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A Meta-analysis of IT Innovation Adoption Factors: The Moderating Effect of Product and Process Innovations

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Completed Research Paper

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Abstract

The aim of our research is to seek an explanation for contradicting results in innovation studies that use technological, organizational and environmental (TOE) factors to explain the adoption of Information Technology (IT) innovations. We do this by taking into account the type of innovation, specifically product and process innovation. We carried out a meta-analysis of 35 IT innovation adoption studies. The results show that five factors consistently affect the adoption decision for both product and process innovations, namely relative advantage, compatibility, top management support, organizational readiness, and competition. Two factors, namely organizational size and external pressure, showed significant effect for product innovations, but not for process innovations. Accordingly, we conclude that distinguishing product and process innovations can be useful in studying the influence of TOE factors in IT innovation adoption.

Keywords: IT innovation adoption, meta-analysis, TOE factors, innovation types, product innovation, process innovation

Introduction

Despite the many benefits Information Technology (IT) might have, organizations often face problems that prevent the adoption of IT innovations (Alshamaila et al., 2012; Jang, 2010). Over decades, various empirical innovation studies have been conducted to seek determinants and inhibitors of innovation adoption. An established innovation adoption framework that is often used in these studies is the Technology-Organization-Environment (TOE) framework (Tornatzky and Fleischer, 1990). The framework consists of three main elements; the technological, organizational, and environmental context. The technological context explains the characteristics of internal and external technologies related to an organization, both those that are already in use at the organization as well as technologies that are available in the marketplace but not currently in use (Rogers, 1983). The organizational context is related to the sources and the characteristics of the organization, while the environmental context refers to the surrounding elements in which an organization conducts its business (Tornatzky and Fleischer, 1990). Each of the contexts in turn is comprised of different factors that have been shown to influence the way an organization decides to adopt new innovations (Baker, 2012). Examples of these factors are relative advantage (Hung et al., 2010; Wang and Tsai, 2002), organizational readiness (Mangula et al., 2014; Alsomali et al., 2011), and competition (Gutierrez and Lumsden, 2014; Sila, 2013).

Although the TOE framework is an established and widely applied framework, the analysis results of the factors among the empirical innovation studies differ. For instance, Tan and Lin (2012) found that relative advantage is one of the predictors of Cloud Computing adoption in Singapore; while Yen et al. (2013) found that relative advantage has no significant influence to the adoption of Radio Frequency Identification (RFID) in Taiwan. Another example of inconsistency in analysis results was revealed in the two following studies: Gutierrez and Lumsden (2014) discovered that top management support has no relationship with the adoption of cloud computing in United Kingdom; while Al Somali et al. (2011) found that top management support is the determinant factor of Business-to-Business (B2B) eCommerce adoption in Saudi Arabia. These issues consequently led to the inconsistency in the results of innovation research.

One way to explain the inconsistent results is by looking at the different types of innovation. According to Damanpour (1987, p. 675), differentiation between types of innovation is "essential in developing realistic theories of organizational innovations". Three pairs of innovation types have been widely recognized in management studies, namely administrative and technical, product and process, and radical and incremental (Damanpour, 1991). The usefulness of the process and product type of innovations to explain the variances in IT innovation adoption level in organizations is demonstrated in several studies, e.g. Damanpour and Aravind (2006), and Damanpour and Gopalakrishnan (1998). To find out whether this may be an explanation of the inconsistent results that are reported in various innovation studies, we use this pair of innovation type as the moderator variable in our study.

In summary, considering the theories and findings aforementioned above, our main research question is as follows:

How does IT innovation type (product versus process) influence the relationship between the technological, organizational, and environmental factors and organizational IT innovation adoption?

The findings of a single study are generally not sufficient to build an overall conclusion on a certain subject, since they may have limitations and biases (Damanpour, 1991). One way to overcome this is to carry out a meta-analysis that combines a set of similar studies to integrate their findings (Hunter and Schmidt, 2000) and to estimate the accuracy of the relationship between two variables (Glass et al., 1981). To answer our research question, we perform a meta-analysis study that combines all the quantitative findings of the selected prior innovation studies to study the results consistency of the relationship between TOE factors and the adoption of IT innovations. Secondly, innovation type (IT product or IT process innovation), is used as a moderator to identify its influence on the relation between TOE factors and IT innovation adoption.

This paper contributes to the literature and on-going research of IT innovation adoption in three ways: (1) by summarizing and reviewing the TOE factors that influence the adoption of IT innovations in organizations, (2) by explaining the influence of IT product innovations and IT process innovations on the TOE factors, and (3) by offering directions for future research on IT innovation adoption in organizations. Researchers may use our study to more clearly understand why the adoption factors found in some studies showed inconsistencies with other studies. IT practitioners may use this study to get a good overview about how they may leverage the use of certain IT innovations in their own organization, as well as the practical challenges they might face when adopting them.

