Evaluation of Strategic IT Platform Investments

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ABSTRACT

Evaluation of strategic IT investments using traditional capital budgeting methods has proven problematic. This especially entails IT platform investments where the immediate short term benefits are not sufficient to justify the investment. At the same time the investment may entail substantial, although highly uncertain strategic future benefits for the firm, subject to different types of risk depending on the type of platform, the organisation involved and the industry environment. This paper presents a conceptual framework for classifying risks associated with major IT platform investments in the Architecture, Engineering and Construction (AEC) industry. It then discusses how a real options methodology can be used to extend the classical Discounted Cash Flow (DCF) approach to evaluate and manage the investment by modelling these risks and the associated strategic flexibility. A simple but powerful binomial lattice model is developed and the methodology illustrated in a realistic example involving an ERP investment.

Keywords

IT investments, evaluation, investment platforms, AEC

INTRODUCTION

The defining characteristic of platform investments is that a substantial part of the total value of the investment requires that follow-up investments be made (Amram and Kulatilaka, 1999). Investing in research and development (R&D) can be seen as the classic example of a platform investment in the sense that ongoing R&D, such as the development of a new pharmaceutical product, usually does not provide direct benefits to the firms in terms of cash flows. The value comes from products R&D releases for further development that may lead to marketable products (Amram and Kulatilaka, 1999). Many IT investments display similar characteristic. One example is an investment in an email system, which opposed to R&D may provide some immediate benefits, such as the ability to substitute email for other less efficient forms of communication. However, the real benefits of the email system are likely to come as its use spreads through the organisation and as other more sophisticated applications are added to the basic email platform (Kulatilaka et al., 1999). Renkema (2000) emphasises that "part of the difficulty with valuing IT infrastructure investments lies in its potential to not only improve current operations, but also more importantly, it has the potential to fuel (or prevent) innovation and provide competitive advantage for years to come" (Renkema, 2000 p.xvi).

This paper presents a dynamic evaluation approach that extends the passive DCF model by encompassing the insights and tools from Real Options Theory. This approach incorporates the value of the managerial flexibility that allows the investment manager to alter the investment strategy and take actions when new information becomes available. The model further deals explicitly with the different sources of risk affecting the value of the investment, and how this risk can be managed throughout the investment process.

RISKS ASSOCIATED WITH IT PLATFORM INVESTMENTS IN AEC

Before turning to the evaluation model, it is important to identify the major risks of this type of investments. The overall risk can typically be classified into the two categories project risk and market risk.

Project risk is composed of different elements of uncertainty that pertain to the investment at hand, but are unique to each investment and the firm making the investment. Dixit and Pindyck (1994) define technical or project risk as the uncertainty relating to the costs and likelihood of accomplishing technical success, which consequently can only be reduced through investment. These are risks that the investing company can manage to a certain degree through incremental investment and internal experts are usually the major sources of the data required to assess them. In an interview study with U.S. and Swedish contractors Svavarsson, Ekström et al. (2003) identified a number of project risks that are associated with large scale IT platform investments:

- **User adoption risk**: If the intended users inside the organisation are not willing to buy into the new business processes, it will be difficult to realize any of the benefits. This is especially true for users whose individual workload may increase as processes are shifted to them from other points in the system.
- **Interaction Risk** (or external user adoption risk): Important features of extensive IT platforms may also require interaction with external partners, such as architects, subcontractors, and material suppliers. The value of the benefits of this type of applications is therefore contingent on the extent to which these parties adopt the technology.
- **Technology risk** includes a multitude of different technical factors related directly to the operation of the system and its ability to provide the promised functionality. Several managers, for example, identified data migration between the old and the new systems as major potential hazard.
- **Vendor Risk** relates to the uncertainty of whether the system provider will be around in the future to provide service for the system. Large system providers may be in less danger of going bankrupt than smaller ones, but there may still be considerable uncertainty surrounding their promises to develop future applications that are industry specific. A buyer of a basic system platform can therefore not know for certain the applications that can be added in the future.

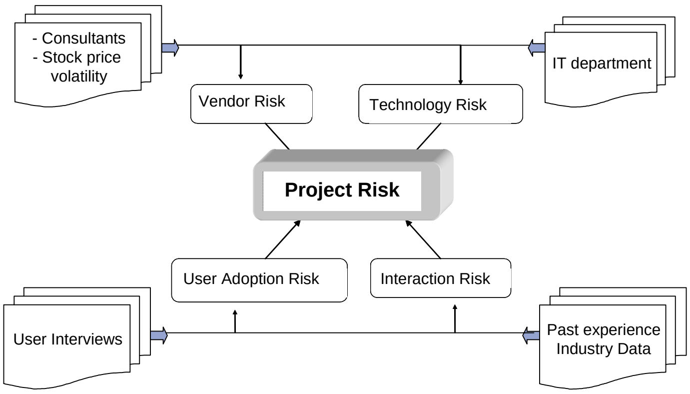

Figure 1. Example of Project risks along with potential sources of information about these risks.

