Using a Mark-to-Market Valuation Technique to Objectively Measure IT Portfolio Value Creation

Research-in-Progress

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ABSTRACT

Enterprise executives frequently face the challenge of making decisions under conditions of significant uncertainty when dealing with IT investments, IT project management and realization of intangible organizational benefits enabled by IT. A suitable methodology for accurately estimating the current financial standing of each project in a portfolio of IT projects over the full project lifecycle is useful for IT managers to understand IT value creation and manage the IT projects across the portfolio. In line with this perspective, we propose a Mark-to-Market valuation technique that enables a standardized approach across diverse IT projects that comprise the IT portfolio. Three main contributions may be drawn from this study: 1) the Mark-to-Market approach is a useful valuation technique in the context of IT projects; 2) practitioners may leverage the technique to assess project value and the performance of the IT portfolio over the lifecycle of such projects; and 3) the consistent treatment of each project allows aggregation and applications of standard portfolio management techniques to the practice of IT portfolio management.

Keywords

Mark-to-Market, Mark-to-Model, IT Portfolio Management (ITPM); realization, project monitoring, Greeks

INTRODUCTION

There has been significant debate regarding whether investment in information technology (IT) leads to improved productivity and/or competitive advantage (e.g. Carr 2003; McFarlan and Nolan 2003). However, there is also a growing set of evidence that investment in information technology does produce value. Such research considers investment and returns at different levels. Researchers have found that overall economic productivity may be attributed to investment in IT through substitution of labor or basic automation and improved process or multi-factor productivity (Brynjolfsson and Hitt 1995; Dewan and Min 1997; Jorgenson 2001). Country level returns on IT investment also suggest that countries that invest in IT infrastructure and higher overall IT investment have benefited in improved productivity (Dewan and Kraemer 2000). Productivity has also been linked to investment in IT across industries, with IT-intensive industries experiencing gains in the value of complementary non-IT assets, while less IT-intensive industries experience improvements via basic automation (Mittal and Nault 2009). Finally, at the firm level, there is additional evidence that IT investment translates into profitability (e.g. Bharadwaj, Bharadwaj and Konsynski 1999; Melville, Kraemer and Gurbaxani 2004; Mithas, Tafti, Bardhan and Goh 2012).

Our study complements the aforementioned research at the economy, country, industry, and firm levels by delving into the process or mechanism at the root of this value creation, the IT project and the associated IT portfolio. Evaluating the process level (the within-firm mechanism) is important aspect of understanding how investment in IT resources translates to business value (Ray, Muhanna and Barney 2005). The IT project is the main tactical level through which IT activity translates to business results for the enterprise. As such, understanding how investments in IT projects and the associated IT portfolio is of high importance to IT managers, general managers and the overall firm. Our approach is to leverage Mark-to-Market valuation, a financial measurement technique often used by commodity traders to dynamically assess the market value of a given asset, and modern portfolio theory (Markowitz 1952), to develop a technique that provides a relatively objective means to quantify and monitor value creation at the level in which is created. The research specifically utilizes the mark-to-market concept to allow managers to evaluate an IT project's attractiveness before, during, and after the project. We suggest that

there are three main contributions of this research. First, mark-to-market concepts are shown to be useful in the context of IT projects in order to provide objective measures of IT success. Second, while many valuation techniques related to IT projects consider the forecasted return on a given investment (cost/benefit, ROI, Internal Rate of Return), this technique proves useful beyond the project lifecycle, to include returns that occur after the work of an IT project is complete (i.e. long-term investments common especially in IT infrastructure projects). Third and finally, this research allows all IT projects, regardless of the heterogeneous nature of those projects, to be treated equivalently in terms of evaluating value creation and applying financial portfolio management techniques (e.g. Markowitz 1952).

THEORETICAL FRAMEWORK

Mark-to-Market

Mark-to-Market (MTM) is a technique that values an asset at its fair market value. The technique has been used to assess realized and unrealized gains and losses for stocks and commodities since the 1950s. Accountants began utilizing the valuation mechanism to recognize unrealized gains and losses of certain assets with the advent of FAS115 (Financial Accounting Standards Board 1993). The accounting practice became especially prevalent as regulatory agencies sought to provide more transparency of a firm's financial standing in the wake of the collapse of the energy trading firm Enron (e.g. FAS133). The premise of mark-to-market accounting is that an unrealized gain or loss may be measured as the difference between the purchase price of the asset and its fair market price. One key benefit of mark-to-market valuation is that assets are constantly assessed in a longitudinal way based on their value relative to the current market value of similar assets. It provides real-time valuation that is not possible in traditional valuation methods such as NPV, ROI and Cost-Benefit analysis that tend to focus on the initiation phase of IT projects.

