Real Options and Subsequent Technology Adoption: An ERP System Perspective

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Abstract

An Enterprise Resource Planning (ERP) system has been identified as having option-like characteristics making such systems unique and different from many Information Systems (IS) technologies. Given the growing need to extend ERP systems beyond the boundaries of an ERP implementing organization, there is need to explore how an ERP system as an IS platform technology, can enable the subsequent adoption of other function-specific applications. Using insights from real options theory, this study proposes a conceptual framework that views ERP adoption as a technology positioning investment with options at each stage of the decision making process. Specifically, in a post-ERP implementation, the study proposed that organizational factors such as managerial flexibility, technical resources and level of technological uncertainty, affect the organizational ease of use of subsequent technology which in turn influences ERP-enabled adoption.

1. Introduction

Enterprise Resource Planning (ERP) systems have drawn increasing attention from information system (IS) researchers since the early 1990s as they attempt to understand how businesses can successfully implement ERP systems. ERP systems are packaged software solutions that integrate hitherto disparate information and business processes within and across functional areas of business. Organizations have embraced ERP systems as solutions to fragmented information, incompatible legacy systems and inefficient business processes [17, 31]. However, the post-implementation results of these ERP implementing companies have been mixed. While some firms have achieved impressive benefits and success from their ERP systems [15, 30] other firms are left to grapple with ways to translate pre-adoption expectations into actual ERP implementation success [15]. Given ERP systems wide use and challenges, it is not surprising that research on its benefits and successful implementations has been increasing. One area that has gained research attention is organizations ability to maximize the benefits and value embedded within the ERP system [31, 25]. ERP systems as platform positioning technologies provide not only a common business process within the firm but also an integrated platform that permits the adoption and integration of third party applications [13, 25, 31]. Little, however, has been done to understand post-implementation adoption decisions enabled by the initial ERP implementation.

Similarly, extant literature have argued about the need to apply the concept of real options on IT investment evaluation when faced with high uncertainty and irreversibility [2, 13, 40] as conventional discounting cash flow (DCF) techniques fail to capture managerial flexibility and the dynamic nature of IT positioning investments [2,5,40,43]. A real option is the right but not the obligation to undertake some business decisions and to obtain benefits from future opportunities. Real options analysis (ROA) can serve as an investment appraisal technique capable of considering risks and uncertainties associated with an investment while recognizing the active management’s impact and options on the investment. DCF analysis while considering cash flows ignores the presence of options and the impact of managerial flexibility in responding to the environmental conditions. Hence applying real options perspectives to ERP implementation allows management not only to recognize these associated options but to deal with uncertainties encountered during ERP deployment. These options can provide firm management with the right and not the obligation to take certain post-ERP implementation decisions such as adopting subsequent ERP-enabled add-ons and applications. Apart from studies aimed at applying ROA to generic full ERP implementation, few studies have focused on the implication of real options analysis on post-ERP
adoption decisions. Yet, ERP systems are by nature long term investments thus the system ‘going live’ should not become the end of the ERP journey but rather should serve as the base for future tactical and strategic beneficial additions. Today’s managers in ERP implementing companies expect the system to provide the baseline infrastructure that will lead to growth, greater agility and flexibility [31].

Against this backdrop, this study conceptualizes ERP-enabled adoption and uses real options theory as an analytical lens to understand how firms can identify the options embedded in an ERP system and how these options shape subsequent technology adoption decisions as organizations attempt to exercise these optional values embedded in ERP systems. This study sets out examine two central research questions that have not been adequately investigated in the ERP benefit literature: (i) What factors influence ERP-enabled adoption? (ii) How does the initial investment in an ERP system affect the ease of use of subsequent technologies? This study attempts to answer these two questions by conceptually and empirically testing an integrated research model that combines the framework of initial ERP, real option factors and subsequent technology factors with survey data collected from employees in wide range of organizations.

Our focus on understanding ERP-enabled adoption using ROA sets this study apart from current literature which primarily examines IT valuation using real options and how ROA can present a complete picture of IT investment values [43, 34]. Given that options are already part of the initial ERP investment, this study extents the current literature by examining factors that influence the organizational ease of use of these options as well as their impact on ERP-enabled adoption. In addition, examining ERP-enabled adoption allows this study to capture ERP implementation as a sequence of managerial decision over time rather than a one shot view that has been applied in previous studies.

