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Digital Transformation and Real Options: Evaluating the Investment in Cloud ERP

Jose Miguel Lozano-Almansa[1], Jorge Tarifa-Fernandez[2*], Ana Maria Sanchez-Perez[3]

Department of Economics and Business, University of Almeria
Ctra. Sacramento s/n, Almeria, Spain
*E-mail: josemiguellozanoalmansa1998@gmail.com; jorgetarifa@ual.es; (*corresponding author); amsanchez@ual.es*

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The purpose of this research is to explore and advance the knowledge regarding digital transformation. Toward this end, this paper is focused on the valuation of the assessment methodologies of cloud ERP projects. The investment in digitalization systems entails high levels of uncertainty, which gives these investment projects a high strategic value. The importance of emergent digitalization in ERP systems has made it necessary to use assessment tools that consider strategic information as well as financial information. In this paper, the real options methodology, specifically the option to defer, is proposed to account for the strategic value of investment projects in digitalization. In this sense, an empirical study is conducted by applying the binomial option pricing model to real data on the costs and revenue of investing in cloud ERP to study its viability.

Keywords: *Cloud ERP; Digital Transformation; Real Option; Option to Defer; Financial Engineering.*

Introduction

Industry 4.0 has already transformed the way that firms relate to each other and their environments (Bazan & Estevez, 2022). In today's environment, an increasing amount of information is generated, which can be a very valuable intangible for decision-making. In addition, the decisions around investments become more complex when enterprise resource planning (ERP) systems are considered to be a potential competitive advantage that provides firms with the ability to make decisions under less uncertainty resulting from more and better information (Sykes *et al.,* 2014).

With the development of technology, a vast amount of data can be processed at lighting speed. However, this requires better data storage capabilities (Meghana et al., 2018). Thus, ERP solutions are not only necessary but also mandatory because of factors such as customer disloyalty, globalization, and uncertainty (Shukla *et al.,* 2012). In the field of information technology (IT), cloud computing has gained great importance in the last decade (Keshwani and Sharma, 2013). Therefore, ERP or cloud ERP (CERP) could be one of the areas of IT that is growing exponentially (AlBar & Hoque, 2017), thus generating an increasing trend among firms of moving their ERP-based applications and databases into the cloud (Peng and Gala, 2014). CERP is an affordable alternative to traditional ERPs, which makes it highly advantageous for firms to adopt these systems (Moh'd Anwer, 2019).

Despite the apparent firm-level benefits of implementing connected technology in its business processes, 60 % of firms tend to fail in the implementation stage, which can be costly, while only 26 % of organizations manage to implement CERP such that they obtain a higher return on investment and profit by increasing customer satisfaction, efficiency, and quality (Shim *et al.,* 2019). According to Kauffman and Li (2005), adopting the right technology at the right time becomes a challenging issue that many managers must face directly if they are to exhibit effective decision-making on behalf of their firms. Further, if the implementation of a CERP system is not properly developed and, therefore, the results obtained are not as expected, then the benefits of adopting such a system have not demonstrated, which makes the investment appear to be riskier than normal for future firms (Skarzauskiene & Kalinauskas, 2012). This makes the investment in CERP systems both attractive and fraught with uncertainty.

According to Lankton and Luft (2008), "a deferral option exists when decision-makers can choose between investing in a new project immediately and deferring the decision until uncertainties about the investment's value are resolved (p. 2010)". Therefore, deferring the investment involved in incorporating a technology as a means of firm adaptation to the demands of its business environment implies important repercussions in regard to its business strategy. Firms often choose to defer an irreversible investment to maintain valuable managerial flexibility in an uncertain environment (Kauffman & Li, 2005). This would mean that in the midst of an era of change and the digitalization of organizations, a firm takes some time to implement some digital technologies that others are already exploiting and have been gaining experience in for years. In short, a CERP system is not a system over which a firm has exclusive use, since it is open to any firm in a way that is personalized to its capabilities and needs. However, making either of these two decisions involves a cost. Therefore, more information is needed about how to make the proper decision at the right time.

From a business perspective, "most of the firms do not use financial hedging due to a lack of knowledge and experience" (Pellegrino *et al.,* 2019; pp. 119). However, real options, implemented through a binomial option pricing model, have been shown to be both feasible and accurate (Cox *et al.,* 1979; Lander & Pinches, 1998). Therefore, a project embeds a real option when it offers management the opportunity to take some future actions (e.g., abandoning, deferring, or scaling up the project) in response to events occurring within the firm and within its business environment (Benaroch & Kauffman, 1999, p. 70). In this sense, an assessment with real options can be a valuable tool when deciding whether to invest in digital technology. Real options provide additional strategic information that assists senior management in decision-making. Therefore, a real options valuation can be key to reaping the benefits of CERP by providing information on the most opportune implementation time while remaining aware of the downsides of digital technology.

In this sense, this study is an attempt to shed light on the integration of financial and strategic information when assessing digital technology investment to reduce uncertainty in supply chain finance. To do so, this work attempts to answer the following questions:

1. How do the specific conditions of digital business transformation affect the decision-making process in the evaluation of a new project with these characteristics?
2. What impact has the real options methodology implementation previously made in digital transformation project investment assessments?
3. From the perspective of digital technology, when it is possible to delay the investment over time to wait for better conditions or to further evaluate the impact of its adoption, how does the level of project risk impact its value?

Overall, this study demonstrates that the specific risk of digital business transformation can be captured by the application of complementary models to financial assessment models. In this sense, we treat uncertainty as strategic flexibility that could add value to the project. In addition, this study enriches the ongoing development of a systematic framework for applying the real options methodology as a strategic tool whose potential benefit lies in its strategic application.

Development of CERP in Business

The current society is facing a change in the way that technology is understood that implies a greater shift. There are an increasing number of devices connected to the internet that seek to provide relevant information about any activity, both for individuals (e.g., sports monitoring or home control) and for organizations (e.g., social networks, inventory control or traceability). In this sense, firms exploit the technologies on the market to offer them to their customers while themselves utilizing them to carry out their activities in a better way (Culey *et al.,* 2020).

