1.63e−08	1.00						
2. Customer-centered index	1,432	−6.57e−09	1.00	0.42***					
3. Foundational index	1,432	−3.23e−09	1.00	0.34***	0.38***				
4. Sales	1,500	228.00	1,060.00	0.20***	0.25***	0.16***			
5. Unique visitors	1,497	1749.59	4,528.55	0.22***	0.30***	0.23***	0.72***		
6. Conversion rate	1,465	0.03	0.03	−0.04	−0.09***	0.10***	0.09***	-0.04	
7. Average ticket	1,476	206.20	300.02	0.05*	0.06*	−0.13***	0.04	−0.06*	−0.18***

Notes: Each of the three indices is constructed as a standardized weighted sum of dichotomous indicator variables. The *Sales* variable has units of millions of dollars. The *Unique Visitors* variable has units in 1000s/month. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Table 3: Frequency table of categorical variables.

	2007	2008	2009
Merchant type			
Catalog/call center	83	84	83
Brand manufacturer	52	56	59
Retail chain	147	149	150
Web-only	218	211	208
Merchandise category			
Apparel/accessories	106	109	115
Automotive parts	3	5	6
Books/music/video	27	27	27
Computers/electronics	56	55	57
Flowers/gifts	14	13	11
Food/drug	21	26	22
HW/home improvement	30	24	24
Health/beauty	24	25	22
Home furnishings	57	52	53
Jewelry	12	12	14
Mass merchant	30	33	31
Office supplies	17	19	16
Specialty/non-apparel	54	54	56
Sporting goods	30	29	29
Toys/hobbies	19	17	17
Fulfillment strategy			
In-house fulfillment	315	329	315
Mixed fulfillment	33	40	54
Outsourced fulfillment	120	121	117

The HT model preserves the merits of both FE and RE estimators. Essentially the HT model is an instrumental variable approach and could potentially mitigate the endogeneity that often arises in nonexperimental studies (Cameron & Trivedi, 2009). The HT method is popular among economists because it allows for correlation between individual effects and explanatory variables (FE) while being able to identify the effects of time-constant regressors (RE). Our econometric model is specified as:

$$\begin{aligned}\text{Ln}(\mathit{Website\ Sales}_{it}) = {} & \alpha_i + \beta_1 \mathit{Year\ 2008}_t + \beta_2 \mathit{Year\ 2009}_t \\ & + \beta_3 \mathit{Foundational}_{it} + \beta_4 \mathit{Customer\ Centered}_{it} + \beta_5 \mathit{Value\ Added}_{it} \\ & + \beta_6 \mathit{Value\ Added\ Squared}_{it} + \beta_7 \mathit{Attrition}_i \\ & + \beta_8 \mathit{Att}_i{}^{*}\mathit{Foundational}_{it} + \beta_9 \mathit{Att}_i{}^{*}\mathit{Customer}_{it} + \beta_{10} \mathit{Att}_i{}^{*}\mathit{Value}_{it} \\ & + \beta_{11} \mathit{Mixed\ Fullfillment}_{it} + \beta_{12} \mathit{Outsourced\ Fullfillment}_{it} \\ & + \boldsymbol{\gamma}^{*}\ \mathbf{Merchant\ Type_i} + \boldsymbol{\eta}^{*}\mathbf{Merchandise\ Category}_i + \varepsilon_{it}. \end{aligned} \tag{1}$$

Table 4 summarizes definitions of variables in the model. The model contains two time-variant exogenous variables (*Year 2008* and *Year 2009*), which are period dummies added to account for time effects (e.g., economic conditions). The vector

Table 4: Variable definitions.

Variables	Description
Regression model	
Sales	\$; annual Web site sales.
Year2008	Dummy variable; 1 if year = 2008.
Year2009	Dummy variable; 1 if year = 2009.
Foundational	*Z*-score; a normalized weighted sum of binary function variables in Table 1.
CustomerCentered	*Z*-score; a normalized weighted sum of binary function variables in Table 1.
ValueAdded	*Z*-score; a normalized weighted sum of binary function variables in Table 1.
ValueAdded Squared	Square term of *ValueAdded*.
Attrition	Dummy variable; 1 if a firm dropped out of top 500 during 2007–2009.
*Att*Foundational*	Interaction between *Attrition* dummy and *Foundational*.
*Att*CustomerCentered*	Interaction between *Attrition* dummy and *CustomerCentered*.
*Att*ValueAdded*	Interaction between *Attrition* dummy and *ValueAdded*.
Mixed Fulfillment	Dummy variable; 1 if an e-retailer uses both in-house and outsourced fulfillment.
Outsourced Fulfillment	Dummy variable; 1 if an e-retailer outsources its fulfillment operations.
MerchantType	Dummy variables for the 4 merchant types listed in Section 3.1.
MerchandiseCateogory	Dummy variables for the 15 merchandise categories listed in Section 3.1.
Additional analysis	
UniqueVisitors	Count; an average estimate of individually identifiable customers per month.
ConversionRate	Dimensionless; a visitor-to-purchaser ratio.
AverageOrderValue	\$/order; average transaction value per purchase.

