Respecifying DeLone and McLean Information Systems Success Model for Measuring ERP Post-implementation Success

Lemma Lessa*, Tigist Mekonnen**, Solomon Negash****

** Addis Ababa University, Assistant Professor of Information Systems, School of Information Science, Addis Ababa, Ethiopia, Corresponding author (Email: lemma.lessa@aau.edu.et)*

***Addis Ababa University, School of Information Science, Addis Ababa, Ethiopia, (Email: tigistmekonnenleo@gmail.com)*

**** Kennesaw State University, Professor of Information Systems, Department of Information Systems & Security, Kennesaw, USA (Email: snegash@kennesaw.edu)*

Abstract

The emergence of Enterprise Resource Planning (ERP) has guided organizations to focus on ensuring their competitive advantages by utilizing its capabilities. This study proposes a theoretical model for measuring ERP post-implementation success and presents empirical findings using a conceptual model derived from the Delone and Mclean Information Systems (IS) success model. Four of the model's dimensions were identified to measure ERP system post-implementation success namely: ERP system Quality, ERP Information Quality, ERP Service Quality, and ERP Post Implementation Benefits. The three quality dimensions of Delone and Mclean's model were used as independent variables to assess the effects on ERP post-implementation success. A total of 233 questionnaires were collected from ERP users at the Commercial Bank of Ethiopia and the data was analyzed using Partial Least Square-Structural Equation Modeling (PLS-SEM) techniques. Results show positive relationships between the model constructs, and the model explained 59.31% of the variance in ERP system post-implementation success.

Keywords

D & M IS Success Model, ERP System Quality, ERP Information Quality, ERP Service Quality, ERP Post-implementation Benefits

Background

In the pursuit of achieving strategic goals and ensuring competitive advantage, organizations are continuously investing on IT/IS. Organizations these days require such investments for various reasons ranging from achieving strategic goals, ease of conducting businesses and delivering services, enhancing individual and organizational performance (Leyh, 2010). Thus, since the late 90's, organizations have opted to the use of integrated IS solutions to achieve their goals (Mukti and Rawani, 2016). One such investment is adoption of Enterprise Resource Planning (ERP) solutions. ERP is an enterprise-wide, modularized information system used for the smooth integration of all the information flowing through an organization and its units (Rashid et al., 2020).

Organizations require ensuring whether ERP value is realized or not as ERP implementation failure is widely experienced. However, ERP post-implementation success and delivery of ERP value is one of the under-researched areas of IS success paradigm (Abu Gahzaleh et.al, 2019; Infinedo, 2015). Several measurement models have been proposed and studied to assess ERP systems at varying phases of its lifecycle, D&M IS success measurement model being the most cited of them all. The D&M IS success measurement model has been adopted to measure Enterprise Resource Planning (ERP) system implementation success by scholars of the domain area (Al-ghazali et al., 2015; Nasser and Zaied, 2012). The post-implementation phase of ERP systems is where organizations reap the benefits of the system and evaluate if the objectives set forth on the pre implementation phase are realized. At this stage, measures such long-term ROI, business process improvements, enhanced efficiencies of both individuals and workgroups and so on are studied. It is often perceived that ERP system success is linked to the successful implementation of the system but contrary to popular belief, post-implementation success is the true perception of success in organizations using ERP (Goyette et. al., 2015). This is due to the fact that the objectives set forth for adopting ERP systems are realized after the system is in use. Besides ensuring the smooth operation of ERP systems, this stage is where the benefits of ERP are in effect. Hence D&M model constructs such as User satisfaction and Use (Intention of Use) are not included since the authors justify that these dimensions are not relevant when the IS system under study is a mandatory organizational IS (Delone and Mclean, 2003). Thus, system quality, information quality, service quality and net benefits from D&M IS success measurement model were used for this study.