Although these technologies provide a differentiating value and are aimed at generating primary information or better methods for developing businesses, cloud systems, the IoT and predictive analytics, as these are the technologies that have aroused the most interest in the business and research world (Ardolino *et al.,* 2018). First, the IoT is the principal technology for identifying information through different devices or sensors (Ceipek *et al.,* 2021). Second, the cloud system manages to store the information provided by the IoT (Gebhard *et al.,* 2021), and finally, that information is used and interpreted by means of predictive analytics technology relying on algorithms (Ardolino *et al.,* 2018).

The most common firm goals in the firm-level implementation of these technologies are enabling monitoring, increasing capacity, maintaining autonomy, and enhancing flexibility (Moeuf *et al.,* 2018), given the presence of means and sources that subsequently generate a higher level of activity-specific information. Specifically, according to Raymond (2005), out of 118 Canadian SMEs implemented advanced manufacturing technologies, most agreed that these practices serve to reduce their operating costs and production times and increase their quality and productivity. In short, these are technologies that are in full implementation and that facilitate new methods of interaction with the environment and new ways of thinking in the face of different information (Tarabasz, 2016). This provides more efficient customer solutions and production systems to the firm (Del Giudice, 2016). This, in turn, boosts competitive advantage in the face of the accelerated innovation cycle that society is currently undergoing while maintaining a certain balance between innovation and the available human and technical capacity (Usai *et al.,* 2021).

All of this can be considered the result of the positive synergy generated by data engineering and human capital, which has generated incremental learning in this field and is a requirement for the future development of the firm (Tervonen *et al.,* 2018). At this point, about the focus shifts to collective intelligence (Maciuliene, 2014), which is an intelligence that arises from society for the provisioning of greater benefits to society itself. This involves both the private and public sectors and progresses through the course of research into more optimized technologies, pro-privacy legislation, and aid to encourage the modernization of infrastructure for small firms or alliances among large firms (Ghaffari *et al.,* 2019). The contribution of intelligence that Industry 4.0 generates for society is undeniable, given its ability to solve problems by providing a more objective and intelligent solution.

The cloud system stores the information provided by IoT devices and curates it for the user to facilitate decision-making through the contribution of knowledge. The traditional ERP system is in a transition process aimed at making a place for itself in Industry 4.0, so it is already in the initial phase of incorporation. This is due to the combination of this system with the IoT and the cloud system, which has allowed a faster response to the customer, as well as a significant increase in productivity and decision-making (Manavalan & Jayakrishna *et al.,* 2019).

CERP refers to the use of computer resources over a network. They are enterprise-wide information systems packages that contain a comprehensive set of software modules, which are aimed at integrating the key logistics in business processes across various functional firm departments by using a single data repository (Rezaei et al., 2016). Therefore, ERP software, when implemented in a cloud environment, becomes CERP (Meghana *et al.,* 2018). The implementation cost of CERP is lower than that of ERP, and the flexibility of clouds ensures a firm competitive advantage (Moh'd Anwer, 2019). In addition, its potential increases when big data technology is combined with CERP (Gupta *et al.,* 2019). In short, 28 % of investment in IT by firms is allocated to cloud storage systems (Chang et al., 2019), and the transition from traditional ERP to CERP is becoming increasingly evident.

The short-term goal is to create a digital ecosystem involving all the members of the supply chain to improve operations (e.g., supply, timing, and demand forecasts and achieve greater transparency and reduced costs (Banerjee, 2018). Achieving this goal, however, requires appropriate investment. On a more technical level of this technology, depending on the type of cloud system hosting adopted by the customer firm, two different types of clouds can arise. On the one hand, public clouds allow organizations to access contracted services over the internet without the need for owning advanced technological equipment or software, as well as reducing costs, risks of obsolescence and maintenance needs (Chang *et al.,* 2019). This is the most common option for adapting ERP software because it shares services and infrastructure through an external provider (Chen *et al.,* 2017), although it poses a risk to privacy and security (Chang & Hsu, 2019). On the other hand, private clouds require an investment in infrastructure because they are hosted in the firm itself. They are accessed through an intranet and are more expensive, but they offer greater peace of mind in terms of security (Chang *et al.,* 2019). Because of this greater security, providers offer this option as an alternative to the public cloud (Chen *et al.,* 2017).

The proper performance and interpretation of cloud storage technology requires the consideration of various factors. Only 13 % of companies correctly implement a CERP system in their business, and 60 % achieve integration, although late (Mahmood *et al.,* 2019). As a result, only 37 % of firms see a smaller return than foreseen on their investment. Therefore, top management can be considered key, as they guide and shape the business culture by carrying out practices that favor the incorporation of new ERP technology. The potential workers who will engage with such as system have to be trained, and fluid communication with management has to be maintained.

The benefits of CERP have been widely studied in the literature. According to Rezaei et al. (2016), the main benefits of adopting CERPs generally include better communication, better access to market information, more efficient coordination, and enhanced collaboration among firms within the supply chain. This is possible because these systems enable the execution of data transactions along value chains, thus helping to disseminate information among departments and among other firms (Salum & Rozan, 2016). This indicates that CERP systems are capable of managing and handling the large volume of operations and information that is created daily within firms (Beheshti, 2006).

Some research has acknowledged the capacity of CERPs to improve cost, flexibility, and agility (Alharbi *et al.,* 2016; Rezaei *et al.,* 2016), to provide better information scalability, reliability, and availability (Gupta *et al.,* 2019), to improve operational process efficiency (Jain and Sharma, 2016), and even to obtain a better understanding of market situations (AlBar & Hoque, 2017; Moh'd Anwer, 2019). Moreover, firms can access advanced computing resources virtually rather than physically (Gangwar *et al.,* 2015). However, if the user cannot access the ERP system without any interruption, then it does not serve its purpose (Awa *et al.,* 2017; Meghana *et al.,* 2018). This reinforces the importance of accessibility not only within firms but also along the supply chain. Thus, an effective CERP is one that provides the valuable interaction of cross-functional operations and the real-time integration of business operations (Yu *et al.,* 2018).

CERP adoption has revolutionized the global business environment due to the development of accessible technological innovations, enhancements, and resources (Balina *et al.,* 2017). However, firms may not be confident in adopting a CERP due to the novel nature of cloud-based applications (Lian, 2005). In this sense, the sunk costs of incumbent ERP systems and the uncertainty costs of new CERP systems might influence a firm toward adopting an on-premises ERP system (Lian *et al.,* 2014). This dynamic has caused some concern and driven a hesitation to adopt this technology despite its wide benefits (Gupta *et al.,* 2018).

