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Determinants of E-Commerce Adoption of Philippine Businesses

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Abstract

Since the late 1990s, the internet has developed as a major force in transforming how companies do their business, which led to the rapid expansion of electronic commerce, or e-commerce. In 2016, the Department of Trade and Industry adopted the Philippine E-Commerce Roadmap in recognition to the potential of e-commerce in the expansion of Philippine businesses. In support to the Philippine E-Commerce Roadmap's first success criteria having 100,000 Micro, Small, and Medium Enterprises (MSMEs) doing e-commerce, this study investigated the determinants of e-commerce adoption using the Philippine Statistics Authority's Survey of Information and Communications Technology as well as the Annual Survey of Philippine Business and Industry. The results showed that internal factors primarily determine e-commerce adoption in the Philippines. These factors include firm size, availability of computers, access to the internet, and firm use of information and communications technology (ICT) in other aspects of firm operations. Further, external factors, such as the growth rate of the industry in which the firm belongs and the market share of the firm have no statistically significant effects on e-commerce adoption. Given these results, this study recommended five actionable steps. First, bottlenecks caused by uncertainty and security concerns should be addressed. Second, government agencies need to support MSME's e-commerce adoption. Third, government agencies should assist firms in adopting ICT. Fourth, government can help provide access to finance to firms intending to adopt e-commerce. Fifth, reducing the cost and improving the quality of internet services should be pursued.

Keywords: *e-commerce adoption, digital economy, industry, Philippines, survey on information and communications technology, MSMEs*

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List of Acronyms

ARMM	Autonomous Region in Muslim Mindanao
ASEAN	Association of Southeast Asian Nations
ASPBI	Annual Survey of Philippine Business and Industry
B2B	Business-to-Business
B2C	Business-to-Consumer
C2B	Consumer-to-Business
C2C	Consumer-to-Consumer
CAR	Cordillera Administrative Region
DICT	Department of Information and Communications Technology
DSL	Digital Subscriber Line
DTI	Department of Trade and Industry
G2E	Government-to-Employee
G2G	Government-to-Government
ICT	Information and Communications Technology
IE	Information Economy
MSME	Micro, Small, and Medium Enterprise
MSMED	Micro, Small, and Medium Enterprise Development (Council)
NCR	National Capital Region
NIR	Negros Island Region
OECD	Organisation for Economic Co-operation and Development
PECR	Philippine E-Commerce Roadmap
PEER	Perceived External E-Readiness
PERM	Perceived E-Readiness Model
POER	Perceived Organizational E-Readiness
PSA	Philippine Statistics Authority
R&D	Research and Development
SICT	Survey on Information and Communications Technology

Determinants of e-commerce adoption of Philippine businesses

Francis Mark A. Quimba and Sylwyn C. Calizo Jr.[1]

1. Introduction

Since the late 1990s, the internet has developed as a major force in transforming how companies do their business. Electronic commerce (e-commerce), which is buying and selling of information, products, and services via computer networks (Kalakota and Whinston 1997), has been rapidly expanding. Total global e-commerce has grown by 24.6 percent in 2016-2017 and is projected to grow by 141.0 percent in the period 2016-2021 (International Post Corporation 2017).

Recognizing the potential of e-commerce in the expansion of Philippine businesses, the Department of Trade and Industry (DTI), through the Philippine E-Commerce Roadmap, targets to expand the share of e-commerce to GDP from 10.0 percent in 2015 to 25.0 percent by 2020 (DTI 2014). The PECR also identified five success criteria, namely:

1. 100,000 Micro, Small, and Medium Enterprises (MSMEs) doing e-commerce;
2. 40.0 to 50.0 percent of internet users doing e-commerce;
3. Fast and competitive internet access;
4. Cybercrime enforcement and protection; and,
5. Online and connected government (i.e., G2G, G2B, G2C, and G2E).

However, estimates derived from the 2014 Annual Survey of Philippine Business and Industry (ASPBI)[2] reveals that only about 400 out of the 220,000 establishments in the country, or less than a percent, have e-commerce sales. Such a statistic could imply that the country needs to drastically modify its strategies in order to achieve its e-commerce targets.

1.1 Objectives of the study

This paper addresses the Philippine E-Commerce Roadmap's first success criteria of having "100,000 MSMEs doing e-commerce." To provide relevant inputs to crafting a strategy that will improve e-commerce adoption among firms and to contribute towards achieving the target of having 100,000 MSMEs engaged in e-commerce, the following research questions shall be explored:

1. What are the characteristics of firms engaged in e-commerce?; and,
2. What factors influence the decision of firms to engage in e-commerce?

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[2] Estimates derived using microdata provided by the Philippine Statistics Authority, 2014 ASPBI.

These research questions are important because these provide a characterization of establishments engaged in e-commerce to policymakers and implementing agencies allowing them to craft targeted policies aimed at supporting these establishments.

1.2 Significance of the study

This study contributes to crafting new strategies by providing background information on the status and performance of e-commerce among Philippine establishments, especially MSMEs. Further, it also provides information on the determinants of e-commerce adoption among Philippine establishments, and it identifies policy bottlenecks that affect the e-commerce adoption among Philippine establishments.

Relatedly, the study is also expected to inform policymakers of the significant factors that affect a firm's decision to engage in e-commerce, which policymakers can use to influence geographic and local factors that could directly influence the decision function of firms.

While the link between e-commerce and industrial development is apparent to policymakers, pushing for the development of the sector is also relevant because of its indirect links to the achievement of the Sustainable Development Goals. Kituyi (2017) suggests that e-commerce can:

1. Become a driver of inclusive growth and sustainable development by empowering women as entrepreneurs and traders (Goal 5, Target 7: "Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance, and natural resources, in accordance with national laws;" and, Target 8: "Enhance the use of enabling technology, in particular Information and Communications Technology (ICT), to promote the empowerment of women");

2. Support productive activities, create decent jobs, entrepreneurship, creativity and innovation, and encourage the formalization and growth of MSMEs, including through access to ICT-enabled financial services (Goal 8, Target 3);

3. Help MSMEs gain access to financial services (including online and mobile payments) and gain their integration into value chains and markets (including virtual marketplaces) (Goal 9, Target 3); and,

4. Contribute to significantly increasing the exports of developing countries, in particular, doubling the share of global exports by Least Developed Countries by 2020 (Goal 17, Target 11).

1.3 Limitations of the study

Since this study utilizes data from the establishment surveys of the Philippine Statistics Authority (PSA), this study covers only establishments engaged in e-commerce (i.e., B2B or B2C). Serafica and Albert (2018) notes that technological developments actually increase the likelihood of e-commerce occurring not only among formal businesses but also between

consumers (i.e., C2C or C2B). However, this study is unable to distinguish the type of e-commerce relative to what is being traded: goods, services, or data (Serafica and Albert 2018). The characteristics of the products being digitally ordered and/or delivered, while closely related to the industry classification of the establishment, needs to be analyzed further as product specific characteristics may affect the engagement of firms in e-commerce. This can occur because of product-related regulations or characteristics.

As this study explores only the determinants of e-commerce adoption, the regression equations are limited only to the characteristics of firms engaged in e-commerce with no explanatory variable looking at specific policy variables. Further study can, for instance, explore the role of incentives on the adoption of e-commerce.

2. E-commerce and the digital economy

PSA adopts the broad definition of e-commerce used by the Organisation for Economic Co-operation and Development (OECD 2002), to wit:

> The sale or purchase of goods and services, whether between businesses, households, individuals, governments, and other public or private organizations conducted over computer-mediated networks. The goods and services are ordered over those networks, but the payment and the ultimate delivery of the good or service may be conducted on- or off-line.

DTI adopts the same PSA definition for e-commerce, to wit: "e-commerce refers to the selling of products or services over electronic systems, such as the Internet Protocol-based networks and other computer networks.[3]"

With practically all establishments belonging to MSMEs,[4] the Philippine government recognizes the need to ensure MSMEs can effectively harness e-commerce in order to support regional and national economic development (OECD 2004; NEDA 2017). This section explores the current literature on MSMEs and e-commerce by answering three main questions, namely: who are the e-commerce adopters? why are firms engaging in e-commerce?; and, what are the factors affecting the success of e-commerce?

2.1 Who are the adopters of e-commerce?

Building on the Perceived E-Commerce Readiness (PECR) model (Molla and Licker 2005), Al-Hudhaif and Alkubeyyer (2011) classified firms according to their degree of e-commerce adoption using the following definitions:

1. Non-Adopters are firms characterized by having no internet connection (i.e., no email);

2. Initial Adopters are characterized by being connected via email but have either no website or have only static e-commerce (i.e., publishing basic company information on the internet without any interactivity); and,

[3] For more basic information about e-commerce, see: https://www.dti.gov.ph/about-e-commerce

[4] For more basic information about MSMEs, see: https://www.dti.gov.ph/business/msmes/msme-resources/msme-statistics

3. Institutional Adopters are characterized by having interactive e-commerce that accepts queries, email, and other form entries from users. This type also engages in transactive e-commerce, which is the online selling and purchasing of products or services. This would include customer services or integrated e-commerce where the website is integrated with suppliers, customers, and other back office systems allowing most of the business transactions to be connected electronically.