Statement of the Problem

Organizations allocate vast amount of time, money and resources in Information Systems (IS). The Ethiopian banking industry is no exception to high IS investments. These IS investments may or may not add value for an organization depending on their success or failure. The Delone and Mclean (D&M) IS success measurement model has been proven to validate such notion (Petter et al., 2008). There is a vast amount of literature on the usage of D&M IS success model for measuring success of different Information Systems initiatives.

The authors of the model acknowledge the boundaries of the framework are still unknown and some of the measurements and constructs of the model have been known to divulge inconclusive results as they have been altered and tested (Delone and Mclean, 2003). Most of the literature that exists around ERP success is centered on implementation success. There is still a big gap in the body of work regarding post-implementation of IS success, specifically ERP success measurements (Ghazaleh et al., 2019 and Lin et al. 2020). In addition, there is still room for empirical works that validate the re-specified D&M IS success measurement models.

Furthermore, there is little literary work on the topic of IS success measurement in the context of Ethiopian organizations.

A study that makes use of a comprehensive framework for measuring ERP post-implementation success is yet to be found in current Ethiopian literature. Although there is a great need for adopting such systems, ERP implementation failure is experienced by organizations including Ethiopian banks. Ensuring whether ERP value has been realized or not through the use of a comprehensive, theoretical model is lacking in the body of knowledge that exists on this problem domain. ERP post-implementation success and delivery of ERP value is one of the most under-researched areas of IS success paradigm (Infinedo, 2015). Furthermore, Despite the importance of post-implementation activities to support the success of an enterprise resource planning (ERP) system, there has been a lack of research into the factors that influence post-implementation success (Abu Gahzaleh et al., 2019). From past studies about ERP, most researchers pay more attention to before or during implementation, only a few studies have investigated the situation after ERP implementation (Lin et.al.,2020). One factor for this is the variety of IS systems that are measured and the context in which organizations are operating under. Some of these contexts include the type of service an organization provides, the role of IS in such organizations, and the cultural as well as national implications that govern and dictate the way businesses are conducted (Nasser and Zaied, 2012). As a result, the model has been altered to fit distinct IS systems and tested accordingly.

Adopting the D&M model for measuring Enterprise Resource Planning (ERP) system implementation success has been proposed by scholars of the domain area (Nasser and Zaied, 2012; Jing and Seon, 2013; Lee-post, 2007; Al-ghazali et al., 2015). Thus this research is an attempt to apply this popular model for measuring post-implementation ERP system success using a case study on Commercial Bank of Ethiopia.

The aim of this study is to determine post-implementation success factors and use the D&M IS success measurement model to find out the most significant factors that amount to ERP system post-implementation success. This research addresses the following two research questions: (i) What are the post-implementation factors affecting the success of ERP during the post-implementation phase? (ii) Which of these factors are most significant to ERP post-implementation success?

Literature Review

ERP System Post-implementation

To identify post-implementation factors, different theoretical approaches have been in place in extant literature. A popular approach is to make use of the project life cycle theory of an IS. Using this theory, four ERP implementation stages were formulated each corresponding to the pre, during and post-implementation of ERP system, namely: programming/preparation and training phase, executive/ transition phase, stabilization/performance and usefulness phase, and finally, ascending/maintenance phase. The first stage entails the selection of an ERP, assembly of a steering committee, determination of high-level project scope and broad implementation approach, selection of a project team manager and resource determination. The second phase has five sub-phases: set-up, re-engineering, design, configuration & testing and installation. It includes tasks to install system, start an implementation project, train the core group, special-subject discuss, medium term and final test. The third stage is where the old legacy systems are replaced by the new system. At this stage the data will be transformed, end-user will be trained, tasks for system repair, extension and transformation will be included until end users are proficient with the use of the new system. The final stage of the ERP system lifecycle is the stage where ERP implementation effect will be compared with the goal that is proposed in the programming sub-phase in order to inspect business process degree and put in place tasks of system upgrade. Thus, critical success factors are dependent on each cycle of the ERP system deployment (Leyh, 2010).

