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Migrating to internet-based e-commerce: Factors affecting e-commerce adoption and migration at the firm level

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Abstract

Web technology has enabled e-commerce. However, in our review of the literature, we found little research on how firms can better position themselves when adopting e-commerce for revenue generation. Drawing upon technology diffusion theory, we developed a conceptual model for assessing e-commerce adoption and migration, incorporating six factors unique to e-commerce. A series of propositions were then developed.

Survey data of 1036 firms in a broad range of industries were collected and used to test our model. Our analysis based on multi-nominal logistic regression demonstrated that technology integration, web functionalities, web spending, and partner usage were significant adoption predictors. The model showed that these variables could successfully differentiate non-adopters from adopters. Further, the migration model demonstrated that web functionalities, web spending, and integration of externally oriented inter-organizational systems tend to be the most influential drivers in firms' migration toward e-commerce, while firm size, partner usage, electronic data interchange (EDI) usage, and perceived obstacles were found to negatively affect e-commerce migration. This suggests that large firms, as well as those that have been relying on outsourcing or EDI, tended to be slow to migrate to the internet platform.

Keywords: Innovation adoption; Migration; Technology diffusion; E-commerce; Internet technology; EDI; Outsourcing

1. Introduction

In recent years, electronic-commerce (EC) has emerged as one of the most active research areas in the field of information systems (IS). The potential of the internet is now widely acknowledged. While some firms, such as Dell, Cisco, Wal-Mart, and Charles Schwab, have achieved tangible improvements in operational efficiency and revenue generation by integrating e-commerce into their value chain activities [7], not all firms have been uniformly successful [4,11,42]. Indeed, firms face a series of obstacles in

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adopting e-commerce [23]. Researchers and managers are struggling to determine the right conditions for adopting e-commerce, and what factors facilitate or inhibit them in migrating to the internet from traditional physical channels [40].

While research has been advancing, literature on e-commerce adoption typically focuses on adoption of either a specific technology, such as email and web presence [5,28,39], or a specific e-commerce application [13]. In this study, we adopted an alternative view, and defined e-commerce as any application of web technologies that enable revenue-generating business activities over the internet. This differentiates our study in several ways: (1) we made a distinction between setting up a website and conducting e-commerce; (2) by focusing on revenue-generating activities, we were able to observe the extent to which firms migrated from traditional channels to the internet. We were interested in looking at the extent to which a firm migrated from the traditional channel to the internet platform, indicated by the percentage of revenue generated from the internet over the total revenue. A significant portion of revenue generated through the internet is an indication of the organization's ability to leverage the internet [48].

We studied two related ways in which firms move to the internet: e-commerce adoption and e-commerce migration. The former refers to whether the firm has started to use the internet for revenue-generating activities. The latter involves the extent of revenues generated from the internet versus those from the traditional channel. These two measures complement each other: while adoption provides a qualitative description of an organizations' behavior, migration captures the quantitative property.

We were particularly interested in examining the importance of technology-related factors and obstacles associated with applying the technology. These factors are important in understanding e-commerce adoption and migration at the firm level but have seldom been studied [49]. By building upon earlier theoretical models of technology adoption [34,38], especially the technology–organization–environment (TOE) framework [43], we developed and tested a model with an emphasis on firm level factors unique to the internet.

2. Theoretical development

2.1. E-commerce adoption literature

Table 1 provides a summary of our review of material on e-commerce adoption. The studies vary in terms of the nature of the technology, research methodology, and measures of e-commerce adoption.

First, the e-commerce technologies investigated are relatively simple, such as establishing corporate websites or email systems. As many companies with web presence do not actually conduct transactions online, the adoption of these simple technologies are less likely to bring fundamental change to the organization. Furthermore, the adoption of simple internet technologies is relatively inexpensive and easy, which makes the adoption decision less controversial; for advanced e-commerce technologies, especially those involving online transactions and integrated with internal business processes, the adoption process is complicated and costly.

Second, there is little empirical data to characterize e-commerce or gauge the scale of its impact on firm performance. This is especially true in "brick-and-mortar" companies, because of the difficulty of developing measures and collecting data [47]. For studies that collected empirical data from multiple companies, the sample size was relatively small (from 62 to 286) with a focus on a narrow industry sector or a specific e-commerce application. These studies moved the frontiers of knowledge forward, but the findings have less generalizability.

Third, studies have used a variety of dependent variables. One is an adoption measure, which typically uses the physical acquisition or purchase of the innovation. As noted by Fichman [17], this is a relatively "thin" measure as there can be significant delay between the purchase and full implementation. Richer information can be found in the assimilation literature, which deals with the extent to which the use of a technology diffuses across organizational work processes and becomes routinized in the activities associated with those processes [18]. The literature normally considers the adoption as a longitudinal process that can be divided into a number of stages, from awareness of the innovation to its full deployment throughout the organization [14,29]. Alternatively, organizational assimilation of e-commerce has been