Alternatively, Wilson, Daniel, and Davis (2014) conducted a cluster analysis on business activities of firms in the United Kingdom to characterize the different companies that have adopted e-commerce. They identified four clusters of e-commerce adopters, namely: developers, communicators, promoters, and life-cycle managers.

On the one hand, Cluster 1 (developers) includes companies at the very start of their e-commerce adoption. This cluster also includes companies who intended to develop e-commerce but have done very little to fulfill that intention. On the other hand, Cluster 2 (communicators) includes companies who use electronic media to communicate with both customers and suppliers, and also to acquire information relevant to their business. This cluster would also include companies using electronic channels to communicate with employees, exchange documents with suppliers, and engage customers' orders. The e-commerce development activity common in this cluster is the development of a brochure website.[5]

Meanwhile, Cluster 3 (promoters) includes developing a mechanism for taking and for receiving payments electronically in addition to essentially all activities done by the communicators. Finally, Cluster 4 (life-cycle managers) builds on Cluster 3 but is more likely to take orders electronically, to provide after-sales service electronically, and to use electronic support for most of the customer life-cycle. The companies in Cluster 4 are also exploring the delivery of goods and services electronically, and they have reached the "halting points" of developing e-commerce activities. Thus, they may be on the lookout for new e-commerce capabilities. Cluster 4 also uses ICT for engaging other stakeholders, such as recruitment, non-inventory purchasing, and interacting with investors and shareholders.

Looking at commonalities among the clusters, Wilson, Daniel, and Davis (2014) observed that technology has a paramount role in e-commerce adoption. They further found that e-commerce adoption, as manifested by the clusters, could be perceived in stages. Companies start with the simplest technologies, such as the use of email and web browsing (cluster 2), then they proceed to having a brochure website, and then finally having a transaction one (clusters 3 and 4).

According to the Small Enterprise Research Report (SERTeam 2006), 87.0 percent of small firms, situated in the northern, midland, and southern regions of Britain, use email and over 66.0 percent use the internet either as a source of information or as a platform for advertising and promoting their products and services. In comparison, other aspects of e-commerce, such as online payments, are not as widely adopted. The SERTeam (2006) also found that only 11.0 percent of SMEs accept online payments, with a further 14.0 percent intending to accept payments within a year. They also noted that a number of companies have expressed their intention to adopt online payments within the year but have failed to do so. The study then concludes that SMEs face difficulties in developing their online activities beyond the most

[5] The IBM Knowledge Center defines a brochure website as "an externally facing site that acts as an organization's presence on the World Wide Web. The overriding focus is on representing the organization's brand to its potential customers."

basic services. The result of SME surveys (SERTeam 2006; Wilson, Daniel, and Davis 2014) are consistent with other studies (Al-Hudhaif and Alkubeyyer 2011; Serafica and Albert 2018) where e-commerce activities are observed to vary across firms.

2.2 Why do firms engage in e-commerce?

A number of studies (WTO 1998; Lynn et al. 1999; Levy et al. 2005) suggest that e-commerce can offer considerable benefits to smaller companies. E-commerce "levels the playing field (Clayton 2000)" for companies by providing them the potential to compete more effectively with their competitors, both large and small. Further, WTO (1998) also observed that engaging in e-commerce through the internet may cause companies to undergo vertical disintegration in order to become more efficient or to gain market power.

Furthermore, firms engage in e-commerce to participate in digital platforms. For instance, the Economist (1997) was able to observe the rising number of digital platforms, which they called "cybermalls" at the time. Digital platforms allow many sellers and buyers to conduct business through the internet. A necessary condition to participate in cybermalls is the ability to engage in e-commerce, which, at the most basic level, would include receiving orders through the internet.

It is also informative to understand the reasons of why firms choose not to adopt an e-commerce strategy. For instance, Harrigan, Ramsey, and Ibbotson (2008), looking at the case of e-commerce adoption by professional services in Northern Ireland, considered two major factors of why small and medium services sector enterprises do not engage in e-commerce: first is the unstructured nature of innovations and second is the inherent uncertainty of technological outcomes.

2.3 What are the factors that affect the adoption of e-commerce?

Al-Hudhaif and Alkubeyyer (2011) reviewed the theories governing the adoption of e-commerce. Their review includes:

1. The Diffusion of Innovations (Rogers 1995; Beatty, Shim, and Jones 2001; Mehrtens, Cragg, and Mills 2001; Zhu and Kraemer 2005);
2. The Theory of Planned Behavior (Ajzen 1991);
3. Technology Acceptance Model (Davis 1989);
4. The Technology-Organization-Environment Model (Drazin, Tornatzky, and Fleischer 1990; Kuan and Chau 2001; Xu, Zhu, and Gibbs 2004; Zhu and Kraemer 2005);
5. Institutional Theory (Chatterjee, Grewal, and Sambamurthy 2002); and,
6. Resource-based theory (Barney 1991; Zhu and Kraemer 2005).

A number of models have been crafted to test these theories and to examine different aspects of e-commerce adoption. On the one hand, the models used by Kraemer, Gibbs, and Dedrick (2003), Hempel and Kwong (2001), and Kshetri and Dholakia (2002) all examine only the external environment of firms whereas Claycomb, Iyer, and Germain (2005) consider technological aspects.

On the other hand, the models developed based on the Technology-Organization-Environment Model framework (Kuan and Chau 2001; Xu, Zhu, and Gibbs 2004; Zhu and Kraemer 2005) have tried to study the organizational context of e-commerce adoption. In these models, only factors such as firm size and scope are included. Others, such as managerial and internal organizational aspects (Molla and Licker 2005) are left unevaluated, which includes the centralization, formalization, and complexity of managerial structure, the quality of human resources, and the amount of slack resources available internally (Xu, Zhu, and Gibbs 2004).

According to Al-Hudhaif and Alkubeyyer (2011), most of these models are designed for developed countries, thereby taking for granted the business environment of these countries where it is commonly observed that environmental (external) factors, such as delivery systems, credit payment, and government regulations, are absent. Financial, legal, and physical infrastructure for e-commerce influences the its adoption. E-commerce models designed for developed countries may not be applicable to developing countries, thus, limiting its applicability and adoption for such purposes (Hempel and Kwong 2001; Kraemer, Gibbs, and Dedrick 2003; Molla and Licker 2005).

Addressing this gap, the perceived e-readiness model (PERM) was developed by Molla and Licker (2005), which analyzes the contextual (external) and organizational (internal) factors that affect e-commerce adoption in developing countries. According to the PERM, these factors could be classified either as internal factors (perceived organizational e-readiness, POER) or as external factors (perceived external e-readiness, PEER).

POER is defined as the managers' perception and evaluation of the degree to which they believe that their organization has the awareness[6], resources[7], commitment[8], and governance[9] to adopt e-commerce whereas PEER is the degree to which managers believe that market forces, government, and other supporting industries are ready to aid in their organization's e-commerce implementation (Molla and Licker 2005). In addition, the PERM model differentiates two levels of adoption: first is the initial adoption of e-commerce and second is the institutionalization of e-commerce.

Wu et al. (2003) identified four general categories for the determinants of e-commerce adoption, namely efficiency, sales performance, customer satisfaction, and, relationship development. They consider these performance outcomes in relation to the level of e-commerce adoption, which they in turn relate to various factors including organizational learning ability,

[6] Awareness represents perception of e-commerce elements in the environment, comprehension of their meaning through an understanding of e-commerce technologies, business models, requirements, benefits and threats, and projection of the future trends of e-commerce and its impact.

[7] This covers a range of resources: human, technological, and business. On the one hand, human resources refer to the availability (accessibility) of employees with adequate experience and exposure to ICT and other skills, such as marketing and business strategy, which are needed to adequately staff e-commerce initiatives and projects. On the other hand, technological resources refer to the ICT base of an organization and assesses the extent of computerization, the flexibility of existing systems, and experience with network-based applications. Finally, business resources cover a wide range of capabilities and most of the intangible assets of the organization. This resource includes the openness of organizational communication, risk-taking behavior, existing business relationships, and funding to finance e-commerce projects.

[8] Commitment is defined as having enough energy and support for e-commerce from all corners of the organization, especially from the strategic apex. It refers to having a clear-cut e-commerce vision and strategy championed by top management, e-commerce leadership, and organization-wide support of e-commerce ideas and projects.

[9] Governance refers to the strategic, tactical, and operational model organizations in developing countries put in place to govern their business activities and e-commerce projects.

customer power, and normative pressure from other organizations. Whilst these success factors need to be treated with care since they have been derived via the intermediate step of the level of e-commerce adoption, they do form a useful starting point for more detailed studies.