Notes: The variables are all obtained from *Internet Retailer.* Some variables for additional analysis were collected by *Nielsen Online* and *comScore*.

of three merchant dummies and 14 merchandise dummies are time-invariant exogenous variables because those characteristics are just part of firm-specific effects but unidentifiable in the ordinary FE modeling. The remaining variables with subscript *it* are all time-variant endogenous variables (i.e., correlated with α_i). The attrition dummy (*Attrition* = 1 if attrition occurs during 2007–2009) is a time-invariant endogenous variable because arguably, the attrition of e-retailers (i.e., dropping out of the top 500 list during 2007–2009) could be attributed to unobserved individual heterogeneity (α_i). Even though an attrition process correlated with α_i should not bias the HT estimates (Bruderl, 2005), for completeness we assess the impact of attrition following the BGLW test procedure (Becketti, Gould, Lillard, & Welch, 1988) and interacting the attrition dummy with the three Web site function indices. Nonsignificance of those interaction terms (β_8, β_9, and

β_{10}) would suggest that the key explanatory variables (i.e., Web site functions) do not differ systematically between firms with and without attrition. Note that as an instrumental variable approach, the HT model requires assuming a subset of regressors to be exogenous and uncorrelated with the firm-specific fixed effect. In addition to verifying that the model meets the order condition for identification (Wooldridge, 2001), we explicitly test the exogeneity assumption in our analysis to avoid generating misleading results based on biased estimates.

EMPIRICAL FINDINGS

Results

We estimated the model using the XTHTAYLOR command in Stata 12 (Stata Corp, 2012). Table 5 illustrates the regression results. Controlling for *merchant type, time*, and *attrition*, all of the three models have significantly good fit according to the Wald's χ^2 test. The Sargan–Hansen statistics and associated *p*-values (all $>> 0.05$) suggest that the exogeneity assumptions are not violated. In all models, the time controls (*Year 2008* and *Year 2009*) are significant and exhibit an upward trend in sales, which is consistent with the general increase in retail e-commerce sales reported earlier. Not surprisingly, *attrition* is negatively associated with sales across all models. We jointly test the interaction terms between *attrition* and the three function indices and find no significant evidence of attrition biases. In other words, Web site functions have a statistically identical impact on firms with and without attrition. We also find that two merchant types—catalog/call center and retail chain—tend to have higher Web site sales (Web-only as the base). This finding may arise from the fact that the two types have relatively wider scopes of operations and benefit from product variety.

Model I presents the base model. Foundational Web site functions show no significant associations with Web site sales, as we expected (*H1*). Next, *H2* is not supported because customer-centered functions do not have a significant impact on e-retailer sales of firms in our sample. Value-added functions, as hypothesized, have a positive yet diminishing impact on sales revenue due to the negative sign of the quadratic term, and thus these findings support *H3*.

Model II controls for 14 *merchandise categories* (toys/hobbies as the base) in which only the mass merchant category exhibits significantly higher Web site sales. The impact of different Web site functions remains nearly the same. Model III further controls for *fulfillment* strategy. Note that the sample size reduces to 1,378 because we do not have access to fulfillment information for all firms in our sample. Interestingly, the Web site sales of firms who adopt a mixed fulfillment approach are on average lower than firms who go for either in-house fulfillment or outsourced fulfillment. With that being said, the nonlinear impact of *value-added* functions is still highly significant even after controlling for numerous factors that could drive Web site sales. The estimation results across the three models are quite stable and suggest consistent support for *H3*.

Discussion and Additional Analyses

Our results suggest that some Web site functions still do have a strong impact on e-retailer sales today, nearly 20 years into the e-commerce era. That effect is

Table 5: HT estimation of sales with various controls.