This article is organized as follows. Section 2 discusses the background literature and associated hypotheses on real options, ERP systems, ERP-enabled adoption, technical resources, managerial flexibility, uncertainty and organizational ease of use. Section 3 outlines the methodology and Section 4 presents the data analysis and reports the empirical findings based on data collected from US firms. Finally, section 5 concludes with a discussion of research findings and implications for theory and practice and limitations.

2. Real Options and ERP systems

The term ‘real options’ was introduced by Steward Myers in 1977 [42]. In the paper, Myers argued that traditional DCF methods had major limitations when it comes to valuing investments with operating and growth options. Myers recognized that option pricing theory could be applied to real assets and non-financial investment. Myers coined the term real options to differentiate the options on real assets from financial options traded in the market [42]. A financial option refers to the right, but not the obligation to buy a stock at a fixed price on or before a given date. When investors buy options, they are spending little to retain the flexibility of putting off decision making until a future date when there is greater certainty. Myers [42] argued that the initial phase of an investment project is implicitly comparable to buying an option and as such, discretionary investment options should be the components of an investment market value. Thus, a real option refers to the right but not the obligation to take some action in the future in responses to an event [5]. Options are established by making initial investments such as creating a joint venture, developing a prototype, implementing a technology platform [22] and firms may decide to exercise these options based on the economic prospects of the investment as well as the business environment. The initial investment gives a firm the ability to commit to an investment partially and defers certain decisions until information becomes clear. After making an initial investment, management will have to wait for signals or more information as to whether or not it is appropriate to exercise these options. Indeed, the framework for real options is based on the understanding that in the face of high uncertainty, postponing the commitment until a substantial part of the uncertainty is known, will give management great value and benefit. ROA explicitly accommodates uncertainty by making it possible for firms to adjust investment decisions during the course of the investment life cycle as necessary information becomes available [22].

Research on ERP systems and real options have focused on valuation and justification issues that managers face prior to project approval. Extant literature attempted to demonstrate that ERP systems as technology positioning investments [13] have option-like characteristics making such systems unique and different from many IS technologies [10]. Consequently, prior studies employed a case study approach and compared ROA with traditional discount factor technique such as Net Present Value (NPV) and decision tree (DT). For instance, Taudes [43] used ROA to reveal that the decision to either update an
existing version of an ERP system or to implement a new version was more complicated and required a valuation technique capable of recognizing future opportunities and benefits. The justification was that the new SAP R/3 would enable subsequent investments such as Electronic Data Interchange-based purchasing and invoicing, workflow application and web base e-commerce. In the same light, Wu et al. [46] suggested that options embedded in ERP systems can serve as a means of mitigating the risk component of the project. The studies argued that although ERP systems are notoriously very risky projects, the options embedded with the system creates managerial flexibility that active management can explore in order to minimize the potential exposure. Wu et al. [46] argued that ERP systems by their nature require a long and rigorous implementation process involving a dynamic active management capable of responding to the changing business environment. Hence, applying real options perspective to ERP implementation allows management not only to recognize these associated options but to deal with uncertainties encountered during ERP deployment. These options enhances flexibility by providing managers with the right and not the obligation to take certain implementation decisions such as adopting, scaling, deferring, switching and abandoning during the implementation process. Ozogul et al. [33] developed a real options based methodology for evaluating and justifying an ERP-based hospital information system. Using a case study, the paper showed that the investment can be justified if the appropriate valuation technique capable of capturing both explicit and implicit values of the investment is applied. The paper identified a multiple-phased approach that involves isolating the options in an investment, the interaction among them and the nature of the flexibilities they offer followed by options evaluation. Furthermore, the study found that recognizing the options enable by investments can better equip managers to deal with uncertainties and associated risk of such investments.

2.1. ERP-enabled adoption

ERP-enable adoption refers to technology adoption that is made possible because of the initial ERP implementation [31]. According to Taudes et al. [43] an ERP system is an example of a software platform that enables the implementation of value creating applications. The study noted that the cost associated with a software platform is typically irreversible and sunk thus, its value mostly lies in the option it creates to build subsequent applications. For instance, Taudes noted that SAP R/3 created a platform to introduce applications based on EDI, workflow management, document management and e-commerce applications. A typical IT investment has components that are capable of creating growth opportunities over time.

