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Management of ERP implementation

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Abstract

Implementation of Enterprise Resource Planning (ERP) solutions, which involve both technical and social uncertainties, is in practice a highly uncertain, risky endeavour. Traditional ERP practices address implementation of ERP as a static process; such practices focus on structure, not on ERP as something that will meet the needs of a changing organization. As a result, many relevant uncertainties that cannot be predefined are not easily accommodated. Options theory, which addresses uncertainties over time, resolves uncertainties in changing environments that cannot be predefined. In this paper, we propose an options perspective on the ERP implementation process with a focus on uncertainty. This perspective takes into consideration the often-changing nature of the companies that undertake ERP implementations. In addition, we present a practical example that demonstrates how to use options theory in context, enabling active management when implementing ERP. By actively managing ERP implementation, management can improve the flexibility of ERP implementation and can take appropriate actions to respond to the changing ERP implementation environment, to achieve more a successful ERP implementation that better meets the needs of the organization.

Keywords: Active management, ERP, Managerial flexibility, Real Options

1. Introduction

Investment in Enterprise Resource Planning (ERP) systems is an important strategy that enables enterprises to achieve competitive advantages and provides good quality of service. An ERP system streamlines business processes by creating an enterprise-wide transaction structure that integrates the key functions of different departments within an integrated information system platform. Through the integration of these diverse systems, organizations can gain a competitive advantage in the rapidly changing digital age. ERP is therefore a key part of the information infrastructure of modern businesses. Recent research has shown that ERP projects have grown to become the largest information system project investment in companies the world over, and furthermore, this trend is expected to continue for years to come (Balasubramanian et al. 1999; Sumner 2000).

However, if ERP projects are not implemented properly, the results can be disastrous, since the rate at which ERP projects fail is surprisingly high, with serious consequences including failure to fulfill anticipated functions and cost/schedule overruns (Benaroch et al.

2000; Bingi et al. 1999; Chen 2001; Griffith et al. 1999). Many companies have seen no alternative but to terminate their ERP projects during the implementation phase once their resources have become depleted, attributable to mismanagement. For instance, Dell Incorporated failed in their ERP project after committing two years and expending \$200 million. Waste Management Incorporated aborted its ERP implementation after spending \$45 million of an estimated \$250 million budget (Abdinnour-Helm et al. 2003). Even worse, failure in ERP projects has led to problems as serious as bankruptcy (Davenport 1998; Markus et al. 2000). Given the significant risks inherent in ERP projects, it is vital that they are actively managed during the implementation phase (Gefen 2004; Ko et al. 2005).

Several streams of study of ERP implementation have provided foundational theories on implementing ERP. One such stream focuses on the interactions between ERP and organizations (Gattiker et al. 2004; Soh et al. 2000; Somers et al. 2003), and makes the observation that ERP implementation is closely intertwined with complex organizational factors, and thus faces both technical and social uncertainties that cannot be predefined in full, thus that ERP must by necessity be actively managed. Another stream of study concentrates on risk factors in ERP implementation. Such studies point out explicit key risk factors, such as process fit and user fit, that unchecked contribute to the failure of ERP implementation (Hong et al. 2002; Mandal et al. 2003; Scheer et al. 2000; Sumner 2000). Other studies investigate risk factors in different ERP implementation phases and note that by actively managing problems that evolve over time, better ERP implementation will be achieved (Kumar et al. 2003; Loh et al. 2004; Markus et al. 2000; Rajagopal 2002; Ross et al. 2000).

Although the value of the role that management may play during ERP implementation has been recognized and many risk factors have been identified for successful ERP implementation, active management is, on the whole, still an implicit concept in the bulk of existing literature that does not address how active management should best implement ERP. Previous ERP implementation has been regulated by net present value (NPV) rules that assume that ERP implementation is static, and thus does not take into account the value that active management may add to ERP implementation.