The factors influencing cloud ERP adoption vary from industry to industry based on the size of the organization and the type of industry (Meghana *et al.,* 2018). In addition, many firms recognize that CERP implementation is a costly process, and that those costs increase in proportion to firm size (Moh'd Anwer, 2019). Therefore, it may be difficult for the top managers and owners of firms to determine which factors will benefit and which will negatively impact their firms (Chang, 2020).

The literature has shown diverse factors that influence the decision to invest in CERP (see Table 1). In this sense, Chang et al. (2019) determined that the quality of the system and the information that it provides are the main generators of net benefit, as greater benefit is perceived through the capacity to solve more problems. However, the main challenge that these companies face is a security risk. Chang and Hsu (2019) compared the main benefits and risks faced by firms that implement CERP, both of which are considered decisive implementation factors. They conclude that the benefits (ease of use and usability) are inversely related to the risks (privacy and security), since the greater this benefit, the less consideration that those costs will receive. In addition, to mitigate the risks, the users feeling of control over the software and the trust placed in the provider, as well as the offered cost, can be decisive factors.

Table 1

Factors that Condition CERP Investment

Factor conditioning the investment	Chan et al. (2019)	Chang and Hsu (2019)	Meghan et al. (2018)	Cheng (2018)	Gupta and Misra (2016)	Peng et al. (2014)
System quality	X			X		X
Information quality	X			X		
Ease of use	X	X	X	X		
Security	X	X	X	X	X	X
Satisfaction	X	X		X		
Width	X	X		X		
Control		X		X	X	
Accessibility			X			
Functionality			X		X	
Information retrieval			X			

Factor conditioning the investment	Chan et al. (2019)	Chang and Hsu (2019)	Meghan et al. (2018)	Cheng (2018)	Gupta and Misra (2016)	Peng et al. (2014)
Compatibility				X	X	X
Flexibility			X			X
Implementation			X			
Maintenance			X			X
Supplier		X	X		X	X
Cost		X	X		X	X

Source: Author's elaboration

The greater the frequency with which research was conducted, the more factors that were detected. On the one hand, Meghana et al. (2018) added five more factors. The first of these relates to ease of use, which implies the accessibility of the data to operators with functional disabilities, the familiarity of all operators with the system, and the ease of understanding of its use, backup, and accessibility, among other characteristics. The second is the generation of information backups and the provisioning of maintenance and of and risk-free and reliable software so that the CERP system operates properly. The third concerns the importance of flexibility, that is, the capacity of the supplier to adapt to the technical requirements of each firm and to provide flexibility for future software changes and system data integration. The fourth directly involves of the security and privacy of the hosted and stored information in case of lost data. Finally, the cost and postsale service are revealed. On the other hand, Cheng (2018) put special emphasis on ease of use and the feeling of improved performance derived from use. Conversely, a poor experience in adopting this technology can negatively affect its ratings, and this can lead to lower performance. Another factor involving some concern for employees is related to the system's compatibility with other applications. In summary, the quality of the information itself and the handling of the system (usability, security, satisfaction, and scope of application) are important, as is its compatibility with the firm's traditional systems.

Gupta and Misra (2016) show the need to involve potential users of the technology (e.g., the respective workers in each area) in its implementation. In their study, a reengineering of the traditional processes and their implementation was carried out with continuous and clear support throughout the entire implementation process. In this case, the factors of platform stability (high power or a low number of failures), its compatibility and its capacity to migrate data to other platforms, the level of confidence in the supplier, the system's cost, and the system's platform security are the main factors. However, Chao et al. (2014) highlighted of the fact that incompatibility with other firm systems can create a dependence on the supplier. In addition, security and information migration (compatibility) are two other essential factors. Finally, another factor considered by the firm in decision making is the system's ease of use, which highlights the importance of intended system operators being properly trained. These are factors that imply a meditated decision, and information on these factors can even be shared with the ERP system auditors so that they can advise the firm on how to implement the system in a way that best suits its needs and capabilities (Gupta & Misra, 2016).

Security is the main concern of both large and small and medium-sized firms when implementing the CERP because the cloud contains confidential information that could affect the firm competitiveness. However, this is not the only factor that managers consider prior to making such an investment. Among them, factors such as the supplier and system compatibility are also important in the event of future changes of the software provider.

Accordingly, investing in CERP becomes a necessity despite certain barriers. The implementation of this technology in most firms can produce great changes and can lead to an improvement in overall firm efficiency. Therefore, the decision to invest in a CERP system should be made in the present moment rather than deferred. However, the deferral option is considered the best option for CERP implementation for three main reasons. First, it allows managers to wait for the best moment to carry out the implementation given the strategic value of each decision. Second, it allows firms to search for other alternatives if they have no time to follow the deferral option. It provides an option for reacting to changes when conditions are not favorable. This enables a firm to adapt to environmental needs as quickly as possible. Third, implementation deferral helps managers configure the deployment of diverse resources and capabilities to complement the development of digitalization.

The Valuation of CERP Projects Using Real Options. An Empirical Application

The traditional method that has most commonly been used to assess investment projects is the net present value (NPV) method. However, this method fails to consider important elements such as the level of volatility in the market where the firm operates or the intrinsic characteristics of the technology itself (e.g., performance, obsolescence, and adaptability). In this sense, real options appear to be a complementary tool that enables the value of the strategic aspects of this kind of investment project to be captured. As a result, a large body of research has emerged around real options. One of the first studies on real options was developed by Black and Scholes (1973), in which they provide an explicit definition and assimilate that definition into a call option. Subsequently, Cox et al. (1979) used the binomial option pricing formula while considering the upward and downward probabilities. This model reinforces the idea of simplicity, as it requires basic mathematics. Similarly, Smith and Nau (1995) recognized that option pricing techniques could be used to simplify decision analyses when some of the risk can be hedged by trading. In addition, the authors also contemplate how decision analysis techniques can be used to extend option pricing techniques to address problems with incomplete securities markets. Later, other approaches were introduced, such as the use of least squares to estimate the conditional expected payoff for the option holder from continuation (Longstaff & Schwartz, 2001) and the introduction of a binomial decision tree for approximating the uncertainty associated with the changes in project value over time (Brandao *et al.,* 2005). In a similar manner, Smith (2005) proposes alternative approaches that rely entirely on risk-neutral valuation and modelling of the uncertainties. More recently, Sinkala and Nkalashe (2015) developed an extension of the Black-Scholes model when liquidity is incorporated into the market, while Carbonara et al. (2018) assessed the value of postponement as a strategy for mitigating disruptions.