2.2. Technical resources

Technical resources refer to the technical capabilities that an organization possesses. It can be viewed as the competence of an organization to develop and maintain an information system. Such technical resources are in the form of expertise of the information system (IS) group in building and maintaining the system, the system know-how of the end-users and the quality of hardware, network application and software applications deployed [19]. Thus, technical resources are important considerations for firms making adoption decisions as firms have to establish an alignment between the technical resources available and the adopting technology or innovation. The path between technical resources and organizational ease of use of subsequent technologies can be seen from the implementation and usability perspective. Inadequate technical resources may undermine the organizational ease of use of subsequent technologies as managers may have the impression that they lack the resources necessary to create the friendly usability environment needed for ERP-enabled adoption. Thus, we propose the following hypothesis:

\[ H_1: \text{Technical resources positively influence organizational ease of use.} \]

2.3. Managerial flexibility

Managerial flexibility refers to manager’s ability to take appropriate actions in response to the changing IT environment and by so doing can achieve more success, and attain investment objectives [46, 13]. Incorporating the value of managerial flexibility has received a lot of attention lately. Jorgensen and Wallace [20] argue that in an environment with high level of uncertainty, ignoring the cost associated with active intervention can significantly affect the estimated project cost. In addition, the real option literature has strongly advocated the inclusion of managerial flexibility value in investment justification. For instance, Dos-Santos [12] argued that flexibility allows management to make considerable adjustments on how a project proceeds after the initial investment and that such ability should be reflected in the project justification. Similarly, Krychowski and Quelin [22] noted that the main impact of real options is the ability to recognize that investment project can evolve over time and that this flexibility is valuable. In fact, real options theory does not dictate the use of any particular
pricing models rather it is an approach that recognizes the value of managerial flexibility in investment justification [4, 8]. Thus, in the face of high uncertainty and irreversibility of the initial investments, omitting the value of managerial flexibility can significantly underestimate the value of a new IT investment [5, 13, 28]. Recently, managerial flexibility has become a key factor in technology deployment in organizations as managers’ grapple with an ever-changing competitive environment. Managerial flexibility allows managers to intervene in containing downside losses and these interventions have value and substantial upside potential [5, 13]. Managerial flexibility and organizational ease of use are two constructs that can be related. If managers are flexible and able to respond to changes, then they are more likely to embrace new technologies. Such a mind set on innovations and new technologies will typically increase the perceived ease of use of a new technology. With organizations having already institutionalized an environment that fosters agility and flexibility, technology adoption will be viewed as a means of dealing with uncertainty. Typically, learning capacities are created in an uncertain environment as people try to be better equipped to deal with changing conditions [23]. Consequently, managerial flexibility can positively influence the organizational ease of use of an adopting technology as managers are aware that they can actively respond to the changing conditions during the technology implementation and project life cycle. Thus, we propose the following hypothesis:

H2: Managerial flexibility positively influences organizational ease of use.

2.4. Level of uncertainty

Uncertainty refers to the frequency of changes and the unpredictability of possible outcomes. The level of uncertainty is an important parameter in firms’ IT investment decision making. According to Fichman [13], uncertainty arises as a result of unpredictability in technology evolution as well as the path dependency such technologies imposes on a firm’s future technology path. This unpredictability stems from inadequate information needed to assess, obtain and implement an IT investment [41]. Thus, IT investment uncertainty exists because of the information gap between the information needed by managers to obtain and implement the technology and the information that is actually available at the time of the decision making [41]. Several factors are responsible for IT adoption uncertainties. Uncertainties may arise due to technology immaturity, complexity and unpredictability of evolutionary path [13] as well as due to environmental uncertainties inherent with the technology [5]. According to Martin et al. [27], environmental uncertainty can create unanticipated changes in circumstances that alter the anticipated outcome of a project. In fact, high level of uncertainty has been identified as a positive driver of option value because greater uncertainty results to higher value of flexibility and the higher the managerial flexibility, the greater the value of embedded options [13]. However, while option values increases with uncertainties, exercising these embedded options is dependent on how these uncertainties decrease over time and managers’ having the necessary information to make decisions. Thus, real options reasoning explores the uncertainty factor by providing the desirability of waiting for uncertainty to be resolved prior to making subsequent investment [35, 28]. Hence, adoption decisions regarding the options are made only when the level of uncertainty has diminished to an acceptable level where decision makers are comfortable enough to exercise these options. Thus, we propose the following hypotheses:

H3: The level of uncertainty negatively influences organizational ease of use.

