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Project Milestones for Managing Risk in Software Development Outsourcing: A Real Options Perspective

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ABSTRACT

Organizations are increasingly turning to outsourcing for software development, in part, to control cost and lower the likelihood of project failure. However, application outsourcing is not without risk. Milestones coupled with gateway reviews are a common mechanism for controlling these risks. Yet, the benefit of milestones must be assessed in light of their associated costs. This paper uses real options theory (ROT) to analyze 15 real world software development projects outsourced by three large organizations. It finds empirical support for the theorized relationship between the number of milestones used in these projects and the degree (and kinds) of risks affecting the projects. This finding indicates that the practices of contract managers in these organizations are consistent with the logic of ROT in planning project milestones. This paper therefore argues that ROT could serve as a basis for enabling managers to plan project milestones in an economically efficient manner.

Keywords (Required)

Milestones, Outsourcing, Real Options Theory, Information Technology Risk.

INTRODUCTION

Organizations are increasingly turning to outsourcing for software development, in part, to control cost and lower the likelihood of project failure. However, application outsourcing is not without risk. It requires gauging the vendor's progress towards meeting project objectives on time, at an acceptable quality level, and within the expected cost. Because of the difficulty in observing vendor behavior, this requirement is extremely challenging. A recent study of outsourced projects observed that organizations which experienced performance problems realized "the need to invest significant effort in overcoming the low behavior observability" (Choudhury and Sabherwal, 2003). Milestones coupled with gateway reviews are one mechanism for controlling these risks.

Milestones have been described as essential to successful software development (Roditti, 1998). However, the benefit of a milestone must be viewed in light of its cost. If milestones are too frequent, the project team could spend an inordinate amount of time preparing and reviewing deliverables that are not essential for the completion of the project. By contrast, if milestones are not frequent enough, issues with the pace of the project's progress may not be detected with enough time for the organization to respond effectively (Sommerville, 1997). Mechanisms that act as "information systems" for gauging vendor behavior must be implemented in a manner that does not obviate the economic benefits of outsourcing (Choudhury and Sabherwal, 2003). This is especially important in the case of software development, as this activity is considered the most expensive to outsource (Barthelemy, 2001). Therefore, it is important that organizations use an adequate framework to determine the number of milestones planned in a project.

From an economic perspective, mitigation of outsourcing project risk (which includes software development risks, vendor reliability, etc.) is likely the only rationale for establishing milestones. Therefore, if milestones are being appropriately used by the organization, one would expect their number to increase in proportion to outsourcing project risk. However, a recent empirical study showed no apparent link between the number of milestones and outsourcing project risk, but demonstrated that project duration exhibited a strong relationship with the number of milestones (Lichtenstein, 2004). The author of this study was unable to explain his observations by using agency theory or transaction cost economics.

Interestingly, a recent empirical study found that IT managers follow the logic of real options theory (ROT) in managing IT investment risk, however, purely based on intuition (Benaroch, Lichtenstein, and Robinson, 2006). On this basis, there is reason to suspect that IT managers are also following the logic of ROT when planning project milestones. If this can be

demonstrated empirically, managers could be shown how the quantitative tools of ROT can be used as a framework for planning milestones in a more economically efficient manner.

This paper uses Lictenstein's (2004) data set to present evidence that contract managers may have followed the logic of ROT when planning project milestones. This is done by demonstrating that, although project duration was shown to be a much more robust predictor of the number of milestones than outsourcing project risk, the combined predictive ability of both risk and project duration is stronger than that of duration alone. This suggests that managers were probably taking into account both duration and certain aspects of outsourcing project risk when planning milestones, something that closely parallels the manner in which ROT treats these parameters in its valuation models.

MILESTONES AND SOFTWARE DEVELOPMENT RISK IN THE LITERATURE

Much work has been published about software development risk. Some of this work identifies project milestones as a mechanism for controlling development risk. It defines milestones and explains their role as risk mitigants, but without empirically exploring their relationship to risk.

Wang, Barron and Seidmann (1997), Richmond and Seidmann (1993), and Richmond, Seidmann and Whinston (1992) view milestones as a mechanism that provides the developer information about project values and costs, motivates the vendors to invest at each particular stage, and fosters competition between vendors during later stages of development. Like Sommerville (1997), Sabherwal (1999) warns that "excessive structural controls can hurt performance due to the time spent reporting [and reviewing] progress rather than developing software." Whang (1992) does not mention milestones by name, but describes "payment schedules" which "are usually tied to the development cycles – paying a fixed portion of the total fee at the completion of each cycle." He develops a model that incorporates these schedules, however, he stops short from empirically testing his model with actual data from software contracts and is silent on the placement of milestones in relation to risk.

