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Article

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An Integrated Perspective of TOE Framework and Innovation Diffusion in Broadband Mobile Applications Adoption by Enterprises

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This study aimed at exploring the critical factors for enterprises to adopt broadband mobile applications. The results are expected to guide enterprises to strengthen their competitiveness. Further, since the broadband mobile applications were integrated with many characteristics of information communication technologies, this study combined the Technology-Organization-Environment (TOE) framework and Diffusion of Innovation Theory in an effort to establish a comprehensive view and to increase the level of understanding. The Structural Equation Modeling and AMOS were applied for analysis; which discovered that the adoption of broadband mobile applications by enterprises is significantly affected by technological, organizational and environmental contexts. This paper also identified eleven critical factors from technological, organizational and environmental aspects, as well as two vital control variables. Based on the research outcome, this paper conducted an in-depth discussion and drew conclusions. Finally, the research implications were provided.

Keywords: Broadband mobile application, technology-organization-environment framework (TOE framework), diffusion of innovation theory, enterprise's adoption, critical factors

JEL: L96, O32

Global mobile broadband communication technology has been evolving into the fourth generation of wireless mobile tele-communications technology standards. With broadband mobile network, the development of innovative mobile applications will then be massively accelerated. Lubbe and Louw (2010) explained from the marketing perspective that the superior advantage of mobile communication and mobile commerce is that the suppliers can now access to the customers via mobile devices anytime anywhere. The rapid evolution of broadband mobile applications has led to a more advanced mobile commerce, which attracts new customers and brings significant revenue for mobile application service providers (Nikou and Mezei, 2013). The characteristics of mobile technology such as connectivity, agility, interactivity and location positioning can bring

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various advantages to enterprises, enhance the efficiency and effectiveness of enterprises, and improve enterprises' competitive advantage (Porter and Millar, 1985)

Barnes (2002) pointed out that the challenge for information based industries such as telecommunication, hardware and software, contents, entertainment and financial industry (Symonds, 1999) is the transformation from a traditional fixed network infrastructure based business model to a whole new mobile network business model. The smartphone, as well as the mobile application platforms (iOS and Android) will also bring significant changes to the value network of manufacturing and service industries (Suh and Kim, 2015).

Broadband mobile network service is widely implemented by telecommunication service providers from all over the world, and the technical characteristics of growing bandwidth have become a core subject in mobile applications development. Many of the past studies focus on the adoption of mobile commerce and mobile applications from the use of traditional 2G/3G/3.5G mobile network (High Speed Downlink Packet Access, HSDPA, and below), yet the researches on broadband mobile applications and enterprise-focused topics remain limited. Yang (2012) revealed that the high data transmission rate of the 4G broadband mobile network will drive more innovative forms of mobile applications, which may also influence user preferences and behavior (Kwak and Yoo, 2012), as such, the enterprises' adopting of broadband mobile application may be triggered and affected by different factors. In this case, this study is targeted at enterprises to analyze by integrating the TOE framework (i.e., Technology, Organization, and Environment framework) (Depietro, Wiarda and Fleischer, 1990; Tornatzky and Fleischer, 1990) and diffusion of innovations theory (Rogers, 1962) in order to further explore various key factors affecting the adoption of broadband mobile applications.

Results of this study attempt to serve as a reference for the continuous innovation and development of mobile applications for enterprises.

The rest of this paper is structured as follows. Literature review and the hypotheses were proposed in the next section. The section three presents the method and process of analysis as well as the results. In the fourth section a discussion based on the findings was mentioned. Then the conclusion in final section with implications, limitations and directions for future study were provided.

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LITERATURE REVIEW

Broadband Mobile Communication Technology

The technical standards guideline published by International Telecommunication Union (ITU) specifies that data transmission rate can reach up to

100 Mbps peak in high-speed mobility state and 1 Gbps in low mobility state, it can be called the fourth generation of wireless mobile tele-communications technology (IMT-Advanced). The Global mobile Suppliers Association (GSA) estimates that by Q2 2016 the global Long-Term Evolution (LTE) telecommunication subscriptions will reach 1.4 billion. 166 operators have deployed networks of LTE-Advanced or 4.5G/LTE-Advanced Pro in 76 countries including the United States, Europe, Australia and Japan (GSA, 2016). Moreover, the Next Generation Mobile Networks Alliance (NGMN) announced that the 5th generation mobile networks (5G) will become operational by 2020 (NGMN 5G White Paper, 2015), which can carry much more data in faster speed than ever, and support more innovative applications such as the Internet of Things (IoT).

Kwak and Yoo (2012) considered that 4G broadband mobile network can not only solve 3G system deficiencies, but also offers other services 3G doesn't offer such as high quality voice transmission, high-definition audio and video broadcasting, and identified five key services attributes of 4G: high-speed data transmission, communication service, channels, on-demand video and other additional services. Jung and Kwon (2015) further found that 3G service users are more concerned about the call quality and customer service, whereas LTE service users are more interested in data transmission quality and price.

Mobile Applications

Shih and Shim (2002) affirmed that mobile commerce built upon the use of mobile applications by enterprises or in a business environment can stimulate transactions among businesses and improve productivity. As such, mobile application is deemed as one of the key driving forces for the development of mobile commerce. Further, different purposes of mobile applications can be developed diversely. Nysveen, Pedersen and Thorbjørnsen (2005) found from the earlier literature that it leads to different methods to distinguish features of mobile applications in view of different importance of characteristics, such as by interaction (Device vs Person) and by the process (Goal-oriented vs Experience-oriented). Nikou and Mezei (2013) have sorted out five categories of mobile services from the past literature and those are communication, entertainment, information, web 2.0, and transaction.