H4: The level of uncertainty negatively influences ERP-enabled adoption.

2.5. Organizational ease of use

Organizational ease of use refers to the degree to which an organization perceives a system to be free from effort. Studies have shown that when innovations are easy to use, system usage and performance can be achieved [38]. Ease of use is thus a characteristic attributable to the process of using the system. Prior research on innovation and adoption has observed that the characteristics of innovation as perceived by the adopting business have influence on the adoption decision [38]. For instance, Rogers [38] suggested that the complexity - which refers to the degree to which an innovation is perceived as difficult to use - has a negative impact on firms’ adoption decisions. Indeed, adopting a technology that requires a great deal of effort during that trial period can be very challenging as the desire to interact with the technology will diminish regardless of its benefits [44].

Organizational ease of use is increasingly becoming a dominate decision factor for firms adopting ERP systems. One reason for this is because firms translate organizational ease of use into easier implementation as well as easy training and support. Thus, we propose the following hypothesis:
H5: Organizational ease of use positively influences ERP-enabled adoption.

Figure 1: Research Model

3. Methodology

The firm is the unit of analysis in this study as such the subjects are IT decision makers within the organization such as, the chief information officer (CIO), chief technology officer (CTO) or vice president of IT operations. These executives are typically tasked with the decision making processes of their organizations technology needs. Dun and Bradstreet’s Million Dollar database [9, 36, 45] – a directory of executives was used to identify a random sample of IT executives. The questionnaires were administrated to a final random sample of management information systems (MIS) directors. Each executive was contacted through email and a web-based link containing the survey instrument was included in the email message. A total of 575 responses were returned. However, 29 responses were discarded due to incomplete questionnaire while additional 27 responses were unusable. In most cases unusable responses were as a result of respondents indicating that they did not have an ERP system. Thus, the final number of usable responses was 519.

4. Results

Data analysis and empirical validation of our hypotheses were done with partial least square (PLS) analysis. PLS allows latent constructs to be modeled as formative indicators as was the case with our data. SmartPLS 2.0 [37] software was used for the analysis. Consistent with prior research using PLS models, this study analyzed the research model in two stages [18, 7, 16]. The first stage involved the assessment of the reliability and validity of the measurement model and the second stage involved the assessment of the structural model [18]. To ensure that the responses in the sample are free from non-response bias, this study followed a procedure by dividing the samples into two groups based on the time when each response was returned. Using this procedure, it was possible to determine statistically whether later respondents were significantly different from earlier respondents. The result did not show any significant differences between the two groups, indicating that non-response bias was not a significant issue that could confound the findings of this study. Also, the study applied the Liang et al. [24] procedure to test the common method bias in PLS. The results revealed that method loadings were insignificant and that indicators variances were considerably greater than their method variance. Thus, this study concluded that the common method bias was not a serious threat to this study.

The adequacy of the measurement model was assessed by evaluating the results of content validity, criterion-related validity, convergent validity, construct validity and reliability tests [3]. The preliminary questionnaire was examined by a panel of IT professionals in ERP implementing organizations as well as by researchers in the area. The questionnaire was then modified based on inputs from these experts. Content validity was thus established by examining prior literature, developing and adapting to existing scale and using a panel of IT professionals and researchers within the area to judge the quality of the instrument [9]. Confirmatory factor analysis was conducted for all of the latent constructs in the model. All item loadings were greater than .60 as recommended by Hair et al [31]. Thus, the items are representative of their respective constructs. Furthermore, the reliability of the scales and measurement items were evaluated. The reliability of the scales is indicated by the composite reliability values and Cronbach’s alpha and all values are above the acceptable 0.7 threshold [32], thus all measures have adequate levels of reliability. Convergent validity was tested using two criteria [14]. First, all indicator loadings should be significant and exceed 0.7 and second, the average variance extracted (AVE) by each construct should exceed the variance due to the measurement error for that construct. Discriminant validity was assessed using three tests. First, an examination of cross-factor loadings indicates good discriminant validity, because the loading of each item on its assigned construct is greater than its loadings on all other constructs [6]. Second, the correlations among the constructs are below the 0.85 threshold [21], suggesting discriminant validity. Third, the square root of the AVE from a construct is greater than the correlations among the construct and all other constructs in the model [14].
In PLS analysis, examining the structural paths and the R-square scores of the endogenous variables assesses the explanatory power of the structural model. Figure 2 shows the results of the structural path analysis. Overall, all of the 5 paths are significant, with a p-value of less than 0.05. The model explained 43% of the variance in overall ERP-enabled adoption. Similarly, technical resources, managerial flexibility and level of technological uncertainty explained 41% of the variance in organizational ease of use of subsequent technology.