Table 1
Literature review on e-commerce adoption

Study	Theory	Methodology	Factors/major findings
Beatty et al. (2001) (I&M)	Innovation diffusion IT adoption	Survey ($N = 286$) Various industries Medium-to-large U.S. firms	DV: Entry timing (pioneer, early adopter, early majority, late majority, laggard) IV: Perceived benefits, complexity, technical compatibility, organizational compatibility, top management support
Chatterjee et al. [11] (MISQ)	Institutional theory Structuration theory	Survey ($N = 62$) Manufacturing & service firms	DV: EC activities and strategies IV: Championship, strategic investment rationale, extent of coordination
Chircu and Kauffman [13] (JMIS)	Technology diffusion theory Limits-to-value model	Case study: Online travel reservation systems	Framework: Value flows → potential value → realized value Valuation barriers: Industry barriers, organizational barriers Conversion barriers: Resource barriers, knowledge barriers, usage barriers
Zhu et al. [49] (EJIS)	TOE framework	Survey ($N = 3100$)	DV: Intent to adopt e-business IV: Technology competence, firm scope, size, consumer readiness, partner readiness, and competitive pressure
Kowtha and Choon [24] (I&M)	Resource-based view IT adoption	Survey ($N = 135$) Travel, financial, and IT sectors	DV: Website development—four generation (information and catalog, database, transaction, integrated site) IV: Prior competencies, firm size, firm age, competitive intensity, strategic commitment to e-commerce
Mehrtens et al. [28] (I&M)	Innovation literature	Case studies SMEs	DV: Decision to adopt—dichotomy (Y/N) IV: Perceived benefits, organizational readiness, external pressure
Teo et al. [39] (IJEC)	Contingency theory, TOE	Survey ($N = 188$) Various industries Small and large firms	DV: Decision to adopt—trichotomy (adopters with website, adopters without website, non-adopters) IV: Technological factors, organizational factors, environmental factors
Vadapalli and Ramamurthy [44] (IJEC)	TOE framework	Case study	Innovation-specific characteristics (the social and technological context) Organization-specific characteristics (organization boundaries, transaction cost economics, and organizational cognition)
Zhu and Kraemer [47] (ISR)	IT business value Resource-based view Dynamic capability	Survey ($N = 260$) Manufacturing firms	DV: Firm performance measures IV: EC capability (information, transaction, interaction, supplier integration); IT infrastructure measures

Note: DV, dependent variables; IV, independent variables; EDI, electronic data interchange. Studies focusing on consumer acceptance of internet commerce, website design, and price comparison are not included.

measured by the degree of different activities being implemented on the corporate website. While these measures depict the extent to which the innovation has been used, they do not provide information on the impact of the innovation. In our study, we chose both an adoption measure (adopter, potential-adopter, and non-adopter) and a direct impact measure (the portion of revenue generated by e-commerce). The two measures helped us gain a more balanced understanding of e-commerce adoption and migration.

2.2. The technology diffusion framework

Tornatzky and Fleischer [43] proposed the technology–organization–environment framework to study the adoption of technological innovations; it identified three aspects of a firm's contexts that influenced adoption and implementation. (1) Technological context—the existing and emerging technologies relevant to the firm; (2) organizational context—in terms of several descriptive measures: firm size and scope, managerial structure, and internal resources; (3) environmental context—the macro arena in which a firm conducts its business: industry, competitors, and dealings with government.

The TOE framework has been utilized for studying different types of innovations [12,22,26,41]. According to the typology of Swanson, innovations can be classified into three categories:

- Type I: technical innovations restricted to the IS functional tasks;
- Type II: applying IS products and services to support administrative tasks of the business;
- Type III: integrating IS products and services with the core business where the whole business is potentially affected and the innovation may have strategic relevance to the firm.

We consider e-commerce to be a Type III innovation, because it is often embedded in the firm's core business processes or is extending basic business products and services, and integrating suppliers and customers in the value chain.

3. Conceptual model and theoretical propositions

3.1. An integrated model of e-commerce adoption and migration

We developed an integrated model to address the adoption and migration of e-commerce. As shown in Fig. 1, this posited six predictors for e-commerce adoption (technology integration, web spending, web functionalities, electronic data interchange (EDI) use, outsourcing partner usage, and perceived obstacles), while controlling for firm size and industry types. These factors were chosen because they were believed to be important in understanding and explaining the phenomenon of interest.

A wide range of factors was found in the literature. Instead of repeating them, we chose to focus on a few

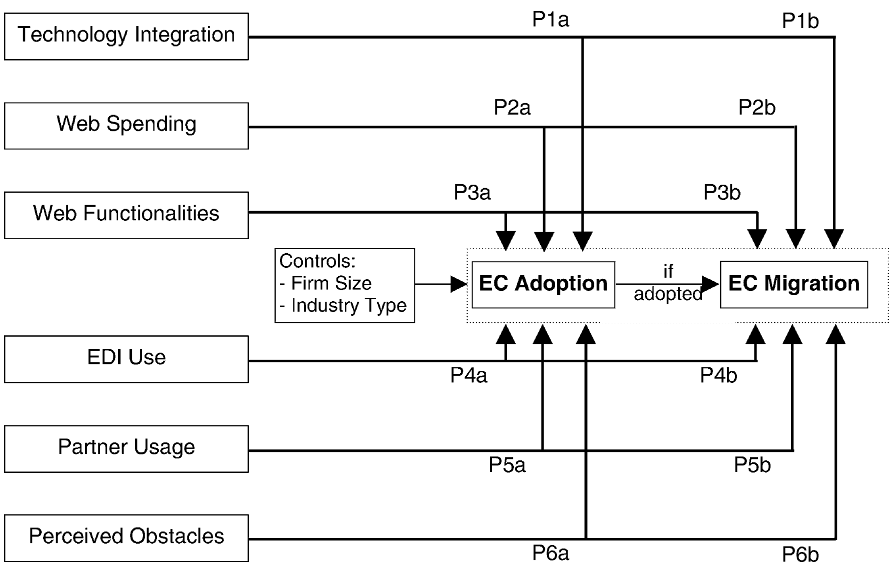

Fig. 1. Conceptual framework for e-commerce (EC) adoption and migration.

factors that are particularly relevant to adoption and migration. While other factors could have been selected, the factors in our model emphasized the fit between the new capability and legacy systems, the web-related technological capability that firms possess, the IS budget devoted to web-related spending, the firm's prior technology base, the strategy that firms take to develop their IT applications, and the perceived obstacles associated with applying the technology. These factors are more related to the technological than the organizational and environmental contexts. First, organizational factors have already been studied [32,33] and environmental factors have been examined [25]. Essential organizational characteristics, such as firm size and industry type, were included in the model as control variables.

Second, the study of IS adoption requires consideration of the specific technology and its use [6], partly because innovation diffusion theories did not provide specific innovation attributes for IS adoption in firms. Fichman argued that classical diffusion variables are unlikely to be strong predictors of adoption and diffusion for complex Type III innovations, suggesting that factors more specific to the technology should be added.