In this paper, we provide the ERP implementation process with an options perspective based on options theory, which addresses uncertainties over time, allowing adaptation to environments that frequently change. In addition, we provide a practical example in which options are used to achieve active ERP implementation management. This paper aims to enable active management of ERP implementation. Active management permits the reshaping of strategies and allows for quickness when reacting to risks, and we show in later sections that it can increase the probability of success for ERP implementations.

2. Theoretical Background

ERP systems are multifunctional in scope and are integrated into a company by nature. They enable companies to shift from traditional modes of operations where the information systems function independently of the business objectives. An ERP system intertwines technology, tasks, people, structure, and culture, but must be implemented not only in the technical subsystem, but also in the social-subsystem (Davis et al. 1985; Koh et al. 2003; Markus et al. 2000; Parr et al. 2000). ERP systems are technological tools that provide a way

to coordinate many facets of a company, enabling resources to be allocated more efficiently than in the traditional ways of business.

When a business implements ERP in its drive to become more efficiently interconnected, risks arise from the new technology, which is loaded with uncertainties that evolve over time that cannot be fully known when making decisions. For example, customization of ERP is a crucial, lengthy, costly aspect of the implementation of ERP systems (Gefen 2002). And studies have shown: many organizations exceed budgets due to more customizing than originally planned (Markus et al. 2000; Swan et al. 1999). Aside from the overruns due to customization, organizations often encounter significantly greater than expected new expenditures for temporary and overtime labor, re-skilling and training during the implementation process (Markus et al. 2000; Sumner 2000).

The employees of an organization play a key role in the implementation and utilization of ERP systems. In order for ERP technology to enable a business to run more smoothly, employee work patterns must change, bringing on social risk factors. User commitment is a major source of uncertainty, for, if people are not properly prepared for the imminent changes, then the consequences are, predictably: denial, resistance, and chaos (Kremers et al. 2000). An ERP implementation must intimately mesh with the social culture of the organization. Watson et al. (1999) reported that ERP implementation suffers in many companies when the culture of the organization is ignored in the rush to put such a complex system as ERP into action. Efforts to make it fit into an organization may require extensive additional training and consulting requirements that cannot be foreseen and must be resolved over time.

ERP implementation is a high-risk proposal, requiring significant capital investment, leading organizations to justify the substantial expenditures with the net present value (NPV) rule (Murphy et al. 2001; Stefanou 2001). NPV provides a measure that takes into account expected benefits and costs. A negative NPV suggests that the costs of ERP outweigh the benefits, and that management should bring to an end their ideas of using ERP. A positive NPV signals to management that the benefits outweigh the costs, justifying the implementation of ERP without a need for future decision-making, simply based on the NPV result.

Unique characteristics of small scale information technology (IT) applications enable the NPV rule to produce accurate predictions based on the known variables, but the reality of the matter is that ERP is not simply a larger scale equivalent. Simple well-defined IT applications such as office automation systems (OAS) and transaction processing systems (TPS), designed to replace workers such as payroll clerks who perform repetitive tasks, work well with the NPV criteria because application costs and benefits are determined relatively easily and requirements are clear (Martinsons et al. 1999; Stefanou 2001). However, applying NPV to ERP implementation can create problems in three ways: unmanageable costs, a staggering amount of time to implement, and difficulty in recouping the investment if it goes sour.

Firstly, ERP differs from other information systems in that substantial costs often emerge unexpectedly. As earlier mentioned, this is often due to customization, training and consulting. These unpredictable costs alone imply that decisions regarding ERP must be made with more caution. In addition, unlike other larger scale IT applications, ERP affects an organizational reengineering process that results in a major organizational change. This

change can be the source of considerable benefits, but, all too often, it is the source of unmanageable costs. Failure to identify the full costs and benefits of ERP investment can have serious problem for ERP implementation (Stefanou 2001).

Secondly, given the rapidly changing world, the long implementation process for ERP gives rise to uncertainties. ERP is significantly more time-consuming to implement than ordinary IT applications, often taking two to five years to get into operation (Hitt et al. 2002). When implementing technology spans years, a revolution in standards can produce an entirely new paradigm, making a discontinuous gap from the old. Doubling the implementation time can more than double the uncertainties.