However, one of the disadvantages of mark-to-market accounting is that the external market may overemphasize the volatility in value especially in illiquid markets undergoing a crisis (Allen and Carletti 2008). In the case of the IT portfolio, there is no market in which a firm may trade its existing or future IT projects, so it is problematic to establish a fair market value for the portfolio of IT projects. Instead, our technique establishes a model for each project as a proxy for the fair market value. The model is the expected return for the project based on all discounted cash flows as of the initiation phase of the IT project. Put simply, the model is the difference between all anticipated future revenues and budgeted future costs as known at the beginning of the project. This technique utilizes the benefit of marking the current financial standing of an IT project versus a model created for internal use by the firm, but avoids the challenges when the valuation's source is external to the firm (i.e. stock market). This technique is intended for internal management of the IT project portfolio, not for the consumption of the external market. Hence, the technique avoids the downside of external fluctuation normally associated with mark-to-market accounting valuation.

Because IT-related projects are almost 100% illiquid (i.e. the firm is not generally able to sell an IT project to a buyer before, during or after its completion in any type of marketplace), there is no true mark-to-market valuation. Instead, we apply the same basic principles of mark-to-market, but "mark" or compare the current value of the IT project against the projected value of the IT project at its inception (the model). The model serves as a substitute for a market valuation in this scenario of illiquidity. The result is a systematic and relatively objective way to measure IT project and portfolio success that is applicable across a diverse set of IT projects. While we are not proposing that any such valuation of IT projects be recognized in the financial reporting by the company in a true mark-to-market accounting sense, the technique of determining fair value estimates from a mark-to-model approach has been shown to be highly correlated to firm value (Kolev 2008). In other words, the valuation technique has strong external validity.

IT Portfolio Management (ITPM)

Briefly, project management is the application of managerial systems to perform a project from the beginning to end, and, as mentioned earlier, it is the primary mechanism for managers to achieve their objectives of schedule, budget, and revenue. The IT portfolio of a firm is regarded as its total investment in computing and communication technology (Weill and Vitale 2002), or the sum total of all IT projects. Concerning the application of portfolio management to the IT portfolio, both academic and industrial people like to refer to Markowitz's modern portfolio theory (Markowitz, 1952) as a foundation and apply it to this context(e.g. Tu and Shaw 2011). In fact, the primary decision model in ITPM is frequently the financial portfolio model used to evaluate investment according to a balance of return and risk.

The increasing embeddedness of IT investment and its integral role in the creation of value for the firm (Davern and Kauffman 2000; Kohli and Grover 2008) has led to increasing levels of IT investment and additional scrutiny of the overall IT portfolio in delivering value (Maizlish and Handler 2005). Additionally, with the increasing influence of IT to all

businesses within the enterprise, many firms has largely increased IT investment during the recent years (Kohli and Grover 2008). Due to the changing nature of a project's financial position, many IT projects cannot easily be measured by traditional financial methods, including NPV, because financial position is rarely assessed after the completion phase of the project. In other words, assessment of financial success rarely includes the associated cash flows that occur after the IT project is closed. More importantly, one major gap in the financial assessment of IT projects is that IT projects typically lack a standard, numeric valuation approach. As a result, assessment techniques common for commodities and available with modern portfolio theory may not be fully leveraged in the management of the IT portfolio. In addition, IT projects are illiquid – there is no market for buying and selling said projects (as compared to stocks for example) since they are firm-specific assets. The illiquidity of IT projects means that assessments are appropriate for internal measurement by the firm, but do not have the same market characteristics required for many of the portfolio management tools.

Real option thinking incorporates in the valuation of a firm's portfolio of assets the choices that it may have (Mahoney 1996; Trigeorgis 1993; Copeland and Antikarov 2001; Mun 2002; Mahoney 2004). Option thinking is a useful technique for assessing the value of flexibility in the context of the IT portfolio (Benaroch and Kauffman 1999; Benaroch, Shah and Jeffery 2005), especially given the value inherent in a multiple stage investment decision (Copeland and Tufano 2004) typical with IT projects. Valuation that leverages a combination of discounted cash flows and real option thinking presents the most realistic assessment of an assets true value (Putten and MacMillan 2004). The common choices available to managers in IT project and portfolio management include staging, abandoning, deferring, scaling and switching to an alternative use (Fichman, Keil and Tiwana 2005). The credibility of using options thinking to evaluate IT portfolio is well-established. We do not preclude the use of real options thinking in this study, but instead real options valuation may serve a useful input to our valuation technique.