Third, the literature on e-commerce adoption suggested that a large variety of variables have been studied. However, there is little consistency in terms of the inclusion of variables in these studies because (1) there was a large span of variables that could be studied; (2) the nature of the technologies differed; (3) the organizational contexts varied. Therefore, we did not attempt to conduct a comprehensive study but focused on technology-related variables that apply to e-commerce technologies.

3.2. Theoretical propositions

3.2.1. Technology integration

Prior to the internet, firms had been using technologies to support business activities along their value chain, but many were "islands of automation"—they lacked integration across applications [45]. The characteristics of the internet may help remove the incompatibilities and rigidities of legacy IS and achieve technology integration among various applications and databases. We define technology integration as the extent to which various technologies and applications are represented on the web platform. This extends the technology notion from a purely technical measure to (1) the relationship between the new technology and the existing base and (2) the use of the technology by the organization. As a type III technology, e-commerce requires close coordination of various components along the value chain. Similarly, the more integrated these existing applications are with the internet platform, the more capacity the organization has to conduct its business over the internet. As a result, those firms would enjoy greater e-commerce migration. This leads to the following propositions:

P1a. *Technology integration is positively associated with e-commerce adoption.*

P1b. *Technology integration is positively associated with e-commerce migration.*

3.2.2. Web spending

Financial resources are an important factor for technology adoption. We defined web spending as the portion of financial resources devoted to web-based initiatives, including hardware, software, IT services, consulting, and employee training. Firms with higher web budget are better positioned to adopt e-commerce. This may also be an indication of the importance that top management places on e-commerce. Hence, firms with greater web spending are more likely to adopt e-commerce as well as migrate offline transactions to the online platform. This leads to the following propositions:

P2a. *Web spending is positively associated with e-commerce adoption.*

P2b. *Web spending is positively associated with e-commerce migration.*

3.2.3. Web functionalities

Web technologies offer a variety of functionalities ranging from static presentation of content to dynamic capture of transactions with provisions for security and personalization [10]. Firms must make use of these technologies and decide how to draw upon their capabilities for e-commerce. Web functionalities help firms provide real-time information to customers, update product offerings and make price change, facilitate self-service via online account management and research tools, and conduct online transactions with suppliers [46]. Therefore, firms that are capable of providing more web functionalities are better positioned to adopt e-commerce and capable web functionalities will make customers as well as trading partners more willing to conduct transactions online with greater migration to e-commerce. This suggests the propositions:

P3a. *Web functionalities are positively associated with e-commerce adoption.*

P3b. *Web functionalities are positively associated with e-commerce migration.*

3.2.4. EDI use

Electronic data interchange was an antecedent of e-commerce. As an interorganizational information system, it had some features in common with internet-based e-commerce [30], but it also exhibited significant differences, as EDI was typically a proprietary technology over a private network controlled by one large manufacturer or supplier [50].

There are conflicting views about the effect of prior technology, such as EDI, on the adoption of internet-based e-commerce. On the one hand, the experience with EDI made organizations more familiar with electronic media. Prior IT infrastructure such as EDI was necessary to leverage and integrate the new technologies [16]. In addition, the organization's culture and operational processes may have already been adapted to fit to an electronic platform, thus reducing the adjustment cost and shortening the learning curve. On the other hand, the implementation of EDI often involved relationship-specific investment between the firm and its trading partners. This could translate into switching costs in migrating to the internet. Also, the incremental benefits of investing in e-commerce may be viewed as small.

Considering the conflicting effects of EDI use on e-commerce adoption and migration, we expected the negative effects to be stronger than the positive ones. Adopting internet-based e-commerce would induce significant switching costs on both end users and business processes [36]. Even after adoption of e-commerce, some portion of the transactions may still be conducted over EDI. This leads to the following propositions.

P4a. *The use of EDI is negatively associated with e-commerce adoption.*

P4b. *The use of EDI is negatively associated with e-commerce migration.*

3.2.5. Partner usage

Many firms have relied on partners or contractors for their IS design and implementation tasks. An outsourcing approach has been popular in driving the growth of applications service providers. Relying on partners for e-commerce implementation may speed up the initial adoption of e-commerce, bypassing the potentially slow process associated with in-house development [3,27]. However, this may slow down an organization's subsequent migration to e-commerce. Outsourcing may seem to be a "shortcut" for e-commerce adoption, but business processes may not be fully aligned with the internet; employees may not get the exposure of e-commerce and thus lack of "buy in"; and organizational culture may remain separated from e-commerce. This leads to two propositions:

P5a. *Greater partner usage is positively associated with e-commerce adoption.*

P5b. *Greater partner usage is negatively associated with e-commerce migration.*

3.2.6. Perceived obstacles

The adoption of e-commerce requires a substantial degree of technical and organizational competence for smooth transition. This assumes a higher dimension of organizational knowledge and the role of human factors in facilitating the adoption process. The notion of learning by doing argues that it takes time and expertise to incorporate complex technologies in an organization [1]. Adoption of a complex technology can also be described as a process of knowledge accumulation, especially when the innovations (1) have an abstract and demanding scientific base, (2) are fragile because they do not always function as expected, (3) are difficult to try before the end system is implemented, and (4) cannot be treated as a black box but it must be incorporated into the business processes to become effective [2]. The adoption of e-commerce seems to possess these properties. When managers perceive such obstacles, they become reluctant to adopt e-commerce.

Such obstacles could also make it more difficult for business to migrate to the internet. These lead to a pair of propositions:

P6a. *Perceived obstacles are negatively associated with e-commerce adoption.*

P6b. *Perceived obstacles are negatively associated with e-commerce migration.*

4. Research methodology

4.1. Data and sample

We adopted a field survey methodology. Telephone interviews were conducted, which allowed trained interviewers to clarify questions to ensure accurate and meaningful responses. A computer-aided telephone interviewing system (CATI) was used. The system provided various automatic data checks while the respondent remained on the line. The survey was conducted between February and April 2001 by a professional firm specialized in IT-related survey research. Eligible respondents were executives or senior managers best qualified to speak about the firm's overall e-commerce activities. At the start of the interview, a screening question asked the respondents whether they would felt qualified to answer questions (see Appendix). Only those who answered positively continued with the interview.