Finally, the most serious problem in applying the NPV rule to ERP implementation is the implicit static worldview held by NPV. It denies possible benefits from active management in ERP implementation. NPV assumes that investments are reversible, and non-deferrable. However, ERP projects are irreversible, deferrable and undertaken in conditions of uncertainty (Dixit 1995; Paddock et al. 1988; Pindyck 1988). Pinpoint now-or-never decision-making by the NPV rule results in a huge opportunity cost; once the course of an implementation process veers differently than expected, management has no way to appreciate appropriate responses to the uncertainties. Loaded with both technical and social uncertainties, future states of ERP implementation cannot be foreseen, and thus active management is critically needed. Failure to consider active management implies that it is unnecessary to resolve uncertainties over time, that the agility of active management is unnecessary, and that nothing needs to be done during the process that could improve the rate of ERP success. Because the NPV rule holds for passive management throughout the lifetime of the project, adopting NPV leads companies to give up active management, which is critical in successful ERP implementation.

Options theory (Black et al. 1973; Myers 1974; Trigeorgis 1993), which addresses the uncertainties of a risky underlying asset, is a better way to deal with uncertainties than NPV. Options are contracts that give the holder the right, but not the obligation, to buy a particular security at a fixed exercise price before a predetermined expiration date. A call options gives the option holder the right to buy a stock at the exercise price when the price is favorable, but does not compel him to buy the stock at an unfavorable price. If exercised, the benefit to a call buyer is the current stock price, less the exercise price and any premium paid for the option. Options theory is especially suitable for projects that involve a high level of uncertainty, noted by Copeland et al. (2001). Researchers in the IT field have investigated the applicability of options theory and have made inroads in applying options theory to IT investments. For example, Dos Santos (1991) and Kumar (1996) suggest that options theory can be applied to IT investments to hedge project risks. Some researchers have employed specific options theory formulas to guide IT field investments. Benaroch et al. (1999, 2000) applied Black-Scholes' (1973) option pricing formula to evaluate the value of deferring investments on the expansion of electronic banking networks. Taudes (1998) applied Margrabe's (1978) formula to growth opportunities of the software platform implementation. Kumar (2002) applied Margrabe's (1978) formula to decide whether to defer a CASE tool project.

As earlier stated, knowledge reveals that ERP implementation is risky and uncertainties cannot be predefined. In addition, at the time a company decides to implement ERP, the

uncertainties cannot be known and they continually evolve over time, even before ERP is implemented. Options theory, which addresses uncertainties that change over time, can provide a way to approach ERP implementation problems by resolving the initially undefined changing environment.

3. ERP as Compound Options

As we will discuss, ERP may be best represented by a non-analytical, compound options model. Options models can be either analytical or non-analytical, single or compound. Most studies on IT specific uses of options theory discuss a single option in an IT project. Analytical models such as the Black-Scholes (1973) formula focus on only one single option. Most of the works mentioned in the previous section use an analytical solution, such as the Black-Scholes formula, which considers a single option and can not deal with multi-options situations.

ERP systems are modular in structure (Debreceeny et al. 2005). Management makes sequential implementation of ERP modules according to the priority of the modules. Organizations go through a self-discovery process during the ERP implementation; they analyze the details of the various business processes and look for improvements. The first phase comprises, as a pilot implementation, basic modules, such as: a purchasing management model, an inventory management model, and a finance module. Sequential upgrade implementation that enhances future business competency includes such as: Supply Chain Management (SCM), Customer Relationship Management (CRM), and Knowledge Management (KM). With ERP, organizations have the opportunity to expand business capabilities by adding new modules for new business functions.