Theoretical Background

The field of innovation adoption is very broad. Innovation adoption has been studied extensively in IS literature, where the majority of the existing studies attempted to identify or examine a number of predicting variables that were assumed having an influence on an organization either to adopt or reject the innovation. Our study focuses on IT innovation adoption at the organizational level. In this context, IT innovation adoption generally refers to the adoption of new product/service technology or new process technology, which intends to maintain or improve organization performance and effectiveness as a response to changes in the organization's internal or external environment, or as an earlier action taken to influence an environment (Damanpour et al., 2009). The adoption of IT innovation contributes to improve productivity and quality as well as to facilitate inter-organizational collaboration and transactions (Lee and Xia, 2006).

Technology-Organization-Environment Factors of IT Innovation Adoption

Rogers' Diffusion of Innovation (DoI) theory (Rogers, 1983) has been a fundamental theory for many studies on IT innovation adoption and diffusion at an individual-level or organizational-level (Tan et al., 2008). Rogers argued that there are four main elements in the diffusion of innovations including innovation characteristics, communication channel, time, and social system. The five innovation characteristics are relative advantage, compatibility, complexity, trialability, and observability, which many studies confirmed as the factors of IT innovation adoption in organizations (e.g., Alshamaila et al., 2012; Tan et al., 2008; Limtongchai and Speece, 2003). In line with Rogers' DOI theory (Rogers, 1983), Tornatzky and Fleischer (1990) developed the technology-organization-environment (TOE) framework, which describes the internal and external characteristics of an organization, as well as the technological characteristics for explaining factors of IT innovation adoption at the organization level. It involves three primary contexts: the technological, organizational, and environmental (Baker, 2012). The technological context describes both the existing technologies in use and emerging technologies that are relevant for the organization (Tornatzky and Fleischer, 1990). Some factors involved in this context are relative advantage, compatibility, complexity, perceived costs, and security. The organizational context refers to the characteristics of an organization that supports the adoption of an innovation such as organizational size, top management support, organizational readiness, and information intensity. Finally, the environmental context relates to the external elements in which an organization conducts its business, such as competitive pressure, government policy, industry pressure, and environmental uncertainty.

Moderating Effect of Innovation Type

Past research has shown that differentiating between types of innovation is essential for understanding how organizations deal with the decision to adopt innovations and for identifying the drivers of innovation adoption (Downs and Mohr, 1976). This is caused by the different characteristics each innovation type has, which influences their adoption at the organizational level (Tornatzky and Fleischer, 1990). Among the various typologies of innovation known in IS and innovation literature, three pairs of innovation types have gained the most attention, namely administrative and technical, product and process, and radical and incremental (Damanpour, 1991). Among these three, product and process innovations have been extensively studied due to their ability to distinguish factors of innovation adoption (Edquist et al., 2001) where some factors may influence one type of innovation and not another. Furthermore, Cohen and Levin (1989) stated that the importance of a specific factor may differ across types. Hence, an understanding to factors that lead to the adoption of product and process innovations is useful to explain the contradicting results of innovation adoption studies.

Product Innovation

At the organizational level, product innovation is a product or service that is new to the market; hence, the newness of a product innovation is defined at a market level (Damanpour and Aravind, 2006). A product is a good or service offered to a customer (Edquist et al., 2001). As a concept, services provided by organizations in the service sector are similar to products introduced by organizations in the manufacturing sector (Miles, 2001). Product innovations focus on external entities of an organization, are primarily market driven, and result in product or service differentiation and/or an increase in product or service quality (Damanpour and Aravind, 2006). The drivers to adopt product innovations are usually either customer demand or the executives' desire to create or purchase new products or services for existing markets, or to find new market opportunities for selling their products or services (Meeus and Edquist, 2006). Thus, we define product innovation as the introduction of a product or service, either developed inside an organization or purchased or leased from a vendor, to meet external users' needs. In our study, we refer this innovation as an 'IT product innovation'.

Process Innovation

In contrast with product innovations, process innovations have an internal focus and are driven by the need to reduce delivery time, lower operational cost, and increase flexibility (Miles, 2001). Furthermore, process innovations function as a facilitator to the production and delivery of goods or services to customers. The newness of process innovation is defined at a micro level such as companies and business units (Damanpour and Aravind, 2006). Process innovations can be categorized into technological process innovations and administrative process innovations (Damanpour et al., 2009; Meeus and Edquist, 2006). Technological process innovations refer to new elements or technologies that are introduced into an organization's production system or service operation for producing and delivering products or services to its customers such as physical equipments, techniques, or systems (Damanpour and Gopalakrishnan, 1998); which consequently may change the way products are produced. Administrative process innovations are new approaches or practices to motivate and reward organizational members, devise strategies and structures of tasks and units, and modify the organization's management processes (Damanpour and Aravind, 2006). In our study, we used both categorizations to define process innovations. In the remainder of this paper, we refer to this type of innovation as 'IT process innovation'.