Valuing IT Projects throughout the Project Lifecycle

According to the Management Body of Knowledge (PMBOK), there are five relevant phases of project management as shown in Figure 1: Planning, Execution, Modification, Realization and Monitoring. Other frameworks may vary, but IT projects are generally conceptualized as occurring in phases with a monitoring aspect as part of the overall process. Unlike many of the IT valuation techniques, our mark-to-market technique addresses projects throughout the lifecycle in a consistent manner. The technique attributes a specific dollar value to the project at every time period throughout the lifecycle. The technique also is useful beyond the phases of the project in which the costs are incurred to include those phases (especially realization) where actual returns are earned.
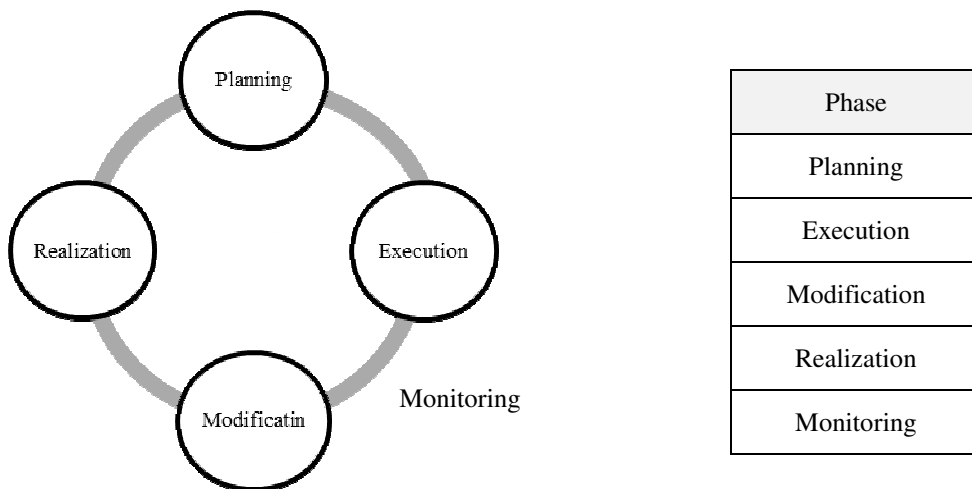

Phase
Planning
Execution
Modification
Realization
Monitoring

Figure 1 – Phases of the IT Project

As for the comprehensive definition for IT portfolio management, Maizlish and Handler (2005) classify the IT portfolio management problem into three phases of IT life cycle: the IT discovery portfolio, the IT project portfolio, and the IT asset portfolio. As such, any technique that is proposed to value an IT portfolio must account for the three phases and must also address the diverse set of initiatives that nearly certain to occur in most organizations. Our approach differs from many of the IT project justification techniques such as cost/benefit analysis, NPV and ROI, especially regarding their use in practice. In practice, the financial attractiveness of a project is almost always evaluated prior to its approval and initiation. However, financial attractiveness is often not measured on an ongoing basis, especially beyond the duration of the IT project itself to

incorporate cash flows attributable to the project. This valuation technique includes the continuous assessment of the financial health of a project before, during and well beyond the implementation of the information technology or system to capture the realized return when it occurs. Since valuing IT investment, especially in IT infrastructure, requires understanding its use value within the organization (Kumar 2004), a complete IT portfolio management tool should incorporate the value realization that frequently occurs after the IT project is completed.

There are three main components in our research framework: (1) Mark-to-Market, (2) IT Portfolio Management (ITPM) and (3) Valuing IT Projects throughout the Project Lifecycle. After applying MTM Valuation technique to evaluating IT portfolio through the project lifecycle, (Realized Return – Realized Cost) + (Unrealized Return – Unrealized Cost) is considered as cash flow process which is in connection with project execution phase, modification phase and realization phase. Along with our research framework, (Expected Return – Original Cost) is seen as planning phase. In the meantime, Greeks can be used to manage the IT portfolio throughout the planning, monitoring and realization phases. The connection between the IT project phases and our approach is summarized in Table 1.

MTM Valuation technique	Phase of the IT Project	Managerial Demonstration
(Expected Revenue – Original Cost)	Planning phase	In connection with IT portfolio plan
(Realized Return – Realized Cost) + (Unrealized Return – Unrealized Cost)	Execution phase, Modification phase and Realization phase	Cash flow process
Whole MTM Valuation	Monitoring phase	Greeks measurement

Table 1   MTM Valuation technique associated with IT Project Phase and Managerial Demonstration

MODEL DEVELOPMENT

Basic Assumptions of the Mark-to-Market Valuation Technique

Each project is measured in the same terms, just as a stock or commodity trader would value each of their assets. Mark-to-Market Value is a single metric that measures project success. Additionally, the measurement of value at every stage of the project allows aggregated reporting across the IT portfolio, and reports to top management will be in terms of change in real dollars instead of "75% of our projects are green" for example.

The Black-Scholes option model has been understood as the foundation with respect to many real options-based approaches. Thus, Benaroch & Kaufman (1999) presented the real options pricing analysis method to evaluate IT project investment, and their contribution is to apply real options into IT project investments domain, which is from traditional financial assets to IT project investments. In line with this perspective, we extend Benaroch & Kaufman (1999)'s method to further propose a MTM Valuation approach to measure IT portfolio in this paper. In Table 2, we show the difference in parameters between Black Scholes option model and Benaroch & Kaufman (1999) approach.