Real options are a very useful financial tool for assessing the investment in emerging IT, which is characterized by high volatility, given that they consider the various scenarios in which such a project could be used in the future. Real options allow the quantitative value of the strategy to be assessed. Thus, the proper interpretation of this indicator is a crucial factor when analyzing whether or not to invest in a CERP system. Lankton and Luft (2008) argued that for managers considering IT investment, the relevance of real options increases as the uncertainty of the project increases.

Real options methodology is commonly used in the literature to assess and justify investments in technology projects (Benaroch & Kauffman, 1999; Kauffman & Li, 2005; McGrath & MacMillan, 2000; Lee & Lee, 2015; van Bekkum *et al.,* 2009; Amram & Kulatilaka, 1999).

Real option implementation helps to make more informed decisions by enabling the estimation and anticipation of future trends (Cowan & Daim, 2011). They "provide a guide for the optimal moment for investment at the same time that optimizes future performance" (Sanchez Perez *et al.,* 2021). In this way, real options are used to "assess the management's ability to wait and to revise the initial operating strategy if future events turn out to be different from originally predicted" (Lander, D.M.; Pinches, 1998). This means that managers are flexible in reacting to uncertainties to take advantage of upside outcomes and avoid downside outcomes by revising their investment strategy (Favato & Vecchiato, 2017).

The economic benefit realized from digitalization is not always easy to calculate. Adner and Levinthal (2004) state that real option methodology should be applied if an investment project has a high level of sunk cost and is highly uncertain. Thus, in digital business transformation investment, where the level of uncertainty is high, real options have an important advantage in risk treatment over traditional methods, namely, the incorporation of uncertainty as a strategic value adding element (Dixit & Pindyck, 1998; Schneider and Imai, 2009; Tarifa-Fernandez *et al.,* 2019). It is necessary to highlight that this strategic value may represent a substantial portion of the project value in many projects (Schwartz & Trigeorgis, 2008).

Two of the most common models for IT valuation are the binomial option pricing model and the Black-Scholes model. On the one hand, Chen et al. (2009) assessed the implementation of an ERP project using the binomial option pricing model. The authors stated that this method can help IT managers produce a well-structured valuation process in IT investment decision-making, as it recognizes the interactions between IT risks and option value in a clear way. On the other hand, while Benaroch and Kauffman (1999) presented the first application of the Black-Scholes model that used a real-world business situation involving IT for testing, Benaroch et al. (2006), following the same model, identified the conditions under which the degree of overvaluation might be severe and unpredictable.

The option to defer is chosen as a form of nonimmediate acceptance of the investment and the postponement if its enactment to a more favorable time (Mascarenas, 2018). This analysis is interesting because it reflects the need of firms need to wait before investing in a CERP system. In this way, the project is carried out when it provides the highest possible value (Kauffman & Li, 2005). For instance, the option to defer is a decisive one for those projects that can be implemented at a reduced cost in the future. When the project value increases as a result of deferment, then the amount of that increase represents the value of deferral.

In this study, the binomial option pricing model is used as the main methodology for assessing the value of a project, including assessing the deferment option. that the fact that changes in revenue expectations occur as time passes is considered (Benaroch & Kauffman, 1999). This method was initially employed to assess financial options under the assumption advanced by some authors, such as Damodaran (2002) and Mascararenas (2007), who proposed that managing real options should be similar to managing financial options because of the similarity between real and financial options. In this sense, the option to defer can be treated as a call option because both instruments represent the right (but not the obligation) to purchase an underlying asset at a future date. The main difference between both instruments is that the option to defer is associated with real assets, and the call option is associated with financial assets (Cruz Rambaud & Sanchez Perez, 2019). In the same way, it should be noted that "options involving real technology choices and strategies are generally much more complex than simple financial options in stock market. These complexities may not allow one to find exact valuation model" (Kim *et al.,* 2009, p. 191). Although the practical implementation of valuing real options is very complex and presents several challenges (De Neufville *et al.,* 2006; Lander & Pinches, 1998), the binomial option pricing model is a very intuitive model whose parameters and the evolution of those parameters over time can be adapted to different scenarios, making it attractive for implementation in business practices, as managers are generally interested in simple and easy-to-use models (Benaroch & Kauffman, 1999). Additionally, it has been recognized as a worthwhile model to use for assessing emerging technology investments, as it poses a special challenge for forecasting value payoffs in the face of uncertain costs, adoption, and diffusion (Benaroch & Kauffman, 1999).

The Collection and Processing of Information

To illustrate how real options can be applied to assess digital technologies, the evaluation of ERP projects has been carried out by using real data on the costs and revenue of investing in CERP taken from the survey conducted by Panorama Consulting Solutions (2018). This survey uses a total of 237 valid responses from companies in North America (91 %), Europe (7 %) and Asia (2 %), whose activity areas are as follows: 43 % manufacturing, 11 % retail and distribution, 11 % finance, real estate, and insurance, 10 % information technology, 6 % professional services, 5 % nonprofit, 3 % education, 3 % construction, 3 % health care, 3 % others and 2 % telecommunications. The Panorama Consulting Solutions (2018) report shows that there is a high growth in the implementation of ERP in the entire supply chain by industries in both the service sector and the public sector.

The analysis of the real option implementation requires the following information: the average revenue of the surveyed companies, the ERP investment and the firm's return on investment. In addition, to complete the information required to carry out the financial valuation using the option to defer, the risk-free interest rate, the success and failure rate of the system's implementation and the upward and downward coefficients are also necessary. Details on how to obtain this information are discussed in the following sections.