Further, Wilson, Daniel, and Davis (2014) found that the factors most significantly associated with e-commerce adoption are support of top management for e-commerce adoption and top management's understanding of how e-commerce can help their business. The study also found that conceptualizing how to apply e-commerce to the business is more of a barrier than understanding the technology itself. They also found that "information technology skills" and "consultancy availability" are significant factors affecting e-commerce adoption. These factors imply the steep resource requirements (internal and external human resources, among others) faced by MSMEs. Another significant factor that affects the adoption of e-commerce for firms is the availability of other projects, which MSMEs prioritize more than e-commerce adoption.

However, Goode and Stevens (2000) mention the conflicting relationship between small and less complex businesses and developing e-commerce adoption. Being small and less complex could imply that e-commerce adoption could easily be facilitated with limited business processes needing complete overhauls. However, small and less complex businesses often lack resources that could be used to invest in e-commerce.

3. Methodology

This research adopts the PERM developed by Molla and Licker (2005), which analyzes the contextual (external) and organizational (internal) factors that affect e-commerce adoption in developing countries. Table 1 presents the internal and external factors that could be explored in this study.

Table 1 Determinants of e-commerce adoption

Internal Factors	External Factors
1. Capabilities of the firm to engage in e-commerce: a. Technology skills of firms' human capital (Nelson and Winter 1982) b. Training and education provided to firms' human capital (Clegg et al. 1997) c. Availability of technology support inside the firm (Davis et al. 1989) d. Innovative capability of the firm (Porter 2001; McCole et al. 2001) 2. Managerial influences 3. Service or product characteristics 4. Financial issues 5. Market orientation	1. Environmental volatility 2. Competition from other firms 3. Imposition of customers or suppliers (Feindt, Jeffcoate, and Chappell 2002; Wilson, Daniel, and Davis 2014)

Source: Authors' framework based on the PERM (Molla and Licker 2005)

To operationalize the PERM, a probit model was estimated wherein the explanatory variables correspond to indicators of internal and external factors affecting e-commerce adoption. Table 2 presents the list of factors tested in the regression model and the corresponding proxy indicators of internal and external factors affecting e-commerce adoption.

Table 2 Determinants of e-commerce adoption, factors in the regression model

#	Factors	Type	Proxy indicators
1	Capability of the firm to engage in e-commerce	Internal	Use of ICT in the following: finance and accounting, human resources, logistics, and research and development
2	Availability of technological support in the firm	Internal	Total number of computers owned by the firm (in log values); Access to the internet
3	Innovative capability of the firm	Internal	Dummy variable for research and development spending by the firm
4	Service or product characteristics	Internal	Dummy variables for industrial classification of the establishment
5	Financial issues	Internal	Output growth of the establishment during the previous time period
6	Environmental volatility	External	Growth of the industry in which the firm belongs during the previous time period
7	Competition from other firms	External	Market share of the firm

Source: Authors' framework

3.1 Sources of data

The main source of data utilized for this study is the Survey of Information and Communications Technology (SICT)[10], particularly the 2013 and 2015 rounds. The SICT contains information on the availability, distribution, access to, and utilization of ICT in both Philippine business and industry. The SICT was first conducted in 2002 with 2001 as the reference period[11]. The SICT classifies industries into core ICT and non-core ICT sectors. The core ICT industries are those referred to as the Information Economy (IE).[12]

To obtain characteristics of the firm and the industry in which the firm belongs, this study also used the 2012 to 2015 rounds of the ASPBI.[13] The ASPBI contains information on the value of output by firms from which the total industry output can be obtained. Share of the firm to the market output can then be obtained from the ASPBI.

For the purpose of this study, a firm is considered to have adopted e-commerce if it answered "YES" to any of the following questions in the SICT questionnaire:

- Question VIII-A: "Did this establishment make purchases for goods and/or services via internet in [reference year]?"

- Question VIII-B: "Did this establishment receive orders for goods and/or services via internet in [reference year]?"

[10] Microdata provided by the Philippine Statistics Authority, SICT.

[11] For more basic information about the SICT, see: https://psa.gov.ph/tags/sict

[12] PSA defines the Information Economy as "the economic and social value created through the ability to rapidly exchange information at anytime, anywhere to anyone." The industries or businesses belonging to the IE is characterized by the intensive use of ICT for a number of functions, including the collection, storage, processing, and transmission of information.

[13] Microdata provided by the Philippine Statistics Authority, ASPBI.

Using these two questions, PSA is able to identify firms that have adopted e-commerce using the OECD definition that defines an e-commerce transaction as "the sale or purchase of goods or services conducted over computer networks by methods specifically designed for the purpose of receiving or placing orders." The goods or services are ordered by those methods but the payment and the delivery of the good or service do not have to be conducted online. Moreover, this definition specifically excludes orders made by telephone calls, facsimile, or manually typed e-mails.

3.2 Econometric model

Following the PERM, this paper estimates Equation 1, which relates the probability of a firm to engage in e-commerce p with a vector of internal and external factors, x. As a means of checking the robustness of the relationships estimated, a number of models were estimated controlling for time, industry, and geographic fixed effects.

$$p_i \equiv Pr(y_i = 1) = F(x_i'\beta) \quad (1)$$

; where, $F(\cdot)$ is the standard normal cumulative distribution function (c.d.f.).

Further analysis on the level of e-commerce adoption was done. An ordered outcomes model, which distinguishes the levels of e-commerce adoption in firms, was used. For this analysis, the authors used a modified version of e-commerce adoption that breaks down e-commerce adoption according to three levels patterned from the study of Al-Hudhaif and Alkubeyyer (2011), namely:

1. No adoption, which includes firms that have no website;
2. Early adoption[14], which includes firms with website but only static e-commerce; and,
3. Full adoption, which includes firms with fully functional e-commerce that allows them to conduct sales and purchases via the internet.

An ordered outcomes model arises when a latent variable y^* crosses progressively higher thresholds. For this study, y^* is an unobserved measure of propensity to adopt e-commerce. For firm i, the propensity to adopt e-commerce is defined by Equation 2 with a normalization, such that the regressors do not include an intercept.

$$y_i^* = x_i'\beta + u_i, \quad (2)$$

Given the three categories for e-commerce adoption, the firm does not adopt e-commerce for very low levels of y^*. The firm is observed to be an early adopter if y^* crosses some threshold α_1 but remains below a certain level α_2. Crossing the α_2 threshold, makes the firm a full adopter of e-commerce.

For this study, the regression parameters are estimated by maximizing the log likelihood using Equation 3:

$$p_{ij} = F(\alpha_j - x_i'\beta) - F(\alpha_{j-1} - x_i'\beta) \quad (3)$$

; where, F is the cumulative distribution of u_i following the logistic distribution $F(z) = \frac{e^z}{1+e^z}$.

[14] Annex 2 provides a detailed description of these three levels' operational definitions.

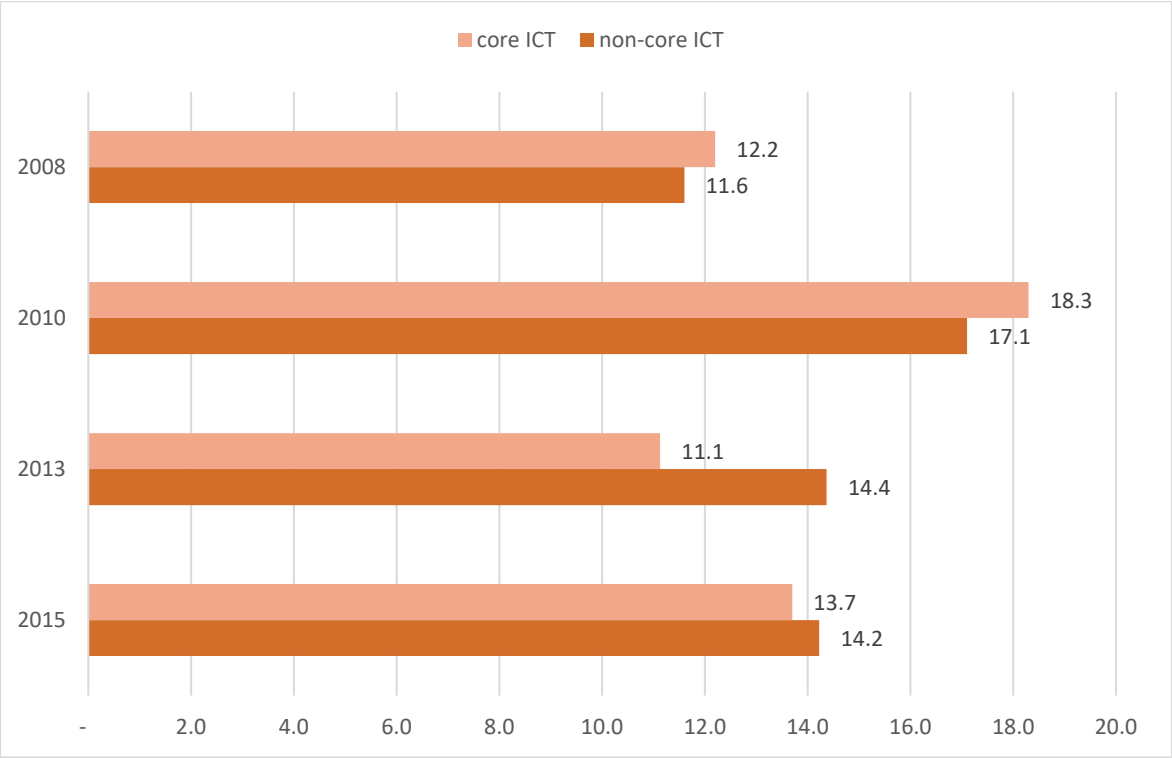
The positive sign of the regression parameters may be interpreted as determining whether the unobserved variable (i.e., propensity to adopt e-commerce) increases with the explanatory variable. In addition, the positive sign of the regression parameters increases the probability of being in the highest category while reducing the probability of being in the lowest category.