ERP implementation is an ongoing business re-engineering process rather than a simple installation of software, and can be represented from phase one as an options formula. ERP implementation allows continual investment in new modules or upgrades to add functionality and to achieve a better fit between the business and the system. In addition, many ERP adopters rely on vendors for extended technical assistance, emergency maintenance, updates, and special modifications. Moreover, requirements evolve over time. As the dynamics of the project make learning by doing crucial, before making the entire investment, additional knowledge about the uncertainties can be gained during the initial phases of implementation.

In terms of options, the first phase outlay in the ERP implementation is equivalent to the option premium. A company invests a small amount, i.e. a sunk cost. The total cost of the project is the exercise price. And the value of the option on ERP implementation is the present value of the total future revenues.

There are many options inherent to ERP implementation. Phased ERP implementation resolves uncertainties as “learning by doing”. By adopting preliminary modules to avoid the huge, irretrievable costs associated with the failure of fully-committed ERP, companies can ascertain more about the project before investing in the entire implementation. In ERP implementation, the management holds three options that are equivalent to compound options as follows.

1) The ERP implementation growth option. Following the first phase, further follow-up investments may be made that enhance the value of ERP. Management may decide to add additional modules in the next phase or wait until there is solid demand in the future.

2) The option to abandon ERP implementation. Should, despite best efforts, the ERP implementation go badly, the management has the option to terminate the project. Salvage value of capital equipment and other assets may be recouped.

3) The option to alter the ERP implementation scale. If more favorable than expected environmental conditions arise, the management can expand the implementation scale by taking on more modules. If the environment evolves unfavorably, the implementation scale may be reduced.

Because ERP implementation involves more than one option, a non-analytical binomial trees model is appropriate. A binomial trees model demonstrates the ERP implementation decision-making process, where sophisticated portfolio of options are embedded by listing all possible branches of each option. One clear advantage is that all calculations may be made with off-the-shelf spreadsheet software. Another advantage of the binomial trees model is that it shows how each option is evaluated and compared in each ERP implementation phase. Thus management can easily and comprehensively apply this method of analysis in ERP implementation.

4. Numerical Analysis

The benefits and costs of ERP were studied by (Gattiker et al. 2004; Ragowsky et al. 2002; Rajagopal 2002). Studies show that by adopting an ERP system, inventory costs can be reduced by an average of 25 to 30 percent and raw material costs can be reduced by about 15 percent. In addition, production time, lead-time for customers, and production costs can be also reduced. The studies also indicate that the cost of implementing ERP is quite high. Software, incremental hardware, training, and implementation support may amount to \$200,000 in a smaller company with approximately \$10 million annual sales, \$600,000 to \$800,000 in a medium-sized company with approximately \$40 million to \$70 million annual sales, and up to several million dollars in a larger company. Verville (2003) showed that an ERP investment of \$80 million generates a reasonable \$130 million in benefits by reducing headcount, improving cash management and achieving additional valuable management.

For our example, a company has decided to implement an ERP project with a total estimated cost of \$80 million: \$30 million in the initial stage and \$50 million in the second stage, as seen in Fig. 1. They estimate a 40% probability of an increase in cash flow based on environmental uncertainty. Conversely, in an unfavorable scenario, there is a 60% probability of a downward cash flow. According to Markus & Tanis (2000), the majority of benefits to the company will be achieved after the second investment phase. With uncertainties, the ERP project value varies over time. In the ideal scenario, the project brings estimated benefits of \$140 million. For a combined upward and a downward movement, it brings estimated benefits of \$100 million. In the worst-case scenario, it brings only \$60 million.

At this point, the company has the option to expand the benefits. In the best scenario, an additional \$50 million may be invested in the project. Alternatively, a more compact investment of \$30 million may be chosen that would yield fewer ERP installation benefits. At

best, \$90 million is achieved in the upward scenario, \$80 million for a combined upward and a downward movement and \$70 million for the worst case in their estimation. The most recent two-year average U.S. T-Bond interest is used, currently around 4% for the risk-free rate.