Several empirical studies have studied CSFs at each stage of ERP implementation and have found the most common ERP post-implementation CSFs are top management support, teamwork and composition, interdepartmental cooperation and communication, project champion or empowered decision-makers, vendor support, user involvement and training, business process re-organization, deliverable dates and smaller scope, and change management (Leyh, 2010). Similar to other information systems, determinants of ERP system success are closely related to success factors affecting the pre-implementation, implementation and post-implementation phases of ERP software lifecycle (Chung, Skibniewski, and Kwak, 2009).

IS Measurement Models

Numerous IS measurement models have graced the realm of IS success measurement for both academic and practical purposes. The 70's witnessed a growth in adoption of technology and prediction of its use, which resulted in a decade search of one of the original IS success measurement models: TAM (Technology Acceptance Model) developed by Davis (Chuttur, 2009). Davis used Fishbein and Ajzens' "Theory of Reasoned Action", which stated that an external stimulus causes an organism to respond. Davis stated that a system's features and capabilities are a stimulus that affect the organisms' (users') motivation to use a system which in turn affects the response which is the actual system use (Davis, 1989).

The focus of his work was IT and he specifically addressed how the acceptance of computers/technology by users and what kinds of measurements and dimensions must be used to predict such pattern of behavior exhibited for adoption of new technology. He proposed a conceptual framework that identified two major technology acceptance dimensions, which to this day are being used as measurements of success dimensions by other popular models (Mclean and Delone, 2003).

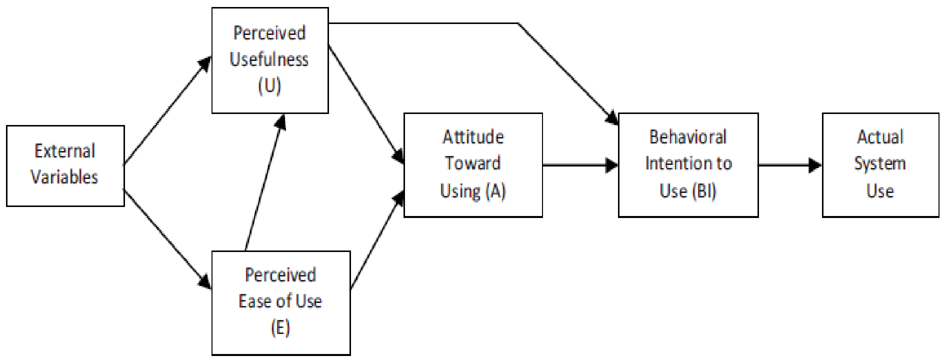

Figure 1. Original TAM model by Davis, 1989.

Although several studies have been proposed by scholars of the domain area, a mere three years after Davis proposed TAM, D&M proposed the first model for measuring IS success which included six dimensions. The lack of a comprehensive framework for IS success measurement, as well as its complexity in nature, was the motivation behind the development of the D&M model (Delone and Mclean, 2003). Moreover, information system success measurement dimensions are not independent but rather multi-dimensional and interrelated. The authors acknowledge that IS success measurement is ill defined and complex in nature mainly due to the lack of recognition of the changing role of IS in organizations and because measurement constructs are inconsistent and often inappropriate. Traditional and direct measures of success like ROI, and benchmarking are not sufficient because intangible benefits of IT are just as important for the measurement of IS success (Delone and Mclean, 2003;2008).

The first D&M model was proposed in 1992 with six constructs known as system quality, information quality, use, user satisfaction, individual impact and organizational impact. The original model is shown in figure 2 below.