Lichtenstein was the first to empirically test the relationship between outsourcing project risk and the number of milestones (2004). He used agency theory and transaction cost economics (TCE) to examine whether three organizations were applying project milestones as a function of risk. Lichtenstein described his findings as "puzzling". Following agency theory, which argues that "high outcome uncertainty justifies investment in monitoring devices," he hypothesizes that the number of milestones increases with risk. Yet, he did not find evidence to support this hypothesis. Rather, he observed that the number of milestones exhibited a relationship with project duration. As to TCE, Lichtenstein also examined dimensions of contract "specificity," on the premise that all complex contracts are incomplete and are constructed to protect against ex-post opportunism of the vendor. TCE theory states that firms are likely to make a good when its production entails specific investment, and when the good must be produced at frequent intervals (Williamson, 2000). A project with a high number of milestones could be considered equivalent to internal production, due to the high degree of control that the milestones provide the organization. Therefore, Lichtenstein hypothesized that the number of milestones increases as contract specificity increases. However, he did not find support for this hypothesis. In summary, Lichtenstein's study found that the number of project milestones could not be adequately explained by either agency theory or TCE.

REAL OPTIONS THEORY AND PROJECT MILESTONES

Milestones are analogous to real options in the sense that they provide the organization flexibility throughout the project development period to change course in response to events occurring in the project environment. Whang (1992) has referred to "payment schedules," or milestones, as being similar to put options in that they offer the organization the opportunity to abandon investment. By providing additional information, milestones also give management the option to expand/contract the project in response to positive/negative events that affect the project. Therefore, project milestones can be considered to serve a similar function as the "change-scale" and "abandon" embedded real options identified in the IT investment literature (Benaroch et al., 2006). If it can be demonstrated that IT managers are (knowingly or unknowingly) thinking of project milestones as embedded real options, they could be valued in a manner similar to operating options that have been shown to exist within technology investments (Benaroch, 2001).

Figure 1 depicts the make-up of the active net present value (NPV) of an investment. As can be seen in the figure, the active NPV includes any embedded flexibility, which is measured by option value, and the investment's passive NPV, which is calculated via traditional discounted cash flow analysis. ROT states that option value is a function of the: (1) value of the underlying investment (usually the passive NPV), (2) variability of the value of the underlying investment, (3) exercise price of the option, (4) time to maturity of the option, and (5) risk-free discount rate. The IS literature commonly agrees that the variability of the underlying investment value is due to risk factors, which are characteristics of the investment or its contextual environment that affect the resulting level of goal attainment. Therefore, we consider this variability to be analogous to the risk of an outsourced project. Because ROT tells us that the value of the option increases as variability

increases, we would expect to see the number of milestones increase as outsourcing project risk increases if the theory is applicable to project milestones. However, the theory also tells us that as the time to maturity of the option increases, which is analogous to the duration of the outsourcing contract, the value of the option increases. Therefore, if project milestones can be thought of as embedded real options, we would expect to see the number of project milestones increase as both outsourcing project risk and project duration increase.

Lichtenstein has already shown that project duration has a predictive relationship with the number of milestones in his data set, and that there is no apparent link between outsourcing project risk and the number of milestones (2004). However, he did not examine the combined predictive ability of outsourcing project risk and project duration. If organizations are truly applying the logic of ROT when planning milestones, we would expect to see evidence of increased predictive power when both duration and outsourcing project risk are considered jointly.

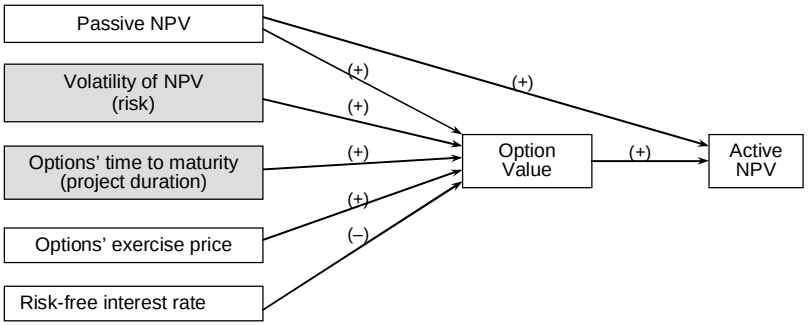


Figure 1

DATA COLLECTED

Data was collected by Lichtenstein (2004) on 15 application development outsourcing contracts from three of the largest firms in Israel. The firms were involved in the services, finance, and production industries. The contracts involved a wide variety of projects, ranging from a size of tens of thousands of dollars to hundreds of thousands of dollars. Additionally, the projects had timelines that were as short as four months to as long as two years, and involved managerial information systems as well as transaction processing systems.