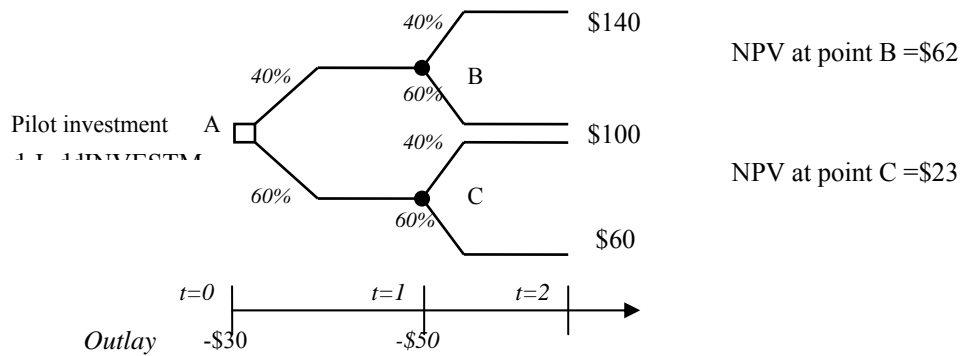
After the initial investment of \$30 million, the management can evaluate the project and have the option to expand, contract, or abandon the project during the second phase. The management will continue to invest another \$50 million to finish the planned ERP project in the best scenario because the underlying value is the maximum among the three options, i.e., expand, contract, or abandon. But, if the environment evolves unfavorably after the initial investment, the management will decide to contract the second phase investment.

If an ERP project is under time constraints or over budget, and thus judged unsuccessful, it can be abandoned midstream with a salvage value of at least 15% of the initial investment. We would recoup at most \$50 million in the best scenario. To demonstrate the value of our approach, we look at the first tree (Figure 1a). Starting at point A, when an initial investment of \$30 million is made at time $t=0$, the outcome evolves either upward or downward, with 40% probability and 60% probability, respectively. When the outcome is satisfactory and takes us to point B, we make an additional investment of \$50 million at point B when time $t=1$; therefore, we get \$140 million project value in the best scenario with 40% probability, and \$100 million with 60% probability, respectively, at point B. The NPV at B is thus

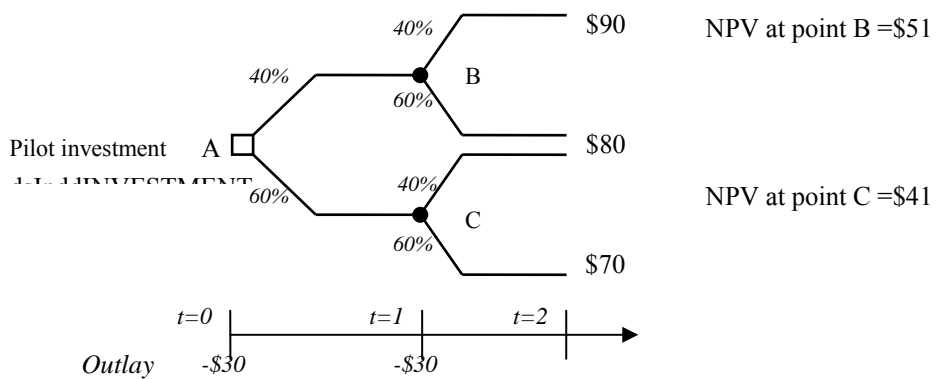
$\frac{140 \times 0.4 + 100 \times 0.6}{1 + 4\%} - 50 = \62 million. If the outcome evolves unfavorably, and thus goes

from point A to point C at time $t=1$, we have two likely outcomes at time $t=2$, i.e., \$100 million and \$60 million, for 40% probability and 60% probability, respectively.