Unhelkar and Murugesan (2010) stated that many enterprises adopt mobile technologies to improve operational efficiency, increase responsiveness and competitiveness, and meet

customer needs, in consequence, mobile applications can provide new business opportunities for companies. While mobile applications incorporate a variety of information communication characteristics, there are also studies about individuals or businesses adopting mobile technologies, and which provide references for this study in exploring various possible factors affecting the adoption of the broadband mobile applications in enterprises. Some aforementioned studies are cloud computing (Almudarra and Qureshi, 2015), mobile innovation (Song, 2014), mobile payment services (Slade ***et al.***, 2015) etc. However, today's mobile applications are far more capable than merely providing voice communication and data transmission back in 2G or 3G era. In addition, mobile broadband network nowadays possesses much more powerful features than the mobile networks of the past, and this network advancement has led to a radical change in the mobile applications to become more integrated and innovated, and thus change the customer habits and business models, and become more conducive to business. Moreover, a significant cognitive gap of business managers generally occurs between the varieties of mobile applications in the latest broadband environment and limited speed of network and bandwidth in old days, as a consequence, it is necessary to conduct further research.

TOE Framework

Technology-Organization-Environment Framework (TOE framework) (DePietro ***et al.***, 1990; Tornatzky and Fleischer, 1990) is an application level framework for research from the organization-level perspective (Piaralal, ***et al.***, 2015). TOE framework proposes three main facets to explore the factors that affect the organization's acceptance of innovation technology. The technological context includes the characteristics and the usefulness of the innovative technology; the organization context contains the internal issues within the company such as management, employee, products and services; and the environmental context involves the issues exist in the business related field, such as the competitors and business partners.

Zhu, Kraemer and Xu (2006a) indicated that the TOE framework has proven to be fairly effective from the past research. A lot of studies about innovation technologies have been done by adopting the TOE research method, including information systems (DePietro ***et al.***, 1990), e-commerce (Rowe, Truex and Huynh, 2012), web service (Lippert and Govindarajulu, 2015), e-CRM (Racherla and Hu,

2008), and cloud computing (Lian, Yen and Wang 2014).

From the above literature, it can be well informed that the TOE framework is widely used on the adoption of different innovative technologies and proven to be validated (Ramdani and Kawalek, 2007). Given that the theme of this study is in regard to the application of innovative technology and from the enterprises perspective, the TOE framework is adopted as the main research model in this research.

Diffusion of Innovations Theory

The concept of diffusion of innovation has long been proposed by scholars. It was widely used in agriculture, medicine, communication, marketing and other fields (Greenhalgh ***et al***., 2005). Rogers (1962) on the other hand, summarized the studies in the fields of anthropology, education, industry, medicine etc., and proposed the diffusion theory of innovation. Rogers elaborated that innovation is "any idea, practice, or object that is perceived as new by an individual or another unit of adoption". Diffusion means "the process by which an innovation is communicated through certain channels over time among the members of a social system". In most studies, innovators are individuals, organizations, clusters, social networks, and even countries (Meyer, 2004).

Rogers (1995) also pointed out that innovation will go through five stages of the adoption process: Knowledge, Persuasion, Decision, Implementation, and Confirmation. In the persuasion stage, the potential adopter will be more involved as compared to the knowledge stage and begin to actively seek out relevant information. Individuals or decision-making units will generate a positive or negative attitude towards an innovation; an innovative perception will also develop, so the perceived characteristics of innovation are particularly important in the persuasion stage. Hence, five perceptual characteristics of innovation i.e. relative advantage, compatibility, complexity, trialability, and observability were identified by Rogers and help to assess the adoption rate. (Rogers, 1995; Bensley and Brookins-Fisher, 2003)

As with the TOE framework, diffusion of innovations theory has also been widely used in recent years in the field of information technology application research, such as web site adoption (Beatty, Shim and Jones, 2001), ERP systems implementation (Bradford and Florin, 2003), mobile banking (Al-Jabri and Sohail, 2012) and e-commerce adoption by small and medium

enterprises (SMEs) (Hussin and Noor 2005; Limthongchai and Speece, 2003; Kendall ***et al.***, 2001)

Integrating DOI and TOE

There have been numbers of literature in the past exploring the use of innovative technologies that combine the TOE framework with the diffusion of innovation theory to better explain the diffusion of innovation from the organizational perspective (Hsu, Kraemer and Dunkle, 2006), and better focus on the impact of both internal and external factors of innovation technology adoption and diffusion (Zhu ***et al.***, 2006a; Tornatzky and Fleischer, 1990), the relevant factors are also validated effectively. As reported by Piaralal ***et al.*** (2015), innovation diffusion theory combined with TOE framework provides a useful theoretical framework for small and medium-sized logistics enterprises to adopt green technology and explore the use of innovation technology by the overall consideration of internal and external factors. Wang, Wang and Yang (2010) combined the important factors of both theories to explore the key factors influencing the adoption of Radio Frequency Identification (RFID) in the manufacturing sector. Ramdani, Kawalek and Lorenzo (2009) combined the TOE framework and diffusion of innovation theory to explore the factors of adoption of enterprise system. In addition, Alshamaila, Papagiannidis and Li (2013) combined both theories to identify the influence factors in the adopting of the cloud computing by SMEs. Oliveira, Thomas and Espadanal (2014) also explored the key factors of cloud computing adoption in service industry and manufacturing by using the TOE framework in combination with innovation diffusion theory.