4. Results and Discussion

4.1 Profile of e-commerce adoption

This section will discuss selected indicators of interest about e-commerce adoption in the Philippines. Annex 1 provides a detailed table of the information contained in this section. Data from the 2013 and 2015 SICT shows that e-commerce adoption of firms is quite low with barely 15.0 percent of firms making purchases or sales via the internet (Figure 1). In 2013, non-core industries have overtaken core industries in terms of e-commerce adoption rate and this has persisted to 2015 despite the increase in e-commerce adoption by core ICT industries in 2015.[15]

Figure 1 E-commerce adoption rate by core ICT classification, 2008-2015

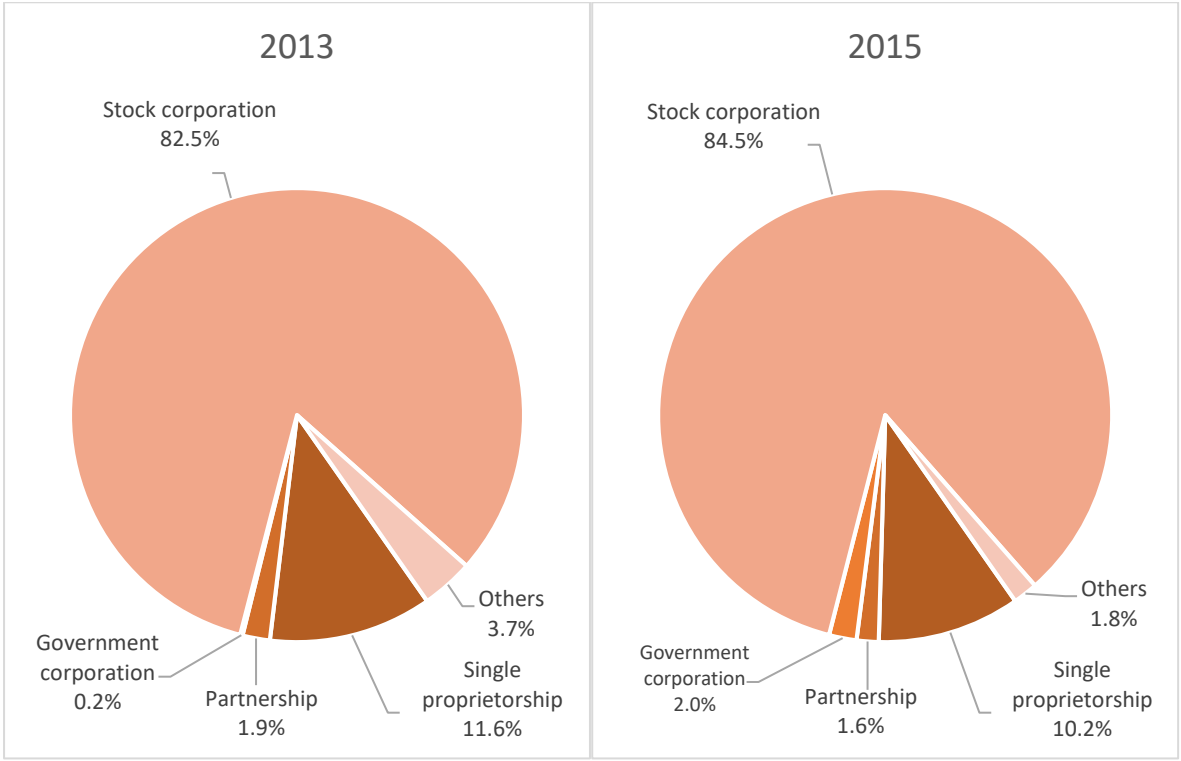


Source: SICT 2008, 2010, 2013, and 2015

[15] Data from earlier rounds of the SICT (2008 and 2010) have core industries leading in e-commerce adoption. It is only in 2013 where the non-core ICT industries have overtaken core ICT industries. It should be noted, however, that PSA introduced, in 2015, a change to the list of industries identified as core ICT.

Majority (more than 8 in 10) of these e-commerce firms are stock corporations. This is followed closely by single proprietorships (1 in 10 firms). There is also an increase in the number of government corporations that are engaged in e-commerce, 2 in every 100 e-commerce firms are government corporations (Figure 2).

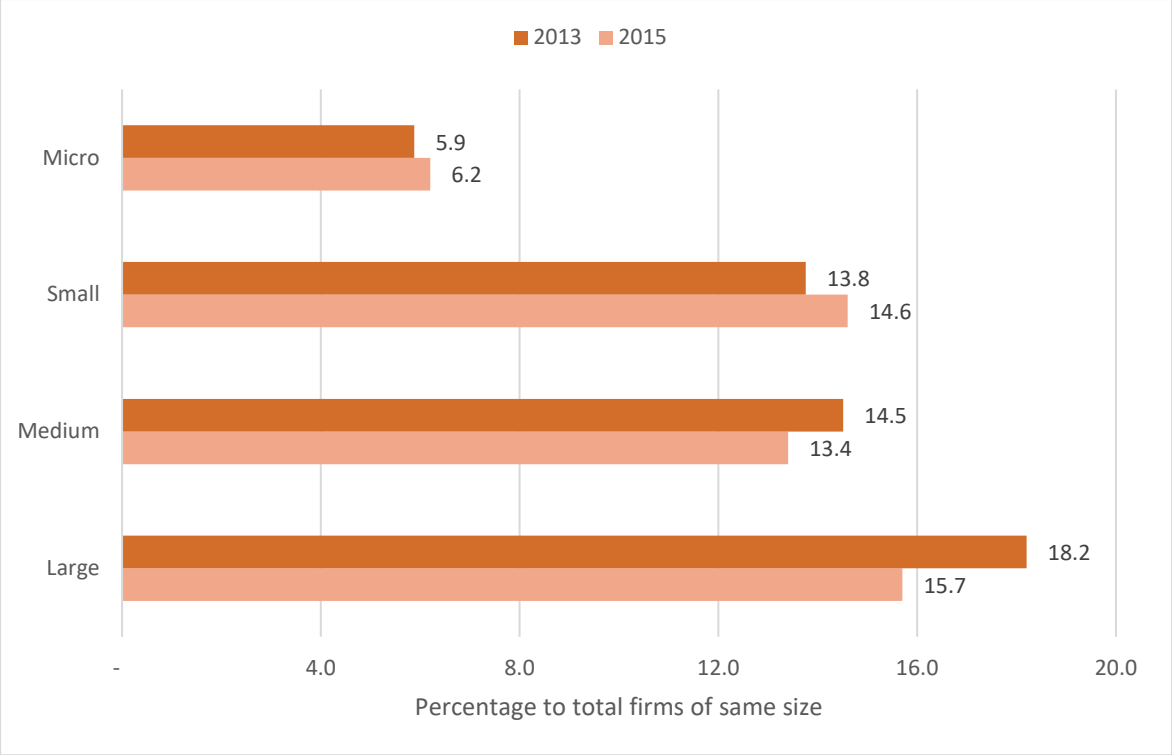
Figure 2 Distribution of e-commerce firms by legal organization, 2013 and 2015



Source: Authors' estimates using the SICT 2013 and 2015

E-commerce adoption is highest among large firms with about 15.7 percent of large firms in 2015 having purchases or sales via the internet (Figure 3). This is lower than the 2013 figure of 18.2 percent. The percentage of medium-sized firms adopting e-commerce also saw a decline in 2015 from 14.5 percent in 2015 to 13.4 percent in 2015. Bucking this trend, however, are the micro and small firms, which saw a slight increase in the percentage of e-commerce adoption. E-commerce adopters among micro-sized firms slightly increased from 5.9 percent in 2013 to 6.2 percent in 2015. Similarly, e-commerce adopters among small firms have increased in 2015 from 13.8 percent to 14.6 percent in 2015.