Figure 2: Research Model with results

5. Discussion and Conclusion

This study examined post-ERP implementation and how organizational factors such as managerial flexibility, technical resources and technological uncertainty affect the organizational ease of use of subsequent technology which in turn influences ERP-enabled adoption. The findings reveal that managerial flexibility significantly and positively impacts organizational ease of use. This result is consistent with the works of Lant and Mezias [23], which suggests that as organizations embrace agility and flexibility, learning capacities are created as a means of mitigating the changing business conditions thus, making users more apt to use new technologies. In fact, decision makers will use their feeling of how comfortable they are with system changes as the main heuristic to guide the agility [39]. Managers are aware that creating an atmosphere that fosters organizational ease of use is a precondition to the effective technology utilization as a response to rapidly changing conditions [26]. With such a mindset, managers are able to respond to changes by creating conditions that will facilitate and enhance organizations ability to embrace and use new technologies. Consistent with our hypothesis, technical resources had significant positive effect on organizational ease of use. This result is consistent with prior IS literature which suggest that the greater the technical resources, the easier it is for new ideas and innovations to be employed and implemented in an organization [11, 1]. Indeed, technical resources enable management to create conditions within the firm that can foster additional technology adoption. Such conditions may come in the area of training, expertise with the IS group and in maintenance. Decision makers will feel comfortable when they know that their organization have the technical expertise necessary to deal with unexpected bottlenecks that may arise from a potential new or additional technology. Therefore, as long as management has adequate technical resources in place, they will be more likely to perceive a higher organizational ease of use of any potential additional technology. Consistent with our hypothesis, organizational ease of use had a significant positive relationship on ERP-enabled adoption. This result is consistent with the IS literature, which suggests that characteristics of the innovation as well as the complexity affects firms adoption decisions [38, 29, 44]. Firms recognize that organizational ease of use can translate to easier implementation of the additional technology being adopted. Further, while past research in organizational ease of use has shown that it influences adoption decisions, this result indicates that in the context of post-ERP implementation adoption, organizational ease of use remains a strong predictor of adoption decisions. This finding is particularly interesting because it reaffirms organizational ease of use as a strong predictor of adoption even when such adoptions are incremental in nature. Thus, decision makers within the firm need to create favorable climate that foster organizational ease of use of the adopting technology in order to meet the adoption goals as well as to attain the desire technology benefit and expectations. Finally, the level of uncertainty was found to have a negative relationship between organizational ease of use and ERP-enabled adoption. As the level of technological uncertainty diminishes, managers are more likely to exercise the options created by the initial ERP platform, leading to ERP-enabled adoption.

Some limitations need to be pointed one. First, the questionnaire was sent to 4337 potential respondents but only 575 responded and out of these 575 responses, only 517 were completed and useful for the analysis. Although the sample size seems adequate, a higher response rate would have added validity. Second, this study adopted a cross-sectional view in measuring the constructs. Such an approach may not adequately capture the interactions among these constructs. Thus, future research can examine ERP-enabled adoption as a process model while capture its subsequent implementation as a sequence of managerial decision over time rather than a one shot view. Similarly, future
researchers are encouraged to compare firms that applied ROA as part of their ERP investment valuation technique and those that did not. Insights gained from such studies will advance our understanding on ROA as a valuation and justification technique.

6. References