Research Methodology

Given the fact that a single study has insufficient capability to build a general conclusion on a certain subject due to its limitations and biases (Damanpour, 1991), prior scholars used a meta-analysis method to gather past empirical studies to seek explanation on the variances that regularly occurred among the findings of the empirical studies of innovation. A meta-analysis measures the effect size between independent and dependent variables of several studies and then combines all the effect sizes to determine the strength and direction of associations between two variables (Hameed and Counsell, 2012). Many measures of effect size have been proposed such as Pearson's correlation coefficient (r), Cohen's d and the odds ratio (OR) (Field and Gillet, 2010). Of these, due to its function as a measure of the strength of the relationship between two variables and its flexibility to convert various statistical values (i.e., p value, F ratio, or other values of different metrics such as Cohen's d) to the r value, we used Pearson correlation coefficient (r) to quantify an effect size.

In our study, a meta-analysis technique is performed (1) to estimate the consistency among the results of a set of empirical studies on IT innovation adoption, (2) to explore how IT product and process innovations affect the relationship between TOE factors, as the independent variables, and the adoption decision, as the dependent variable, and (3) to identify the strength and direction of each relationship.

Data Collection and Coding

A series of steps were carried out in our meta-analysis study. As an initial step, we performed an extensive literature review using Google Scholar with the keywords "IT innovation adoption" and "TOE framework". In addition, the reference sections of the selected articles were also examined for further review. We selected articles based on the following criteria:

- the study includes IT innovation adoption or intention to adopt as the dependent variable;

- the study is carried out at the organizational level;
- the study measures two or more TOE factors as the independent variables; and
- the study is supported by quantitative data and reported statistical values such as *r* (Pearson correlation), *F*, *t*, *Z*, *p,* means, and/or standard deviations.

In addition, we used the following rules:

- if several publications are based on one data set, only one publication is included; and
- if one publication discusses multiple correlations of a distinct combination of size and adoption variables, they are included and counted as multiple studies.

Consequently, 8 of 43 studies were excluded from our initial database; hence, 35 IT innovation adoption studies derived from 32 articles were selected, as described in table 1.

Our research samples cover the time period from 1995 to 2015, and are published in 28 journals and 7 conference proceedings that are widely recognized in the field of IS. Each sample is classified into two different groups based on the aim of the IT innovation adoption: studies that adopted IT innovation to increase organizations' competitiveness and customers' satisfaction are categorized as IT product innovation; while the group of IT process innovations consisted of studies that adopted IT innovation to increase efficiency and effectiveness of the processes inside organizations in facilitating the production and delivery of goods or services to the customers. Accordingly, there are 15 and 20 studies in the group of IT product innovation and IT process innovation respectively.

Independent Variables

Due to the large number of TOE factors known in IT innovation studies, we must carefully choose which of these factors will be studied in our meta-analysis as the independent variables. Hence, for the second step, we reviewed the selected papers and listed all factors that were studied in at least five innovation studies. This resulted in the selection of four technological factors, three organizational factors, and three environmental factors. Relative advantage (29 studies), compatibility (16 studies), observability (six studies), and trialability (five studies) were included as technological factors; organizational readiness (28 studies), top management support (18 studies), and organizational size (16 studies) belonged to organizational factors; and external pressure (19 studies), competition (18 studies), and external support (10 studies) are included as environmental factors. The following paragraphs provide brief definition of these variables.

Relative Advantage. The degree to which innovation is perceived by potential adopters as to provide greater benefits than the current practices (Rogers, 1983). Relative advantage has been found to be one of the best predictors and positively related to an innovation's rate of adoption (Borgman et al., 2013; Tan and Lin, 2012). Some scholars called this factor "perceived benefits" (e.g., Jang, 2010; Alam, 2009) or "perceived usefulness" (Pearson et al., 2008).

Compatibility. It refers to an innovation that is perceived consistent with existing values, current needs, and previous experience of potential adopters (Rogers, 1983). Compatibility has been confirmed as an essential factor for IT innovation adoption (e.g., Mangula et al., 2014; Gutierrez and Lumsden, 2013).

Trialability. According to Roger (1983), trialability refers to the degree to which an innovation may be experimented with on a limited basis. Several studies revealed that trialability is considered as one of the most important components in the process of adopting an innovation (e.g., Alshamaila et al., 2012; Ramdani and Kawalek, 2007).