The Average Revenue of the Surveyed Companies

Table 2 shows how the total annual revenue is calculated. On the one hand, the information in Columns 1 and 3 are extracted directly from the report by Panorama Consulting Solutions (2018, p. 6). On the other hand, the treatment of this information is shown in Columns 2 and 4. Specifically, the second column shows the median of the revenue range proposed by the report. The fourth column shows the median of each range multiplied by its corresponding percentage of companies, so the sum of all the values in the fourth column reflects the average aggregated revenue of all the companies surveyed.

Table 2

Average Revenue of the Surveyed Companies

Revenue range (million dollars)	Median range (million dollars)	Percentage of companies	Median range x percentage of companies
1–25	13	2	0.26
25–50	37.5	13	4.875
50–300	175	40	70
300–500	400	29	116
500–1,000	750	12	84
1,000–5,000	3,000	2	60
Más de 5,000	5,000	2	100
	$435,135,000		

Source: Author's elaboration based on Panorama Consulting Solutions (2018).

Investment in ERP as a Percentage of Total Revenue

The report also provides the percentage of annual revenue that the companies in the sample have invested in the total ERP project, where "it is not uncommon for the total cost of the project to exceed four percent of annual revenue depending on the type of ERP implementation" (Panorama Consulting Solutions, 2018, pp. 7)

In Table 3, Columns 1 and 3 reflect the data extracted directly from Panorama Consulting Solutions (2018, pp. 7) and Columns 2 and 4 display the processing to obtain the investment in ERP as a percentage of total revenue. Therefore, the sum of the fourth column shows the average percentage that the sample companies have invested in ERP over their total income, which is 1.225 %. Once this percentage has been obtained, it is multiplied by the total average annual income (whose calculation is shown in Table 1), resulting in $5,330,403.75, which is the average ERP.

Table 3

Percentage of Total Revenue Devoted to ERP

Investment range (%)	Median range (%)	Percentage of companies	Median range x percentage of companies
Less than 0.5	0.5	44	0.0022
0.5–1	0.75	14	0.00105
1–2	1.5	26	0.0039
2–3	2.5	10	0.0025
3–5	4	4	0.0016
More than 5	5	2	0.0010
			1.225%

Source: Author's elaboration from Panorama Consulting Solutions (2018).

Return on Investment in ERP

Finally, Panorama Consulting Solutions (2018, pp .27) indicates the return on investment in years through the payback value. Specifically, the payback collects, in terms of time, information on the greater revenues that are due to the implementation of the ERP systems. Table 4 shows the data extracted directly from the report (Columns 1 and 2), as well as the treatment of the information to adjust it to the present analysis (Column 3).

The third column shows the product between the timeline to recoup costs and the percentage of companies that correspond to these periods. In this case, it should be noted that only 97 % of the data can be used, as the remaining 3 % obtained a "does not know or does not answer" response in the survey. Thus, as a result, we find that the average timeline for recouping CERP investment costs is 2.89 years.

Starting from the formula of the static payback (Investment/cash flow per period), and having the information regarding the average time of recovery of the investment (2.89 years) and the cost of the investment ($5,330,403.75), the variable "cash flow per period" can be solved:

$$Payback = \frac{Investment}{Cash\ flow\ per\ period}; \quad (1)$$
$$2.89 = \frac{5{,}330{,}403.75}{Cash\ flow\ per\ period};$$
$$Cash\ flow\ per\ period = \$1{,}840{,}032.61.$$

As this value is the cash flow arising from the project for one year, in the third year when the investment has already been recovered (assuming that income is linear), the accumulated cash flow value is $5,520,097.83.

In this way, given that the sum of the flows in a three-year period and the investment cost are known, the net present value can be calculated as the difference between these values, which is $ 189,694.08.

Table 4

Average Timeline to Recoup ERP Investment Costs

Timeline to recoup costs (years)	Percentage of companies	(Timeline to recoup costs x percentage of companies)/97
Less than 1	4	0.04
2	24	0.48
3	50	1.5
4	16	0.64
More than 5	3	0.15
		2.8969 years

Source: Author's elaboration from Panorama Consulting Solutions (2018).

Risk-Free Interest Rate

The employed risk-free interest rate used for reference is the yield of the 3-year US bond as of December 2018, so that it is consistent with the information in the report, which also dates from 2018. The yield for that date is 2.459%, and the nomenclature employed to identify it is r_f.

Success and Failure Probability

From the ERP report of Panorama Consulting Solutions (2018, pp. 35), 42% (p) of the companies in the sample consider their investment in the project successful, compared to 58% (q) that have not implemented it as planned and therefore have not obtained the expected results. In the same way, as the upward and downward coefficients, the success and failure probability are variables that depend on project uncertainty.

Upward and Downward Coefficients

The value of u is calculated from the success probability formula. The first part of Equation 2 is used to find the value of p (probability of success). However, this value has already been provided in the Panorama Consulting report (2018); thus, given the risk-free rate, the unknown variable of the equation is u (upward coefficient):

$$p = \frac{1 + r_f - d}{u - d}; p = \frac{1 + r_f - \frac{1}{u}}{u - \frac{1}{u}}; 42\% = \frac{1 + 2.459\% - \frac{1}{u}}{u - \frac{1}{u}}, \tag{2}$$

from which it derives d (downward coefficient):

$$d = 1/u.$$

After solving u from Equation 2, we obtain two possible results (u_1 = 1.4104 and u_2 = 0.8667). Since the upward coefficient takes place in a positive scenario, its value should be greater than 1. Therefore, the final result of the coefficient upwards, u, is 1.4104. Finally, if we apply $d = 1/u$ to obtain the coefficient downwards, we obtain the result of 0.7090.

Next, Table 5 shows a summary of the parameters obtained to facilitate the calculation of the option value. Specifically, the parameter, its meaning and its calculated value are set out, as well as the source of the information and whether these data needed processing or whether the original data from the report are used. In this last column, in brackets, you may find the section in which the processing of the valuation variables is carried out.