As Thong (1999) suggested that due to the rapid evolution of information technology and its characteristic, whether a single theoretical model can be applied to all the subjects is still arguable. Oliveira and Martins (2011) also indicated that it would be important to combine more than one theoretical model in future studies in order to have a better understanding of the adoption of complicated innovation technologies. Hence, this study integrates the innovation diffusion theory with the TOE framework and proposes an integrated research model.

Innovation Technology Adoption Stage

Organizational innovation usually has different stages of processes (Grover and Goslar, 1993). As noted earlier, Rogers (1995) pointed out that innovation experiences five stages: knowledge, persuasion, decision, implementation and

confirmation. Grover and Goslar (1993) also divide organizational innovation into three stages: initiation, adoption and implementation. Furthermore, Zhu ***et al***. (2006a) identified three important stages of initiation, adoption and routinization from the point of view of the adoption of e-business. The “Initiation” stage begins with the perception and assessment of an innovation, to measure the performance improvement and potential benefits of an enterprise's value chain activities. In the “Adoption” stage, decisions are made to formally allocate resources needed to fully deploy the innovation. Then, in the “Routinization” stage, the innovation must be accepted by members of the enterprise; which can be widely used and deployed

Considering that the characteristics of broadband mobile applications which may involve the personal mobile devices and user habits of all members of the enterprise, as well as customers and suppliers; therefore, it is very crucial in the adoption and implementation stage rather than in the initiation stage. As a result, this study divides the process of adoption into three stages: Initiation, Adoption and Implementation, in order to have a full spectrum of facets and factors through the model structure analysis. In addition, this study measured the three enterprises’ adoption stages with nine gradual questions in the questionnaire, e.g., “I wish the company could adopt the broadband mobile applications”, “My company has just adopted the broadband mobile applications”, and “We would recommend our clients or suppliers to adopt the broadband mobile applications”.

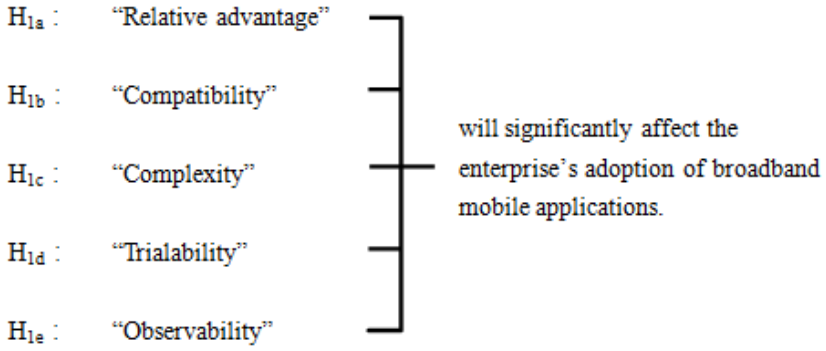
Hypotheses and Research Model

Given the diversified characteristics of information and communication technology that broadband mobile applications possessed, which have been widely discussed in varieties of literature; also the determinant factors of technological, organizational and environmental context were tested, this study sourced from mentioned literature to explore the possible factors that may affect the adoption of broadband mobile applications accordingly. The theoretical basis for each factor is provided as follows.

-The Technology Context

Alshamaila ***et al***. (2013) in the study on SMEs’ adoption of cloud computing combined the TOE framework with diffusion of innovation theory, which adopted the five perceptual characteristics from Rogers’ innovation diffusion theory. Ramdani ***et al***. (2009) integrated the innovation diffusion theory as a theoretical basis of technological factors for exploring the impact on SMEs’ adoption of

Enterprise system. As such, this study integrated the five perceptual characteristics of innovation in the persuasion stage of innovation diffusion theory as factors in the technological context, and also referred the previous research of related innovation technology topics. Zhu ***et al***. (2006b) found that compatibility is the most important factor influencing the post-adoption in European enterprises' adoption of digital transformation. The research results of Wang ***et al***. (2010) showed that due to the ongoing development of RFID, there is no common standard



developed yet, and there are still issues in system integration with the company's existing internal information system, so the complexity and compatibility for the manufacturing industry adopting RFID have respectively significant negative and positive impacts. Low, Chen and Wu (2011) identified that the relative advantages and complexity on cloud computing are inversely related to enterprises adoption. Sin Tan ***et al***. (2009) found that relative advantage, compatibility, complexity and observability in the technology context are the main factors influencing the SMEs' adoption of ICT in Malaysia. Alshamaila ***et al***. (2013) in the study of SMEs' adoption of cloud computing found factors in the technology context which have significant impact, including relative advantage, compatibility, and complexity, as well as the trialability which contributes to reduce uncertainties in adoption. To sum up, this study proposed the five factors of innovative diffusion theory with the following hypotheses:

-The Organization Context

Low ***et al***. (2011) in the research of cloud computing found that the support of high-level executives in the organization is a significant factor influencing enterprises' adoption. Lin (2014) in their research about electronic supply chain management system adoption stated that since the user is encouraged to participate and to solve problems between trading partners, and also the enterprises need to quickly strengthen the systematic knowledge in order to

enhance the awareness and reduce the resistance, the management support and absorptive capacity, as well as the competitive pressures in the environment context are significant factors in both "Likelihood of e-SCM Adoption" and "Extent of e-SCM adoption" stages. Hollenstein (2004) argued that the knowledge capital generated through learning and experience will bring the advantage in applying new technology to enterprises, so absorptive capacity is one of the most important factors in adopting innovative technology. In addition, Thong (1999) revealed that the information intensity of company's products and services has a significant impact on the adoption of information technology by small businesses. Al-Qirim (2008) also indicated that the information intensity of products and services is a significant factor influencing the adoption of e-commerce websites by small businesses. Moreover, Mirchandani and Motwani (2001) found that one of the major problems faced by enterprises was the lacking of knowledge in information system by the employees, so employees' knowledge was also a significant factor influencing the adoption of e-commerce by small businesses. Considering the characteristics of innovative technology, this study propose the following hypotheses based on the four factors discussed above:

H_{2a} : "Information Intensity"

H_{2b} : "Management Support"

H_{2c} : "Employees' knowledge"

H_{2d} : "Absorptive Capability"

will significantly affect the enterprise's adoption of broadband mobile applications.