Market risk affects all companies in the industry in the same manner and is generally not controllable by individual companies. In AEC, market risks include, for example, labour costs, interest rates, the number of available projects to bid on, mortgage rates and currency fluctuations. Many of these risks can be assessed from financial market data or construction indexes provided by organizations, such as FWDodge and Construction Market Data Group in the US.

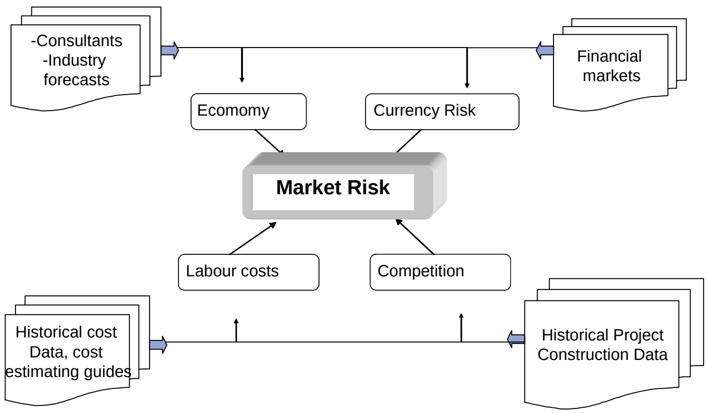

Figure 2. Different components of the market risk and potential information sources

A DYNAMIC EVALUATION APPROACH

There are two main characteristics of IT investments that can result in the investment being undervalued by the traditional DCF analysis. First, in the case of most large IT initiatives there is flexibility to control the investment and implementation process though the use of pilot projects and staged implementation. This provides the investment manger the operating flexibility to change the investment strategy as more information about project specific and market uncertainty becomes available. This flexibility includes options to slow down or speed up further implementation, and in some cases it may also be appropriate to expand or scale down, or even abandon, later phases. The cost of the investment should not bee seen as a single one time commitment at the start of the project, but rather as a sequence of investment instalments, starting with the pilot project, and extending throughout the investment process. Trigeorgis (1988) describes this characteristic as *intra-project compoundness*, i.e. the investment is in fact a compound option where the investment cost at each phase represents the cost of acquiring the option to continue with the next phase until the implementation is completed.

The second element is when the IT investment entails platform opportunities, i.e. further potentially valuable applications can be added to the existing system. In this case extra value results from the option value of future follow-up investments that are contingent on the initial investment (Trigeorgis and Mason, 1987). Now in stead of having different phases in a single project, the platform investments creates multiple options for interdependent follow up investment projects that are contingent on the initial platform. In order to invest in additional applications, the investor needs to make an initial investment in the platform, which creates a series of *inter-project compound* options (Trigeorgis, 1988). This interdependence is similar to the intra-project compoundness above, but rather than having multiple compound options in a single IT project, now there is a sequence of different interdependent projects that are essentially options on options.

These characteristics result in an asymmetry in the risk profile of the IT investment. The staging of the implementation of a single IT investment project (inter-project compoundness) and the platform opportunities of an IT investment program (intra-project compoundness) allow the investor to take advantage of the upside potential of uncertainty while at the same time limit the down side value effects. As a result the distribution of potential future values of the investment becomes skewed, i.e. there is a higher chance of a favourable outcome than an undesirable outcome. The most important implication here is that investments with a negative net present value (NPV) may now potentially be justifiable because of the value of future investment opportunities (options) that are ignored in the NPV estimation. Intuitively that also suggest that the more uncertain the payoff of the IT investment, the more valuable this managerial flexibility becomes. The Real Options Approach (ROA) allows us to value the sequential interdependence of the different phases of the IT investment and the strategic value of having the option to expand the investment at a future date.

ERP systems are a good example of both these characteristics as the systems are composed of multiple applications that are integrated into a single platform. In some cases individual applications can be implemented in stages throughout the organisation. This is especially relevant in the AEC environment as the companies are often highly decentralised in terms of business units. An application could for example be implemented in a single division, and later gradually expanded into other divisions depending on both market uncertainties and project specific uncertainty. New applications are also added to the platform in the same fashion depending on the capabilities desired by the company. These later applications are then essentially options on options, or compound options. This means that in some cases these options can be exercised simultaneously, but due to both financial constrains and limited number of IT support personal, it is more likely that the investments will be executed in sequence.