Black-Scholes Model		Benaroch and Kauffman (1999)	
$C = SN(d_1) - Ee^{-rt}N(d_2)$ $d_1 = \left[\ln\left(\frac{S}{E}\right) + \left(r + \frac{1}{2\sigma^2}\right)t\right] / \sqrt{\sigma^2 t}$ $d_2 = d_1 - \sqrt{\sigma^2 t}$		$C = AN(d_1) - e^{-r/t}XN(d_2)$ $d_1 = \ln\left(\frac{A}{X}\right)\eta T / \sigma\sqrt{T} + \frac{1}{2}\sigma\sqrt{T}$ $d_2 = d_1 - \sigma\sqrt{T}$	
Parameter/variable	Managerial interpretation	Parameter/variable	Managerial interpretation
C	Value of call option	C	Value of a call option to defer the investment
S	Current stock price	A	Present value of expected revenues from the operational project
E	Exercise price of call	X	Cost of converting the investment opportunity into an operational project

R	Annual risk-free rate of return	r_f	Annual risk-free interest rate
σ^2	Variance (per year) of the continuous return on the stock	σ	Volatility of expected revenues
T	Time (in years) to expiration date	T	Maximum time to defer conversation of the investment opportunity into an operational project
N(d)	Probability that a standardized, normally distributed, random variable will be less than or equal to d	N(d)	Probability that a standardized, normally distributed, random variable will be less than or equal to d

Table 2 Parameters for Black-Scholes Model and Banaroch and Kauffman (1999)

Since Black-Scholes proposed option-based model, many people have started to measure financial portfolio through measurement of Greeks. Benaroch & Kaufman (1999) developed a bridge to transfer the use of the Greeks from traditional financial assets (Black Scholes) to IT project. In this regard, we extend Benaroch & Kaufman's (1999) real options pricing analysis method and further propose a MTM Valuation approach which incorporates revenue realization in order to accurately measure the value and the performance of IT portfolio. Hence, all projects can be monitored periodically based on MTM Valuation technique, so relevant information associated with project portfolio may be updated during whole project lifecycle. Along with this consideration, the IT project managers are able to figure out both project completeness and its cash flow process at the same time. The main features of Benaroch & Kaufman (1999) and our MTM Valuation approach are described in Table 3.

Methodology	Benaroch and Kauffman (1999)	MTM Valuation approach
Greeks are associated with project phase	Benaroah and Kaufman's Greeks are mainly focused on project planning phase.	New Greeks based on MTM approach are connected with both cash flow process and project planning phase.
Monitoring mechanism	Assess the value of deferring project for different deferral period	Dynamically update Revenue associated with Cost During project and After project
Project value	V is regarded as Call option value according to Benaroch and Kauffman (1999).	As for V in Greek's measurement, we use MTM value in our approach.
Greeks measurement	Greeks from Benaroch and Kauffman (1999) = f (project size) Project size can be regarded as project cost here.	New Greeks = f (departure A-X from both cash flow process and planning phase) Departure can be included realized revenues and costs vs. planned revenues and costs. (Difference between planned and realized)

Table 3 How MTM Valuation Extends Option Approach

In the meantime, the longitudinal reassessment of the value of each project as if each project was a commodity allows the application of a wealth of portfolio risk management tools (e.g. the "Greeks" – Delta (price), Theta (time), and Vega (volatility); and further, the ability to apply common financial tools introduces the idea of hedging into the management of the IT Portfolio in order to reduce overall portfolio risk. This model enables the monitoring of projects beyond cost realization (which normally stops at project closure) and into the revenue realization that is likely to occur after project closure. In order to clarify the Greeks definition among three methods that we used in this paper, we present the basic mathematical definition in Table 4.

Greeks	Greeks from Black-Scholes Model	Greeks from Banaroch and Kauffman (1999)	Greeks from MTM Valuation
Delta (Δ)	Delta $= \frac{\partial C}{\partial S}$	Delta $= \frac{\partial C}{\partial A}$	Delta $= \frac{\partial V \text{ of MTM}}{\partial A}$
Vega (Λ)	Vega $= \frac{\partial C}{\partial \sigma}$	Vega $= \frac{\partial C}{\partial \sigma}$	Vega $= \frac{\partial V \text{ of MTM}}{\partial \sigma}$
Gamma (Γ)	Gamma $= \frac{\partial^2 C}{\partial S^2}$	Gamma $= \frac{\partial^2 C}{\partial A^2}$	Gamma $= \frac{\partial^2 V \text{ of MTM}}{\partial A^2}$

Table 4 Greeks definition among three methods

Quantitative Component – Mark-to-Market Valuation

The Mark-to-Market valuation is simply the best available information on revenues less costs associated with the project (realized and unrealized) as compared to the "mark", or the revenue less cost as estimated at initiation of the project. Therefore, it is a comparison of the current financial position at a given time period compared to the originally estimated financial position of the project. It can be written as:

Mark-to-Market Valuation, V = (Realized Revenue – Realized Cost) + (Unrealized Revenue – Unrealized Cost) – (Estimated Revenue – Original Cost)

i = time period for the overall portfolio

j= time period for each project, with T as the last period where the project realizes costs or revenues.

k= current date

$$
\underbrace{V_{i,j,k}}_{\text{Mark-to-Model Valuation}} = \left(\underbrace{\sum_{j=0}^{j<k; \ i,j,k\geq 0;} R_j - \sum_{j=0}^{j<k; \ i,j,k\geq 0;} C_j}_{\text{Realized Revenue} - \text{Realized Cost}} \right) + \left(\underbrace{\sum_{j=k}^{j=T; \ i,j,k\geq 0} R_{j\geq k} - \sum_{j=k}^{j=T; \ i,j,k\geq 0} C_{j\geq k}}_{\text{Unrealized Revenue} - \text{Unrealized Cost}} \right)
$$

$$
- \left(\underbrace{\sum_{j=0}^{j=T; \ i,j,k\geq 0} R_{i,0} - \sum_{j=0}^{j=T; \ i,j,k\geq 0} C_{i,0}}_{\text{Estimated Revenue} - \text{Original Cost}} \right)
$$

Methodology and Simulated Data

Ultimately, our objective is to demonstrate the usefulness of the valuation technique with real world IT portfolio data. As research-in-progress, we have developed a simulated IT portfolio to demonstrate the valuation technique and to pilot test the empirical model. The simulated IT portfolio is constructed to represent the IT investments of a company with revenues at the median size, just over $10 billion in revenue, for a Fortune 500 company (CNN Money 2012). Average enterprise IT investment is assumed to be 3.5% of revenue, matching Gartner's estimate of average IT spending in 2012 and their forecasted metric for 2013 (McGittigan et al. 2013). This means that our simulated portfolio is roughly based on a total enterprise annual IT investment of $369 million. Projects are constructed based on an average project size of $4.1million, but drawn randomly from an F-distribution (df_1=3, df_2=6) to provide the expected skewed distribution associated with many relatively small projects and a few very large projects. The assumption regarding project size is consistent with the notion that about one quarter of human resources on IT projects work on "business transformation projects" (PMI, Inc. 2012). Based on these assumptions, 90 IT projects formed the simulated IT portfolio.

We then developed scenarios to represent the environmental shocks and operational uncertainty inherent in project financials over time. For example, we assume a 12% standard deviation in actual project costs and actual revenues as compared to forecast, consistent with PMI's estimate of project dollars at risk (PMI, Inc. 2012). Therefore, descriptive statistics for the Simulated IT Portfolio is shown in Table 5. The consequence is that the simulated scenarios realistically depict project cost overruns, late project deliveries and failure to achieve estimated project revenues. Scenarios are constructed such that IT project costs and associated returns are quantified over time. The IT portfolio includes projects that start and finish at varying times and have different project durations. In this way, the simulated portfolio mirrors the complexity of an enterprise's IT portfolio.

Using these scenarios we apply our Mark-to-Market valuation technique to the simulated portfolio. For each project and time period (assumed to be by the month to enable monthly assessment and reporting), the Mark-to-Market value is calculated as described in the previous section. This enables the organization to apply one metric to reflect the current financial standing of the project. As we demonstrate later, this allows the application of common financial tools to understand performance and assess risk in the overall portfolio.

Variable	Mean	Median	Std Dev.
Budget Cost	$11,764,184	$3,557,709	$41,143,429
Project Duration	11.1 months	9.0 months	6.9 months

Table 5   Descriptive Statistics for the Simulated IT Portfolio

RESULTS

The simulation affords three main results: demonstration of the Mark-to-Market valuation, calculation of the "Greeks"; Delta(Δ), Vega (Λ) and Gamma(Γ), for the IT portfolio, and determination of a new proposed metric for IT portfolio risk management.