	Model I Base Model	Model II Controls for Merchandise	Model III Controls for fulfillment
Intercept	17.736***(0.259)	17.196***(0.724)	16.970***(0.880)
Year 2008	0.114***(0.012)	0.114***(0.012)	0.114***(0.012)
Year 2009	0.182***(0.012)	0.182***(0.012)	0.186***(0.013)
Foundational	0.008(0.012)	0.008(0.013)	0.007(0.013)
Customer-centered	−0.016(0.018)	−0.017(0.019)	−0.008(0.018)
Value-added	0.068***(0.021)	0.067***(0.022)	0.078***(0.021)
Value-added squared	−0.023**(0.009)	−0.023*(0.009)	−0.027**(0.009)
Attrition	−1.099*(0.437)	−0.861**(0.318)	$-0.780^{\dagger}$ (0.402)
Attrition* foundational	0.015(0.046)	0.015(0.049)	0.014(0.046)
Attrition* customer	0.009(0.049)	0.009(0.052)	−0.016(0.056)
Attrition* value	0.024(0.038)	0.024(0.040)	0.040(0.041)
Catalog/call center	0.613*(0.295)	0.714**(0.216)	0.756**(0.263)
Brand manufacturer	0.060(0.331)	0.154(0.252)	0.206(0.308)
Retail chain	0.376(0.255)	0.431*(0.188)	0.494*(0.03)
Apparel/accessories		0.387 (0.614)	0.563 (0.744)
Automotive parts		0.786(0.895)	0.977(1.073)
Books/music/video		0.770(0.691)	0.990(0.828)
Computers/electronics		0.707(0.662)	0.919(0.804)
Flowers/gifts		0.367(0.763)	0.558(0.917)
Food/drug		0.743(0.658)	0.873(0.807)
HW/home improvement		−0.045(0.680)	0.165(0.820)
Health/beauty		0.466(0.683)	0.690(0.822)
Home furnishings		0.079(0.628)	0.273(0.762)
Jewelry		0.421(0.746)	0.647(0.915)
Mass merchant		1.646*(0.686)	1.861*(0.827)
Office supplies		0.829(0.707)	1.067(0.851)
Specialty/non-apparel		0.154(0.252)	0.264(0.777)
Sporting goods		−0.273(0.710)	−0.034(0.710)
Mixed fulfillment			−0.111**(0.040)
Outsourced fulfillment			−0.101*(0.049)
Model statistics			
N	1,432	1,432	1,378
Number of firms	608	608	595
Wald χ^2	261.62	303.39	303.00
p-value	0.00	0.00	0.00
Sargan–Hansen statistic	0.49	1.56	1.56
p-value	0.48	0.21	0.21

Notes: Values in parentheses are standard errors. $^{\dagger}p < 0.10$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

robust given the fact that many other relevant factors are controlled for in our models. Specifically, value-added Web site functions turn out to be a prominent factor that drives sales performance over the 2007–2009 period. Interestingly, the *foundational* and *customer-centered* functions exhibit insignificant effects. As Web site technology advanced and customers became familiar with online shopping, basic Web site attributes perhaps could no longer serve as a differentiator for attracting customer interest. Even though the parameters of the foundational and customer-centered functions are not statistically significant at the firm-year level, one cannot fully rule out their potential impacts. For example, in 1999 several firms' ineffective basic order-generating functions made the 1999 Christmas shopping season a nightmare for both customers and e-retailers. Customers had to face delayed or wrong deliveries and deal with frustrating return procedures, whereas e-retailers found their profit shrank as operating costs skyrocketed after the selling season (Pyke, Johnson, & Desmond, 2001). In reality, the rudimentary functions will always be required to make shopping reliable and convenient and to enable e-retailers to deploy complementary value-added functions for e-retailers to reap the rewards of service features that excite customers.

To obtain a deeper understanding about the impact of Web site functions on e-retailer sales, we further decompose Web site sales into three underlying components—Web site traffic, conversion rate (i.e., visitor to purchaser ratio), and average order value—because by construction Web site sales is the product of the three elements. From the same data service company (*Internet Retailer*, 2011), we obtain data on the conversion rate and average order value. We approximate Web site traffic as an e-retailer's average *monthly unique visitors*, which is defined as an unduplicated count of individually identifiable customers (Serrano-Cinca et al., 2005). Using the same set of Web site function indexes and controls, we perform the HT estimation for exploratory purposes and report the results in Table 6.

The left column of Table 6 shows that value-added Web site functions also exhibit an inverted U-shaped association with Web site traffic. Customer-centered Web site functions, interestingly, show a marginally significant positive association with Web site traffic. It is somewhat intriguing that the effect of value-added Web site functions is pivotal only upon Web site traffic, whereas value-added functions have no significant association with conversion rate and average order value. Although the literature suggests that better service process attributes lower purchase-related anxiety and thus improve conversion rate (Putsis & Srinivasan, 1994; Moe & Fader, 2004), our sets of Web site functions surprisingly reveal no impact on conversion rate. In addition, although practitioners (e.g., Adobe Consulting, 2011) claim that value-added Web site functions can enhance average order value by directing online shoppers to additional items, we find no significant association between Web site functions and average order value.

We postulate that average order value largely depends on the type of product/service offering, which is a critical determinant of price as well as shopping volume. The main effect of Web site functions may be absorbed by our controls for merchant and merchandise because those controls cover a fair amount of differences in products and services. Conversion rate is very complex and involves various behavior dynamics. For example, Moe and Fader (2004) propose six components that drive conversion behavior. In addition to e-retail store design features (i.e., Web site functions), various factors including demographics, panelist behavior at other Web sites, and the sequence of pageviews (e.g., duration, type of pages examined) all affect the likelihood of converting Web site visits into purchases (Moe & Fader, 2004). Given the complexity of online

Table 6: HT estimation of traffic, conversion rate, and average order value.