Table 5

Summary of the Necessary Parameters for Calculating the Value of the Deferment Option

Parameter	Meaning	Value	Source	Treatment and section
A0	Initial investment	\$5,330,403.75	Panorama Consulting (2018)	YES (2)
A3	3 years discounted initial investment	\$5,733,376.27	Panorama Consulting (2018)	YES (2)
VA	Year 3 cash flows	\$5,520,097.83	Panorama Consulting (2018)	YES (3)
VAN	*VA* – *A*0	\$189,694.08	Panorama Consulting (2018)	YES (3)
rf	Risk-free interest rate	2.459%	Investing	NO (4)
p	Success probability	42%	Panorama Consulting (2018)	NO (5)
q	Failure probability	58%	Panorama Consulting (2018)	NO (5)
u	Upward coefficient	1.4104	Panorama Consulting (2018)	YES (6)
d	Downward coefficient	0.7090	Panorama Consulting (2018)	YES (6)

Source: Author's elaboration.

Calculation of the Option Value

ERP technology is characterized by a high level of uncertainty given the large number of variables on which its success is based. To be prepared, organizations should consider the evolution of every variable, and the implementation of real options in the project assessment is a possible solution.

Evolution of Value

First, once the necessary data for the application of the option have been obtained, we calculate the project value evolution depending on the different scenarios. To do this, the binomial method is used. Figure 1 shows how the present value of the flows that would be perceived directly from the ERP investment is expected to evolve and their probability of occurrence. To clarify, it should be noted that by following a binomial distribution, the probability of occurrence of each scenario is 45 % for the successful scenario (p) and 55 % for the unsuccessful scenario (q) (Panorama Consulting Solutions, 2018).

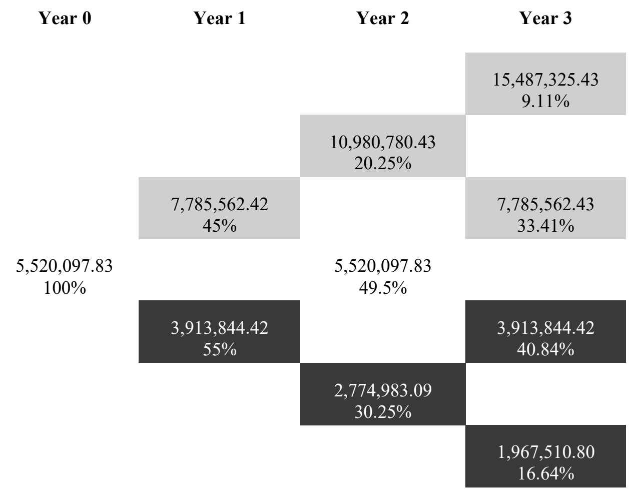

Figure 1. Present Value Evolution Using the Binomial Model

Source: Author's elaboration.

Next, the binomial trees for years 0, 1, 2 and 3 are analyzed briefly:

- Year 0: Starting from the present value of the cash flows ($5,520,097.83), the next step is calculating the possible scenarios in year 1.
- Year 1: To calculate the upward scenario, it is necessary to multiply the upward coefficient by the value of the cash flows in year 0 (see Figure 2). In this way, we can see that there is a 45 % probability that it increases by 41.04 % and a 55 % probability that it decreases by 29.1 %.

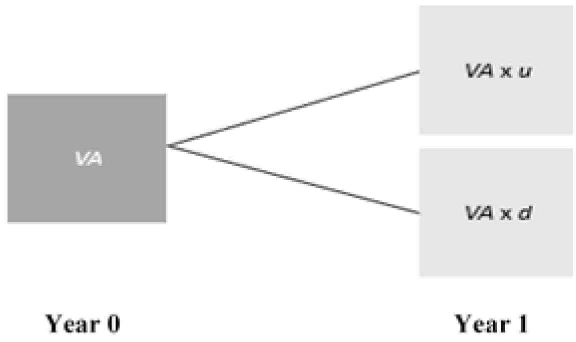

Figure 2. One-Year Evolution by the Binomial Method

Source: Author's elaboration.

- Year 2: In this year, there are three possible scenarios (Figure 3), although belonging to a scenario in year 1 only allows for two possible scenarios in year 2. In other words, in the event of finding the positive scenario in year 1 (with a value of flows of $7,785,562.42), in year 2 there can be either an upward scenario with a value of $10,980,780.43 or a downward scenario with the value that the flows had in year 0 ($5,520,097.83). As in year 1, to calculate flows, it is necessary to make the product of the corresponding scenario in *n*-1 by the upward (*u*) or downward *(d*) coefficient. In this way, we can see how there is a 20.25 % probability that their amount will increase and a 30.25 % probability that it will decrease. In addition, there is a 49.5 % probability that the flow will maintain its value in year 0.

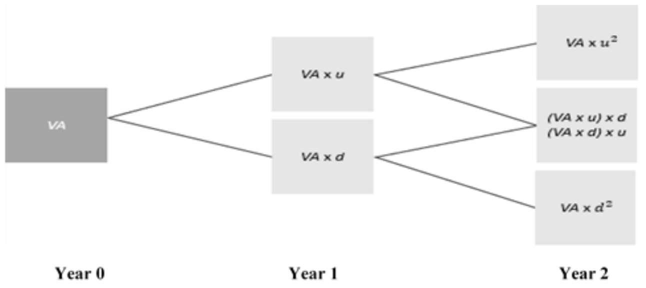

Figure 3. Two-Year Evolution by the Binomial Method

Source: Author's elaboration.

- Year 3: Finally, for this year, there are four possible scenarios (see Figure 4), and the procedure for calculating them is the same as that used to calculate the value of the flows in year 2. Thus, we can see that there is a 9.11 % probability that the positive scenario will increase and a 33.41 % probability that it will decrease. Thus, there is a 40.84 % probability that the negative scenario will increase and a 16.64 % probability that it will decrease.

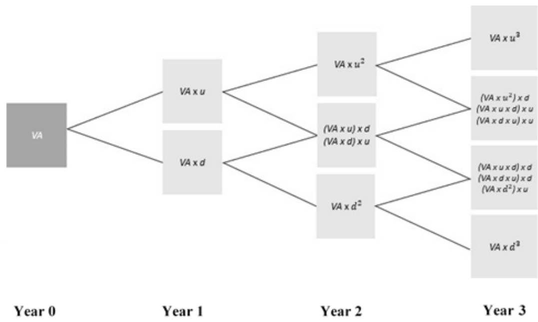

Figure 4. Three-Year Evolution According to the Binomial Method

Source: Author's elaboration.