First, the simulation allows the determination of the net Mark-to-Market valuation of a portfolio of IT projects. The simulated IT portfolio was monitored for a period of three years, with projects starting and ending at various time periods. Two metrics are reported related to the Mark-to-Market valuation. The first is the Mark-to-Market valuation in total dollars. This metric captures the net difference in dollars between the current financial standing of the project and the financial standing of the project as estimated during the initiation phase. It allows an organization to observe, monitor and quantify the net departure of its portfolio of IT projects from the planned financial estimates. Mark-to-market valuation is reported in Figure 2 for the three year period. This result may be subject to dramatic differences depending on the size of the IT investment. A large company that invests a significant dollar figure in IT can expect that its Mark-to-Market net valuation to be higher than a smaller company with a lower IT budget. The Mark-to-Market valuation can be scaled as a ratio of the Mark-to-Market net / estimated budget cost. This second metric means that departures from estimates may be compared on equal footing regardless of the size of the project. The second metric is reported in Figure 3.
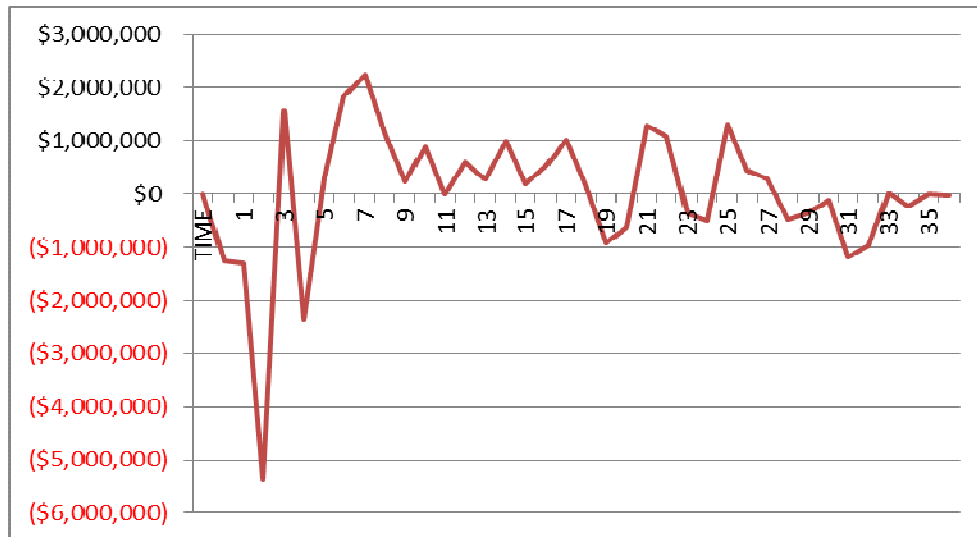

Figure 2   Simulated Mark-to-Market Valuation ($) at different time periods (36 months)
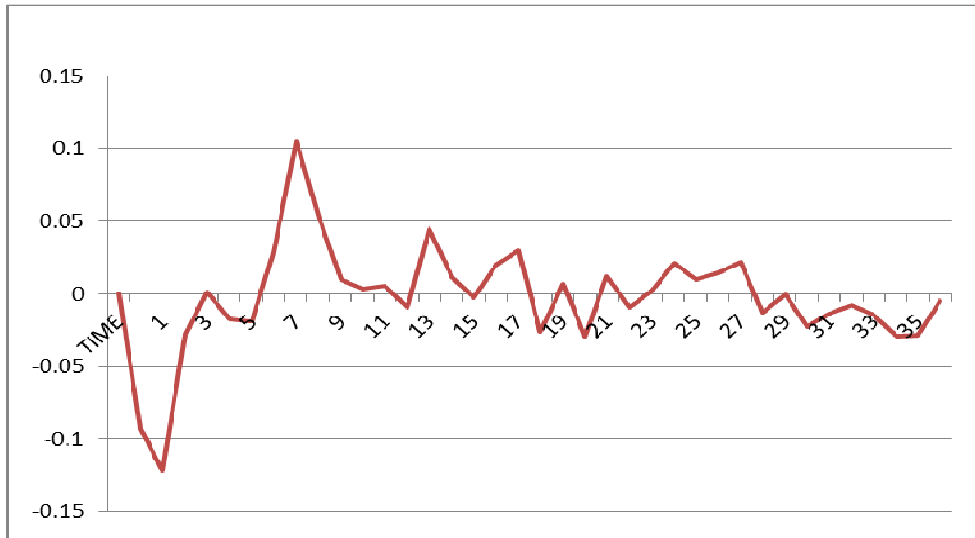
Figure 3 Mark-to-Market Valuation Scaled by Estimated Project Cost at different time periods (36 months)

We follow the approach of Benaroch and Kauffman (1999) customized for an IT portfolio in calculating the "Greeks"; Delta (Δ), Vega (Λ) and Gamma (Γ). We report Delta, Vega and Gamma by time period for the simulated IT portfolio. The results are reported in Figure 4, 5, and 6 respectively. Through Delta calculation, we are able to understand the rate of change of MTM value related to changes in expected revenues of IT portfolio. Additionally, with regard to Vega calculation, we can figure out how to assess the rate of change of MTM value in connection with the sensitivity to volatility in IT portfolio. As for Gamma calculation, we can apply Gamma to evaluating the rate of change in Delta associated with changes in expected revenues of IT portfolio.
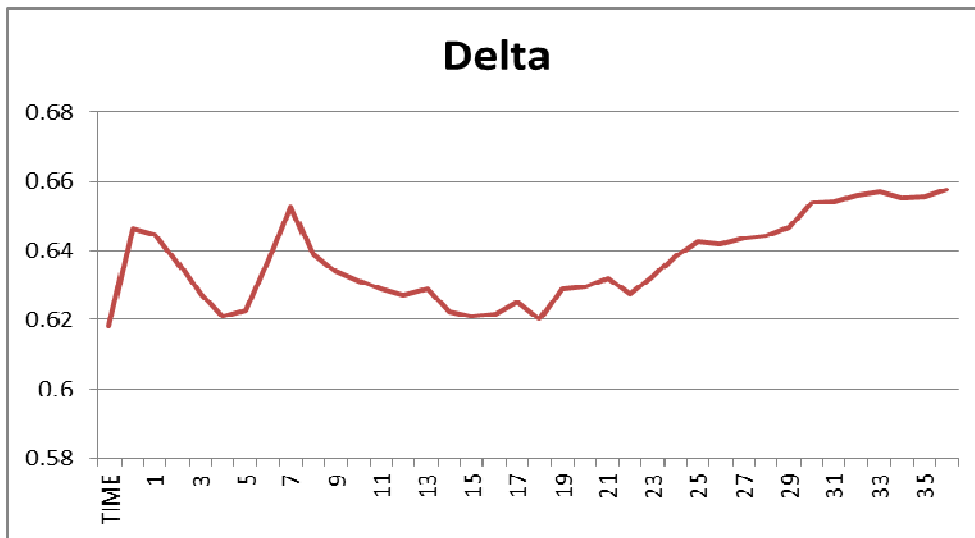