The evaluation model

Analogous to financial options a company that owns a real option has the right, but not the obligation to make a potentially valuable investment. The main difference between a financial option and real option is that the real options are applicable to “real” assets (an excellent overview of Real Option theory can be found in (Trigeorgis, 1995)). There are several different ways to evaluate both real and financial options. The analysis model developed here is based on the binomial or lattice approach using risk neutral probabilities. In a lattice model the value of the underlying asset (V) is assumed to take one of two possible values at each step of the lattice, it can either increase by a factor of $u>1$ or decrease by a factor of $d<1$. For computational ease, it is usually assumed that $u=1/d$, which implies that the tree is recombining. These movements in the value of the underlying asset are directly related to the volatility (σ) of its value. The equations for the up and down movements are:

$$u = e^{\sigma\sqrt{T/n}} \text{ and } d = e^{-\sigma\sqrt{T/n}} \qquad (1)$$

The second step is to derive the risk-neutral probabilities to solve for the option value. The risk neutral probability is based on the volatility of the underlying asset a risk-free interest rate (usually the rate of return on a zero coupon government bond), and is simply the solution for the probabilities in a binomial lattice. The formula for the risk-neutral probabilities is shown below (for a detailed derivation of the equation see for example Trigeorgis (1996)).

$$P = \frac{e^{(rf*\delta t)} - d}{u - d} \qquad (2)$$

These two sets of equations are consistently applied to all real options binomial modelling regardless of its complexity (Mun, 2002). However, for the tree to be recombining requires that the uncertainty or volatility of the asset remains constant over the option lifetime. In the case of platform IT investments, like ERP, it is likely that the volatility will change over the different periods as new phases of the system are implemented and additional applications added to the system. This is because uncertainty about such factors as user adoption and technological factors are resolved as the firm gathers more information through the different stages of the investment. This is often characterised as a learning effect. To capture this learning effect we expand this simple evaluation approach to include multiple recombining lattices with different volatilities and investment costs.

CASE STUDY EXAMPLE

The case example used to illustrate the model involves a General Contractor, Constructive Inc. Although the company is fictitious, the case is based on data from interviews with IT executives in US and Swedish construction companies (Svavarsson et al., 2003) as well as data from system vendors. The company offers four types of construction services on the US market: Residential Construction, Building Construction, Industrial Construction and Heavy Engineering Construction. Currently the firm's project management (PM) and financial management (FM) systems are getting old and expensive to maintain. The systems are made up of numerous different software applications that were implemented at local levels of the organisation in different time periods. The systems are therefore not integrated with each other, nor are they connected with a central databank. Constructive's management sees this as a major drawback and is now faced with the decision whether to embark on an expensive upgrading and maintenance of these systems or replacing them with a new ERP system[1].

Investment alternatives

The decision problem does not only involve deciding whether to continue using the existing systems or invest in an ERP system, but also comparing different alternative ERP systems and analyse the value of each option in terms what functionalities to include, and how the flexibility allowed by individual alternatives affect the profitability of the different investment decisions.

An initial technical evaluation performed produced a shortlist with the following mutually exclusive alternatives displayed in table 1 (all numbers are in millions of dollars).

	System A		System B		Maintain Old System	
	FM	PM	FM	PM	FM	PM
Software (Licence fees and maintenance)	0.576	0.384	0.240	0.160	0.180	0.120
Hardware (Servers and desktops)	0.180	0.120	0.170	0.120	0.162	0.108
Implementation (configuration and integration)	0.756	0.504	0.410	0.280	0.315	0.210
IT personal training	0.421	0.281	0.280	0.216	0.120	0.080
User Training	2.203	1.469	1.436	1.224	1.020	0.680
Sub total	4.136	2.758	2.536	2.000	1.797	1.198
PV Total Investment cost	$6.894		$4.980		$2.995	

Table 1. PV Cost calculations for Financial and Project Management systems

Upgrading and maintaining the current systems assumes a fixed investment strategy, which essentially entails that the investment decision is a go/no-go decision. As this alternative means that only necessary upgrade investments are done to

[1] An additional alternative could have been enterprise application integration of existing systems (Irani et al 2003); however although not considered here the model can be easily extended to accommodate this alternative.

extend the lifetime of the existing system, technological and user adoption risk is minimal. System B has a similar user interface as the old system but builds on a common platform that allows the FM and PM systems to be integrated which results in additional benefits. This alternative, however, does not allow for further applications to be integrated to the platform, and has therefore very limited expandability. System A is the most expensive of the three alternatives, but offers the greatest flexibility in terms of additional down stream applications that can be integrated to the platform.