1a Investment (expanded) of \$50 at $t=1$



1b Investment (contracted) of \$30 at $t=1$



1c To abandon project at $t=1$

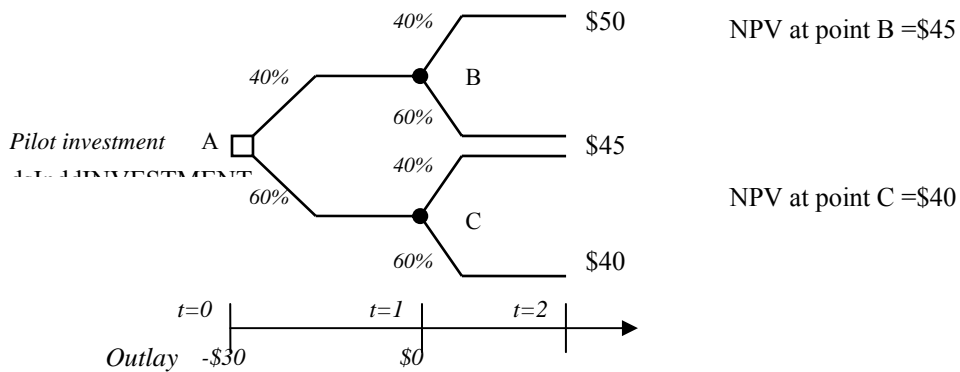


Figure 1 The ERP investment decision tree

Thus the NPV at point C equals $\frac{100 \times 0.4 + 60 \times 0.6}{1 + 4\%} - 50 = \23 million. Similarly, in the

second tree (Figure 1b), when the outcome from point A to point B is good, we make an additional investment of \$30 million at point B when time $t=1$, and thus get \$90 million in the best scenario with 40% probability and \$80 million with 60% probability at point B. The

NPV at point B is thus $\frac{90 \times 0.4 + 80 \times 0.6}{1 + 4\%} - 30 = \51 million. If the outcome evolves

unfavorably, and thus goes from point A to point C at time $t=1$, we will have two likely outcomes at time $t=2$, namely: \$80 million and \$70 million. Thus, the NPV at point C equals

$$\frac{80 \times 0.4 + 70 \times 0.6}{1 + 4\%} - 30 = \$41 \text{ million.}$$

Consider the third tree (Figure 1c), where the management does not have to pay for the project salvage value. With possible salvage values of \$50 million, \$45 million, and \$40

million, the NPV at point B is $\frac{50 \times 0.4 + 45 \times 0.6}{1 + 4\%} - 0 = \45 million. This is a relatively small

amount compared to the NPV at time $t=1$ in the other two trees (\$62 million and \$51 million). The same is true for the NPV of \$40 million at point C, compared to \$23 million and \$41 million, respectively, in the other two trees. This implies that the salvage value of the ERP system is too small for the management to abandon the project midway, so the value of the option to abandon is zero. Since a call option with price S and strike price X at the end of the period makes its value $C_u = \max(uS - X, 0)$, we choose the max NPV at point B and point C, namely, \$62 million and \$41 million. We therefore choose to make an additional \$50 million investment at point B, and an additional \$30 million investment at point C (See Figure 2).

Following up with the back-forward calculation, the value at point A is $\frac{62 \times 0.4 + 41 \times 0.6}{1 + 4\%} = \48 million. We subtract the initial investment of \$30 million from \$48

million and get \$18 million, namely, the compound option value, see Figure 2d. We now calculate the value of making a full investment of \$80 million without any option. The NPV

at point B in Figure 1a is $\frac{140 \times 0.4 + 100 \times 0.6}{1 + 4\%} = \112 million, and $\frac{100 \times 0.4 + 60 \times 0.6}{1 + 4\%} = \73

million at point C; thus, the NPV for the ERP implementation project is $\frac{112 \times 0.4 + 73 \times 0.6}{1 + 4\%} -$

$80 = \$5$.