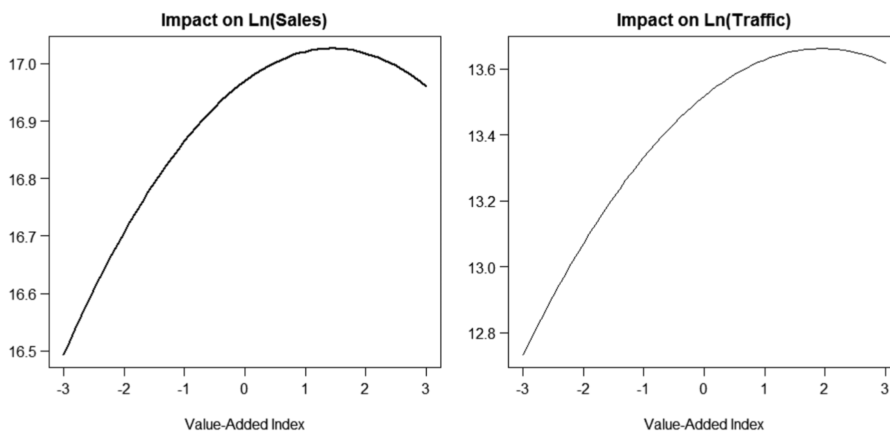
	Model IV Ln(Web site Traffic)	Model V Ln(Conversion Rate)	Model VI Ln(Average Order value)
Intercept	13.503***(0.826)	−3.882***(0.371)	4.2767**(0.378)
Year 2008	0.083**(0.026)	−0.069***(0.017)	−0.002(0.007)
Year 2009	−0.123***(0.027)	−0.084***(0.017)	−0.008(0.007)
Foundational	0.024(0.028)	−0.006(0.017)	−0.001(0.007)
Customer-centered	0.074†(0.039)	−0.021(0.024)	−0.005(0.010)
Value-added	0.149**(0.045)	−0.001(0.028)	−0.005(0.012)
Value-added squared	−0.038*(0.019)	0.001(0.012)	0.004(0.005)
Attrition	−0.697†(0.384)	−0.287†(0.158)	0.172(0.164)
Attrition* foundational	−0.046(0.097)	0.061(0.060)	0.020(0.026)
Attrition* customer	−0.229†(.119)	0.007(0.074)	−0.001(0.031)
Attrition* value	−0.071(0.086)	−0.001(0.054)	−0.011(0.023)
Catalog/call center	0.237(0.245)	0.419***(0.099)	0.047(0.107)
Brand manufacturer	0.512† (0.286)	−0.347**(0.115)	0.163(0.126)
Retail chain	0.694**(0.214)	−0.152† (0.088)	0.006(0.093)
Apparel/accessories	−0.304(0.694)	0.428(0.309)	0.383(0.321)
Automotive parts	0.578(0.996)	−0.079(0.418)	0.668(0.448)
Books/music/video	0.423(0.771)	0.419(0.345)	−0.106(0.360)
Computers/electronics	−0.417(0.750)	0.054(0.334)	1.151**(0.346)
Flowers/gifts	−0.055(0.855)	0.988**(0.377)	0.003(0.396)
Food/drug	−0.455(0.751)	1.048**(0.329)	0.230(0.345)
HW/home improvement	−0.672(0.764)	−0.084(0.338)	1.185**(0.351)
Health/beauty	−0.365(0.766)	0.932**(0.338)	0.272(0.352)
Home furnishings	−0.549(0.711)	−0.057(0.318)	1.053**(0.328)
Jewelry	−0.524(0.852)	−0.052(0.370)	1.388***(0.388)
Mass merchant	0.835(0.771)	0.363(0.341)	0.425(0.354)
Office supplies	−0.385(0.791)	0.893*(0.346)	0.764*(0.363)
Specialty/non-apparel	−0.215(0.725)	0.328(0.322)	0.300(0.335)
Sporting goods	−0.981(0.798)	0.191(0.351)	0.738*(0.365)
Mixed fulfillment	0.175*(0.085)	−0.019(0.053)	−0.015(0.022)
Outsourced fulfillment	−0.048(0.106)	−0.032(0.064)	0.011(0.027)
Model statistics			
N	1,378	1,355	1,363
Number of firms	595	585	588
Wald χ^2	153.24	223.16	155.48
p-value	0.00	0.00	0.00
Sargan–Hansen statistic	1.07	1.59	0.06
p-value	0.30	0.21	0.81

Notes: Values in parentheses are standard errors. $^{\dagger}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

conversion behavior, the seemingly surprising finding on conversion rate is not unreasonable.