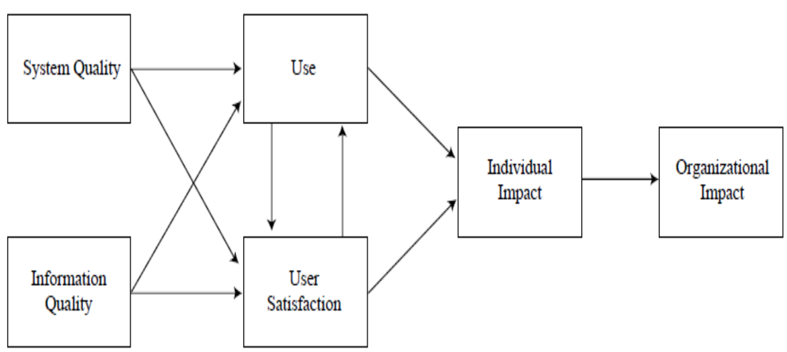

Figure 2. The Original D&M IS Success Measurement model, 1992.

After the original framework was published, a surplus of subsequent research followed to test validity of the dimensions and to prove their interdependence. Numerous scholars have scrutinized, altered, and tested this model which resulted in its modification in 2003. Several researchers offered alterations to the original model but four major proposals to modify the original model were worthy of consideration due to the level of detailed empirical evidence they offered (Petter, Delone, and Mclean, 2008).

The first to suggest an alteration to the model were Seddon and Kiew, based on the Seddon Model of IS success, four years after the original model was proposed (Delone and Mclean, 2003; Mukti and Rawani, 2016). They argued that an IS usefulness does not represent actual use of the system. They asserted that for voluntary systems, use construct is an appropriate measure but for mandatory IS, usefulness (same as perceived usefulness by TAM) is a better measure of success than use (Seddon and Kiew, 1994). But this notion was not accepted by D&M who claimed there can be substantial changeability of the Use construct, even for mandatory IS. The second modification to the original model was proposed by Pitt due to the popularity of marketing literature, called SERVQUAL, which suggested a new dimension to be included (Pitt, 1995). This dimension was Service Quality, which is a measure of the quality of support given by the IT department. This dimension was accepted by D&M due to the changing IS role in organizations over the following decade (Delone and Mclean, 2003). The third study for modifying the original model came from Seddon, who argued the model was too complex because it integrated both process and variance models within the same framework.

These new pieces of evidence were accepted by D&M which resulted in the inclusion of the Intention to Use construct along with the original Use construct. The final alteration was the inclusion of the Net Benefits construct to the original model due to the fact that other levels of an organizations' entities such as workgroups, industries and societies are affected by an IS besides Individual Impacts and Organizational Impacts. After reviewing ten years of empirical research on the area of IS success that used their model, and conducting their own study using each of the six dimensions in 15 pairwise associations of each construct, D&M published the final D&M IS success measurement model in 2003. The revised model is shown on figure 3.

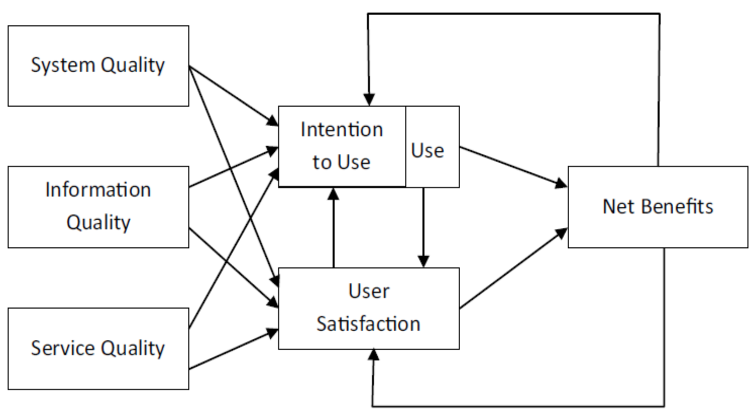

Figure 3. The revised D&M IS Success Measurement Model, 2003.