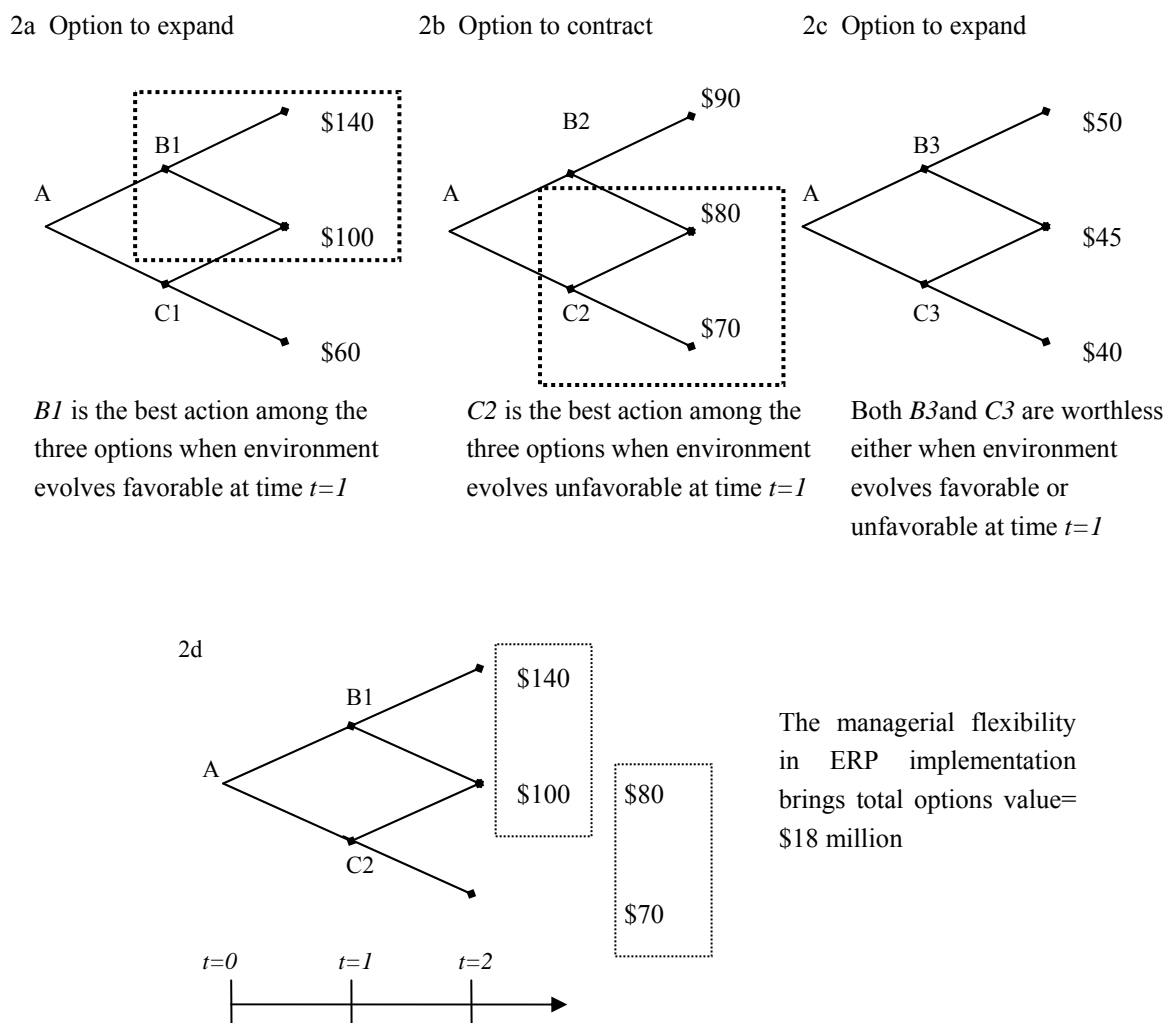


Figure 2 Active ERP management by options

We now examine the value of each option. For the expand option value, see Figure 1a in which the firm makes an initial investment of \$30 million at $t=0$ and an additional investment

of \$50 million at $t=1$. Because the NPV at point B equals $\frac{140 \times 0.4 + 100 \times 0.6}{1 + 4\%} - 50 = \62

million, and the NPV at point C is $\frac{100 \times 0.4 + 60 \times 0.6}{1 + 4\%} - 50 = \23 million. The expand option

value equals $\frac{62 \times 0.4 + 23 \times 0.6}{1 + 4\%} - 30 = \7 million. Since the compound option value consists of

a project NPV and managerial flexibility, and the option value to abandon is zero in this case, the option value of contracting is $\$18 - 7 = \11 million.