Calculation of the Project Value with the Option to Defer

After obtaining the evolution of the flows, the value of the project is calculated considering the value of the three-year deferment option (see Figure 5). The procedure starts in the year in which the investment is to be deferred (in this case, year 3). The value has to be calculated in the 4 scenarios that are relevant at this point in the timeline. This value has a maximum of between 0 and the difference between the value of the flows and the disbursement of the capitalized investment to year 3 (A_3), as we can see in Equation 3:

$$Max(VA_{3n} - A_3; 0) \qquad (3)$$

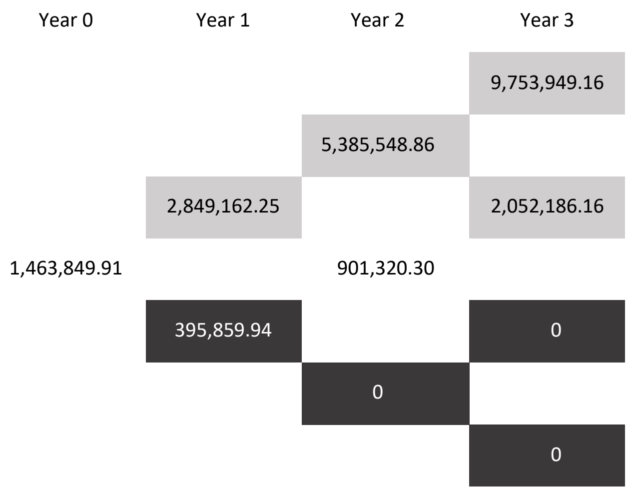

Figure 5. CERP project value with the option to be deferred calculated using the binomial method

Source: Author's elaboration.

By applying Equation 3, the results for year 3 are next:

- VA_{31}: Max (15.487.325.43-5.733.376,27; 0) = 9.753.949,16
- VA_{32}: Max (7.785.562,43-5.733.376,27; 0) = 2.052.186,16
- VA_{33}: Max (3.913.844,42-5.733.376,27; 0) = 0
- VA_{34}: Max (1.967.510,80-5.733.376,27; 0) = 0

The next step is to calculate the option value in the years before the set deferral. To do so, it is necessary to solve Equation 4:

$$\frac{Max(VA_{3n} - A_3)p + Max(VA_{3n+1} - A_3)q}{(1 + r_f)} \quad (4)$$

By applying Equation (4), the results of years 2, 1 and 0 are:

- $VA_{21}: \frac{9{,}753{,}949.16 \text{ x } 0.45 + 2{,}052{,}186.16 \text{ x } 0.55}{(1+0.02459)} = 5{,}385{,}548.86$
- $VA_{22}: \frac{2{,}052{,}186.16 \text{ x } 0.45 + 0 \text{ x } 0.55}{(1+0.02459)} = 901{,}320.30$
- $VA_{23}: \frac{0 \text{ x } 0.45 + 0 \text{ x } 0.55}{(1+0.02459)} = 0$
- $VA_{11}: \frac{5.385.548{,}86 \text{ x } 0{,}45 + 901.320{,}30 \text{ x } 0{,}55}{(1+0{,}02459)} = 2{,}849{,}162.25$
- $VA_{12}: \frac{901{,}320.30 \text{ x } 0.45 + 0 \text{ x } 0.55}{(1+0.02459)} = 395{,}859.94$
- $VA_0: \frac{2{,}849{,}162.25 \text{ x } 0.45 + 395{,}859.94 \text{ x } 0.55}{(1+0.02459)} = 1{,}463{,}849.91$

The last result, i.e., $1,463,849.91, represents the average value of an ERP project with the option to defer for three years. To summarize, the data obtained from the above calculations are shown in Table 8.

Table 6

Summary of the Results

Subject of study	Value without the option	Value with the option	Real option value
An ERP project with the option to be deferred 3 years	$189,694.08	$1,463,849.91	$1,274,155.83

Source: Author's elaboration.

Discussion and Conclusions

Industry 4.0 is increasingly being applied to business management. This enables greater and faster technological innovation, which serves to provide firms with technological solutions to enable better decision-making processes. However, the speed of this change can even pose a problem for those firms that implement the technology too soon, since the systems could become obsolete in a short period of time, forcing the firm to renew the system. Such renewals, depending on the conditions and types of systems involved, could indicate a dependency on the supplier in the event of issues with data migrations or incompatibilities in the systems, so this is not a desirable scenario. In addition, when managers evaluate new projects, they may face several choices beyond simply accepting or rejecting the investment. These include delaying decisions until the market conditions are more favorable or deciding to start small and expanding later if the initial results are good (Kim *et al.,* 2009). The information generated by ERP systems, and the potential information that could be obtained through them, covers a wide range of sources that enable the firm to make decisions more complete and therefore face less risk by finding a scenario with less uncertainty. This improves the flow of financial information through the supply chain. In this way, both suppliers and customers are able to obtain reliable information in real time regarding firm requirements.

The decision to invest in a CERP is influenced by a large number of variables pertaining to the optimal development of the personnel responsible for operating the new ERP technology. These variables range from investment factors such as security and the desired levels of control, cost, and compatibility to the implementation process and the path to normal development after implementation. In this sense, the decisive elements relate to the implementation of the system and its subsequent monitoring. In addition, the fact that the ERP system incorporates all decision-making areas of the firm and that any incident involving the system can pose a problem for the continuation of its activities. According to Kim et al. (2009), strategic technology choice is an extremely important determinant of a firm's competitiveness. Thus, having strategic flexibility and exploring strategic decision dimensions are proven to be important factors for improving a firm's value. Specifically, the use of real options makes the analysis and identification of the most valuable investment configuration easier by treating risk as operative flexibility (Benaroch, 2002). In this sense, real options have been recognized as an appropriate perspective from which to assess investment projects in technology under uncertainty and risk (Amram & Kulatilaka, 1999; Kauffman & Li, 2005).