Observability. It refers to the degree to which the results of an innovation are visible to others (Rogers, 1983). Previous studies have shown that observability was positively related to the adoption decision of IT innovation (e.g., Tan et al., 2012; Limthongchai and Speece, 2003). When there are visible examples of successful adopters, potential adopters also tend to adopt.

Top Management Supports. Support for adopting new innovations by top management ensures that there is commitment in resource allocation, which in turn creates an organizational climate conducive to the innovation (Yen et al., 2013). Many studies on IT innovation adoption confirmed that successful innovation adoption can be achieved through the support given from the top management (e.g., Yen et al., 2013; Al-Somali, 2011).

Organizational Size. It is often reported that large organizations tend to adopt more innovations, largely due to their greater flexibility and ability to take risk (Low et al., 2011). Meanwhile, Thong and

Yap (1995) found that small enterprises are less likely to adopt because of their limited capital and IT expertise. Therefore, organizational size is considered as one of the major determinants of IT innovation as confirmed by several prior studies such as Teo et al. (2009) and Pang and Jang (2008).

#	Author(s)	Article Type		Time Period		Innovation Type	
		JRN	PRC	1995-2000	2001-2015	PD	PR
1	Alam (2009)	√			√	√	
2	Alam et al. (2011)	√			√	√	
3	Alqahtani & Wamba (2012)		√		√		√
4	Al-Somali (2011)	√			√	√	
5	Borgman et al. (2013)		√		√		√
6	Gutierrez & Lumsden (2014)		√		√		√
7	He et al. (2008)	√			√	√	
8	Hung et al. (2010)	√			√		√
9	Huy and Filitrault (2006)		√		√	√	
10	Jang (2010)	√			√		√
11	Khemthong & Roberts (2006)	√			√	√	
12	Kuan & Chau (2001)	√			√		√
13	Limthongchai & Speece (2003)		√		√	√	
14	Looi (2005)	√			√	√	
15	Low et al. (2011)	√			√		√
16	Mangula et al. (2014)		√		√		√
17	Pan & Jang (2008)	√			√		√
18	Pearson & Grandon (2008)	√			√	√	
19	Premkumar & Roberts (1999)	√		√			√
20	Premkumar & Roberts (1999)	√		√			√
21	Premkumar & Roberts (1999)	√		√			√
22	Premkumar & Roberts (1999)	√		√			√
23	Ramdani et al. (2009)	√			√		√
24	Rizaimy et al. (2011)	√			√	√	
25	Seyal et al. (2004)	√			√	√	
26	Sila (2013)	√			√	√	
27	Tan & Lin (2012)		√		√		√
28	Tan et al. (2008)	√			√	√	
29	Teo et al. (2009)	√			√	√	
30	Thong (1999)	√		√			√
31	Thong & Yap (1995)	√		√			√
32	Wang & Tsai (2002)	√			√	√	
33	Wu & Subramaniam (2011)	√			√		√
34	Yen et al. (2013)	√			√		√
35	Zailani et al. (2009)	√			√		√
Total		28	7	6	29	15	20
Journal (JRN), Conference proceedings (PRC), Product Innovation (PD), Process Innovation (PR)							

Table 1. Distribution of Studies Included in Meta-analysis Procedure

Organizational Readiness. Organizational readiness consists of three organizational resources namely financial, IT expertise, and technology. It is believed that lack of these resources will prevent organizations to adopt IT innovations (Ramdani et al., 2009). The following terms points out to the organizational readiness: "technical competency" (Alqahtani and Wamba, 2011), network reliability (Sila, 2013), "technology readiness" (Low et al., 2011), and "IS capability (Hung et al., 2010).

Competition. Competition may drive organizations to initiate and adopt innovations to maintain their competitive edge (Premkumar and Roberts, 1999). Previous scholars found that intense competition motivates the adoption of innovation (e.g., Gutierrez and Lumsden, 2014; Pearson and Grandon, 2008). In some studies, this factor was called by the terms of "competitive pressure" (Pang and Jang, 2008), and "competition intensity" (Huy and Filiatrault, 2006).

External Pressure. External pressure is considered as the degree of direct or indirect pressure perceived by an organization from its suppliers, customers, competitors or government to adopt a specific innovation (Oliveira and Martin, 2011)."Industry pressure" (Yen et al., 2013), "trading partners pressure" (Low et al., 2011), "customer power" (Khemthong and Roberts, 2006), and government pressure (Kuang and Chau, 2001) are several names that represent the external pressure.

External Support. It refers to the availability of support for adopting IT innovations given by a government and a third party company or a vendor. Some studies used the terms of "regulatory policy" (Pang and Jang, 2008), "government policy" (Yen et al., 2013), and "regulatory environment" (Al-Somali et al., 2011) to call this factor.

In our study, we expect that all factors are positively related to IT innovation adoption.