This revised model was used by the domain area researchers and practitioners to measure the success of various IS applications by taking all or few of the six dimensions. After its revision, D&M IS success model has been the most widely used and frequently adopted IS success measurement model because it is the most cited and empirically tested model to date (Petter, Delone, and Mclean, 2008). This model is chosen for the purposes of this research not only because of its popularity, but also due to the fact that adopting a comprehensive model for measuring IS in Ethiopian Organizations is non-existent. The final version of the D&M model consists of six dimensions of success and has been the topic of interest in the field of Information Science for the last three decades. The model has been adopted and re-specified to measure different IS such as mobile and internet banking applications, business intelligence applications, knowledge management applications, and enterprise systems like ERP (Nasser and Zaied, 2012; Al-ghazi, et al., 2015).

Research Design

This study is a quantitative, confirmatory research that studies the causal relationship between constructs of the proposed model. It is confirmatory research due to the fact that it attempts test or confirm a theoretical hypothesis (Kennedy, 2014). The original use and user satisfaction dimensions of the model is not included in this investigation since ERP system success is most associated with system quality, information quality, service quality, individual impacts, workgroup impacts and organizational impacts (Zareravasan and Mansouri,2016). CSFs considered in this study that pertain to ERP post-implementation are top management support, interdepartmental communication and co-operation, vendor support, user involvement and training, and change management. Since re-specifying the D&M model requires consistent use of their constructs, the post-implementation CSFs identified from literature are used as measures of the dependent variables. The target population for the study is ERP users at Commercial Bank of Ethiopia (CBE) using one or more modules purchased from Oracle. The proposed conceptual framework is shown in Figure 4.

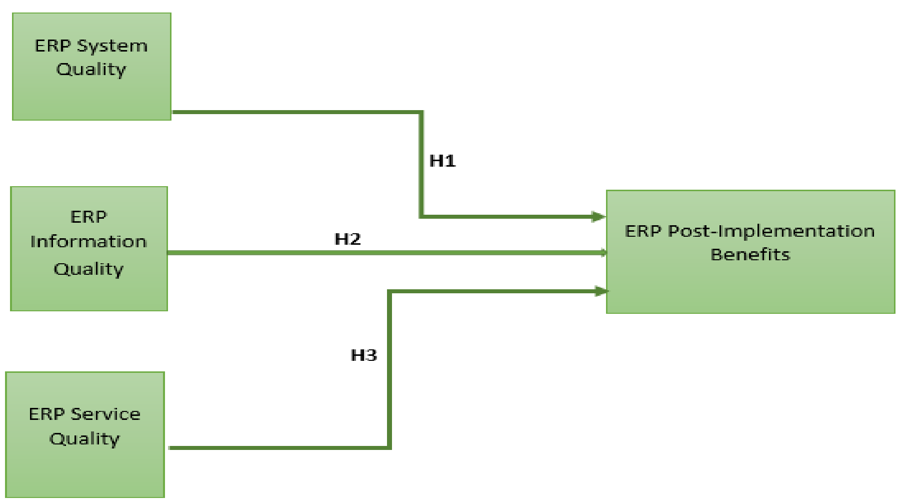

Figure 4. ERPPIS: Proposed model for measuring ERP post implementation success.

ERP System Quality

The system quality dimension is defined by Delone and Mclean as the desirable outputs of the IS with measurements such as ease of use, flexibility, system reliability, and ease of learning, as well as system features of intuitiveness, sophistication, and response times. ERP system quality constructs have been identified as ERP system ease of use, productivity (Infinedo, 2006; Wei,et al., Leong and Ooi, 2009). Thus, assuming that ERP system quality characteristics positively affect the overall ERP post-implementation system success, the 1st hypothesis is drawn.

H1: ERP system quality positively affects ERP Post-implementation benefits.

ERP Information Quality

Information quality is defined as the characteristics of the system outputs users require such as, management reports and web pages (Delone and Mclean, 2003, 2008). Information quality of ERP systems is related to all ERP implementation phases and are measured by whether the report produced by the system is usable, concise, comprehensible, pertinent, available, and in a correct format (Dezdar and Sulaiman, 2011). Thus, assuming that information quality of ERP systems positively affects the post-implementation benefits of ERP systems, the second Hypothesis was drawn.