The sample frame was obtained from a Dun & Bradstreet database that contained representative firms in the entire local market, regardless of computerization or web access. A stratified sampling method without replacement was used, with a predetermined number of firms selected randomly from each firm size and industry category to ensure an unbiased representation of the sample distribution. It was considered important to include both adopters and non-adopters in the sample so that we could examine how the proposed factors influenced both adopters and non-adopters. More than 2000 interviews were conducted in the United States and Canada. Samples that had any of the following characteristics were excluded:

(1) interviews that had missing values on the dependent variable;
(2) firms without a public website;
(3) organizations belonging to the public sector, such as government and education, because their main purpose was not in generating revenues.

This left us with 1036 observations in the usable sample.

Table 2 presents the descriptive statistics of the final sample. Titles of the respondents reflect large variations in the nature of the IT management responsibilities in these organizations. There was also a wide range of firm size (from fewer than 50 to more than 10,000 employees). The firms represent three industries: manufacturing, retail/wholesale, and service. Overall, the sample represented a wide range of firms, increasing the generalizability of the results.

Table 2
Sample description (sample size = 1036)

Variables	Frequency (%)
Country	
United States	838 (80.9%)
Canada	198 (19.1%)
Title of the respondent	
President, Owner, or Managing Director	157 (15.2%)
Chief Information Officer (CIO)/Chief Technology Officer/VP of information systems	92 (8.9%)
IS Manager, Director, Planner	281 (27.1%)
Other manager in IS department	99 (9.6%)
Business Operations Manager	52 (5.0%)
Administration/Finance Manager	76 (7.3%)
Firm size	
Fewer than 50	271 (26.2%)
50–99	74 (7.1%)
100–199	144 (13.9%)
200–499	171 (16.5%)
500–999	85 (8.2%)
1000–4999	137 (13.2%)
5000–9999	44 (4.2%)
10000+	96 (9.3%)
Industry	
Manufacturing	590 (56.9%)
Retail/wholesale	70 (6.8%)
Services	376 (36.3%)

4.2. Variables and constructs

4.2.1. Dependent variable

The dependent variable in the model was a categorical variable with three groups, i.e., non-adopters, potential adopters, and adopters. Depending whether a company has generated revenues from internet sales in the prior 12 months and whether it expected to generate revenues from internet sales in the next 12 months, we defined non-adopters as firms having 0% revenue from internet sales in both years, potential adopters as firms having 0% online revenue in the prior year but expecting to have positive online revenues the current year, and adopters as firms having greater than 0% online revenues in both years. The dependent variable in the migration model was operationalized as the revenue from the internet divided by the total revenue (see Appendix).

4.2.2. Independent variables

Technology integration was measured by asking respondents the level of integration of various IT systems with the internet. The systems covered major IT functional areas, including ERP, CRM, SCM, materials management, inventory control, accounting, and financial management. Together they reflect how well the IT systems are connected on a common platform. Web spending was measured by the percentage of the firm's IS operating budget devoted to web hardware, software, IT services, consulting, and employee training. Web functionalities was measured as the number of web-services provided by the website based on Zhu and Kraemer' definition and listed in Appendix. EDI use was a binary variable: companies that were currently using EDI were coded as one, otherwise zero. Partner usage was measured as the degree of using partners or contractors in IT-related areas (website design and operation, implementation, and application development). Perceived obstacle was measured by asking respondents to describe their perceived level of difficulty in managing their websites along a 5-point Likert-scale.

4.2.3. Control variables

Some of the cross-sectional variations can be explained only if controls are appropriately applied. To control for firm- and industry-specific effects, we employed two control variables: firm size [15,35], total number of employees, and industry type, coded into three dummy variables, representing retail/wholesale, service, and manufacturing industries.

5. Data analysis and results

5.1. Measurement model

Three independent variables, technology integration, perceived obstacles, and partner usage, were measured by multiple indictors. Therefore, we needed to assess their psychometric properties. Before the assessment, missing data were removed by listwise deletion, so that only complete observations would be used [20]. This resulted in an $N = 806$ sample for testing the measurement model.

A combination of exploratory and confirmatory factor analysis methods was used in validating the measurement of the multi-item constructs. The sample with complete data on the multi-item constructs was randomly split into two sub-samples to enable cross-validation. The first sub-sample ($N = 406$) was used for exploratory factor analysis (EFA) while the second ($N = 400$) was used for confirmatory factor analysis (CFA). The reason for conducting both EFA and CFA is that the EFA procedure allowed us to drop some invalid items from the scale while CFA then refined the scale to ensure the validity of the instrument using a different sample. To ensure that the two sub-samples were comparable and unbiased, we tested the equity of the means of the demographic data in the two sub-samples. The results of *t*-tests showed that there was no significant difference between the two sub-samples.

5.1.1. Exploratory factor analysis

A principal component analysis with oblimin rotation was used to examine the factor structure of the measures in the first sub-sample. Three factors emerged with eigenvalue above 1.0, explaining a total of 64% of the variance in the data. Items with low loadings on the intended factor or high cross-loadings on other factors were removed. The resulting instruments (as presented in Appendix) were evaluated for reliability, convergent validity, and discriminant validity.

The reliability or internal consistency was assessed by computing Cronbach's alpha and composite reliability. They were all above 0.8, which is higher than the 0.7 threshold normally considered as minimum [31]. Convergent and discriminant validities were examined by both factor loadings and a

Table 3
Fit indices for the measurement model

Fit indices	Recommended value	Measurement model
χ^2/d.f.	≤3	2.33
Goodness-of-fit (GFI)	≥0.90	0.92
Adjusted goodness-of-fit (AGFI)	≥0.80	0.90
Normalized fit index (NFI)	≥0.90	0.92
Non-normalized fit index (NNFI)	≥0.90	0.95
Comparative fit index (CFI)	≥0.90	0.95
Root mean square residual (RMSR)	≤0.10	0.06
Root mean square error of approximation (RMSEA)	≤0.08	0.06

Note: N/A means not applicable.

correlation matrix. All items load highly (>0.60) on their associated factors, showing convergent validity. Furthermore, all items loaded much higher on the associated factors than on any other (with no cross-loading greater than 0.25), demonstrating discriminant validity.