Meta-analysis Procedure

We used a random-effect model to conceptualise our meta-analysis, instead of a fixed-effect model. This choice is based on the assumption that the samples in the individual studies are taken from a population with varying effect sizes. Hedges (1992) argues that populations in meta-analysis studies have different average effect sizes which can be assumed as super population samples. We adopted the method of Hedges and Olkin (1985) that was cited from Field (2001) to calculate the mean effect size; the one of the three popular meta-analysis methods in behaviour and social sciences other than the Rosenthal and Rubin (1982) and Hunter and Schmidt (2000) methods. In general, they provide similar results (Field, 2001). Further, another reason to use this model is because it allows us to generalize our findings beyond the studies employed in our meta-analysis or to build unconditional inferences (Hedges and Vevea, 1998).

To start our meta-analysis procedure, we initially determined the effect sizes of all the observed samples with Pearson's correlation coefficient "r". However, since several articles provide no information about the r values, or report the effect sizes in different metrics, we use an equivalent formula to derive the r values from t, Z, F and *p-values* (Rosenthal, 1991). Further, when only the means and standard deviations are available, we used Cohen's d measure to obtain the d value and convert it to r (Glass et al., 1981; Rosenthal, 1991). For our statistical calculations, we used Excel with the formulas suggested by Rosenthal (1991), Hedges and Olkin (1985), and Ellis (2010). Once the effect sizes were obtained, we then converted them into a standard normal metric (Zr) using Fisher's r-to-z transformation (Fisher, 1921) to normalize their distributions and accurately stabilize the variance of correlation coefficients (Hameed and Counsell, 2012).

Secondly, we estimated the random-effects weighted averages of the effect sizes using a variance component that incorporates both between-study variance and within-study variance to form new weights (Hedges and Olkin, 1985). The values of the between-study variance are based on a constant (subtraction of the total weights and the quotient of the total weights squared and the total weights), number of correlations (k), and Q (homogeneity) that were performed on a fixed-effect model. The estimation of between-study variance is set to zero if it yields a negative value or if the Q statistics are homogeneous. The weighted average effect sizes were then transformed back to the r metric.

Thirdly, we utilized the 95% confidence interval to estimate the significance of the population effects based on the weighted mean effect size and its standard error (Hedges & Olkin, 1985). If the confidence interval equals or is below zero, this means that there is no population effect between two variables. In contrast, when it falls between 0 and 1, we may conclude that the relations between two variables are statistically significant. The strength of the relationship can be referred as small (0 - 0.1), medium (+0.1 - 0.5), strong (+0.5 - 1.0) (Cohen, 1977).

Fourthly, we calculated the significance degree of the effect size heterogeneity using the probability value of heterogeneity from the distribution of the Q statistic with $k - 1$ degree of freedom, with k being the number of studies (Hedges and Olkin, 1985). The larger the p value of heterogeneity, the greater the variance of effect sizes accross studies ($p > 0.1$); which gives indication to the introduction of random-effect model for individual determinant factor.

In the last step, we conducted a t-approximation test by employing formula suggested by Wagner and Gooding (1987) to identify the effects of both IT product and IT process innovations in moderating the determinants – innovation adoption relationship.

Results

In total, there are 35 studies derived from 28 journals and 7 proceedings included in our meta-analysis. These studies were aggregated to seek confirmation on the relationship between determinant factors and IT innovation adoption. Ten TOE factors, as described in the previous section are used as independent variables. The dependent variable for the study is 'adoption of IT innovation'. Further, two types of IT innovation namely IT product innovation and IT process innovation were employed as the moderator variables, which are assumed to have an influence on the relationship between TOE factors and IT innovation adoption. Accordingly, 15 IT product innovations and 20 IT process innovations were identified. Generally, we carried out three rounds of meta-analysis in our study: (1) an overall analysis of IT innovations, (2) an analysis of IT product innovations, and (3) an analysis of IT process innovations. The following sections discuss each of them.

Overall Analysis of IT Innovation Studies

For each independent variable, as seen in table 2, we present the total sample size (N), number of correlations (k), mean correlation (Zr), 95% confidence interval (CI), test of homogeneity (Q), and the effect size heterogeneity measured by the probability value (*p-het* value**)**. As a whole, 24,238 samples and 165 correlations were involved to analyse a cumulative correlation of the TOE factors and IT adoption relationship. The studied sample sizes ranged from 1,100 to 4,701 respondents. The 95% confidence interval for mean correlations contained no zero and negative signs; hence they revealed a positive significant association between all factors and IT adoption. Furthermore, we noted that most factors have a medium effect on IT adoption, except for the trialability factor, which is considered weak ($Zr = 0.063$). To identify the effectiveness of both moderators in influencing the relationship between independent and dependent variables, we conducted a moderating effect test for each factor with regard to the p value of heterogeneity possessed by each variable. The results indicate that all variables have a p value of heterogeneity greater than 0.1 (ranging from 0.183 to 0.632); which suggests that the heterogeneity is insignificant and we can continue with the moderator analysis procedure.