H2: Information quality of ERP systems positively affects the resulting ERP post-implementation benefits.

ERP Service Quality

ERP service quality of IS refers to the degree of excellence in support offered by the vendors, the consultants and IS department (Delone and Mclean,2003,2008). Depending on how the ERP post implementation tasks are being managed, either the IS department quality of support or vendor/consultant quality is the topic of measurement. Recommended measurements of service quality are reliability of the IS unit, responsiveness of the IS staff for support requests, assurance and empathy of the personnel staff. Thus, ERP service quality measures for the purposes of this study is trustworthiness, reliability, responsiveness, assurance and experience of IS staff and vendors/consultants (Wei,Loong, Leong and Ooi,2009).

H3: ERP service quality positively affects ERP system post-implementation benefits.

ERP Post-implementation Benefits

Extant literature views ERP post-implementation benefits from the individual, workgroup and organizational perspectives (Abu-shanab and Khairallah, 2015). Post implementation CSFs pertaining to individual impact, workgroup impact and organizational impact are categorized under ERP post-implementation benefits. Thus, measures for ERP post-implementation benefits are perceived usefulness for job impact at the individual level (Wei, Loong and Ooi, 2007; Petter Delone and Mclean,2008).

H4: ERP post implementation benefits are positively associated with ERP system success.

Measurements items were identified for each of the models constructs from previously validated variables for measuring IS success. Then the questionnaire was distributed for user groups which included management, IS department, and users, each with different levels of usage of the ERP system. The questionnaire was initially designed to be distributed online but due to response rates being unexpectedly low, there was a need to resort to hard-copy printouts for collecting the data. The initial online questionnaire was distributed via email for all active ERP users at CBE which were 467 and only 27 responses were received in a period of three weeks, which is only a 9% response rate. Then 300 hard copies were distributed to different head office organs with active users of the ERP system and 275 responses were collected successfully, with 91.67% response rate. Since hard-copy questionnaires pose a risk of incompleteness, only 206 were found fully complete. Those with any missing entries were automatically rejected. Hence a total of 233 (27 responses online and 206 usable questionnaires filled in hardcopy) responses were considered for data analysis.

Data Analysis and Discussion

The data preparation for analysis was performed using two stages. The first stage was analyzing the demographic data. SPSS tool was used to present the demographic output. The second stage of data analysis involves the use of SEM techniques and calculating PLS values that involve multiple instances of correlation and regression analysis via the use of SmartPLS 2.0.

Validity and Reliability

For ensuring the models predictability powers, internal consistency reliability, indicator reliability, convergent validity and discriminant validity were checked. Internal consistency reliability refers to the consistency across the parts of a measuring instrument (Taherdoost, 2016). According to Taherdoost, a scale is said to have high internal consistency reliability if the items of a scale go together and measure the same construct. Both Cronbach's alpha and composite reliability values for measuring reliability due to the fact that Cronbach's alpha has the assumption that all indicators are equally reliable (Wong, 2013). As shown in table 1, the measurement model shows Cronbach's alpha value ranging from 0.8363 to 0.9599 and a composite reliability value ranging from 0.8888 to 0.9637, which are well above the desired value of 0.70. This indicates high levels of internal consistency and reliability of all reflective constructs of the measurement model.

Construct	Variable Name	AVE	Cronbach's α	Composite Reliability
ERP System Quality	ESQ	0.5447	0.9064	0.9226
ERP Information Quality	EIQ	0.5926	0.9140	0.9290
ERP Service Quality	ESRVQ	0.6100	0.9599	0.9637

ERP Post Implementation Benefits	EPIB	0.5909	0.9592	0.9629

Table 1. Cronbach's α, Composite reliability and AVE values of ERPPIS Model

According to Wong (2013), values of 0.70 and above specify high indicator of reliability of the reflective variables of the model and the reliability of each variable is calculated separately. Outer loading for ERP system quality construct ranges from 0.6500 to 0.7952, ERP information quality outer loadings range from 0.7209 to 0.7989, ERP service quality outer loading values range from 0.7290 to 0.8345, and ERP post-implementation outer loading values rage from 0.7087 to 0.8200. Accordingly, all outer loading values of reflective indicators are above the preferred value of 0.70, which proves the indicator reliability of reflective variables of the model. Table 2 shows outer loading range of values for each latent variable, which are above the accepted value of 0.7.