The implementation process of all tree alternatives will proceed in four steps (figure 3). The first phase is a limited implementation (upgrade) of the FM system, followed by full implementation in the second stage. The third phase involves limited implementation of the PM system and the final stage is the full implementation of the PM system. In the case of system A, at the end of the fourth stage the company has an option to expand the system by adding on new applications. Management is especially interested in the Human Resource (HR) application that can be fully integrated to the platform and is specifically designed for the construction environment. Conservative estimates by the company's IT manager, financial experts and project managers, estimate the potential value of the resulting capabilities, steaming from reduced labour supervision and project overhead costs, will result in a 50% increase in total project value at the cost of $1.02 million, given that the previous implementation phases have been successful.

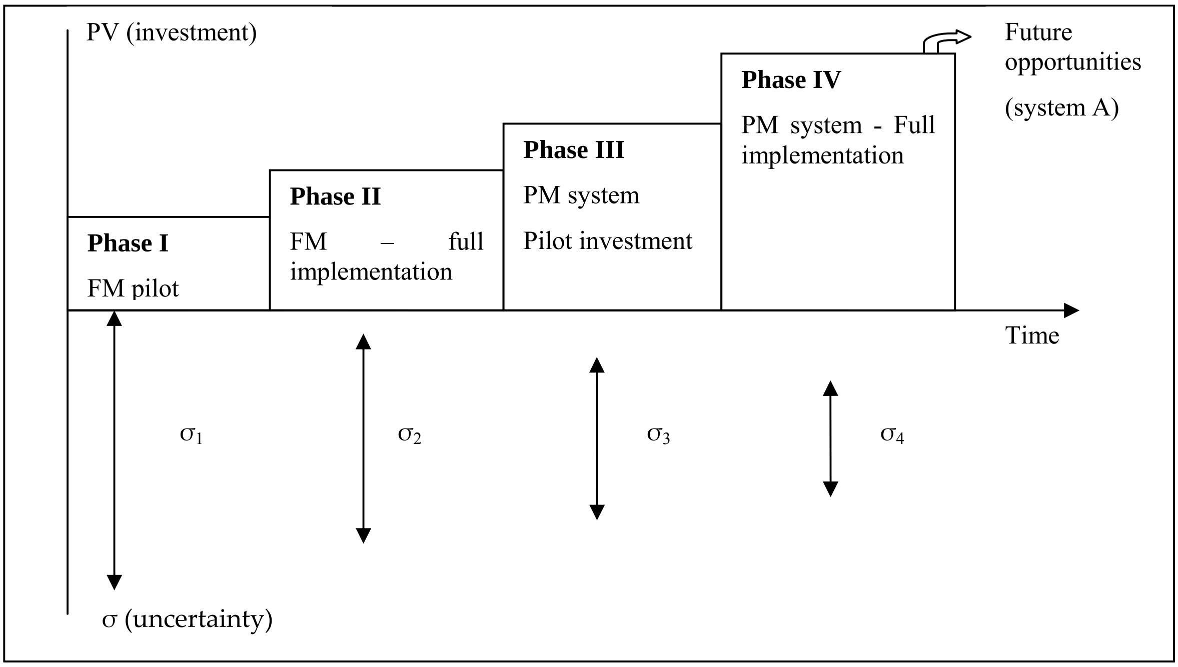

Figure 3. Different stages of the investment process and the evolution of investment uncertainty

The first step in the evaluation is to perform a DCF analysis of the different investment alternatives which provides the PV of the investments assuming no flexibility. The next step is to identify and analyse the uncertainties that affect each of the investment alternatives. As the investment program progresses through the different stages, more information about project specific uncertainties, like user adoption and technological risk, becomes available and total uncertainty is reduced with time (figure 3). The output of the risk analysis is used to create an event lattice using the binomial real option approach described in the previous section. We then construct the option evaluation lattice by incorporating the decision alternatives at each phase of the investment program into the event lattice. Finally starting at the end of the lattice working backwards through the option lattice, we solve for the value of the investment using the risk neutral probability approach

Estimating the Present Value of the investment (PV)

The analysis is based on a simple cost-benefit model which incorporates the firm's project cost-revenue structure (table 2), the company's market share and general market demand.