Independent Variables	N	k	Z_r	95% CI		Q_{tot}	*p-het.* value
				Lower	Upper		
Relative Advantage	4,701	29	0.202	0.146	0.256	24.92	0.632
Compatibility	2,405	16	0.179	0.107	0.249	14.39	0.496
Trialability	1,100	5	0.063	0.003	0.122	5.92	0.206
Observability	1,143	6	0.159	0.102	0.216	4.15	0.528
Top Management Support	2,150	18	0.136	0.094	0.178	22.05	0.183
Organizational Readiness	4,278	28	0.211	0.143	0.278	29.85	0.320
Organizational Size	1,909	16	0.163	0.086	0.238	13.32	0.577
Competition	2,605	18	0.173	0.090	0.254	15.26	0.577
External Pressure	2,829	19	0.141	0.105	0.178	19.39	0.368
External Support	1,125	10	0.175	0.117	0.232	7.07	0.565
Total sample sizes: 24,238 - Total number of correlations: 165							
Sample Size (N), Number of Correlations (k), Mean Correlations (Zr), 95% Confidence Interval (CI), Test of Homogeneity (Q), and Probability Value of Heterogeneity (*p-het*. value)							

Table 2. Overall analysis of IT innovation studies

Analysis of IT Product and Process Innovation Studies

In order to further investigate the relationship consistency between two variables, types of IT innovation were distinguished into two different groups: IT product innovation and IT process innovation. These two innovation types are considered as moderator variables. Next, the same procedure that we applied to the overall correlations was executed on both subgroups to calculate their effects on the relationships between the different TOE factors and IT innovation adoption.

Independent Variables	**N**	***k***	**Z_r**	**95% CI**		**Q_{tot}**
				Lower	**Upper**	
Relative Advantage						
Product Innovations	2,600	13	0.281	0.190	0.354	11.13
Process Innovations	2,101	16	0.123	0.079	0.164	12.39
Compatibility						
Product Innovations	1,514	7	0.264	0.167	0.344	4.93
Process Innovations	891	9	0.096	0.029	0.161	10.97
Trialability						
Product Innovations	854	3	0.043	-0.025	0.110	1.89
Process Innovations	246	2	0.138	0.011	0.258	2.62
Observability						
Product Innovations	854	3	0.153	0.085	0.217	1.69
Process Innovations	289	3	0.155	0.037	0.265	2.40
Top Management Support						
Product Innovations	*770*	*4*	*0.211*	*0.138*	*0.275*	*4.20*
Process Innovations	1,361	14	0.092	0.038	0.145	10.74
Organizational Readiness						
Product Innovations	*2,028*	*10*	*0.333*	*0.194*	*0.437*	*11.85*
Process Innovations	2,505	20	0.127	0.088	0.166	16.18
Organizational Size						
Product Innovations	507	3	0.289	0.198	0.360	3.64
Process Innovations	1,402	13	0.132	0.046	0.215	10.09
Competition						
Product Innovations	1,066	5	0.279	0.066	0.455	4.31
Process Innovations	1,520	13	0.124	0.073	0.173	13.90
External Pressure						
Product Innovations	1,203	7	0.167	0.110	0.220	9.08
Process Innovations	1,626	12	0.122	0.073	0.170	8.86
External Support						
Product Innovations	806	5	0.223	0.152	0.284	0.84
Process Innovations	503	6	0.126	0.037	0.212	3.78
Product Innovation → Total sample size: 12,195 – Total correlations: 60 Process Innovation → Total sample size: 12,444 – Total correlations: 108						
Sample Size (N), Number of Correlation (*k*), Mean Correlation (*Zr*), 95% Confidence Interval (CI), Test of Homogeneity (*Q*), t' approximation (t' value)						

Table 3. Analysis of IT Product and Process Innovations

Table 3 shows that a total of 60 correlations have been extracted from 15 studies that are classified in the IT *product innovation* group. The overall mean correlations and confidence intervals exhibit that all factors, except for trialability, have a significant association to the adoption of IT (0.066 < 95% CI < 0.455) with a medium level of strength (0.153 < *Zr* <0.335). For trialability, we found that zero is included in the interval (-0.025 < CI < 0.110), which this indicates that this factor has a negative impact to IT innovation adoption with the mean correlation value approaching to zero (*Zr* = 0.046). For the *process innovation* group, we extracted 108 correlations from 20 studies. The analysis shows that the positive effects on IT adoption are significant for all factors (0.011< 95% CI <0.265). The overall mean correlations are greater than 0.1 (0.092< *Zr* <0.155), suggesting a moderate influence of all factors to IT innovation adoption.