-The Environment Context

There are results from the past studies shown that competitive pressures are a significant factor influencing the adoption of information technologies by enterprises (e.g., Ghobakhloo, Arias-Aranda and Benitez-Amado, 2011). Li (2008) found that both competitive pressures and external support were significant factors of the use of e-procurement in manufacturing. Teo, Lin and Lai (2009) found that trading partners will also significantly affect the adoption of e-procurement. Similarly, Stockdale and Standing (2006) found that key trading partner is an important factor influencing the adoption of e-commerce by SMEs. Besides, the government's attitude is also considered to be one of the important factors influencing the adoption of innovative

technology. Dahnil ***et al***. (2014) pointed out that government attitudes, policies and initiatives are important factors influencing the adoption of innovative technology by SMEs. Lee ***et al***. (2014) considered government support as one of the conditions to promote the adoption of cloud computing among the enterprise. In this study, we incorporated the above mentioned important factors into the following hypotheses:

H_{3a} : "Competitive Pressure"

H_{3b} : "Business Partner"

H_{3c} : "External Supports"

H_{3d} : "Government Supports"

will significantly affect the enterprise's adoption of broadband mobile applications.

-Control Variables

Different types business of enterprises for the application of an innovative technology will take a different attitude; Hsu ***et al***. (2006) found that for US firms, the manufacturers compare the distribution and financial industries tend to be more willing to adopt e-business. However, Teo ***et al***. (2009) conducted a study in adopting e-procurement by 141 firms in Singapore and the industry type was used as the control variable, the results showed no significant difference. Moreover, this different attitude may also occur in organizations of different sizes, such as Ifinedo (2011) in the study of internet/e-business technologies for Canadian SMEs using company size and industry sector as control variables. Siamagka ***et al***. (2015) also used the size as a control variable in the study of social media adoption by B2B organizations. Thus, the industry type (service/manufacturing) and company size are incorporated as control variables with reference to the above studies and were further examined in the three stages of adoption.

Sample and Questionnaire

Given that the broadband mobile applications possess the features of various applications, this study referred to the previous literature and developed the questionnaire. The factors definition and references are summarized in Table 1 (see Appendix-I).

The responses were tapped by the Likert 5-point scale. First of all, two Ph.D teachers reviewed and provided feedbacks on items or questionnaire, then the pre-questionnaires were given to 40 managers and employees (22 high-level and 18 mid-level) selected from the project database of the Ministry of

Economic Affairs. The respondents were asked to read the instruction before filling the questionnaire. A total number of 40 valid pre-questionnaires were collected, and the test results of reliability and validity were all found up to the standard. The semantic amendments have been made into four questions according to the feedbacks and suggestions. In the formal stage, the main databases were chosen from the project system of industrial promotion organizations in cooperation with economic department of government, such as the National Association of Small and Medium Enterprises and Corporate Synergy Development Center, by following random sampling. The respondents hold mid-level or above positions in their organizations. 411 questionnaires were distributed in both hard copy and via email, which obtained a valid response rate of 73.72 percent and has reached to the acceptable level (Rigdon, 2005). The statistical data are shown below in Table 2; and the sample characteristics are shown in Table 3

	Distributed	Return	Invalid	Valid	Valid Percentage
Via Email	135	101	8	93	68.89%
Hard Copy	276	231	21	210	76.09%
Total	411	332	29	303	73.72%

Table 2: Questionnaire Distribution and Returns

-The Analysis of Measurement Model

In this study, the structural equation modeling (SEM) was used to analyze the data. Based on Hair ***et al.*** (1998), the two-stage analysis was proceeded. First, all variables were tested in the measurement model, the cronbach's α of technological, organizational and environmental context and adoption were .89, .89, .93 and .87 respectively, which showed that the questionnaire had good reliability. Secondly, the confirmatory factor analysis (CFA) was used to test the convergent validity and discriminant validity of each facet and to validate the appropriate model for structural model analysis (Pijperset ***et al.***, 2001). The model fit, factor loading and convergent validity of each facet were individually examined. According to Bagozzi and Yi (1988), two factors' loading showed offending estimate (i.e., complexity did not reach .50 and government supports showed over .95) which then been removed. Then the combined reliability after the test was above .70, the average variance extracted (AVE) ranged from .55 to .80, which were in accordance with the standard proposed by Bagozzi and Yi (1988) - the combined reliability should be above .60, and the AVE should be above .50. Further, the validities were in accordance with the requirement value of .50 as proposed by Fornell and Larcker (1981). Thus, the results indicated that

	Subject	Valid Samples	Percentage	Cumulative Percentage
Number of Employees	Under 4	33	10.89	10.89
	5~19	77	25.41	36.30
	20~49	64	21.12	57.42
	50~99	32	10.56	67.98
	100~200	44	14.52	82.50
	Over 200	53	17.49	100
Industry Type	Services	228	75.25	75.25
	Manufacturing	75	24.75	100
Company Age	Under 1 year	13	4.29	4.29
	1~3 years	24	7.92	12.21
	3~7 years	59	19.47	31.68
	7~10 years	45	14.85	46.53
	10~13 years	28	9.24	55.78
	Over 13 years	134	44.22	100
Position Level	Mid-Level	136	44.89	44.89
	High-level	104	34.32	79.21
	CEO	26	8.58	87.79
	Board member	1	0.33	88.12
	other	36	11.88	100

Table 3: Sample Characteristics

the model has reached an acceptable level. Detailed are given in Table 4 (see Appendix-II). In summary, the proposed research architecture is shown below in Figure 1 (see Appendix-III).