Self performed work		Contracted work	
Design Cost	7.00%	Administration cost	9.80%

Construction fee	3.50%	Direct labour	12.80%
Project overhead	7.50%	Material	19.20%
Labour supervision	4.90%	**Net Margin**	**7.40%**
Labour	27.90%	**Total**	**100.00%**

Table 2. Constructive Inc. project cost structure for industrial constructions

The estimation of the cash flows from each phase of the investment process are based on how the new capabilities enabled by the IT investment, as well as the required organisational and process reengineering, influence each of the factors in the cost structure of the different types of construction services, and how these changes affect the net project margin (table 2). This process is repeated for each of the operating divisions in the firm that are identified as relevant to the new capability and the results are summed up for each time period. For example, the financial application of system A is expected to enable a reduction in project overhead by .5% and .2% reduction in administrative cost, on average when fully implemented. This translates into a .7% increase in the net project margin (pm) on each project for that particular type of services. The resulting cash flows are then derived by multiplying the net margin change (Δpm) with the company's market share (ms) times the current total market demand (D) for the each type (i) of construction services the company offers.

$$\text{Net cash flows (CF)} = \sum_{i=1}^{n} \Delta pm_i \left(ms_i \times D_i \right)$$

For the sake of simplicity, it is assumed that the implementation time for all three alternatives is the same or 6 months for each phase (this assumption can easily be relaxed). Fixed costs are charged directly to each project as a flat project based tax, and thereby reflected in the individual project area cost/revenue structure. Other benefits that are not captured directly in terms of changes in the cost structure of individual projects, such as changes in how the company is perceived as an innovator and technology leader (often classified as soft benefits), are modelled and quantified through how they affect the companies market share (ms) in each area of the firms operating units. A successful acquisition of a new IT enabled capability may for example increase customer satisfaction which will directly influence the company's ability to attract more projects in the future. The net cash flows are further adjusted for depreciation, amortization and changes in net working capital, in order to derive the *free cash flow* of each investment alternative (V0). The discounted cash flow analysis is based on expected values of each input parameter and then discounted based on the companies cost of capital and risk profile of the investment program. The results of the DCF analysis are presented in table 3.

Assessing the risk of the investment

The analysis model uses a consolidated approach (Copeland and Antikarov, 2001, Mun, 2002) to combine different sources of uncertainty into a single measure of volatility using Monte Carlo simulation. This allows us to simulate how each uncertain parameter, affects the volatility of the annual expected return on the investment based on its expected distribution. The learning effects in the investment process are accounted for by using multiple recombining lattices with changing volatilities. Figure 4 shows the how each of the uncertainties impacts the value of the investment through the DCF model. The simulated variable is the natural logarithm of the annual return on the investment (rt).

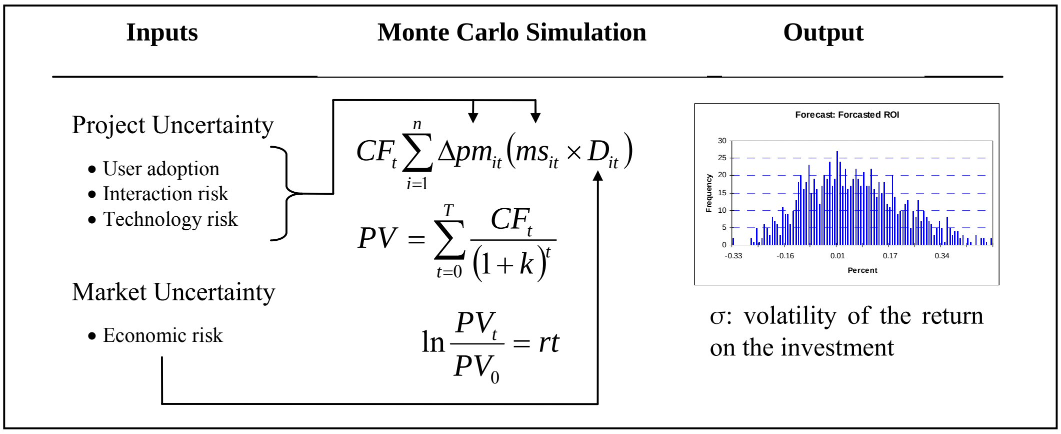

Figure 4. The risk analysis of the investment value

The different sources of project specific uncertainty are estimated base on subjective estimations by management about the expected probability distribution of the different parameters. Technological uncertainty is for example estimated by the IT manager, which based on his experience and knowledge of the system estimates the probability of possible contingencies that can happen during the implementation phase of the system. During the investment process the project specific uncertainty declines as more information about technological feasibility of the system as well as user adoption (effects both the net margin of every construction project and total market share of the company). The market related risk (influences the size of the market or (D)) on the other hand is estimated by the volatility of the relevant construction industry market index. A summary of the results from both the DCF analysis and Monte Carlo Simulation are presented in table 3.