Moderating Effect Analysis

Furthermore, to identify the effect of both moderator variables in distinguishing the relationship between determinant factors and IT innovation adoption, we conducted a *t*-approximation test by calculating the mean correlations, observed variances, and number of correlations (*k*). As pointed out in table 4, we found that relative advantage, compatibility, top management support, organizational readiness, organizational size, competition, and external support are positively significant having relationship with IT product innovations; while IT process innovations have effectively moderated the relationship between IT innovation adoption and the following factors: relative advantage, compatibility, top management support, organizational readiness, and competition. The significant level of these factors in motivating the adoption decision varies from $p < 0.5$ until $p < 0.05$. Accordingly, these findings indicate that both moderators are discovered to be effective in differentiating the determinants – IT innovation adoption relationship.

Independent Variables	***t'*-approximation Test (*t'* value)**	
	Overall Studies *vs* IT Product Innovations	**Overall Studies *vs* IT Process Innovations**
Relative Advantage	2.685***	4.151***
Compatibility	4.976***	5.053***
Trialability	NS	NS
Observability	NS	NS
Top Management Support	2.868***	15.112***
Organizational Readiness	2.341***	2.984***
Organizational Size	3.911***	NS
Competition	1.223**	1.616**
External Pressure	1,.043**	NS
External Support	NS	NS
*** $p < 0.05$ (one-tailed); ** $p < 0.1$ (one-tailed); NS: No Significant		

Table 4. Moderating Effect Analysis

Discussion

In this paper, we presented a meta-analysis of empirical findings from 35 innovation adoption studies to identify the major determinants of IT adoption. Through the use of the technology-organization-environment framework (TOE) as our fundamental innovation theory, 10 factors that cover technological characteristics (relative advantage, compatibility, trialability, and observability); organizational characteristics (top management support, organizational readiness, and organizational size); as well as environmental characteristics (competition, external pressure, and external support), have been selected and included as the independent variables. Moreover, a pair of IT innovation type, namely IT product and IT process innovation, were further analysed as moderator variables, to identify their effect on the relationship between determinants and IT adoption. After a series of correlation tests to all studies and both IT types, an approximate *t*-test was carried out to seek the influence of the moderators on the relationship between each factor and IT innovation adoption.

According to table 3 and 4, five factors consistently confirmed having a moderate significant effect to motivate the adoption decision of both IT innovation types. These five factors are relative advantage, compatibility, top management support, organizational readiness, and competition. Trialability, observability, and external support have constantly shown having no significant influence to the adoption of IT product and IT process innovations. For the remaining two factors, namely organizational size and external pressure, we found a significant impact to the adoption of IT product innovation, but no significant effect for IT process innovation adoption.

In line with our expectations, two attributes of technological context namely relative advantage and compatibility consistently revealed significant results derived from the overall correlation analysis, suggesting that both attributes are considered essential in motivating the adoption of an IT innovation. The *t*-approximate test results confirm the significance of these relationships. Organizations are more likely to adopt IT innovations, if they perceived new innovations as being better than the previously introduced innovations and if they are believed to be beneficial to the organizations. Moreover, organizations who believe that certain IT innovations correspond with their existing systems, present needs, or prior experiences are more inclined to adopt such innovations since it will decrease the uncertainty. Other determinants that regularly proved having significant impact on the decision-making process of IT adoption are the organizational factors top management support and organizational readiness. Contributions given by senior management are critical in the success of IT innovation adoption. They may use their power to convince the entire organization regarding the important of such innovations, to encourage them to actively participate in the adoption process, and to prepare necessary resources for the adoption of IT innovations. The readiness of organizations to adopt a particular IT innovation is closely related to the presence of three organizational resources include financial, employees' knowledge in areas relating to the intended innovation, and technology infrastructure. The lack of one of these resources is likely declining the intention to adopt such innovations. One of the environmental factor namely competition, also consistently yielded positive significant effects to promote the adoption of IT innovation on the overall test results. Competition may drive organizations to initiate and adopt innovations as to maintain their competitive edge, to keep their survival, as well as to compete in their market place.

Contrary to our expectations, the following three factors: trialability, observability, and external support, consistently produced no significant results according to the test of moderating effects; even though the last two factors constantly delivered positive results in the correlation analysis. Recalling the explanation of IT product and IT process innovations, the decision to adopt both IT innovation types are equally important, directly or indirectly, to the services that are provided for the existing customers. In a business world, intense competition is inevitable. In order to maintain their competitive edge, organizations must have the ability to take decisions fastly and accurately. Delay in the decision making, particularly a decision to adopt a new innovation, might result in a loss of the opportunity to gain benefits from their business. With regard to the definition of these three factors, the decision to adopt both IT innovation types are highly dependent on third parties such as support from the government, free trials offered by IT vendors, or the existence of organizations that have sucessfully adopted the IT innovation. Such dependency may certainly prolong the adoption decision-making process that consequently causes financial loss for the organizations. Accordingly, these factors are presumed having no significant effect to the adoption of both moderator variables.