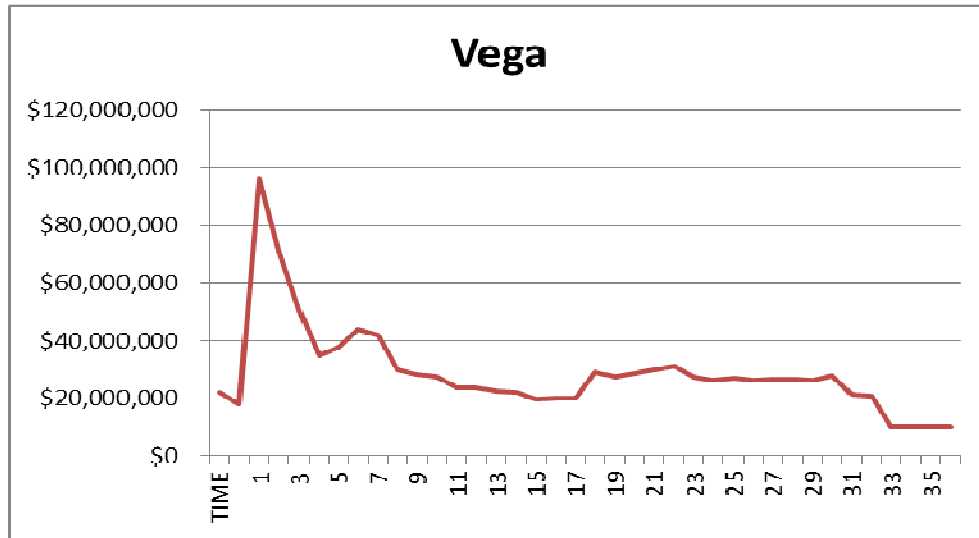**Figure 4 IT Portfolio Average Delta at different time periods (36 months)**

Vega

Figure 5 IT Portfolio Average Vega at different time periods (36 months)
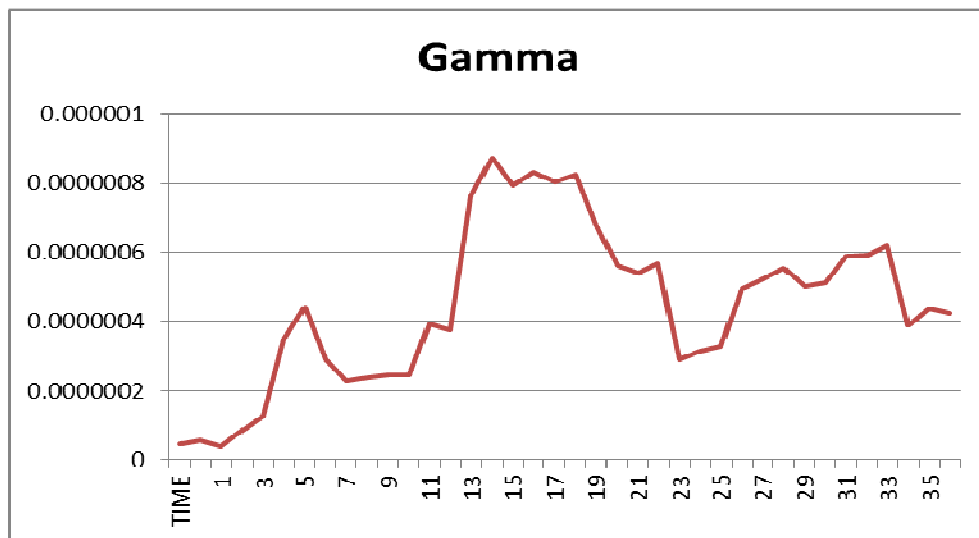
Gamma

Figure 6 IT Portfolio Average Gamma at different time periods (36 months)

The results themselves depend on the nature of the IT portfolio and are only intended to serve as an example. However, the benefit of the proposed Mark-to-Market valuation technique is that project status is reported in dollars and may be treated as commodity assets.