	DCF Analysis	System A	System B	Maintain old system
Phase I	PV Free Cash flows	0.700	0.700	0.550
(FM)	Investment Cost (X_1)	1.655	1.192	0.719
	Volatility (σ_1)	0.450	0.45	
Phase II	PV Free Cash flows	1.950	1.700	1.300
(FM)	Investment Cost (X_2)	2.482	1.788	0.978
	Volatility (σ_2)	0.360	0.350	
Phase III	PV Free Cash flows	0.850	0.650	0.440
(PM)	Investment Cost (X_3)	1.103	0.800	0.479
	Volatility (σ_3)	0.310	0.250	
Phase IV	PV Free Cash flows	1.700	0.927	0.650
(PM)	Investment Cost (X_4)	1.655	1.200	0.719
	Volatility (σ_4)	0.240	0.200	
	Total PV Free Cash flows (V_0)	5.200	3.977	2.940
	PV Investment costs	6.894	4.980	2.895
	NPV	-1.694	-1.003	0.045

Table 3 A summary of the DCF analysis and risk profile of the different investment alternatives

The Event tree

The real option evaluation proceeds in two basic steps. The first step is to construct an event tree that models the present value of the investment in a binomial lattice (equation 1). The second step is to derive the total investment value using risk neutral probabilities (equation 2) in an options valuation lattice, which is based on the event tree with the investment decisions build into it. The uncertainty affecting the value of the investment is different from one stage of the investment to the next, as new information becomes available and project specific uncertainty is reduced. Due to the changing volatility the branches of the tree are non-recombining, in this case a combination of four recombining binomial lattices, so the lattice therefore quickly becomes large. In figure 5 below, which shows the event tree for investing in system A, we only show the top branch of the lattice in detail, which is one of three braches in the lattice.