-The Analysis of Structural Model

First, in the goodness of fit test, the overall model fit is shown in Table 5. The χ^2/df ratio was 1.88 which fitted the parsimonious fit value (less than 3) in reference to Hair ***et al***. (1998). Then Browne and Cudeck (1993) pointed out that the GFI should be greater than .80; and according to the study of Wu and Wang (2006), that the goodness of fit index can be in accordance with the recommendation of Hadjistavropoulos, Frombach and Asmundson

Indicator of Goodness-of-fit	Standard Value	Examination Result
RMR	<0.08 (Jöreskog and Sörbom 1993)	0.066
RMSEA	<0.08 (Hu and Bentler 1999)	0.054
TLI(NNFI)	>0.9 (Bentler and Bonett 1980)	0.918
CFI	>0.9 (Bentler and Bonett 1980)	0.924
NFI	>0.8 (Hadjistavropoulos et al. 1999, Hair et al. 1998)	0.852
GFI	>0.8 (Browne and Cudeck 1993)	0.825
AGFI	>0.8 (Hadjistavropoulos et al. 1999)	0.800
χ2/d.f.	<5 (Bentler and Bonett, 1980)	1.882

Table 5: Overall Fits of Models

(1999) and Hair ***et al***. (1998): AGFI> .80, NFI> .80. In this study, GFI was .82, AGFI was .80 and the NFI was .85 which reflected the good values. Besides, the RMSEA was .05, which was in accordance with the suggestion of Hu and Bentler (1999) that the value of RMSEA should be less than .08. It is concluded that the fit of the structural model data in this study was in a good range.

stages it showed insignificant results, only in the "Initiation" stage, the *t*-value showed 10.54 and the *p* value showed .001, which reached the significant level. Yet the homogeneity assumption was rejected after the homogeneity of variance test (Levene's test: 8.78, p = .001), the results were further compared by Brown and Forsythe (1974) and Welch (1951) test and showed that value in the group of

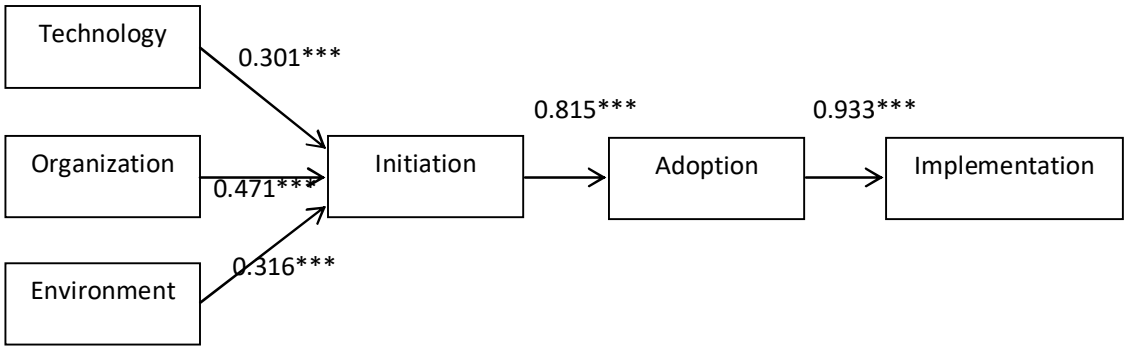


Figure 2: Results of Structural Modeling Analysis

The results of the verification of factors are shown in Table 6 (see Appendix-IV). A total number of 11 factors showed significant results.

-Control Variable Test

First of all, in the variable "company size" analysis, the ANOVA showed different results in various stages. In the "adoption" and "implementation" company size with more than 200 employees is significantly lower than in the groups which under 200 employees. It can be deduced that the size of the company and the adoption of broadband mobile application have an inverse correlation.

Next, in the analysis of "industry type", the results of independent sample *t*-test indicated that the

	Sum of Squares	***df***	**Mean Square**	***f***	**Sig.**
Between Groups	40.251	5	8.025	10.545	.000
Within Groups	226.736	297	.763		
Total	266.987	302			

Table 7: ANOVA of Business Size

manufacturing and service industries showed different results at various stages. In the final "implementation" stage, there was no significant difference. Yet, in the "initiation" and "adoption" stages the results were significant, and the value of service industries group was higher than the manufacturing group after the comparison. The results of the three-stage analysis are shown in Tables 8 and 9 below.

	Levene' test		***t*-test for Equality of Means**				
	f	Sig.	*t*	*df*	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Initiation	.012	.914	-3.160	301	.002	-.38974	.12334
Adoption	1.928	.166	-2.084	301	.038	-.26746	.12832
Implementation	1.374	.242	-1.951	301	.052	-.21132	.10833

Table 8: Independent Sample t-test

	Industry	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Initiation	1	75	2.71	.88978	.10274
	2	228	3.1031	.93824	.06214
Adoption	1	75	2.6733	.85224	.09841
	2	228	2.9408	.99769	.06607

Table 9: Group Statistics

DISCUSSION

The Technology Context

In terms of technology context, the relative advantage and compatibility showed significant results in line with the research results of Premkumar and Roberts (1999) for enterprises adopting innovative information technologies and online data access, and Sin Tan ***et al.*** (2009) on the adoption of information technology, indicated that the broadband mobile applications possess a similar information communication technology characteristic. Zhu ***et al.*** (2006b) in the study of digital transformation for European companies also revealed that the e-business value chain activities, which rely on communication tools, are now shifted from paper/telephone/fax to digital form, and the priority of digital assets and information flow within the enterprise has gone up, thus the compatibility of communication has become a key driving force.