5.1.2. Confirmatory factor analysis

We used LISREL8.30 to perform the confirmatory factor analysis on the second sub-sample. The fit of the overall measurement model was estimated by various indices (see Table 3). The χ^2-statistics was not used because of its sensitivity to large sample size. Instead, the ratio of χ^2 to degrees-of-freedom (d.f.) was used. A value of 2.33 was obtained, which was within the recommended value of 3 [9]. Also all fit indices were above 0.90, indicating good model fit. Finally, the root mean square residual (RMSR), which indicates the proportion of the variance not explained by the model, was 0.06, implying a good fit between the observed data and the proposed model [8]. RMS error of approximation (RMSEA), which describes the discrepancy between the proposed model and the population covariance matrix, was 0.06, which was also lower than the recommended cut-off value of 0.08.

Next, we proceed to examine the instruments' reliability, convergent validity and discriminant validity [37]. Similar to the results of the EFA, Cronbach's alpha (composite reliability) was 0.85 (0.81) for technology integration, 0.91 (0.91) for partner usage, and 0.89 (0.89) for perceived obstacles, indicating high reliability of the measures. Convergent validity was tested by factor loadings (see Table 4), which are considered as significant if greater than 0.50 or 0.70 following a stricter criterion [19]. All the factor loadings were greater than 0.50 with a majority of them above 0.70. Also, all items loaded significantly ($p < 0.01$) on their underlying construct, indicating high convergent validity. Discriminant validity was tested by examining whether the shared variance between constructs was lower than the average

Table 4
Results of the confirmatory factor analysis

	Factor loadings (standardized)	S.E.	*t*-Value
Technology integration (Cronbach's alpha =0.85; composite reliability = 0.81)			
INT1	0.58	N/A	N/A
INT2	0.71	0.11	10.53
INT3	0.64	0.10	9.82
INT4	0.53	0.11	8.65
INT5	0.62	0.10	9.64
INT6	0.76	0.11	10.97
INT7	0.71	0.12	10.54
INT8	0.60	0.10	9.41
Partner usage (Cronbach's alpha = 0.91; composite reliability = 0.91)			
PAR1	0.81	N/A	N/A
PAR2	0.73	0.06	16.07
PAR3	0.89	0.05	20.80
PAR4	0.84	0.06	19.26
PAR5	0.83	0.06	19.08
Perceived obstacle (Cronbach's alpha = 0.89; composite reliability = 0.89)			
OBS1	0.76	N/A	N/A
OBS2	0.83	0.06	17.14
OBS3	0.83	0.05	17.17
OBS4	0.79	0.06	16.38
OBS5	0.74	0.06	15.13

Note: N/A, the first item of each construct is specified as a fixed parameter having a value of 1.0. Therefore, the standard errors (S.E.) and the *t*-values cannot be estimated.

Table 5
Discriminant validity

	Technology integration	Partner usage	Perceive obstacle
Technology integration	0.42		
Partner usage	<0.01	0.68	
Perceived obstacle	0.03	0.55	0.63

Note: Diagonals represent the average variance extracted. Other entries represent the shared variance.

variance extracted of the individual constructs they were, and thus the instrument demonstrated discriminant validity (see Table 5). Thus, the measurement model demonstrated adequate psychometric validity and internal consistency.

5.2. Adoption model: multi-nominal logistic regression

Multi-nominal logistic regression was performed to test our propositions, with non-adopters (0), potential adopters (1), and adopters (2) as the three-category dependent variable. We chose this technique over multiple regressions because our dependent variable was categorical rather than continuous. Also, logistic regression requires fewer assumptions than discriminant analysis and was, thus more robust in the face of data conditions that could negatively impact discriminant analysis.

We denote p covariates (including control variables) and a constant term by the vector, $\mathbf{x}$, of length $p+1$, where $\chi_0 = 1$. The two logit functions are defined as:

$$g_1(\boldsymbol{x}) = \ln\left[\frac{P(Y=0|\boldsymbol{x})}{P(Y=2|\boldsymbol{x})}\right] = \beta_{10} + \beta_{11}\text{Firmsize} + \beta_{12}\text{Indus1} + \beta_{13}\text{Indus2} + \beta_{14}\text{TechInte} + \beta_{15}\text{WebSpend} + \beta_{16}\text{WebFunc} + \beta_{17}\text{EDI} + \beta_{18}\text{PartUsg} + \beta_{19}\text{PercObs} = \boldsymbol{x}'\beta_1 \quad (1)$$

$$g_2(\boldsymbol{x}) = \ln\left[\frac{P(Y=1|\boldsymbol{x})}{P(Y=2|\boldsymbol{x})}\right] = \beta_{20} + \beta_{21}\text{Firmsize} + \beta_{22}\text{Indus1} + \beta_{23}\text{Indus2} + \beta_{24}\text{TechInte} + \beta_{25}\text{WebSpend} + \beta_{26}\text{WebFunc} + \beta_{27}\text{EDI} + \beta_{28}\text{PartUsg} + \beta_{29}\text{PercObs} = \boldsymbol{x}'\beta_2 \quad (2)$$

where β_i's are the coefficients; the names of the independent variables are self-explanatory. Then, the conditional probability $P(Y=j|\mathbf{x})$ for $j = 0, 1, 2$, can be expressed as:

$$P(Y=j|\boldsymbol{x}) = \frac{1}{1+e^{g_1(\boldsymbol{x})}+e^{g_2(\boldsymbol{x})}}, \quad \text{for } j = 0, 1, 2 \quad (3)$$

We classified the sample ($N = 1036$) into non-adopters, potential adopters, and adopters (see Table 6). Cases with missing data were removed, leaving us with a total of 627 cases for regression analysis. The randomness of the missing data across the six independent variables and two control variables were tested by the correlations among the dichotomous variables generated from the original variables by replacing valid data with a value of one and missing data with a value of zero. The majority of the correlations between any pair of dichotomous variables were below 0.1, and the highest correlation was below 0.3. Therefore, we considered the deletions to be appropriate.