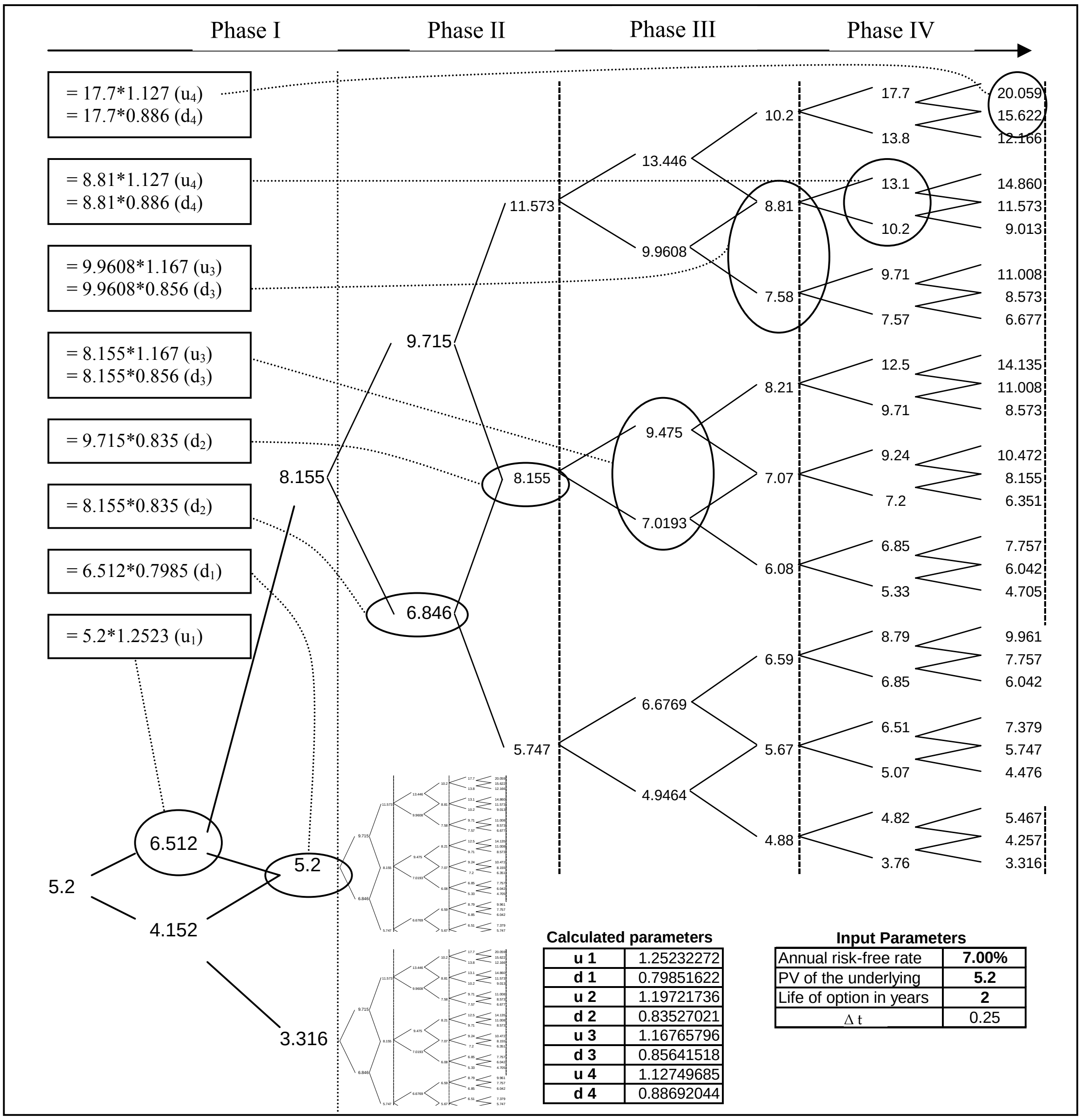

Figure 5 Event tree for the System A investment program

Each stage of the investment program is modelled in two steps, where each step is a three month period. Increasing the granularity of the model, by devising each phase into more steps in the lattice will result in more precision, however in order to keep the example as simple as possible, we use only two steps in the analysis that follows. The boxes in the diagram show the calculations behind the numbers displayed in the lattice, and in the bottom left corner is a table with the different input parameters needed to construct the lattice.

The Real Options evaluation lattice

At each stage of the investment program the company can decide whether to proceed with the next phase or abandon further implementation in favour of upgrading the existing system at the fixed cost described in table 1. Due to the contingent nature of the different investment phases, implementing phase II is not possible unless phase I is completed, phase III is not possible without completing phase II and so on. The investment is therefore evaluated as a sequential compound option. In the case of system A there is an additional expansion option at the end of the fourth phase; the company has the option to expand the system by adding the HR application to the ERP platform at the cost of $1.02 million. The evaluation proceeds in the same fashion as in the example in section 2. However, as each phase is essentially an option to proceed to the next phase the option valuation lattice is performed in four steps, where each step corresponds to the individual investment stages. Therefore we need to construct five different option lattices for system A and four for system B. The evaluation starts with the longest term option based on the event tree, and then the second longest option is evaluated based on the first option lattice and so on until the first investment stage. Due to space constrains we only show the final option valuation lattice for system A in figure 4, that combines the results of all the intermediate option lattices.