Construct	Outer loading Values
ESQ	0.7500 - 0.7952
EIQ	0.7209 - 0.7989
ESRVQ	0.7290 - 0.8345
EPIB	0.7087 -0.8200

Table 2. Outer loading for Indicator Reliability

Convergent validity refers to the extent to which measures of one construct, which is related to another construct in theory, is in fact related to that construct in reality (Taherdoost, 2016). AVE values above 0.50 are considered to possess convergent validity (Wong, 2013). As shown in table 1, AVE values for all constructs are above the preferred value of 0.50, demonstrating measures of each latent variable converge to measure their respective constructs. Another measure of validity is discriminant validity which is the extent of how much a latent variable is able to account for more variance in the observed variables with itself and other constructs within the same conceptual model (Fornell & Larcker, 1981). The square root of AVE values and cross-loading values are used to measure discriminant validity. Using Fornell and Larcker criterion, the square root of AVE values must be larger than the correlation values of each of the latent constructs. AVE values for ESQ is 0.5447 which means the square root is 0.7380: a value greater than both ESQs correlation values with other constructs of the model EIQ, 0.7260 and EPIB, 0.6755 solidifying discriminant validity of the latent variable ESQ. Table 3 shows the discriminant validity values of ERPPIS model. No indicator variable should have a higher correlation with another latent variable than with its output of cross-loading values.

Constructs	EIQ	EPIB	ESQ	ESRVQ
EIQ	**0.7698**			
EPIB	0.6649	**0.7687**		
ESQ	0.7260	0.6755	**0.7380**	
ESRVQ	0.6422	0.6701	0.5727	**0.7810**

Table 3. Fornell-Larcker Criterion Analysis for Checking Discriminant Validity

For testing hypothesis, examining duality of t-statistical values and p-values reveals significant relationships between latent variables. Recommended value of t-statistics is equal to or greater than 1.96 with 95% confidence interval or a p-value of <0.05 (Taherdoost, 2016). Table 4 shows the result of hypothesis test for direct effects of the ERPPIS model latent variables.

Hypothesis	Constructs	R Squared	Path Coefficient	T-Statistics	P-Values	Status
H1	**ESQ->EPIB**	0.5931	0.3306	3.2812	0.001	Accepted
H2	**EIQ->EPIB**		0.1972	2.5460	0.012	Accepted
H3	**ESRVQ->EPIB**		0.3592	4.3385	0	Accepted

Table 4. R Squared, T-Statistics and P-values of ERPPIS model.

According to Wong (2013), R^2 values that are 0.25 and under are considered weak, between 0.25-0.50 are moderate, and those between 0.50 and 0.75 or above are considered substantial. R^2 Values of the endogenous variable EPIB and ERPPIS are 0.5931. This means that 59.31% of the variance of the variable EPIB is explained by the latent variables ESQ, EIQ, and ESRVQ. This value is indicative of a substantial statistical significance of the independent variables explaining the dependent one. ESQ, EIQ, and ESRVQ are independent variables hypothesized to influence the overall post-implementation benefits of the ERP system from the resulting benefits of individual impact, workgroup impact, and organizational impact (H1, H2, and H3). T-Statistics values for the relationship between ESQ and EPIB is 3.2812, EIQ and EPIB is 2.5460, ESRVQ and EPIB is 4.3385, which are all above 1.96 with p-value<.05, thus H1, H2, and H3 were accepted.