The insignificant impact of Web site functions on conversion rate and average order value perhaps suggests that the online retailers in our sample operate under the condition of *mutatis mutandis* (i.e., “The necessary changes having been

Figure 2: Impact of value-added functions.



made.”). As top Internet retailers, they have surpassed the bar in implementing Web site functions in order to reduce purchaser-related anxiety or to recommend automatically the best products possible. Nonetheless, our analysis of Web site traffic implies that building a visitor-friendly platform through value-added and customer-centered Web site functions is essential for online retail channels. Such Web site functions allow customers to enjoy all the conveniences and experiences of shopping in a store through any computer and mobile devices from any locations, which eventually drive eventually driving Web site traffic.

A major takeaway associated with this supplemental analysis is that value-added Web site functions affect e-retail sales mainly via their impact on Web site traffic. Nevertheless, the positive effect of value-added Web site functions on traffic is unlikely to monotonically increase. As discussed earlier, the positive image of advanced Web site functions will reach a turning point beyond which any additional efforts may not receive further customer attention to generate Web site traffic. Adding more value-added Web site functions after the turning point would increase consumers’ cognitive load and even hurt Web site traffic as online shoppers may start to feel overwhelmed and turn away from those convoluted Web site functions.

To better illustrate the diminishing impact of the value-added Web site functions, we plot the impact of those functions on Ln(sales) and Ln(traffic) using parameters estimated from Model III in Table 5 and Model IV in Table 6 while holding everything else constant. Figure 2 shows the expected concave shapes. Because the value-added index on the x-axis of Figure 2 is a normalized Z score with mean $= 0$ and standard deviation $= 1$, the figure allows us to assess the impact of moving above or below a certain number of standard deviations. As shown in the left panel of Figure 2, the positive impact of value-added functions on Web site sales keeps increasing until the e-retailer reaches about 1.5 standard deviations above the industry average. Moving to the extreme (e.g., 2 or 3 standard deviations above the industry average) starts to hamper sales performance. The right panel exhibits a similar curvature in Web site traffic, although the diminishing rate caused by going far above average seems to be weaker. Nevertheless, both panels of Figure 2 suggest that when the number of value-added functions an e-retailer possesses is below average (i.e., value-added $<< 0$), the firm may end up having much lower Web site sales and traffic on average.

Voss (2003) points out that e-service as a proactive experience imposes severe challenges upon firms and not all value-added functions are successful. It is difficult for firms to excel in all those advanced e-service dimensions and some technological interfaces create challenges to the successful delivery of e-services (Ba & Johansson, 2008). In addition to the powerful law of diminishing marginal returns, e-retailers who overstretch their efforts along the value-added dimension may become distracted by exploratory/experimental technologies. Such a distraction may dilute their engagement in carrying out basic retailing tasks well, and eventually may harm sales performance through service failures, which is a well-known phenomenon shown to hurt purchase intentions in different service contexts (Holloway & Beaty, 2003; Rao et al., 2011).

As the returns from value-added attributes start decreasing, investment beyond a certain point may not be justifiable by their marginal revenue contributions. As the net impact of these technological efforts starts turning downward in Figure 2, what managers probably should do is to subjectively and carefully measure the need to maintain their Web services at a certain level so that customer dissatisfaction can be averted and economic efficiency is maintained. To sum up, although we do not intend to exaggerate or excessively discount the value of Web site functions, we are convinced that a failure to grasp the importance of such capabilities may undermine the performance of Internet retailers.

CONCLUSION

Our paper captures the contemporary impact of many different Web site functions. We complement prior research by bringing econometric rigor and a theoretical model to rationalize those functions. We employ an e-service sand cone model (Voss, 2003) to categorize Web site functions and examine the necessity and payback of having those technological attributes for customer service encounters. The theoretical model rationalizes why e-retailers keep adopting advanced information technologies and designing more sophisticated features into their online retail stores (Spiller & Lohse, 1997). We derive a set of research hypotheses, apply Q-sorting to categorize individual e-retail service functions, and specify an empirical model to be tested. The econometric analysis sheds light on the influence of Web site functions on Internet sales. Because selling online is still a rising trend and certainly here to stay (Grewal & Levy, 2009), our finding is of pragmatic value to both pure e-retailers and click-and-mortar retailers who aim to revamp their Web sites or consolidate their existing Web site functions.