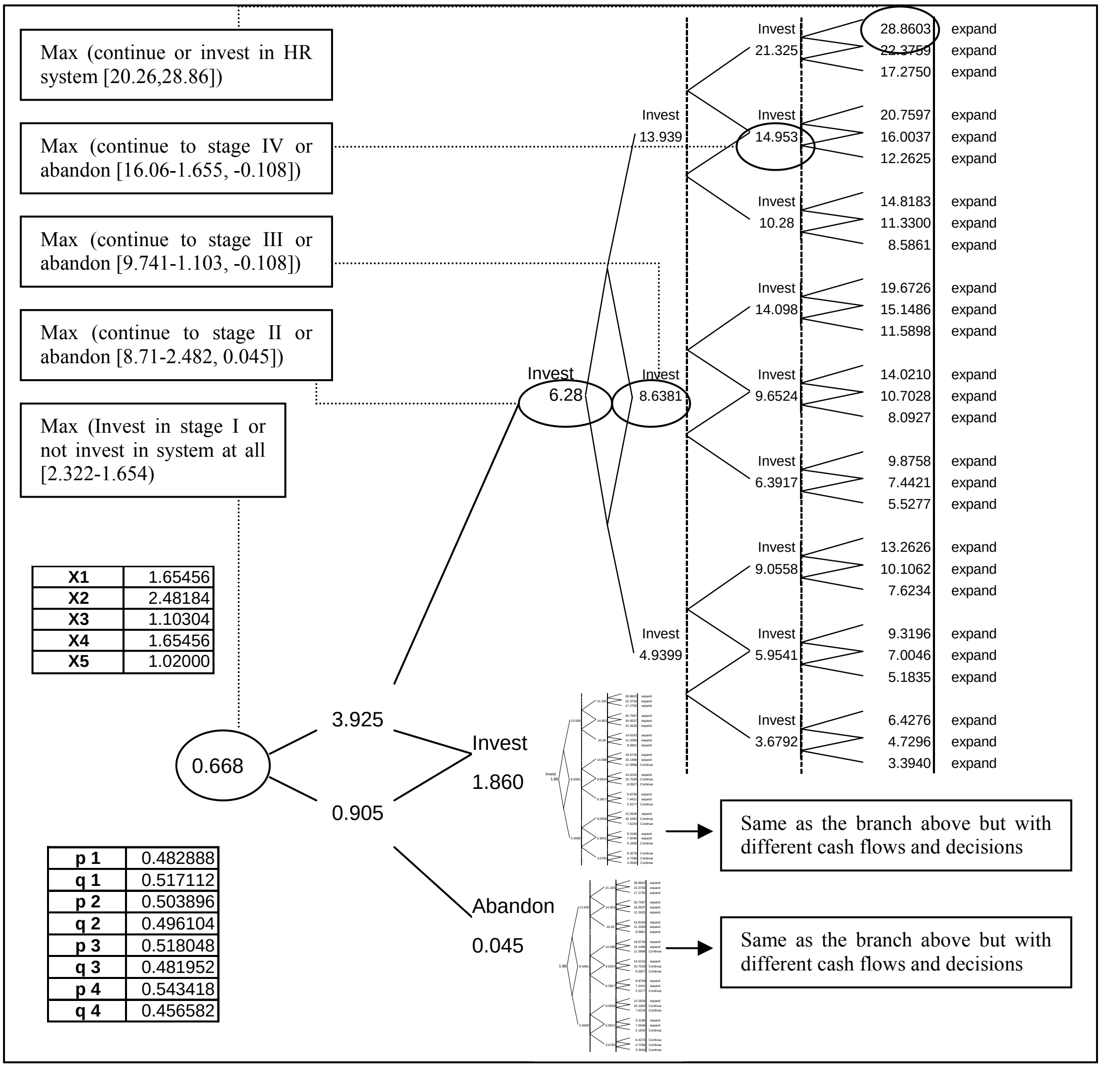

Figure 6 Combined Option Evaluation lattice for System A

The first node of the option lattice gives the total value of the investment program for system A. Each value in the evaluation lattice is the maximum of either continuing to the next phase of the investment program (discounted at the risk free rate of 7% equal to the return on a two year zero coupon government bond) or abandoning further investments. These decisions are then reflected down the lattice to the initial time period where the decision of whether or not to invest in the first stage. We can see for example in figure 6, that in the third phase that if the development of value of the first two phases has been downward the preceding periods, the optimal decision is to abandon further investment in favour of upgrading the existing PM system. The same type of analysis was applied to System B. The results from the analysis are summarised in table 4.

	System A	System B	Upgrade

NPV	-1.694 [3]	-0.559 [2]	0.045 [1]
Real Option Value	**0.668 [1]**	**0.157 [2]**	**0.045 [3]**
Difference	*2.362*	*0.716*	*0*

Table 4 Summary of the results from the static and dynamic investment evaluation

The results from the dynamic evaluation are quite different from that of the simplistic DCF analysis. The difference between the NPV and Real Options outcome is the value of the managerial flexibility to alter the investment strategy, and in case of system A, the added value of the option to expand the platform investment at a later date. It is interesting to note that the ranking of the different investment alternatives based the dynamic evaluation is the opposite of what the NPV method gives in terms of financial value. The NPV ranks (ranking is shown in brackets) the system upgrade as the only alternative that meets the investment criteria of a positive net present value. The dynamic evaluation revealed that system A, the least feasible alternative according to the NPV, is actually the most valuable investment alternative. System B now also has a positive NPV and ranks second of the three alternatives. The value of the third alternative, upgrading the exiting system, is unchanged as it does not involve any flexibility to react to new information.

CONCLUDING REMARKS

This paper presented a Real Options based dynamic evaluation approach to evaluate complex IT platform investments in the AEC environment. A hypothetical case-study involving an ERP system was used to demonstrate the application of the model. The advantage of this model over the static DCF evaluation is twofold. First the model captures the interdependence of staged investment and implementation of large platform investments like ERP. The model implicitly incorporates the value of the flexibility the investing firm has to adapt its investment strategy as more information becomes available about project specific uncertainty, like user adoption and technology risk, as well as market uncertainty. The value of this managerial flexibility is ignored in the DCF approach which can result in the investment being grossly undervalued, especially in the case of high risk investments. Secondly, the dynamic real options approach can be used to evaluate the value of future down stream applications that can be added to the existing platform investment. The value of these future opportunities often constitutes a substantial part of the total investment value. The DCF approach however, is unsuitable for this kind of future options, as it assumes a fixed investment strategy and a constant discount rate. This was clearly demonstrated in the case example, where one investment alternative involved a system where new applications could be integrated to the system at a later date. The DCF valuation failed to capture the true value of this option to expand the system and thereby seriously undervalued the total investment value, rendering the investment as unjustifiable.

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