Further, trialability has reached to a significant level, as Ramdani ***et al***. (2009) in the study of the adoption of enterprise systems stated that getting a trial version before the adoption is important to the enterprise. The results of observability also showed a significant result and matched the researches of both Hussin and Noor (2005), and Limthongchai and Speece (2003) in adoption of e-commerce. In addition, this study also suggests that it's easy to observe the diversity and wide range of use of the mobile broadband application around the people, the observability of mobile broadband application has become more important.

The Organization Context

The four factors within the organizational context all showed significant results. First, the information intensity showed significant result in line with the study results of Al-Qirim (2008) on the adoption of e-commerce communications and applications technologies. Ghobakhloo ***et al***. (2011) suggested that companies will consider the technology relevant to their products and services, enterprises with high IT relevance are more likely to use e-commerce to improve competitiveness. Next, the significant result of top management support is consistent with previous studies such as cloud computing (Oliveira ***et al***., 2014; Borgman ***et al***., 2013), e-procurement (Teo ***et al***., 2009), Enterprise System (Ramdani and Kawalek, 2007), e-commerce (Stockdale and Standing, 2006), EDI (Premkumar and Roberts, 1999). This validates that the characteristics of broadband mobile technology are similar to the IT tools for data exchange used inside or between the enterprises. Oliveira ***et al***. (2014) claimed that top management in the enterprise can show their support for adoption of cloud computing by supporting money and resources. Employees' knowledge showed a significant result, which is compatible with the study results of Mirchandani and Motwani (2001), and Scupola (2009); the former research indicated that employee's knowledge was one of the most important factors in company's website adopting. Scupola (2009) also reported that employees' knowledge in both Australian and Danish companies is important factor for e-commerce adoption, especially in the case that Australian CEOs who have paid more attention to the e-commerce recommendations from employees. Absorptive capability reached to a significant result, which is consistent with the results of research by Lin (2014) in e-SCM (supply chain management), and Hollenstein (2004) in information communication technologies. As Park, Suh and Yang (2007) elaborated that the knowledge of ERP systems

includes multiple functional aspects (e.g., positivistic/anti-positivistic and constructive aspects), hence, the status of absorptive capacity is easy to perceive by employees and regarded as very crucial. This study believes that multi-functional features are also embodied in today's rapid developed broadband mobile applications.

The Environment Context

Business partner in the environment context showed a significant result. Li (2008) revealed in the research that pressure from suppliers or trading partners, like competitive pressures, drives companies to adopt e-procurement to gain and maintain competitive advantage. While competitive pressure also revealed a significant result in this context. Zhu ***et al***. (2006a) found that in some low ICT-intensity countries, the incentive to use e-business is not necessarily due to perceived competitive advantage, but to avoid lagging behind the technological curve, therefore, the competitive pressure is more apparent than in high ICT-intensity country. Ifinedo (2011) also claimed in the research of the Internet/e-business technologies in SMEs from Canada that SMEs are more likely to adopt innovative technologies in a high competitive region. At last, external support also produced a significant result. Ramdani and Kawalek (2007) in the research on the adoption of enterprise system commented that the external support can prove to be the most challenging factor for vendors. Similarly, Attewell (1992) also pointed out that external support can help SMEs to cross knowledge barriers.

Controls

The test of first control variable “company size” showed different results in the three stages of adoption, and reached to the significant level only in the initiation stage, wherein a reverse correlation appeared. That is, the smaller the enterprise size, the higher the willingness in adopting broadband mobile applications. This study suggests that although the large enterprises have a higher financial capability and more skilled employees, the traditional bureaucracy may be disadvantageous to initiate an innovative technology. In comparison, SMEs have higher flexibility and more willingness to try the innovative technology with relatively lower difficulty level. However, the company size was insignificant in both adoption and implementation stages, which explained that once the company has started the innovative process, the company sizes show no significant influences in the latter stage.

The test of the second control variable has different results from the first control variable. “Industry type” reached to the significant level in

both initiation and adoption stages and failed in the implementation stage. In addition, the result of the analysis revealed that the service sector had a higher adoption rate than the manufacturing sector. This study suggests that unlike the big IT system such as SCM or ERP, broadband mobile application is not so sophisticated, and does not need to require an information department or IT human resources in order to operate, or even no longer need a desktop or laptops to run the system, but through the more convenient individual mobile devices that allow each member of the enterprise to use it at any time and location. Hence, the service industry relies more on people's direct contact and communicate, easy access information and content delivery, has a higher possibility and intention of adopting broadband mobile applications in compare with manufacturing sector. Thereafter due to the approaching cognition, making the differences between these two sectors gradually eliminate in the implementation stage.