Figure 3 Average adoption rate of e-commerce via internet by firm size, 2013 and 2015



Source: Authors' estimates using the SICT 2013 and 2015

4.1.1 Which industries have engaged in e-commerce more?

Table 3 shows that in 2015, the industry with the highest proportion of establishments adopting e-commerce would be water supply, sewerage, waste management, and remediation activities (33.1%), human health and social work (25.3%), and accommodation and food service activities (25.1%). Since 2013, human health and social work, and accommodation and food service activities have been consistently among the top industries with high e-commerce adoption rate.

What is surprising is the sharp increase in water supply, sewerage, waste management and remediation activities from 0.0 percent to 33.1 percent in 2015. On the one hand, such trend is apparent in a number of industries, namely: electricity, gas, steam, and air-conditioning supply, which also saw a sharp increase from 0.0 percent to 11.1 percent, and construction with an increase from 0.0 percent to 6.9 percent. On the other hand, the following industries, namely: financial and insurance activities, and real estate activities have seen very sharp declines in the share of establishments with e-commerce via the internet.

The average for the entire country in 2015 is just 14.1 percent, which represents a very low adoption of e-commerce among industries. Despite the rapid changes in technology and increase in the penetration rate of the internet, the average proportion of firms utilizing e-commerce in the country has remained virtually unchanged from 2013 to 2015. which implies that the industries are unable to keep pace with the use of available technology in their business operations.

Table 3. Average adoption rate of e-commerce via internet by main industry, 2013 and 2015

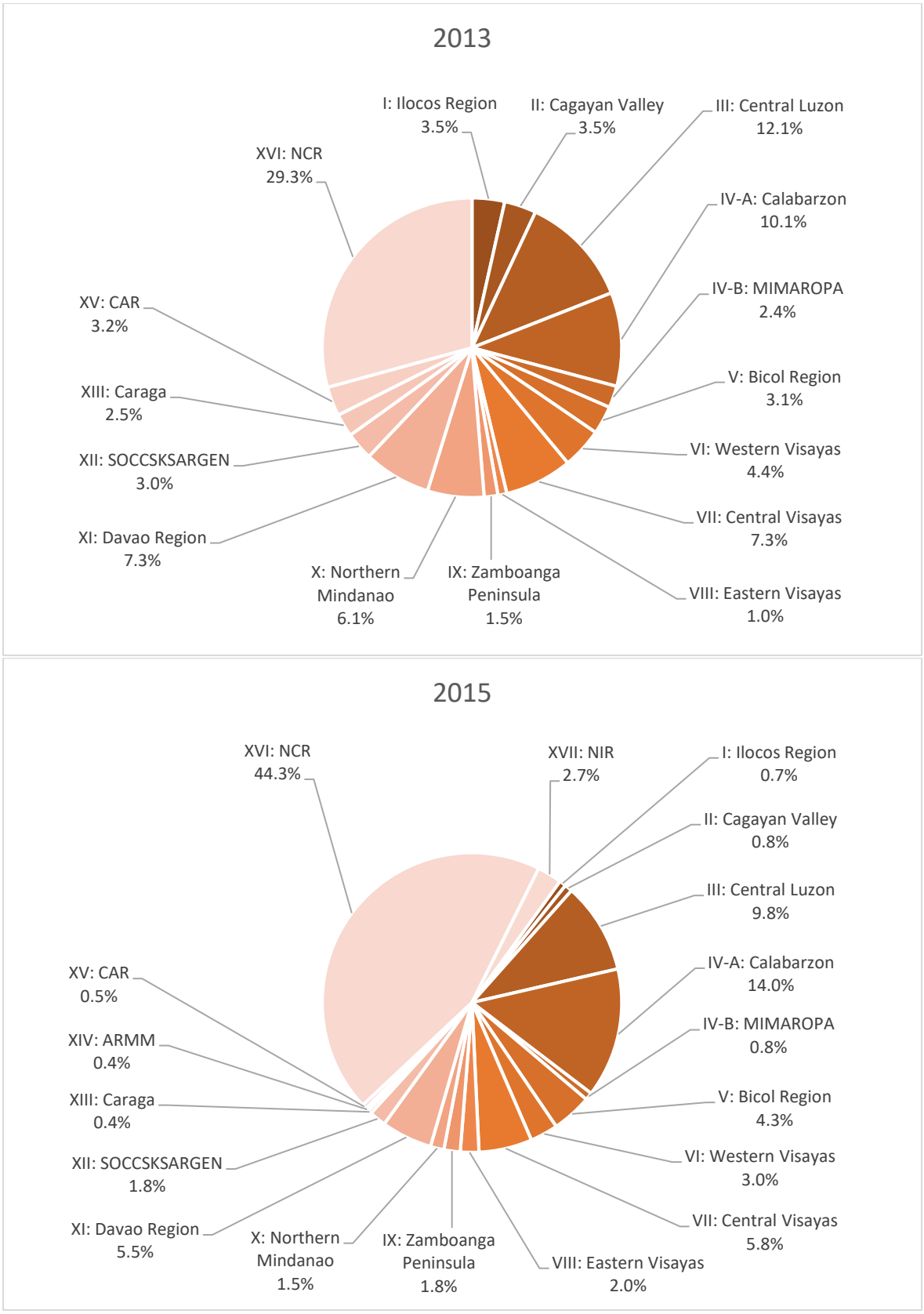
		2013		2015	
		No. of establishments	% with e-commerce	No. of establishments	% with e-commerce
2009 PSIC Section	**Philippines**	**38,103**	**14.0**	**37,851**	**14.1**
A	Agriculture, forestry, and fishing	1,181	9.0	1,159	11.1
B	Mining and quarrying	157	3.2	134	6.2
C	Manufacturing	6,787	25.9	6,538	16.2
D	Electricity, gas, steam, and air-conditioning supply	224	-	224	11.1
E	Water supply, sewerage, waste management, and remediation activities	336	-	339	33.1
F	Construction	1,079	-	1,122	6.9
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	8,732	5.8	8,610	15.2
H	Transportation and storage	1,116	24.3	1,158	4.7
I	Accommodation and food service activities	5,487	25.9	5,493	25.1
J	Information and communication	3,274	7.4	2,823	15.7
K	Financial and insurance activities	1,053	24.1	1,449	0.3
L	Real estate activities	498	18.2	594	4.8
M	Professional, scientific, and technical services	875	28.6	839	14.1
N	Administrative and support service activities	1,687	9.0	1,795	17.6
P	Education	3,565	1.3	3,574	0.0
Q	Human health and social work activities	1,000	16.8	1,015	25.3
R	Arts, entertainment, and recreation	287	3.2	279	8.0
S	Other service activities	765	7.7	706	0.8

Source: Authors' estimates using the SICT 2013 and 2015

4.1.2 Which regions have more e-commerce adopters?

Figure 4 shows that e-commerce firms are mostly located in the National Capital Region (NCR), Central Luzon, and Calabarzon. In 2015, the same proportions can be observed with NCR taking up more than 40.0 percent of the share of e-commerce firms. Together with Calabarzon and Central Luzon, these three comprise more than half of e-commerce firms in 2013 and around 70.0 percent in 2015. Central Visayas, where Metropolitan Cebu is located, has the largest share of e-commerce firms in Visayas while Davao Region, where Metropolitan Davao is located, also has a significant share of e-commerce firms in Mindanao.