To assess the overall fit of the model, we used the chi-square test and pseudo R^2 [21]. First, we adopted

Table 6
Sample classification (sample size = 1036)

Percent of revenue from internet sales	=0% in past year	>0% in past year	Total
=0% in next year	595 (non-adopter)	7 (quitter)	602
>0% in next year	106 (potential adopter)	328 (adopter)	434
Total	701	335	1036

the chi-square test for the change in the log likelihood (−2LL) value from the base model (intercept only) to the proposed model (with intercept and independent variables). This is comparable to the overall F-test in multiple regressions. The chi-square difference is significant at 0.000 level. Another indicator of the overall fit of the model is pseudo R^2. In logistic regression, both the Cox and Snell R^2 and the Nagelkerke R^2 act as the R^2 measure in multiple regressions. We chose the Nagelkerke R^2 because it is a modification over the Cox and Snell R^2 and has a range of 0–1. The Nagelkerke R^2 is 0.303 for the overall model, indicating that the model can explain approximately 30.3% of the variance in the dependent variable.

Multi-nominal logistic regression does not make any assumptions of normality, linearity, and homogeneity of variance for the independent variables. But we still need to perform analysis of multi-collinearity among the independent variables, the linearity in the logit for each of the independent variables, and the possible influence of outliers. Multi-collinearity can be detected by examining the standard errors for the beta coefficients. None of the standard errors of beta coefficients in our model was larger than 2.0, providing evidence that multi-collinearity is not a concern. Second, we performed Box–Tidwell transformation to test for the assumption of linearity in the logit for each of the independent variables. All the interaction terms were insignificant, indicating that the linearity assumptions were met, except for web spending. This implied that the logistic regression may potentially have underestimated the degree of relationship of web spending to the dependent variable and will, thus lack power. Since web spending was found to be significant in the regression analysis, this violation of linearity does not affect our results and interpretation. Finally, we ran multiple binary logistic regressions and used those results to test the exclusion of outliers. Through this process, we identified a total of eight outliers. Removing these outliers has minimum impact on the prediction accuracy of the model, thus the multi-nominal logistic regression model with all cases could be interpreted.

The results of the multi-nominal logistic regression are presented in Table 7. In the overall model, four of the six independent variables were significant: technology integration, web spending, web functionalities, and partner usage. Next, we used the adopters as the base group, and tested the predicting power of the independent variables in differentiating the other two groups from the base group. The results of two separate regressions showed that the set of significant variables in the overall model could successfully differentiate the non-adopters from the adopters, suggesting that lower technology integration (negative β), lower web spending, lower web functionalities, and higher partner usage (positive β) distinguished the non-adopters from the adopters. In the second model, only web functionalities

Table 7
Multi-nominal logistic regression analysis on adoption

	Overall R^2 = 30.3%		Non-adopter vs. adopter		Potential adopter vs. adopter	
	d.f.	Sig.	β_1	Sig.	β_2	Sig.
Control variables						
Firm size	2	0.000***	0.241	0.000***	−0.005	0.942
Industry type	4	0.542				
Type1 (retail/wholesale)			−0.560	0.261	−0.466	0.462
Type2 (service)			0.148	0.563	−0.252	0.465
Type3 (manufacture)			Baseline		Baseline	
Independent variables						
Technology integration	2	0.000***	−0.934	0.000***	0.282	0.170
Web spending	2	0.000***	−0.022	0.000***	−0.013	0.035*
Web functionalities	2	0.000***	−0.465	0.000***	−0.305	0.003**
EDI	2	0.383	−0.242	0.246	0.073	0.799
Partner usage	2	0.013*	0.464	0.003**	0.294	0.177
Perceived obstacle	2	0.369	−0.104	0.397	0.116	0.468

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

and web spending were significant predictors in differentiating the potential adopters from the adopters. This makes sense because the difference between potential adopters and adopters is smaller than that between non-adopters and adopters.

The signs of the coefficients of the significant variables were consistent across the two separate logistic regressions. Technology integration, web spending, and web functionalities had a positive effect on e-commerce adoption, supporting P1a, P2a, and P3a. EDI use and perceived obstacle were insignificant in predicting e-commerce adoption behavior. Therefore, P4a and P6a were not supported. An interesting finding was that partner usage had a significant negative effect on e-commerce adoption, which was in the opposite direction to P5a. Firm size also had a surprising negative effect on e-commerce adoption, indicating that large firms were slow in adopting e-commerce. Finally, there was no significant difference among the three industry sectors in their progress to e-commerce adoption.

5.3. Migration model: multiple regression

With migration as the dependent variable, the regression model is:

$$Y = \beta_0 + \beta_1\text{Firmsize} + \beta_2\text{Indus1} + \beta_3\text{Indus2} + \beta_4\text{WebInt} + \beta_5\text{PerObs} + \beta_6\text{ParUsg} + \beta_7\text{WebSpe} + \beta_8\text{EDI} + \beta_9\text{WebSer} + \varepsilon \quad (4)$$

where Y is the dependent variable (i.e., the percentage of revenue from internet sales in 2000), β_i's the coefficients, and ε is the error term.

Only firms with positive online revenue ($N = 335$) in 2000 were used for regression analysis (see Table 6). Again, listwise deletion was used, leaving 239 usable sample.[1] The results of the multiple regression analysis are reported in Table 8. The model is significant at 0.000 level for both the control and the independent variables. Multi-collinearity among the independent variables and control variables was assessed by VIF and variance proportions (VIF larger than 10 or variance proportions in excess of 0.90 are indictors of multi-collinearity). The results confirmed that there is no multi-collinearity among these variables. Table 9 summarizes the proposition testing results.