PRACTICAL IMPLICATIONS

This study discussed three aspects of the TOE framework, namely technological, organizational and environmental contexts having positive impact on the broadband mobile applications adoption. There are eleven factors explored, and the impact of the two control variables i.e. company size and industry type are also identified. All these results bring in several critical insights for both enterprises and broadband mobile applications providers. For the enterprise, the management team should make sure that the new application must be compatible with the existing system, then gets involved with the change, helps employees to absorb the information and builds up the knowledge assimilating structure within the enterprise. Continued supports from external actors along with the willingness and ability of the business supplier and buyer must also be taken into account in order to ensure successful and effective use. The results also showed that in attempts to enhance customer communication, as well as to reduce cost and increase profits, SMEs with higher flexibility are more willing to adopt broadband mobile applications; on the contrary, management level from large enterprises must have the mindset to change the attitude of acceptance in innovative mobile broadband applications, in order to help enterprises' sustainable development. Similarly, manufacturing companies must consider the advantages of broadband mobile applications, and invest more resources to keep up with rapidly changing of mobile trends and to ensure long-term competitiveness. Further, from the perspective of the

application providers, aside from good functional design, the trial version and platform optimization should be included in the product development and marketing stage, so as to be more attractive and accepted by the enterprise and the market. In addition, after-sales support and knowledge-sharing with the customers will increase the willingness to adopt the application, and ensure clients' successful operation afterwards.

Theoretical contributions

The continuous improvement of technical characteristics leads to more powerful mobile applications into the market, and remains a key element for sustainable development of enterprises and industries. Yet, there exists few studies focused on the topic from enterprise perspective, this study aims to propose a research framework and commence the empirical research, in an effort to establish a preliminary basis for related research and discussion subsequently. Then, this paper combined the TOE framework with diffusion of innovation theory, hoping to have a broader view and extensive insights in environmental and organizational aspects apart from technology diffusion perspective, and then to develop a reference model for the follow-up research. Finally, this study applied company size and industry type as control variables; as a result, it may also be useful for the follow-up study in exploring the possibility of different variables.

LIMITATIONS AND FURTHER DIRECTIONS

Because of the limitation of research scale, it was hard to incorporate all the variables presented in past literature of innovation technology. Nonetheless, this study has still tried to achieve unbiased results through data collection, comparisons, and selections from related papers as many as possible. Also, to keep on further in-depth researching into distinct enterprises via the field interviews to acquire an intensive perspective in the adoption of broadband mobile applications will be instructive. Finally, this research adopted the point of view of overall mobile applications in consideration of the understanding of the participants and enterprises, thus, for applications with specific characteristics such as voice, data, video or other interactive features, the researches can be continued hereafter considering customer's point of view and value in the future.

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Appendix-I

Context	Factors	Definition	References
Technology	Relative Advantage	An innovation is perceived as being better than the idea it supersedes (Rogers, 1995)	Ghobakhloo et al., 2011; Premkumar and Roberts, 1999; Kendall et al., 2001
	Compatibility	An innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 1995)。	Beatty et al., 2001; Lian et al., 2014
	Complexity	An innovation is perceived as relatively difficult to understand and use. (Rogers, 1995)。	Premkumar and Roberts, 1999; Al-Jabri and Sohail, 2012
	Trialability	An innovation may be experimented with on a limited basis. (Rogers, 1995)。	Kendall et al., 2001; Al-Jabri and Sohail, 2012
	Observability	The results of an innovation are visible to others. (Rogers, 1995)	Kendall et al., 2001; Al-Jabri and Sohail, 2012
Organization	Information Intensity	Information intensity of product or service measured by the currency of information, reliability of information and timeliness of information. (Thong, 1999)	Thong, 1999
	Top Management Support	Through business management, time and resources investment and effective execution, to resolve related issues. (Alshamaila et al., 2013)	Premkumar and Roberts, 1999; Lin, 2014; Lian et al., 2014
	Employees' knowledge	The level of innovative technology knowledge of the employee within the organization. (Thong, 1999)	Rowe et al., 2012
	Absorptive Capability	The organization can gain and apply relative knowledge both from external and internal, in order to creating a profitable opportunity (Lin, 2014)	Lin, 2014
Environment	Competitive pressure	The level of pressure from competitors within the same industry. (Alshamaila et al., 2013)	Premkumar and Roberts, 1999; Ghobakhloo et al., 2011
	Business Partner	Relationship with suppliers and customers. (Lin, 2014)	Ghobakhloo et al., 2011; Lin, 2014
	External Supports	Supports from technical service providers, training partners or relative associations. (Stockdale and Standing, 2006)	Premkumar and Roberts, 1999; Ghobakhloo et al., 2011
	Government Supports	Government policy, measures or incentives. (Dahnil et al., 2014)	Lian et al., 2014; Rowe et al., 2012; Li, 2008
Control Variables	Industry Type	Service sector/ Manufacturing sector	Oliveira and Martins, 2008
	Company Size	Total number of the Employee (Zhu et al., 2006a)	Lin, 2014

Table 1: Factor Definition and References

Appendix-II

Variables	Question Item	Loading	Factor Loading	CR Value	AVE
Relative Advantage	RA1	0.873	0.624	0.859	0.671
	RA2	0.806			
	RA3	0.775			
Compatibility	CP1	0.923	0.774	0.924	**0.803**
	CP2	0.940			
	CP3	0.821			
Complexity	CX1	0.804	0.405	0.718	**0.499**
	CX2	0.883			
	CX3	0.269			
Trialability	TR1	0.787	0.738	0.838	**0.634**
	TR2	0.749			
	TR3	0.850			
Observability	OB1	0.845	0.727	0.778	**0.642**
	OB2	0.919			
	OB3	0.663			
Information Intensity	II1	0.770	0.622	0.802	**0.575**
	II2	0.789			
	II3	0.714			
Top Management Support	TM1	0.859	0.868	0.887	**0.724**
	TM2	0.863			
	TM3	0.830			
Employees' knowledge	EK1	0.685	0.847	0.796	**0.569**
	EK2	0.862			
	EK3	0.703			
Absorptive Capability	AC1	0.821	0.925	0.786	**0.553**
	AC2	0.754			
	AC3	0.646			
Business Partner	BP1	0.724	0.912	0.823	**0.609**
	BP2	0.833			
	BP3	0.780			
External Supports	ES1	0.802	0.863	0.877	**0.704**
	ES2	0.869			
	ES3	0.844			
Competitive Pressure	CP1	0.866	0.915	0.785	**0.703**
	CP2	0.933			
	CP3	0.699			
Government Supports	GS1	0.709	0.972	0.758	**0.511**
	GS2	0.723			
	GS3	0.713			