Figure 4 Distribution of e-commerce firms by region, 2013 and 2015

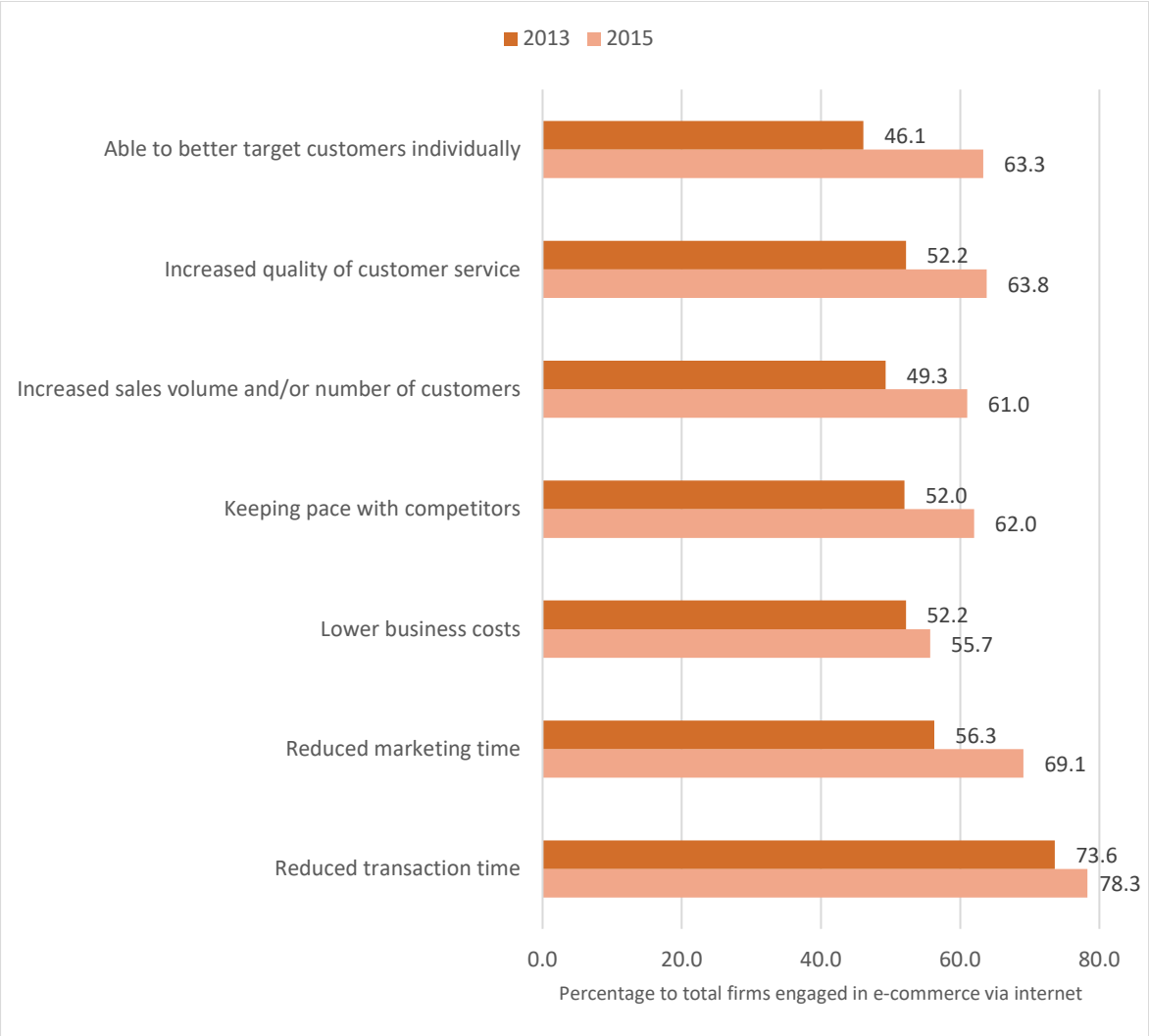


Source: Authors' estimates using the SICT 2013 and 2015

4.1.3 What are the benefits and bottlenecks relevant to e-commerce?

The SICT also contain questions about the benefits gained from and the perceived bottlenecks to adopting e-commerce. Figure 5 shows that, from among e-commerce adopters in 2015, the top three benefits are the reduced transaction time (78.3%), the reduced marketing time (69.1%), and the increased quality of customer service (63.8%). This ranking has remained unchanged since 2013. While lowering business costs and reduced transaction time remained consistent between 2013 and 2015, other benefits have experienced a surge. The largest increase is in the firm's ability to better target customers individually, which experienced a 17.2 percentage point increase.

Figure 5 Percentage of firms engaged in e-commerce via internet by perceived benefits of e-commerce, 2013 and 2015

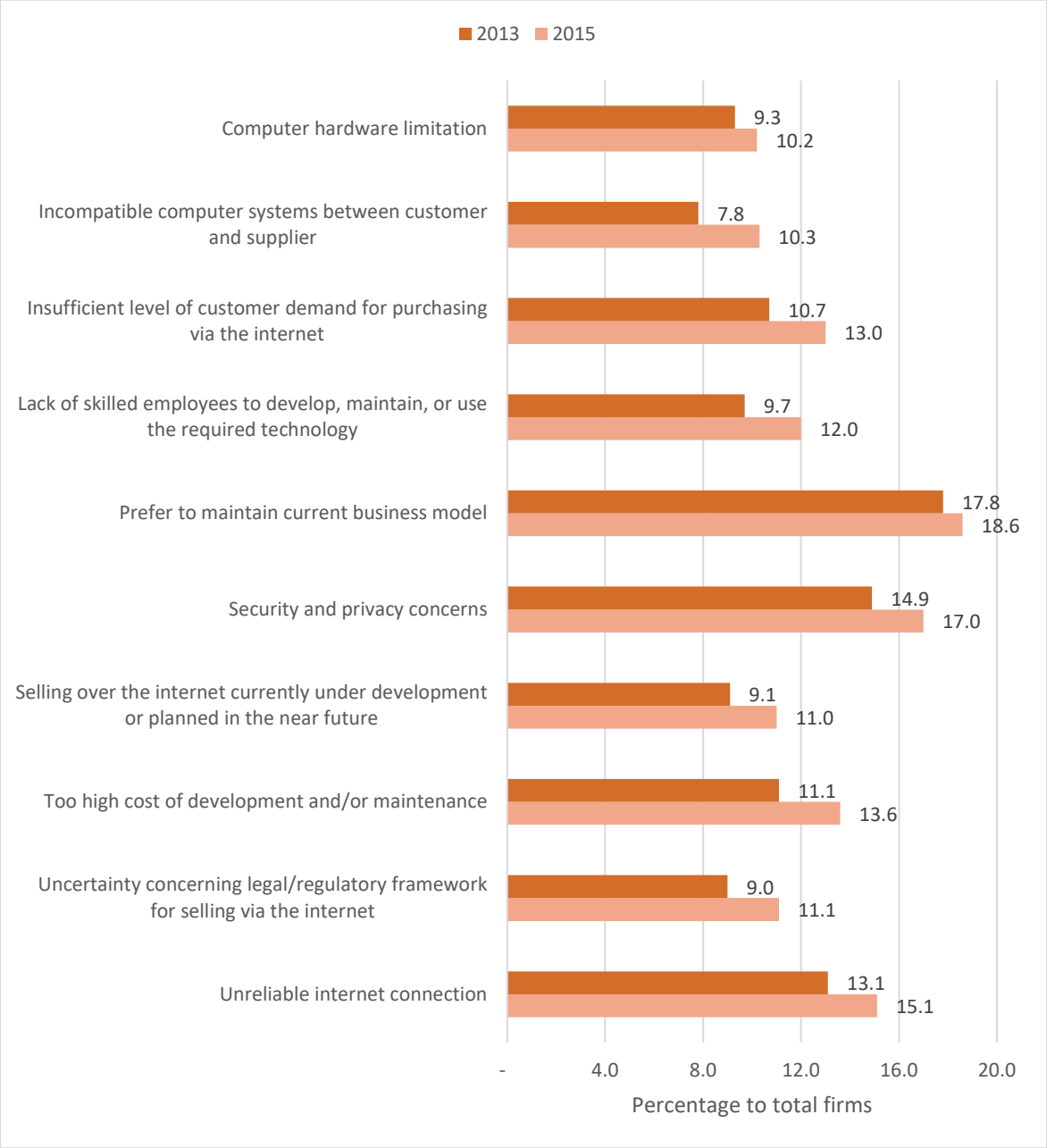


Source: Authors' estimates using the SICT 2013 and 2015

The SICT identified 10 bottlenecks in the questionnaire. Figure 6 shows that in 2015, firms identified their preference to maintain the firm's current business model as the greatest

bottleneck to e-commerce adoption (18.6%). This is followed by security and privacy concerns (17.0%) and unreliable internet connection (15.1%). This ranking has also remained unchanged since 2013. Interestingly, two bottlenecks experienced the highest increase of 2.5 percentage points from 2013 to 2015. These two are the incompatibility of computer systems between customers and suppliers, and the high cost associated with the development and/or maintenance of an e-commerce system.

Figure 6 Firms engaged in e-commerce via internet by perceived bottlenecks to e-commerce adoption



Source: Authors' estimates using the SICT 2013 and 2015

4.2 Determinants of e-commerce adoption

This section presents the results of regression models that explore the relationship of e-commerce adoption with various internal and external factors. Annex 2 provides the operational definitions of these factors. The results in Table 4 show that one of the key determinants of e-commerce adoption would be firm size (as measured by total employment). For instance, the results in Model 1 shows that a one unit increase in firm size is associated with an increase in the likelihood of firms increasing e-commerce adoption by about 0.005 percent. The results are fairly robust even after controlling for geographical location or industry.

Further, Models 1 and 4 both show a positive and statistically significant correlation between output growth and the likelihood of adopting e-commerce. This indicates that as the industry grows, the likelihood of firms to engage in e-commerce increases by 0.00006 percent.

As expected, the number of computers (expressed in logs) is positively associated with e-commerce adoption. This indicates that the more computers are owned by the firm, the more likely it is going to adopt e-commerce. Related to this would be the source of internet, which is positively and significantly associated with e-commerce adoption.

As proxy indicators for firm perception on ICT, the study included dummy variables for the use of ICT on various operational departments of the firm such as finance and accounting, human resource, logistics, and research and development (R&D). The results show that firms that utilize ICT in a number of functions have a higher likelihood of adopting e-commerce.

All the models include a dummy for 2015 and a dummy for R&D expenditure. The dummy for R&D expenditure is positive and significant across all models, which indicate a positive correlation between R&D expenditure and the adoption of e-commerce.

It is also important to note the factors that seem to have no effect on e-commerce adoption, such as the firm's market share, the output growth of the firm, and the age of the firm (expressed in its logs) since all have statistically insignificant effects to e-commerce adoption.