Our findings carry useful managerial implications. First, our analysis implies that e-retail managers must be aware of the direct impact of certain classes of Web site attributes on Web site sales revenues, and thereby allocate necessary resources to improve their Web site operations. Yet the investment in Web site functions is not simply a matter of trying to deploy every single function. According to our findings, top-level "value-added" Web site functions that inspire customers should be the contemporary focus, because they are most strongly related to marginal revenue gains and Web site traffic elicitation. Second, we want to point out that the continuous improvement of Web site operations is an art of balancing the exploitation of foundational functions against the exploration for and experimentation with value-added functions. On the one hand, firms that lag in basic Web site functions often have to step up their foundational functions in order to create an appropriate platform for later deploying value-added functions. On the other hand, Internet retailers that excel in offering value-added functions must still ensure that foundational functions do not deteriorate and lead to breakdowns in the surrounding system, in order to exploit the beneficial value-added functions to the greatest extent possible.

This study has four potential limitations. First, total online sales are critical but cannot fully represent all of the performance outcomes in an e-retail business. Our analysis of Web site traffic, conversion rate, and average order value is exploratory. More formal theorizing and modeling efforts are needed to articulate the dynamics between the three fundamental components of Web site sales revenues. Second, although the way we aggregate the binary Web site attributes is shown to be valid in previous studies (Chou, 2013; Tsai et al., 2013), our construction of foundational, customer-centered, and value-added indices does not address potential within-group interactions among those binary Web site attributes, which is a challenging empirical issue. We encourage future studies to employ a complimentary use of quantitative and qualitative methods to explore the mutual dependencies of individual Web site functions. Third, it is possible for the linkage between Web site functions and Web site sales to be mediated by other factors such as operational effectiveness, or customer satisfaction. Our exploratory analysis of decomposing Web site sales into three underlying components to some extent covers the intermediate process of sales generation. Although formally testing mediation hypotheses is beyond the scope of our study, we encourage subsequent studies to analyze mediating relationships to gain a holistic understanding of how technological features affect sales performance. Finally, our panel is somewhat short, meaning that intertemporal structural changes are difficult to identify econometrically. We aim to get data sets covering an even longer timespan in order to fully exploit the process dynamics over time. We encourage other researchers to do the same.

REFERENCES

Adobe Consulting (2011). *Boosting average order value with automated recommendations*, accessed April 24, 2013, available at: http://success.adobe.com/en/na/programs/products/digitalmarketing/migration12/1208_21408_boost_average_order_value_with_recommendations.html.

Anderson, N. (1981). *Foundations of information integration theory*. New York, NY: Academic Press.

Angst, C. M., Devaraj, S., Queenan, C. C., & Greenwood, B., 2011. Performance effects related to the sequence of integration of healthcare technologies. *Production and Operations Management*, *20*(3), 319–333.

Ayanso, A., & Yoogalingam, R. (2009). Profiling retail web site functionalities and conversion rates: A cluster analysis. *International Journal of Electronic Commerce*, *14*(1), 79–113.

Ba, S., & Johansson, W. C. (2008). An exploratory study of the impact of e-service process on online customer satisfaction. *Production and Operations Management*, *17*(1), 107–119.

Baird, A. (2012). *Extending diffusion of innovation theory with consumer influence the case of personal health records (PHRs) and patient portals*. PhD Dissertation, Arizona State University.

Becketti, S., Gould, W., Lilliard, L., & Welch, F. (1988). The panel study of income dynamics after fourteen years: An evaluation. *Journal of Labor Economics*, *6*(4), 472–492.

Block, J. (1961). *The Q-sort method in personality assessment and psychiatric research*. Springfield, IL: Charles C. Thomas.

Bollen, K., & Lennox, R. (1991). Conventional wisdom on measurement: A structural equation perspective. *Psychological Bulletin*, *110*(2), 305–314.

Boyer, K. K., & Hult, T. M. (2006). Customer behavioral intentions for online purchases: An examination of fulfillment method and customer experience level. *Journal of Operations Management*, *24*(2), 124–147.

Bruderl, J. (2005). *Panel data analysis*, Teaching Note, University of Mannheim.

Brown, S. R. (1980). *Political subjectivity: Applications of Q methodology in political science*. Yale University Press. New Haven, Connecticut.

Cameron, A. C., & Trivedi, P. K. (2009). *Microeconometrics using STATA*, College Station, TX: Stata Press.

Chircu, A. M., & Mahajan, V. (2006). Managing electronic commerce retail transaction costs for customer value. *Decision Support Systems*, *42*(2), 898–914.

Chou, Y. C. (2013). *Adoption and business value of mobile retail channel: A dependency perspective on mobile commerce*. PhD Dissertation, Arizona State University.

Cusumano, M. A., Kahl, S., & Suarez, F. (2009). A theory of services in product industries. *CDB Research Brief*, *11*(1), 1–6.

Darley, W. K., Blankson, C., & Luethge, D. J. (2010). Toward an integrated framework for online consumer behavior and decision making process: A review. *Psychology & Marketing*, *27*(2), 94–116.

De P., Hu, Y. J., & Rahman, M. S. (2010). Technology usage and online sales: An empirical study. *Management Science*, *56*(11), 1930–1945.