The results of using the net present value (NPV) tool show that the investments in ERP would generate an average profit (average NPV) in the third year following the investment of $189,164.08 ($VA$-$A_0$), so from an a priori sense, the project seems economically viable. However, if we consider the possibility of deferring the investment for three years, the value of the project increases to $1,463,849.91. In other words, even though the implementation of the project is justified at the present time, it is preferable to follow the strategy of deferring the investment for three years. This is consistent with the claim of Benaroch and Kauffman (1999), who stated that many IT projects involve infrastructure and wait-and-see deployment opportunities as the firm learns more about its environment over time. This is because the risk of the project increases its value as the investment is delayed. Specifically, the value of the project with a three-year deferral option is 7.72 times the present value of the flows minus the investment (NPV method), assuming the value of the deferral option to be 87.04% of the total project value.

We start from the inverse relationship between the probability of ERP system implementation success (p) and its opportunity cost (i.e., as the probability of success decreases, the opportunity cost of investing at the current time increases compared to that of the deferral option). This is in line with Lankton and Luft (2008), who stated that as the higher that the uncertainty of the project is, the more that the expected value of the option to defer increases, which is consistent with the real options theory (Kumar, 1996). This is explained by the fact that higher likelihood of project failure, deferral becomes preferable pending better decision-making conditions, such as better information or a lower frequency of change. According to Chen et al. (2009), "a higher market risk means bigger fluctuations in market conditions. The real option valuation technique can capture valuable opportunities in case of favorable changes but cut off negative branches in case of pessimistic market conditions, to avoid possible losses" (p. 784). Therefore, despite being a traditional technology, its combination with the cloud system and its incorporation into Industry 4.0 make these investments in CERP technology very uncertain, which can generate great added value during a time when the investment can be unprofitable. In this way, it is necessary to highlight the fact that the uncertainty that surrounds digital business transformation projects is the cause of the high value of our focal real option, namely, the option to defer (Kim et al., 2009). Thus, deferral can resolve some of the uncertainties, given that "the greater the risk, the more learning that can take place and the more valuable the deferral option is. This is consistent with what the finance theory postulates about the effect of uncertainty on the value of financial options" (Benaroch, 2002, p. 10).

The real options tool can be very interesting, as it enables an evaluation of strategy, which is a parameter that is not offered by traditional financial valuation tools. Furthermore, its application in such a volatile and changing sector as the IT sector, considering all the advances that we've experienced in recent years the magnitude of these advancements, gives this methodology great value for managers considering investing in ERP system projects. The specific methodology employed in this paper to assess the real option, which is based on the binomial option pricing model, is a good alternative for evaluating projects that involve technologies. Despite the binomial model's conceptual simplicity, its flexibility allows the analyst to model more complex parameters as well as their evolution over time (Benaroch & Kauffman, 1999). In the same way, given that the binomial option pricing model is based on the NPV, whose parameters are familiar to managers, this model is transparent and clear, which is line with Amram and Kulatilaka (1999) and Benaroch et al. (2006), who claimed that the model's transparency and clarity are its most important features.

This paper provides, from a theoretical and practical perspective, a substantial advance in assessing the particular risks faced by a company undertaking digital transformation, specifically that of cloud-based ERP project methodologies. Currently, the implementation of digital technology raises ambivalent feelings since, on the one hand, its implementtation has a positive impact on variables such as performance, while on the other hand, its implementation is associated with high levels of uncertainty that are derived, in part, from a high degree of obsolescence. This puts managers under great pressure to make the best possible decision.

Uncertainty is considered the operational flexibility in a project, and the correct application of the real option model enables the exploitation of this flexibility so that the project can be carried out at the optimal time and possible losses in the case of less favorable scenarios can be avoided. Therefore, the real option deferral is a methodology that allows for dealing with the specific risk involved in those investments whose implementation timing plays a crucial role. The detection and use of this flexibility offers a high strategic value that may be quantified through the consideration and implementation of real options. In any project assessment, it is necessary to contemplate strategic value in a way that is complementary to financial value. Specifically, this methodology has the utmost importance in the case of highly uncertain projects.

Every firm's strategy involves, at some point, allocating resources to opportunities that may compete with each other. It is therefore crucial to know whether to invest now, to wait or to do nothing. Each of these options entails a set of benefits that are linked to subsequent decisions. In this sense, real options, and in particular the deferral option, provide crucial strategic information that goes beyond the financial nature of the decision. Therefore, this study, by analyzing the deferral option, contributes to the literature by presenting a systematic framework that can be used as a strategic tool whose potential lies in its strategic application.

Although some advantages and disadvantages of adopting CERP systems have been highlighted in this paper, there are other concerns regarding such implementation from the operational perspective. This is of particular interest since decisions about the implementation of any digital technology must be aligned with the general and specific objectives of the firm as well as being aligned the firm's resources and capabilities. Thus, what may appear a priori as a good investment option may entail implementation issues of an operational nature (e.g., system quality, ease of use, compatibility) that may affect the planned results. Considering these factors, the strategic importance of real options as a critical element for congruence between investment decisions and the operational implementation of the investment is highlighted in this study.

One limitation of this paper is that model implementation is conducted in the real world from a global perspective. It would be interesting for future studies to disaggregate this global perspective into different countries, regions and industries. In this way, the model implementation results could be studied and compared across different situations. In the same way, the model for assessing real options, specifically the model developed in this paper that is focused on the option to defer, could be applied to assess any digital technology decision that involves significant uncertainties.

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Authors' Biographies

José Miguel Lozano-Almansa received a bachelor's in management and business administration from the University of Almería (Spain). He also holds a Master's in Auditing from the University of Granada (Spain). His main interests include supply chain, financial operations, and public accounting.

Jorge Tarifa-Fernández is an Associate Professor of Operations Management at the University of Almería, Spain. His research is focused on supply chain management, digital technology, and equal opportunities. His research interest has mainly focused on supply chain integration and the development of strategic capabilities and has appeared in journals such as the International Journal of Logistic Management or Business Process Management Journal. He is also interested in digital technologies management and skill-biased technology. In addition, he is currently developing new approaches to the intersection between disability and employability to grow diversity in the workplace.

Ana María Sánchez-Pérez is an Associate Professor in the Department of Economy and Business of the University of Almería (Spain). Her research field is focused on the valuation of financial-random operations. The results of her research work are particularly noteworthy: the precise and manageable expressions that introduce the binomial method in the valuation of different real options. Likewise, the models developed have been applied to assess the value of the flexibility of projects framed in Industry 4.0. These contributions are published in scientific international journals with high impact, books, and international conferences.

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