Table 4 Marginal effects on e-commerce adoption via internet of internal and external factors

	(1)	(2)	(3)	(4)	(5)
VARIABLES					
market_share	-0.230	-0.257	-0.256	-0.228	-0.238
	(0.168)	(0.169)	(0.169)	(0.169)	(0.171)
tot_outputgr	-0.0306	-0.0300	-0.0296	-0.0310	-0.0559**
	(0.0237)	(0.0235)	(0.0235)	(0.0236)	(0.0237)
log_age	0.00604	0.00571	0.00592	0.00607	0.00317
	(0.00432)	(0.00427)	(0.00430)	(0.00432)	(0.00426)
log_te	0.00496*	0.00569**	0.00488*	0.00518*	-0.00374
	(0.00288)	(0.00287)	(0.00287)	(0.00291)	(0.00303)
output_gr	6.18e-05*	6.04e-05	5.95e-05	6.18e-05*	5.69e-05
	(3.70e-05)	(3.83e-05)	(3.84e-05)	(3.70e-05)	(3.94e-05)
owncpph	0.00529	0.00471	0.00536	0.00543	0.0146
	(0.0120)	(0.0119)	(0.0118)	(0.0120)	(0.0114)

log_total_computers	0.0121***	0.00868***	0.00886***	0.0119***	0.0174***
	(0.00275)	(0.00278)	(0.00282)	(0.00279)	(0.00293)
dummy_2015	0.0194**	0.0193**	0.0193**	0.0195**	0.0179**
	(0.00808)	(0.00800)	(0.00799)	(0.00808)	(0.00800)
ict1_finance	0.0343***	0.0307***	0.0305***	0.0343***	0.0275***
	(0.00859)	(0.00857)	(0.00856)	(0.00859)	(0.00862)
ict2_hr	0.0191**	0.0169*	0.0157*	0.0192**	0.0143
	(0.00916)	(0.00913)	(0.00913)	(0.00915)	(0.00918)
ict3_logistics	0.0709***	0.0625***	0.0618***	0.0708***	0.0566***
	(0.0102)	(0.0101)	(0.0101)	(0.0102)	(0.0100)
ict4_research	0.0515***	0.0433***	0.0446***	0.0515***	0.0471***
	(0.0106)	(0.0104)	(0.0104)	(0.0106)	(0.0104)
dummy_rnd	0.0993***	0.101***	0.1000***	0.0991***	0.0681***
	(0.0211)	(0.0213)	(0.0212)	(0.0211)	(0.0203)
mode5_dsl		0.0170*	0.0160*		0.0175**
		(0.00894)	(0.00907)		(0.00892)
mode6_wireless		0.0237***	0.0235***		0.0241***
		(0.00766)	(0.00765)		(0.00762)
mode7_mobile		0.0668***	0.0671***		0.0688***
		(0.00936)	(0.00937)		(0.00936)
Constant					
Regional dummies	No	No	Yes	No	No
Industry dummy	No	No	No	Yes	Yes
Observations	9,934	9,934	9,932	9,934	9,934

Source: Authors' estimates using a pooled SICT 2013 and 2015 dataset with additional indicators from ASPBI
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Consistent with the results of the probit models in Table 4, the results of the ordered logit model in Table 5 shows the importance of owning computers in the adoption of e-commerce. The probability of fully adopting e-commerce for firms is associated with an increase of about 0.0534 as the total number of owned computers increase. Using ICT in company operations, particularly in finance and accounting, logistics, and R&D, also increases the likelihood of fully adopting e-commerce.

Moreover, firms doing R&D is also positively associated to a full adoption of e-commerce. Similarly, full adoption tends to be more likely for firms in the industry and services sector compared to firms in the primary sector. Firms in the manufacturing sector are also more likely to adopt e-commerce relative to firms in the primary sector.

Table5 Marginal effects of ordered logit model

	(1)	(2)	(3)
VARIABLES	No Adoption	Early Adoption	Full Adoption
market_share	-0.201	0.0708	0.130
	(0.234)	(0.0826)	(0.152)
tot_outputgr	-0.00838	0.00296	0.00542
	(0.0321)	(0.0113)	(0.0208)
log_age	-0.0377***	0.0133***	0.0244***
	(0.00598)	(0.00217)	(0.00386)
log_te	0.00676	-0.00239	-0.00438
	(0.00428)	(0.00151)	(0.00277)
output_gr	-0.000121**	4.27e-05**	7.84e-05**
	(5.19e-05)	(1.84e-05)	(3.36e-05)
owncpph	-0.00799	0.00284	0.00515
	(0.0169)	(0.00606)	(0.0109)
log_total_computers	-0.0825***	0.0291***	0.0534***
	(0.00416)	(0.00171)	(0.00274)
dummy_2015	0.00902	-0.00318	-0.00584
	(0.0110)	(0.00388)	(0.00713)
ict1_finance	-0.0711***	0.0256***	0.0456***
	(0.0112)	(0.00418)	(0.00714)
ict2_hr	-0.0133	0.00472	0.00859
	(0.0119)	(0.00426)	(0.00768)
ict3_logistics	-0.0400***	0.0138***	0.0263***
	(0.0127)	(0.00425)	(0.00843)
ict4_research	-0.0787***	0.0260***	0.0527***
	(0.0138)	(0.00429)	(0.00961)
dummy_rnd	-0.0719***	0.0231***	0.0488***
	(0.0238)	(0.00693)	(0.0169)
mode5_dsl	-0.0733***	0.0272***	0.0460***
	(0.0120)	(0.00474)	(0.00733)
mode6_wireless	-0.0230**	0.00808**	0.0150**
	(0.0102)	(0.00355)	(0.00663)
mode7_mobile	-0.0893***	0.0295***	0.0598***
	(0.0117)	(0.00372)	(0.00811)
dummy_manuf	-0.237***	0.0621***	0.175***
	(0.0421)	(0.00688)	(0.0356)
dummy_services	-0.186***	0.0736***	0.112***
	(0.0270)	(0.0117)	(0.0155)
Observations	9,934	9,934	9,934

Source: Authors' estimates using a pooled SICT 2013 and 2015 dataset with additional indicators from ASPBI
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

5. Conclusion and Policy Recommendations

5.1 Conclusion

This study looks at the factors that affect the firms' adoption of e-commerce. Using secondary data from PSA, this study found that there has been a low adoption rate of e-commerce in the Philippines with about 1 in every 7 firms adopting e-commerce in 2015. This is quite low considering the rapid pace at which the digital economy is growing in the country.

Data from the SICT also shows that most of the e-commerce adopters are stock corporations and are located in regions associated with mega-cities. Further, e-commerce adoption has been reported to benefit firms through increased efficiency by reducing transaction time and reducing marketing time. Firms in 2015 have also increased recognition of other benefits, such as improving customer service and providing more personalized customer service. Furthermore, significant bottlenecks to e-commerce adoption as identified by firms in 2015, include firms' preference to retain their current business model, security concerns, and unreliable internet connection.

Using a probit regression model, this study explored the internal and external factors that may affect firms' e-commerce adoption. It finds that the internal factors primarily determine e-commerce adoption in the Philippines, particularly firm size, availability of computers, access to the internet, and firm use of ICT in other aspects of firm operations, which are all positively correlated to e-commerce adoption. Proxy indicators for external factors, such as growth of the industry in which the firm belongs and the market share of the firm (as a proxy for competition), have no statistically significant effects on e-commerce adoption. The results are essentially robust even after differentiating the firms according to their degree of e-commerce adoption.

5.2 Policy recommendations

The results of this study support five policy recommendations. First, bottlenecks caused by uncertainty and security concerns should be addressed by strengthening awareness in data security and supporting firms' capability to protect their e-commerce platform.

Second, government agencies need to support MSME's e-commerce adoption by specifically targeting support to them. The results of the probit regression show that firm size is positively correlated to e-commerce adoption, which means that having a larger firm is associated with a higher probability of adopting e-commerce. Conversely, this result implies that MSMEs may have difficulty adopting e-commerce. Reports indicate that the Department of Information and Communications Technology (DICT), together with DTI, are closely working together to support the adoption of e-commerce by MSMEs (Lim 2018). While the promotion of e-commerce is a strategic action plan identified by DTI to achieve the goal of making MSMEs, particularly to be:

> Ready and able to penetrate as well as expand and strengthen their role in domestic, regional, and global markets. Access to markets is the sustained ability of MSMEs to be competitive in selling their products and services to existing and new markets, under a climate of fair, free, and socially responsible and environment-friendly trade practice (MSMED 2018).

It is important to note that the promotion of e-commerce needs to be coupled with strategies that would address other bottlenecks, such as the preference to maintain a firm's current business model and the unreliability of internet connection.