Dellarocas, C. (2003). The digitalization of word-of-mouth: Promise and challenges of online reputation systems. *Management Science*, *49*(10), 1407–1424.

Diamantopoulos, A., & Winklhofer, H. M. (2001). Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, *38*(2), 269–277.

Ferdows, K., & De Meyer, A. (1990). Lasting improvement in manufacturing performance: In search of a new theory. *Journal of Operations Management*, *9*(2), 168–184.

Fiske, S. T., & Taylor, S. E. (1991). *Social cognition* (2nd ed.). New York, NY: McGraw-Hill.

Forbes, L. P., Kelley, S. W., & Hoffman, K. D. (2005). Typologies of e-commerce retail failure recovery strategies. *Journal of Services Marketing*, *19*(5), 280–292.

Frank, G. H. (1956). Note on the reliability of Q-sort data. *Psychological Reports*, *2*(3), 182.

Grewal, D., Iyer, G. R., & Levy, M. (2004). Internet retailing: Enablers, limiters and market consequences. *Journal of Business Research*, *57*(7), 703–713.

Grewal, D., & Levy, M. (2009). Emerging issues in retailing. *Journal of Retailing*, *85*(4), 522–526.

Heim, G. R., & Field, J. M. (2007). Process drivers of e-service quality: Analysis of data from an online rating site. *Journal of Operations Management*, *25*(5), 962–984.

Hill, T. (1989). *Manufacturing Strategy, Text and Cases*. Irwin. Homewood, Illinois.

Holloway, B. B., & Beatty, S. E. (2003). Service failure in online retailing: A recover opportunity. *Journal of Service Research*, *6*(1), 92–105.

Internet Retailer (2011). Top 500 Guide® http://www.internetretailer.com/top500/.

Janda, S., Trocchia, P. J., & Gwinner, K. P. (2002). Consumer perceptions of Internet retail service quality. *International Journal of Service Industry Management*, *13*(5), 412–431.

Khalifa, M., & Limayem, M. (2003). Drivers of Internet shopping. *Communications of the ACM*, *46*(12), 233–239.

Keeney, R. L. (1999). The value of Internet commerce to the customer. *Management Science*, *45*(4), 533–542.

Lightner, N. J. (2004). Evaluating e-commerce functionality with a focus on customer service. *Communications of the ACM*, *47*(10), 88–92.

McKenzie, J., Braswell, B., Jelsma, J., & Naidoo, N., (2011). A case for the use of Q-methodology in disability research: Lessons learned from a training workshop. *Perspectives in Rehabilitation*, *33*(21–22), 2134–2141.

Meehl, P. E. (1956). Wanted—a good cookbook. *American Psychologist*, *11*(6), 263–272.

Meyers-Levy, J., & Sternthal, B. (1993). A two-factor explanation of assimilation and contrast effects. *Journal of Marketing Research*, *30*(3) 359–368.

Moe, W. W., & Fader, P. S. (2004). Dynamic conversion behavior at e-commerce sites. *Management Science*, *50*(3), 326–335.

Nakane, J. (1986). *Manufacturing futures survey in Japan, a comparative survey 1983–1986*. Tokyo, Japan: Waseda University, System Science Institute.

Nikolaeva, R. (2005). Strategic determinants of web site traffic in on-line retailing. *International Journal of Electronic Commerce*, *9*(4), 113–132.

Palmer, J. (2002). Web site usability, design, and performance metrics. *Information Systems Research*, *13*(2), 151–167.

Pentina, I., & Hasty, R. W. (2009). Effects of multichannel coordination and e-commerce outsourcing on online retail performance. *Journal of Marketing Channels*, *16*(4), 359–374.

Piccoli, G., Brohman, M. K., Watson, R. T., & Parasuraman, A. (2004). Net-based customer service systems: Evolution and revolution in web site functionalities. *Decision Sciences*, *35*(3), 423–455.

Putsis, W. P. Jr., & Srinivasan, N. (1994). Buying or just browsing? The duration of purchase deliberation. *Journal of Marketing Research*, *31*(3), 393–402.

Pyke, D. F., Johnson M. E., & Desmond, P. (2001). E-fulfillment: It is harder than it looks. *Supply Chain Management Review*, *5*(1), 26–32.

Rabinovich, E., & Bailey, J. (2004). Physical distribution service quality in Internet retailing: Service pricing, transaction attributes, and firm attributes. *Journal of Operations Management*, *21*(6), 641–672.

Randall, T., Netessine, S., & Rudi, N. (2006). An empirical examination of the decision to invest in fulfillment capabilities: A study of Internet retailers. *Management Science*, *52*(4), 567–580.

Rao, S., Griffis, S. E., & Goldsby, T. J. (2011). Failure to deliver? Linking online order fulfillment glitches with future purchase behavior. *Journal of Operations Management*, *29*(7–8), 692–703.