For the remaining factors, organizational size and external pressure, we found a different influence on the adoption of both IT innovation types. Organizational size and external pressure found to be positive in affecting the adoption of IT product innovations; while IT process innovations have no significant relations with the two factors. In a simple explanation; IT product innovation is a type of innovation that has a direct involvement with the external users or existing customers of an organization. The decision to adopt IT product innovations must be carefully taken since failure in implementing the innovations will influence the organizations' performance and customers' satisfaction. To ensure that an IT product innovation is adopted successfully, it requires organizational readiness to provide all the necessary resources including infrastructure, finance, and IT expertise. Therefore, it is expected that organizational size is closely related to the adoption decision of product innovation because large-sized organizations are more ready in terms of organizational resources than small-sized organizations. In addition, large-sized organizations have greater flexibility and a stronger ability to take risk. The tight competition experienced in business has forced organizations to stay competitive and keep innovating to achieve customer satisfaction that consequently leads to customer loyalty. Meeting all the customers' "pressures" or needs is one of the ways to manage customer loyalty. It is suggested to not disregard the pressure received from external parties such as customers, suppliers, or the government. Accordingly, external pressure is found to be a significant trigger of IT product innovation adoption.

Conversely, as described in table 5, these two factors have no significant effect to the adoption of IT process innovations. As we have explained earlier, this type of innovation is driven by the needs of an organization to improve the internal process of an organization as to support the production unit and the services for the organization's customers. Therefore, the adoption of IT process innovation is not affected by external pressure. Reduced delivery time, lower operational cost, and increased flexibility are some advantages that are expected from adopting IT process innovation. From a business perspective, these benefits are required by organizations, either in small-sized or large-sized organizations. Hence, organizational size has no significant relation with IT process innovation adoption.

Limitations

Care should be taken into account in interpreting our results, particularly for trialability and observability factors. Lack of available correlations of these two factors on different groups of moderator might influence the effectiveness of moderators to validate the significance impacts of relationship between such factors and IT adoption. We assume that if there were more sample studies and correlations, the result could have been more accurate and better explained. However, these results can only be accepted temporarily and need to be explored in more depth.

In our study, we classified each innovation into two different groups based on the criteria we set by referring to the suggested common definition. However, in some prior meta-analysis studies involving IT product and IT process innovations, there were quite some differences on the placement scheme of innovations compared to ours. Hence, this might affect the correlation number of each factor in both groups.

Conclusion

Our study contributes to explain the inconsistency phenomena in empirical findings on IT innovation adoption studies. The results indicate that the utilization of innovation types as moderator variables, particularly IT product and IT process innovations, could effectively differentiate the determinants - IT innovation adoption relationship. Seven factors, specifically relative advantage, compatibility, top management support, organizational readiness, organizational size, and competition, are found to be the predictors of IT product innovations adoption; while five factors, namely relative advantage, compatibility, top management support, organizational readiness, and competition have regularly encouraged the adoption of IT process innovations. All of these factors have a positive moderate impact to both IT innovation types. Moreover, we suggest further investigation for the following factors: trialability, observability, and external support that are constantly found having no significant effect to IT innovation adoption of the two types of innovation. In sum, as our preliminary conclusion, we confirm that distinguishing IT product and IT process innovations as moderator variables are useful to test the consistency of determinant factors and IT adoption relationship and to estimate the strength and direction of such relationship.

Our study has implication for further research and general practice. For research activity, the uniformity in defining an attribute or a determinant factor as well as in classifying a certain innovation into two different groups of IT innovation type could be used as major issues on further research. The use of other innovation types such as radical and incremental innovations and the involvement of other determinant factors such as organizational culture and managers' characteristics may also be considered to gain a new perspective on subjects that might influence the relationship between determinants and IT adoption. We assumed that the employment of other innovation types would give different results compared to product and process innovations due to their different goals of utilization in organizations. Additionally, since we we need more samples and correlations, unpublished studies could be tested for Type I error publication bias and if it is possible, they could be included on the meta-analysis study to understand and explain the significance of relationship among two continuous variables. Finally, we encourage research collaboration with other scholars to replicate this study in order to obtain more comprehensive results. In terms of the implication for general practices, our findings also contribute as a reference for managers and practitioners to create a strategy in adopting IT product and process innovations and in anticipating the obstacles that might hinder the adoption of such IT innovation.

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