Third, government agencies can assist firms in adopting ICT in their business operations. This recommendation is supported by the robust results across all models wherein a positive correlation between ICT use in the firm and e-commerce adoption was found. Firms familiar with the use of ICT in its operations (i.e., finance and accounting, human resource, supply chain and logistics, or R&D) would be ready to adopt e-commerce. One government intervention to improve e-commerce adoption would be to increase awareness and knowledge of the firm on applications of ICT in various functions of the firm. Another intervention that could be pursued by the government would be to provide seminars or lectures on the applications of ICT on finance and accounting, human resource, and supply and logistics. This finding provides another input to the strategic action plan of DTI to promote e-commerce to MSMEs. An initial step to promoting e-commerce would be to influence the firms to adopt ICT in its basic operations. This would address initial concerns of firms, particularly MSMEs, when they decide to adopt e-commerce. Another strategy would be to provide incentives to e-commerce adoption considering that this would require investment in computers and other hardware, and in a more reliable internet connection.

Fourth, government can help provide access to finance to firms intending to adopt e-commerce. Access to computers and having a reliable internet connection is foundational to e-commerce adoption. Thus, to promote participation in e-commerce, there is a need to ensure that firms have access to these private goods by providing them with access to financing, which can be used by firms to invest in physical capital needed to support their adoption of e-commerce.

Fifth, reducing the cost and improving the quality of internet services is necessary for establishments to adopt e-commerce, particularly for MSMEs. In July 2017, the Association of Southeast Asian Nations (ASEAN) adopted the Manila Call to Action for ASEAN MSMEs, which specifically identified the Philippines to "address the country's glaring lag in internet speed, quality and cost relative to the region, and establish a wide and secure e-payments system to facilitate wider e-commerce (MSMED 2018)." Thus, it is important that the Philippines hasten its effort to address, such a barrier to e-commerce participation.

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Annex

Annex 1 Distribution of e-commerce firms via internet by selected firm characteristics

	2013			2015		
	non-core ICT	core ICT	Total	non-core ICT	core ICT	Total
Total Observations, firms with e-commerce via internet	**4,865**	**473**	**5,338**	**4,843**	**513**	**5,356**
Firms with e-commerce via internet by legal organization (% to column total)						
Single proprietorship	11.7	11.0	11.6	10.9	3.3	10.2
Partnership	1.9	2.5	1.9	1.6	1.4	1.6
Government corporation	0.2	-	0.2	2.1	0.2	2.0
Stock corporation	82.3	85.2	82.5	83.7	92.2	84.5
Non-stock, non-profit corporation	1.3	1.1	1.3	0.8	1.9	0.9
Cooperative	2.7	0.2	2.5	0.7	1.0	0.7
Others	-	-	-	0.1	-	0.1
Firms with e-commerce via internet by economic organization (% to column total)						
Single establishment	64.6	78.4	65.8	60.5	76.4	62.1
Branch only	15.5	8.7	14.9	26.4	10.9	24.9
Establishment and main office	19.4	12.9	18.9	12.1	12.7	12.2
Main office only	0.5	-	0.4	0.9	-	0.8
Firms with e-commerce via internet by size (% to column total)						
Micro	0.3	27.1	2.7	0.2	21.8	2.2
Small	61.4	53.1	60.7	79.7	58.3	77.6
Medium	19.9	6.8	18.7	9.4	9.6	9.4
Large	18.4	13.1	18.0	10.8	10.3	10.8
Firms with e-commerce via internet by regional location (% to column total)						
I - Ilocos Region	3.7	1.5	3.5	0.7	1.4	0.7
II - Cagayan Valley	3.7	0.8	3.4	0.9	0.4	0.8
III - Central Luzon	12.5	7.2	12.1	10.5	3.5	9.8
IVA – Calabarzon	9.7	14.6	10.1	14.6	8.0	14.0
IVB – MIMAROPA	2.6	-	2.4	0.8	1.0	0.8
V - Bicol Region	3.2	1.7	3.1	4.6	1.2	4.3
VI - Western Visayas	4.5	3.0	4.4	3.1	1.8	3.0
VII - Central Visayas	7.5	5.5	7.3	5.5	8.4	5.8
VIII - Eastern Visayas	0.9	1.5	1.0	2.1	0.6	2.0
IX - Zamboanga Peninsula	1.6	0.6	1.5	1.8	1.4	1.8
X - Northern Mindanao	6.6	1.3	6.1	1.4	1.8	1.5
XI - Davao Region	7.8	2.1	7.3	5.8	2.7	5.5
XII – SOCCSKSARGEN	3.2	0.6	3.0	1.8	1.9	1.8
XIII – Caraga	2.7	0.8	2.5	0.4	1.0	0.4
XIV – ARMM	-	-	-	0.4	-	0.4
XV – CAR	3.3	1.5	3.2	0.4	1.4	0.5
XVI – NCR	26.5	57.3	29.3	42.3	63.2	44.3
XVII – NIR	n/a	n/a	n/a	2.9	0.6	2.7
Firms with e-commerce via internet by industry section (% to column total)						
Agriculture, Forestry, and Fishing	2.2	-	2.0	2.6	-	2.4
Mining and Quarrying	0.1	-	0.1	0.2	-	0.1
Manufacturing	34.5	16.5	32.9	21.5	3.7	19.8
Electricity, Gas, Steam, and Air-Conditioning Supply	-	-	-	0.5	-	0.5
Water Supply, Sewerage, Waste Management, and Remediation Activities	-	-	-	2.3	-	2.1
Construction	-	-	-	1.6	-	1.4
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	7.6	28.1	9.4	26.2	9.0	24.5
Transportation and Storage	5.6	-	5.1	1.1	-	1.0
Accommodation and Food Service Activities	29.2	-	26.7	28.5	-	25.8
Information and Communication	-	51.2	4.5	-	86.2	8.3
Financial and Insurance Activities	5.2	-	4.8	0.1	-	0.1
Real Estate Activities	1.9	-	1.7	0.6	-	0.5
Professional, Scientific, and Technical Services	5.1	-	4.7	2.4	-	2.2
Administrative and Support Service Activities	3.1	-	2.8	6.5	-	5.9
Education	1.0	-	0.9	-	-	-
Human Health and Social Work Activities	3.5	-	3.1	5.3	-	4.8
Arts, Entertainment, and Recreation	0.2	-	0.2	0.5	-	0.4
Other Service Activities	0.8	4.2	1.1	-	1.2	0.1

Source: Authors' estimates using the SICT 2013 and 2015

Annex 2 Operational definitions of e-commerce adoption, and internal and external factors

Variable	Name	Type	Definition	Remarks
ecommerce_firm2	E-commerce via internet	Binary	Firm is engaged in e-commerce via internet	
peer	No adoption	Categorical (0, 1, 2)	Firm has a website (SICT Section VII, A)	
	Early adoption		Firm has a website and/or answered "Yes" to any of the questions in (SICT Section VII, C.1-3)	
	Full adoption		Firm has a website and/or answered "Yes" to any of the questions in (SICT Section VII, C.1-11)	
market_share	Market share	Percentage	Firm's share of industry total output at the PSIC 2009 division level	Estimates computed using ASPBI microdata. GDP deflators based on World Bank data.
tot_outputgr	Total output growth	Percentage	Industry's output growth in constant 2010 prices at the PSIC 2009 division level	
output_gr	Output growth	Percentage	Firm's output growth in constant 2010 prices	
log_age	Firm age	Logarithm	Firm's age (ASPBI Item 3)	
owncpph	Filipino-owned firm	Binary	Firm capital participation is at least 60 percent Filipino-owned (ASPBI Item 6)	
log_te	Total employment	Logarithm	Firm's total employment (ASPBI Item 7.c)	
dummy_rnd	Research and development activity	Binary	Firm has incurred research and development expenses (ASPBI Item 13)	
dummy_2015	Year fixed effects	Binary	Firm reference year is 2015 (SICT reference year)	
dummy_manuf	Manufacturing Industry	Binary	Firm's main activity is PSIC 2009 Section C (SICT Section I, A.1)	
dummy_services	Services Industry	Binary	Firm's main activity is not PSIC Section A, B, or C (SICT Section I, A.1)	
log_totalcomputers	Total owned computers and other hardware	Logarithm	Firm's total owned computer hardware regardless of type (SICT Section II, A.1)	Frequency includes units under "Others"
mode5_dsl	Broadband internet connection of the firm	Binary	Firm has an existing DSL connection (SICT Section IV, A.2a)	
mode6_wireless		Binary	Firm has an existing wireless connection (SICT Section IV, A.2b)	
mode7_mobile		Binary	Firm has an existing cellular mobile broadband connection (SICT Section IV, A.2c)	
ict1_finance	ICT usage in the operations of the firm	Binary	Firm uses ICT for finance accounting and auditing (SICT Section V, A.3)	
ict2_hr		Binary	Firm uses ICT for human resources (SICT Section V, A.4)	
ict3_logistics		Binary	Firm uses ICT for supply chain and logistics (SICT Section V, A.8)	
ict4_research		Binary	Firm uses ICT for research and development (SICT Section V, A.12)	

Source: Authors' definitions based on the SICT and ASPBI