Table 1 summarizes the results and shows that there are great differences between the NPV and real options perspective. Firstly, the positive NPV (\$5 million) advises that

management implement ERP immediately, and hold that advice static throughout the implementation lifetime, regardless of any available active management. Thus the NPV value (\$5 million) is much less than the value of the ERP implementation project where options are embedded, because NPV does not capture the full ERP value brought by active management shows by real options (\$18 million). The value of the active management may be measured by the difference in values between NPV, which passively manages ERP, and options values with active management.

The value of active management comes as a result of three parts of the ERP implementation. The option to contract enables the management to control unexpected excess expenditures, and also lowers risks of failure of a ERP implementation due to budget overruns. The option to expand enables the management to make use of the unlimited potential benefits, such as a beyond expectation favorable situation in the ERP implementation coming from prevailing user commitment or decline of the hardware costs. The value to abandon enables the management to predefine maximum losses for ERP implementation. ERP projects that goes over timeline and budget overruns are controlled and abandoned, preventing unlimited commitment of resources which eventually exhaust all the organizations resources.

Table 1 Results Summary

Perspective	Amounts	Implication
Passive perspective by NPV	\$5 million	<p>The positive value suggests an immediate ERP implementation decision.</p> <p>Neglects uncertainty.</p> <p>The ERP implementation is passively managed throughout the ERP project lifetime, ignoring any managerial flexibility.</p> <p>Inadequate ERP investment decisions based on the NPV rule do not capture the full value of ERP and can incur huge opportunity losses.</p> <p>Considers the environment in the ERP implementation absolutely the same as the management predicted, which is almost impossible especially for a rapidly changing IT environment and when complex organizational factors are involved.</p>
Active management by options	\$18 million	<p>Quite different from NPV rules.</p> <p>The difference is the value of managerial flexibility.</p> <p>Takes uncertainty into account.</p> <p>Active ERP management is made available to react to an evolving environment.</p>

5. Conclusions

ERP implementation is costly, lengthy, and risky, replete with complex organizational factors such as initially unknown requirements, unexpected user adoption contingencies, and rapidly changing IT environments. Allowing ERP implementation to be regulated by NPV causes a situation where management is unable to respond to uncertainties, thus creating huge opportunity costs. With NPV, management doesn't take advantage of favorable environment changes, can't control an ERP implementation budget, and can overcommit resources, and ERP can fail as a result. Previous knowledge reveals that phased ERP implementation resolves different uncertainties in different phases. Under this basis, we view ERP implementation with a sequence-of-decisions options perspective, rather than a single-decision event. The results suggest that treating ERP implementation as options provides agility in constant changing environment by to have flexible plans that can adjust to future conditions, and gain better benefits by such active management.

Our study demonstrates how active ERP implementation management is achieved by the options perspective. Future research can be conducted into case studies and empirical comparisons of the effects of the options perspective and the differences between the passive management and the actively management in ERP implementation. Our study has implications for both researchers and practitioners. For researchers, although ERP implementation has been one of the most significant challenges in the last decade, relatively little research has been conducted into how to support active management in ERP implementation. Active ERP implementation management is still an implicit concept in existing literature. We explicitly discuss active ERP management to bridge the gap and extend the literature by offering an options perspective in ERP implementation. This perspective resolves the uncertainty inherent in ERP implementation. In addition, we explicitly explore how active management can be made. For practitioners, because most companies still make decisions without an explicit understanding of options (Copeland et al. 2001) this paper helps them to take appropriate actions to respond to the changing ERP implementation environment, and achieve more successful ERP implementation.

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