This shows that the direct effect of ESQ, EIQ and ESRVQ on EPIB with path coefficient 0.5931 are significant. From the result of the hypothesis tests, we can see that ERP service quality has the highest significance in affecting ERP post-implementation with path coefficient value of 0.3592, t-value of 4.3385 and p-value<0.05. This shows that the level of support and synergy with the IS department is critical for taking advantage of ERP system post-implementation benefits from individual, workgroup and organizational perspectives. ERP system quality also has significant effect on ERP post-implementation benefits with a path coefficient value of 0.3306, t-value of 3.2812, and p-value <0.05. ERP information quality is the least impactful with path coefficient value of 0.1972 but the result of the t-statistics 2.5460 and p-values<0.05, it is still significant for H2 to be accepted.

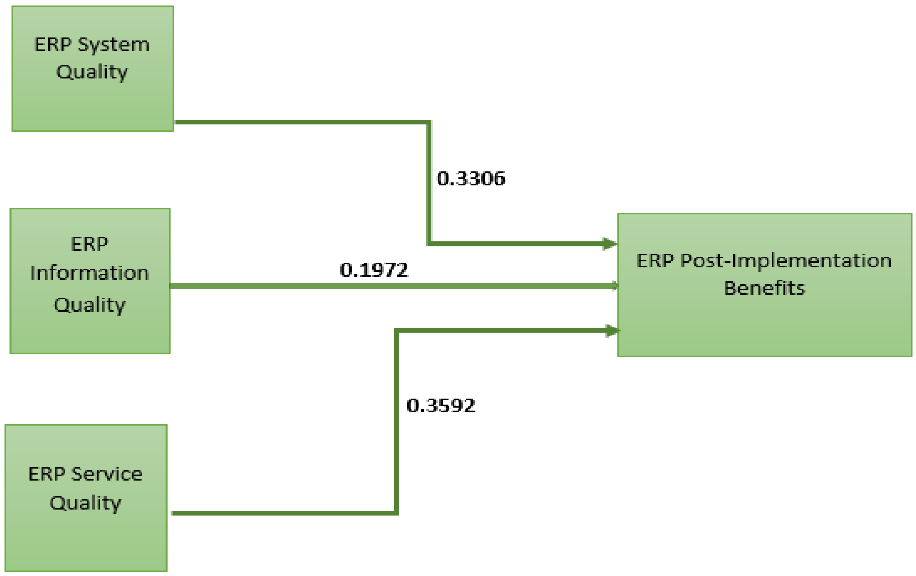

Figure 5. Hypothesis Test Result

Conclusion and Implications for Future Research

This study is a contribution to the realm of IS success literature that offers empirical results using D&M revised model for measuring ERP post-implementation success. It specifically demonstrated ERP system post-implementation measurement and factors associated with it. ERP is a multifaceted IS that has different phases, hence building a model that can fully measure its success needs to be studied at each phase of the software's lifecycle. Identifying CSFs associated with pre-implementation, ERP implementation, and post-implementation phases is highly important since this guides what constructs to use and which associated indicators to select that accurately measure the chosen constructs. Making use of the results of such empirical findings not only fosters the culture of IS evaluations, but it also allows ERP system administrators, managers, and users to make changes to which aspects of the system need attention to heighten its success. According to the study's findings, the involvement of IS department and management is critical for the overall success of ERP systems. So, organizations should provide a quality level of support for their users in order to achieve organizational IS success. Organizations should also place great value on the benefits offered by ERP systems by engaging users in inter-departmental and sub-unit communications. By highlighting what users will benefit from, ERP systems can bring organization-wide cooperation, which may attribute to the success of ERP systems. Empirical results from this study can be used to further strengthen what drives ERP systems to be successful in the post-implementation phase. Future research can revolve around vendor and consultant qualities as well as change management which are CSFs identified during the post-implementation phase, and modifying the D&M model to include these two factors as success predictors may increase the predictability power of the model for assessing ERP system post-implementation success for future researches.

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