Table 8
Multiple regression analysis on migration

	Sig.	R^2	β	Sig.
Control variables	0.000	0.085		
Firm size			−0.235	0.000***
Industry type				
Type1 (retail/wholesale)			0.124	0.062
Type2 (service)			0.192	0.003**
Type3 (manufacture)			Baseline	
Independent variables	0.000	0.334		
Technology integration			0.094	0.156
Web spending			0.408	0.000***
Web functionalities			0.184	0.004**
EDI			−0.116	0.048*
Partner usage			−0.152	0.027*
Perceived obstacle			−0.142	0.048*

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

All independent variables are significant, except for technology integration. Web spending and web functionalities contributed positively to e-migration, supporting P2b and P3b. EDI use, partner usage, and perceived obstacles are all negatively related to e-migration, consistent with P4b, P5b, and P6b. Firm size was also found to be negatively associated with e-migration. Finally, there is significant difference in e-commerce migration across different industry types.

We performed further analysis on the technology integration variable to see whether the insignificant result was due to the differences in the nature of the enterprise information systems. We invited a panel of six IT experts to classify the eight applications. Based on their opinion, we classified the applications into two categories: internally and externally oriented systems. The former included ERP, accounting and financial management, materials management and inventory control, and order processing and fulfillment systems; the latter included CRM, SCM, sale force automation, and custom service support. Multiple regression analyses using the two new integration variables showed that the integration of externally oriented enterprise systems with the web has a significant positive impact on migration ($\beta = 0.153$, $p = 0.018$), while the integration of the internally oriented systems

[1] The highest correlation between any pair of dichotomous variables was 0.34, thus the two variables share about only 10% of the total variance. Therefore, the missing data was random and the deletion did not distort our sample.

Table 9
Proposition testing results

Independent variables	Adoption		Migration	
	Propositions	Supported	Propositions	Supported
Technology integration	P1a (+)	Y	P1b (+)	Partially
Web spending	P2a (+)	Y	P2b (+)	Y
Web functionalities	P3a (+)	Y	P3b (+)	Y
EDI	P4a (−)	N/S	P4b (−)	Y
Partner usage	P5a (+)	N (−)	P5b (−)	Y
Perceived obstacle	P6a (−)	N/S	P6b (−)	Y

Note: Y, Yes; N, No; N/S, not significant.

remained insignificant ($\beta = 0.054$, $p = 0.405$). Therefore, proposition P1b was partially supported.

6. Discussion and implications

6.1. Major findings and interpretations

6.1.1. E-commerce adoption

We found that there were three drivers for e-commerce adoption: technology integration, web functionalities, and web spending. First, firms that have more web-compatible technologies are more likely to be early adopters of e-commerce. Second, the number and variety of web functionalities indicate the level of technological capabilities as well as the strategic emphasis that are placed on e-commerce by the organization: such technological capabilities are positively related to the adoption of e-commerce. Third, the development of e-commerce initiatives requires secured budget on web related hardware, software, and internal staff support. This is consistent with the observation from industry that many e-commerce projects failed to succeed due to insufficient funding.

Meanwhile, there are three unexpected findings about e-commerce adoption inhibitors. First, EDI use did not prevent firms from adopting internet-based e-commerce. While firms with EDI were less motivated to adopt new technology as a replacement, they were better prepared for e-commerce innovation. Second, partner usage was found to inhibit firms' adoption of e-commerce. While using partners may speed up the development process of simple applications, more sophisticated systems would involve integration with existing IT systems and business processes, coordination among different functional departments in the organization, and fundamental changes in organizational structure and process reengineering. Therefore, firms that are using outsourcing partners for IT applications are likely to be late adopters. Third, perceived obstacles do not have significant impact on the adoption. It might be the case that firms reporting higher levels of obstacles in managing the website are those with more sophisticated applications.

The factors discussed above can successfully distinguish non-adopter from adopters. For potential adopters, the factors that differentiate them from adopters are web functionalities and web spending. These firms appear to have built a suitable environment for the change, and only need to add more functionality to the websites or need more budgets to transit to full adopters.

6.1.2. E-commerce migration

Although adoption is a necessary prerequisite for migration, factors affecting adoption may actually have a different effect on migration. While higher level of technology integration makes it easier for firms to adopt e-commerce, this cannot guarantee success on the internet. In-depth analysis shows that the integration of externally oriented enterprise systems with the web is more significantly associated with larger portion of online transactions than the integration of internally oriented systems.

Web functionalities and web spending continue to be positively related to the level of e-commerce migration after adoption. Websites with more functionality are more likely to provide good services to customers and business partners, who become more willing to conduct transactions online. Similarly, a large IT budget helps to secure the necessary resources for continuous development and extension of web services.

EDI usage and perceived obstacle become significant variables, while partner usage continues to be negatively associated with e-commerce migration. The existence of EDI apparently reduces the extent of e-commerce migration. The use of partners also limits the extent to which a firm can integrate e-commerce capabilities because partners or contractors may find it difficult to understand the business operations and strategies. Finally, perceived obstacles slow down the firms in conducting large-scale migration to e-commerce.

6.1.3. Firm size and industry type

In our study, firm size was found to be negatively related to e-commerce adoption and especially to e-commerce migration. This is consistent with Zhu and Kraemer's findings that large firms are slowed down by their structural inertia. Differences among industries also seem to influence the migration of e-commerce. Firms in the service industry tend to have higher migration level as they deal with intangible products. In addition, the value chain processes of most service firms can be easily digitized.

6.2. Implications for research and management

Our work builds upon prior adoption research but is different in important ways. First, it demonstrated the value of tailoring the technology diffusion framework to understand the adoption of complex innovation. By focusing on factors that are unique to the characteristics of the internet, we found several factors that had not been examined previously. These factors, together with firm size and industry type, account for approximately 30% of the total variance in the adoption model and 42% in the migration model. Our framework could be used for studying e-commerce transformation or other Type III innovations. Furthermore, we have developed several constructs, including technology integration, partner usage, and perceived obstacles. These instruments have passed various reliability and validity tests.