The data items collected for each of the 15 contracts is summarized in Table 1. The risk-based measures were collected based on the instrument that Barki, Rivard and Talbot (1993) developed and validated for the assessment of software development risk. Since some of the items in this instrument pertain only to in house software development projects, Table 1 identifies the items that are relevant to outsourcing projects.

Type of Data		Collected Information	Relevant to Outsourcing
Descriptive Data Collected through review of contracts and employee interviews		- **Project duration (in months)** - **Number of project milestones** - **Hardware and software costs**	**X** **X** **X**
Risk-Based Measures	**Uncertainty Measures** Risk factors based on the instrument developed by Barki et al. (1993).	- **Technological newness** - **Application size (scope)** - **Organizational (vendor's) expertise** - **Application complexity** - Organizational (client's) environment	**X** **X** **X** **X**
	Potential Loss Measures Measures impact of project failure on 7 individual organizational characteristics. Collected based on the instrument developed by Barki et al. (1993).	- **Profitability** - Customer relations - **Reputation of IS department** - **Organizational efficiency** - Market share - Reputation of user department - **Ability to carry out current operations**	**X** **X** **X** **X**
	Vendor Risk Measures Measures the ability of the vendor to accomplish 4 specific project goals as perceived by contract managers. Collected based on criteria developed by Barki et al. (1993)	- **Ability to meet cost targets ("cost risk")** - **Ability to meet timeline ("schedule risk")** - Ability to maintain application - **Ability to achieve long-term effectiveness ("effectiveness risk")**	**X** **X** **X**

Table 1. Items Relevant to Outsourcing Projects

ANALYSIS

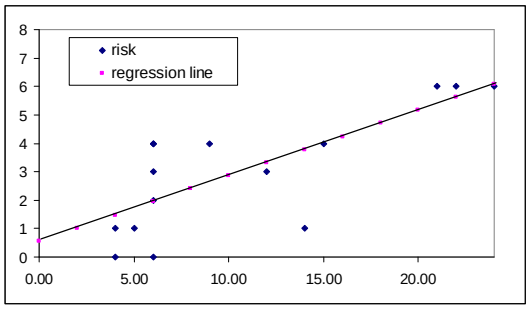
Ordinary Least Squares (OLS) regression was used to determine if there was any relationship between the risk-based measures and the number of project milestones. The goal of this initial analysis was to examine whether risk alone is a good predictor of how many milestones a project would have. The results of this analysis are shown in Table 2.

Our analysis of the individual risk-based measures showed that organizational (vendor) expertise, profitability, cost risk, and effectiveness risk were statistically significant in predicting the number of project milestones. Additionally, like Lichtenstein, we found that project duration exhibited better predictive ability than the risk-based measures alone. The results of this analysis have demonstrated that contract managers may be considering some dimensions of outsourcing project risk when planning the number of project milestones. However, the identified relationships are weak. If the organizations in this study were placing milestones based on risk alone, one would expect that the predictive ability of the risk-based measures would be much higher.

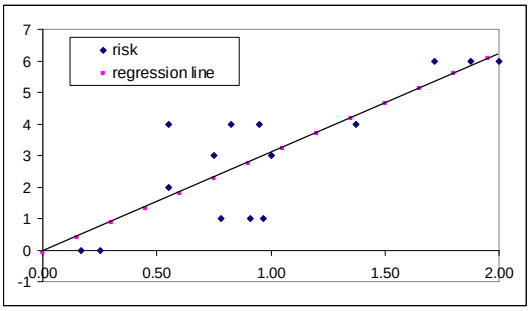
		Factor alone		Factor & duration	
Data Type	**Independent Variable**	**Adj-R^2**	**p-value**	**Adj-R^2**	**p-value**
	Project duration	**53.9%**	**0.002**	N/A	N/A
Uncertainty Measures	Technological Newness	0.0%	0.412	40.1%	0.006
	Application Size	0.0%	0.770	35.3%	0.012
	Organizational (vendor) Expertise	**37%**	**0.009**	**56.9**	**0.0007**
	Application complexity	4.2%	0.226	38.2%	0.008
Potential Loss Measures	Profitability	**21.8%**	**0.045**	**57.7%**	**0.0006**
	Reputation of IS department	4.3%	0.229	11.6%	0.115
	Organizational efficiency	7.6%	0.924	21.9%	0.045
	Ability to carry out current operations	3.3%	0.245	18.2%	0.282
Vendor Risk Measures	Ability to meet cost targets	**39.4%**	**0.007**	**67.3%**	**0.000**
	Ability to meet timeline targets	4.5%	0.222	39.5%	0.007
	Ability to meet long-term effectiveness	**15.9%**	**0.800**	**42.5%**	**0.005**

Table 2. Ordinary Least Squares (OLS) Regression Results

We then examined the ability of the risk-based measures to predict the number of milestones when combined with project duration. As can be seen in Table 2, the predictive ability of four of the factors improved when combined with duration, where cost risk was one risk-based measure that improved a notable amount above that of duration alone. The combined model for cost risk and project duration has an adjusted R-Squared value of 67.3% as compared to 53.9% for the model that only considers duration. The predictive ability of the combined model can also be seen graphically. Figure 2 depicts a scatterplot and fitted OLS regression line of the number of project milestones versus a weighted value that represents both cost risk and duration. A scatterplot of duration versus the number of milestones is also included for comparison.