Table 4: Measurement of Potential Variables of Loadings, CR Value and AVE

Appendix-III

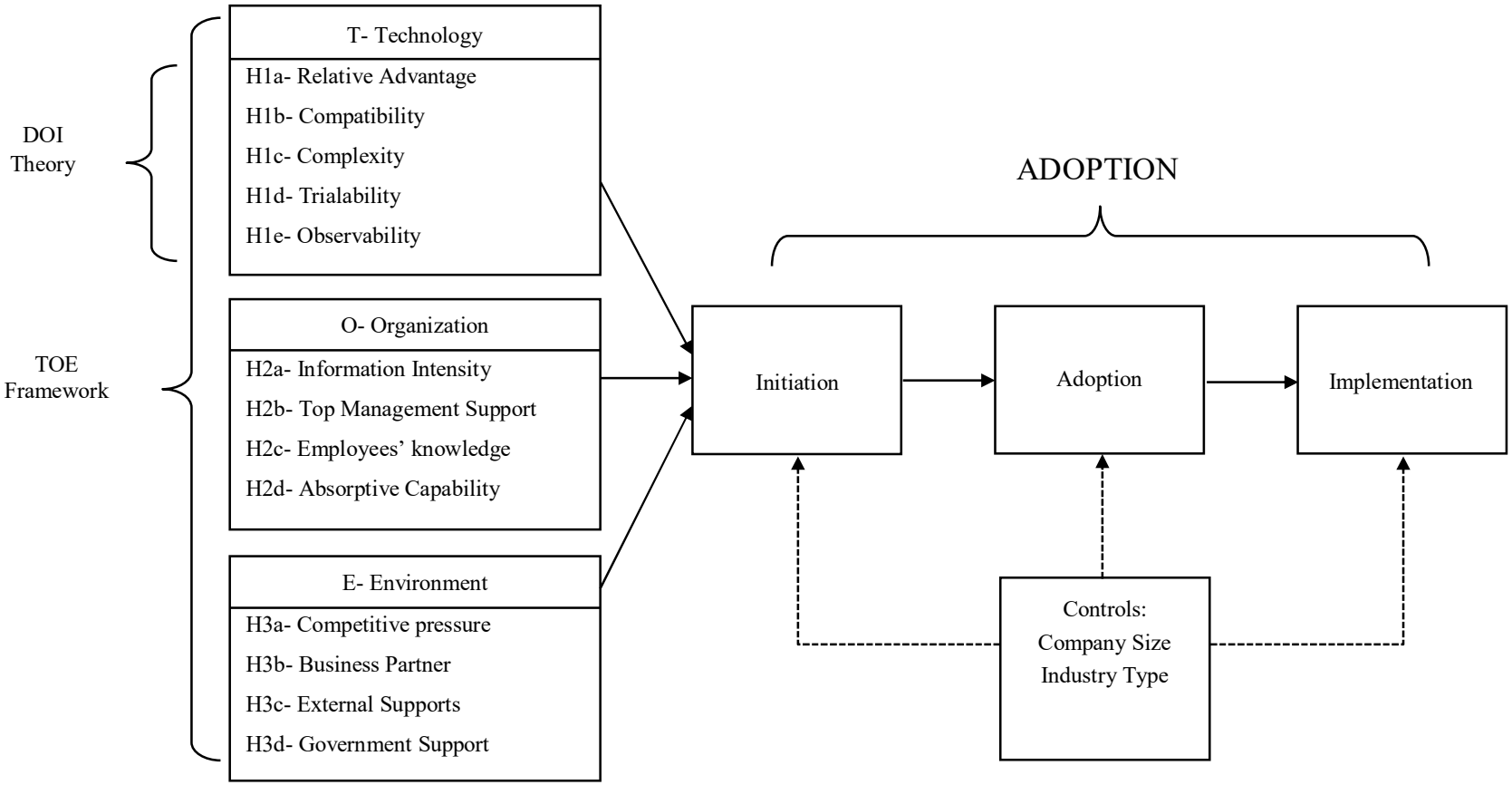

Figure 1: Research Model

Appendix-IV

				Estimate	S.E.	C.R.	P
H1a	Relative Advantage	<---	Technology	0.799	0.098	8.145	***
H1b	Compatibility	<---	Technology	1.223	0.133	9.191	***
H1d	Trialability	<---	Technology	1.095	0.131	8.38	***
H1e	Observability	<---	Technology	1.059	0.127	8.346	***
H2a	Information Intensity	<---	Organization	0.794	0.099	8.052	***
H2b	Top Management Support	<---	Organization	1.746	0.196	8.918	***
H2c	Employees' knowledge	<---	Organization	1.591	0.198	8.049	***
H2d	Absorptive Capability	<---	Organization	2.439	0.442	5.515	***
H3a	Business Partner	<---	Environment	2.215	0.349	6.347	***
H3b	External Supports	<---	Environment	1.708	0.195	8.752	***
H3c	Competitive pressure	<---	Environment	2.269	0.313	7.241	***

Table 6: Results of Regression Weights