Second, by conducting a large-scale field study, we obtained a broad sample of data representing a variety of industries. This increases the external validity of our study. Third, the nature of e-commerce technology that we studied was more complex and more closely related to core business processes. Therefore, in contrast to simple web presence, the e-commerce technology we examined may affect firms in more fundamental ways.

Finally, we chose a unique perspective and examined the extent of e-commerce migration from traditional platform to the internet. The two related measures complement each other and provide a more balanced view of firms' adoption and assimilation of e-commerce into the core business activities.

We believe the key limitations of this work are:

1. Our dataset was cross-sectional. We were able to test associations but not causalities. We do not know how these relationships will change over time.
2. We focused on examining specific firm level factors for e-commerce. Our definition of e-commerce and the choice of variables might be narrow.
3. There are other factors influencing e-commerce migration that we left out, especially environmental ones, which were excluded because of the difficulty of developing universally applicable questionnaire items that suited the variety of the organizations.

Our results have important implications for managers who are involved in efforts to introduce complex Type III innovations into their organizations or are interested in expanding their e-commerce applications and generating more revenue. Our study sought to help firms become more effective in moving from a traditional channel to the internet by identifying the profile of early and sustained e-commerce adopters. For non-adopters and potential adopters, it provides a mechanism for self-evaluation. For adopters, it helps to determine the pace of e-commerce migration as well as identify the areas in which firms can focus on in order to leverage the benefit of e-commerce.

6.3. Concluding remarks

The global reach of the internet makes it a powerful business resource. As more contemporary firms seek to transform their value chain activities and business strategies through the adoption of internet-based e-commerce, there is a growing demand to understand what factors are likely to facilitate such a migration.

Our study contributes to the decision-making process by demonstrating the value of tailoring the technology diffusion framework to the adoption of e-commerce and identifying new factors that fit to the characteristics of Type III innovation. The findings of our study offer managers guidelines to assess the time to launch e-commerce and to transform traditional value-chain activities to the internet based on the technological readiness of their firms.

Appendix A. Measures

A.1. Screening question

Do you feel that you are qualified to answer questions about your site's overall e-commerce activities? (1: Yes; 2: No).

What is the name and title of the person at your site who would be best qualified to answer these questions? [Thank respondent and terminate. Try to start over with referral.]

A.2. Dependent variables

A.2.1. Adoption

What percentage of your organization's revenues was generated from the internet in the past 12 months?

What percentage of your organization's revenues is expected to be from the internet in the next 12 months?

Non-adopter (0)	Online revenue from the internet was zero last year and expected to remain zero this year (within the next 12 months)
Potential-adopter (1)	Online revenue from the internet was zero last year but expected to be greater than zero this year
Adopter (2)	Online revenue from the internet was greater than zero last year and expected to continue to be positive this year

A.2.2. Migration

Percentage of organization's revenues generated from the internet over total revenues in the past 12 months.

A.3. Independent variables

A.3.1. Technology integration

How integrated is each of the following systems with the internet in your organization? Please report on a 1–4 scale, with 1 being that the system is not in use at this time, 2 being that the system is not currently integrated and has no plan to be integrated during the next 12 months, 3 being that the system is not currently integrated but is planned to be integrated during the next 12 months, and 4 being that the system is fully integrated with the web already.

Applications	
INT1	Customer relationship management (CRM)
INT2	Enterprise resource planning (ERP)
INT3	Supply chain management (SCM)
INT4	Customer service support
INT5	Accounting and financial management
INT6	Materials management and inventory control
INT7	Order processing and fulfillment
INT8	Sales force automation

A.3.2. Web spending

What percentage of your firm's IS operating budget in the past 12 months was devoted to web-based initiatives, including hardware, software, IT services, consulting, and employee training?

And what will that be in the next 12 months?

A.3.3. Web functionalities

Which of the following functionalities are currently available on your website? (1: Yes; 0: No.)

A. Detailed information about your organization's products and services.
B. Online self-service capability (e.g., technical support information that can be downloaded by customers).
C. Customer service that is integrated with a call center.
D. Free services such as email, personalized web pages, hosting and storage for registered users.
E. Customization capability enabling customers to configure product features online.
F. Account management with security provision.
G. Online community features such as bulletin boards and chat rooms.
H. Multiple language support (support at least one foreign language other than English).
I. Mobile internet accessibility (the website can be accessed by mobile devices).

A.3.4. EDI use

Does your organization transmit or receive accounting, planning or material management documents, such as purchase requests, bills of materials, and invoices, electronically, using any type of electronic data interchange, including standard EDI or any similar electronic system? (1: Yes; 0: No.)

A.3.5. Partner usage

For which of the following tasks does, or would, your organization use partners (or contractors)? Please report on a 1–4 scale, with 1 being that the firm carries the task fully in house and does not use partners, 2 being that the firm carries the task partly in house and partly uses partners, 3 being that the firm mainly uses partners for the task, and 4 being that the firm fully uses partners on the task.

Tasks	
PAR1	Implementation tasks
PAR2	Web designing
PAR3	Integration with back office databases
PAR4	Operation of the website such as hosting and managing
PAR5	Application development

A.3.6. Perceived obstacles

Using a 5-point scale where 1 is "not at all difficult" and 5 is "very difficult", please rate the difficulty of the following aspects of operating your website.

		Not at all difficult	Moderately difficult			Very difficult
OBS1	Perceived internal resistance to change	1	2	3	4	5
OBS2	Entrenchment with existing proprietary systems and infrastructure	1	2	3	4	5
OBS3	Logistics/ fulfillment issues	1	2	3	4	5
OBS4	Lack of IT staff or EC expertise	1	2	3	4	5
OBS5	Finding customers online	1	2	3	4	5

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