Duration (Adj-R^2=53.9%)



Cost risk & Duration – weighted (Adj-R^2=65.6%)

Figure 2. Scatterplot and Fitted OLS Regression Line

DISCUSSION

Our analysis of Lichtenstein's data set has provided evidence that the surveyed organizations may be applying the logic of ROT when planning project milestones. Not only do our results show that the contract managers are likely considering both dimensions of outsourcing project risk and duration when determining the number of milestones (evident by the increased predictability of the model that contains both parameters), they also indicate that these parameters are being considered in a manner that closely corresponds to ROT. In general, the examined application projects have a lower number of milestones when project duration is short. ROT tells us that the value of an option is lower when it has a shorter time to maturity.

Additionally, the projects have more milestones when certain dimensions of outsourcing project risk are higher. ROT indicates that the value of an option increases as the variability of the underlying asset increases. Our results are important for several reasons. If planned incorrectly, project milestones can be very costly to the organization. This indicates the need for an adequate framework that will allow organizations to place an economic value on milestones. Despite attempts, past research has not been able to provide such a framework. This paper is the first to provide evidence that ROT could be a valuable tool to efficiently plan project milestones.

FUTURE RESEARCH

Due to the information available in our data set, we focused our analysis on two ROT parameters: variability of the underlying asset and time to maturity. It would be interesting to examine the planning of project milestones as a function of exercise price as well. Exercise price is probably the most complex parameter to estimate from the perspective of project milestones. This is primarily due to the chief function of a milestone, which is to provide the organization information needed to assess the progress of the project and determine appropriate action. Depending on the information received, the organization may then choose to abandon or change the scale of the project or any dependent projects. These different actions could involve widely varying costs. Since milestones are planned during the contracting process, it may be difficult to estimate at such an early stage what actions would be necessary and what the corresponding costs would be. Therefore, milestone values may need to be computed for various scenarios. Future research could involve tracking application projects from the contracting process forward and surveying management to determine their beliefs on possible future actions and costs based on milestone outcomes. The valuations estimated during the contracting process could then be compared to actual results in order to determine their accuracy. Such a study would help to further evaluate the robustness of ROT as a framework for planning project milestones.

Our results should be compared to a similar analysis done with a larger data set. The data set used for this paper only contained information on 15 application projects in three organizations. Additionally, the size of the involved projects and country-specific practices may limit the generality of our study. It would be interesting to see if the same conclusions are reached with a data set that contains more projects or involves more organizations in other countries. Additionally, we found that only three risk-based measures had predictive relationships with the number of milestones, and only one risk-based measure was statistically significant when combined with project duration. Future studies are needed to validate our results.

Further, our data set included information on the number of milestones. It would be helpful to understand the milestones in more detail. Each milestone will likely have a different cost and intensity of effort. If the milestones in the preceding analysis were somehow normalized for this cost and effort, a different picture may emerge. Whang (1992) focused on staged software development contracts that could be easily abandoned without incurring legal penalties. Information on the divisibility of the contracts could lend more insight as to how milestones are planned.

It would also be interesting to analyze more qualitative data concerning management rationale regarding the planning of milestones. Our empirical analysis has uncovered possible relationships between the number of milestones and outsourcing project risk along with project duration. Interviews with management could validate whether these parameters are actually being considered when milestones are planned.

CONCLUSION

The results in this paper are an important contribution to software development contracting. Project milestones serve an important role as risk mitigants in application outsourcing. However, if planned incorrectly, they can be very costly to the organization. Because of this, there is a need for an adequate framework that will allow organizations to plan milestones in an economically efficient manner. Past research has attempted to provide such a framework, but has been unsuccessful. This paper presents the position that real options theory may be able to serve as such a framework. It does this through empirical analysis demonstrating that contract managers may have, knowingly or unknowingly, followed the logic of the theory when planning milestones in three separate organizations. Although past outsourcing research has indicated that control mechanisms such as milestones are important to monitor vendor behavior, we believe that this paper is the first to suggest a framework that allows organizations to plan them in an economically optimal manner.

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