Serrano-Cinca, C., Fuertes-Callen Y., & Mar-Molinero, C. (2005). Measuring DEA efficiency in internet companies. *Decision Support Systems*, *38*(4), 557–573.

Sismeiro C., & Bucklin, R. E. (2004). Modeling purchase behavior at an e-commerce web site: A task-completion approach. *Journal of Marketing Research*, *41*(3), 306–323.

Spiller, P., & Lohse, G. (1997). A classification of Internet retail stores. *International Journal of Electronic Commerce*, *2*(2), 29–56.

Srinivasan, S. S., Anderson, R., & Ponnavolu, K. (2002). Customer loyalty in e-commerce: An exploration of its antecedents and consequences. *Journal of Retailing*, *78*(1), 41–50.

StataCorp. (2012). *Stata Statistical Software: Release 12*. College Station, TX.

Starbuck, W., & Milliken, F. (1988). Executive perceptual filters: What they notice and how they make sense. In D. Hambrick (Ed.) *The executive effect: Concepts and methods for studying top managers*. Greenwich, CT: JAI Press, 35–65.

Stephenson, W. (1953). *The study of behavior: Q-technique and its methodology*. Chicago, IL: University of Chicago Press.

Suarez, F. F., Cusamano, M. A., & Kahl, S. J. (2013). Services and the business models of product firms: An empirical analysis of the software industry. *Management Science*, *59*(4), 420–435.

Thomas, D. B., & Baas, L. R. (1992). The issue of generelization in Q methodology: "Reliable schematics" revisited. *Operant Subjectivity*, *16*(1), 18–36.

Tsai, J. Y., Raghu, T. S., & Shao, B. B. M. (2013). Information systems and technology sourcing strategies of e-retailers for value chain enablement. *Journal of Operations Management*, forthcoming., *31*(6): 345–362.

United States Census Bureau. (2012). *Quarterly retail e-commerce sales, 2nd quarter 2012*. August 16, accessed September 12, 2012, available at http://www.census.gov/retail/mrts/www/data/pdf/ec_current.pdf.

Voss, C. A. (2003). Rethinking paradigms of service: Service in a virtual environment. *International Journal of Operations and Production Management*, *23*(1), 88–104.

Wooldridge, J. M. (2001). *Econometric analysis of cross section and panel data*. Cambridge, Massachusetts: MIT Press. Cambridge, Massachusetts

Xia, Y., & Zhang, G. P. (2010). The impact of the online channel on retailers' performances: An empirical investigation. *Decision Sciences*, *41*(3), 517–546.

Xue, M., & Harker, P. T. (2002). Customer efficiency—concept and its impact on e-business management. *Journal of Service Research*, *4*(4): 253–267.

Howard Hao-Chun Chuang is an assistant professor in the Department of Management Information Systems in the College of Commerce at National Chengchi University. He holds a Ph.D. in information and operations management from the Mays Business School at Texas A&M University. Dr. Chuang's research interests include service science and management, retail operations, supply chain, applied statistics, and system dynamics. Prior to his academic career, he served as a supply corporal in Penghu defense command of Taiwan army.

Guanyi Lu is an assistant professor in the Department of Global Business Analysis in the College of Business at Oregon State University. He earned his M.S. in management information systems and Ph.D. in information and operations management from the Mays Business School at Texas A&M University. Dr. Lu's research interests include supply chain security, risk management, behavioral operations management, supply chain integration, and information and communication technology. Prior to his academic career, he served in a leading Asia-based original equipment manufacturer as an assistant supply chain manager.

David Xiaosong Peng is an assistant professor in the department of Decision and Information Sciences of C.T. Bauer College of Business at University of Houston. He received his M.A. in information systems from Carnegie Mellon University and Ph.D. in operations and management science from the Carlson School of Management, University of Minnesota. His research examines operations strategy in manufacturing and professional service organizations, and impacts of information technology on manufacturing and service processes and practices. His research has appeared in the *Journal of Operations Management, Production and Operations Management, Decision Sciences Journal, Journal of Supply Chain*

Management, International Journal of Operations & Production Management, International Journal of Production Research, IEEE Transactions on Engineering Management, and Journal of Operations and Supply Chain Management. Prior to his academic career, he was a procurement manager at a Fortune 500 manufacturing firm.

Gregory R. Heim is an associate professor in the Department of Information & Operations Management in Mays Business School at Texas A&M University. He holds an A.B. in economics from The University of Chicago and a business administration Ph.D. in operations and management science from the Carlson School of Management at the University of Minnesota. Dr. Heim's research interests include service/e-service operations, management of technology, quality management, and econometric analyses of supply chain management. His articles have appeared in *Decision Sciences, Journal of Operations Management, Journal of Service Research, Manufacturing & Service Operations Management, Production and Operations Management,* and several other journals. Prior to his academic career, he was an econometric consultant.