Finally, we suggest an additional parameter to complement the "Greeks" in assessment of the IT portfolio. We use the Greek letter, Iota (I), to reflect the trajectory of IT portfolio with respect to its financial health as compared to its estimated financial payoff at the beginning of the project where M is the scaled Mark-to-Market value and t is the time period. Iota is the average slope or change in the Mark-to-Market value for the projects over time, represented by the partial derivative of the Mark-to-Market value with respect to time, a regression coefficient of the Mark-to-Market valuation with respect to time:

$$I = \frac{\partial M}{\partial t},$$

Iota is similar in most respects to the Greek theta (which is the change in value with respect to time or the time decay), however there is one departure. The new measure, Iota, reflects the change in value with respect to the original budgeted

financial standing. Therefore, it is particularly relevant to practitioners trying to keep IT projects on track vs. original estimates. It may be used to identify concerning trends in the financial performance of the IT portfolio. For example, a manager may observe Iota for a window of time and detect an alarming negative trend in value. Figure 7 provides one example of such a trend associated with our simulated data.
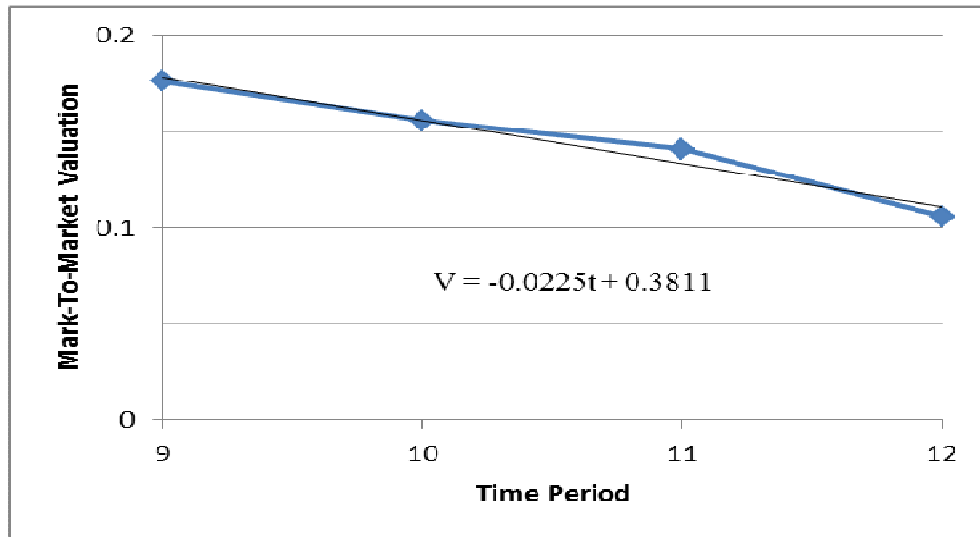

Figure 7 Evaluating Trends in Portfolio Financial Performance Using Iota

The utility of this new measure is that it reflects a relevant portfolio attribute that may enable portfolio and project managers to monitor and address problems related how the firm's IT portfolio is tracking vs. estimates.

CONCLUSION AND FUTURE RESEARCH

This study suggests a Mark-to-Market valuation technique applying to IT portfolio management to assist an enterprise's decision makers in monitoring an IT portfolio's real value over multiple time periods, especially beyond cost realization to include revenue realization. Our research-in-progress provides a demonstration of the Mark-to-Market valuation, a calculation of relevant "Greeks" that may be used to manage risk of the IT portfolio and the introduction of a new metric to understand the trend in financial performance for an IT portfolio.

This research serves as a starting point for other potentially fruitful research avenues. There are opportunities to enhance the existing simulation to include the complementarity, or synergy, that is common among IT projects (Jeffrey and Leliveld 2004; Tu and Shaw 2011). In the current implementation, projects are treated independently. Additional scenarios may be executed via the simulation platform in order to provide sensitivity analysis to the results. For example, we allow for project costs and revenues to vary randomly based on an average assessment of value at risk (PMI, Inc. 2012), however some firms are better or worse at managing their IT projects. A simulated IT portfolio representing a firm with a tendency to exceed project budgets on most of their IT projects may provide new and interesting insights. As mentioned above, the ultimate interest with this work is to demonstrate the use of the Mark-to-Market valuation with real IT portfolios and validate that the Mark-to-Market valuation provides a measure that is correlated with project success. Additionally, the Greeks are designed to measure the performance and risk of a commodity portfolio. While our valuation technique does allow for a consistent metric and enables the use of the Greeks as a tool to manage the IT portfolio, there is an opportunity to develop additional measures to further complement the "Greeks" and provide specific metrics that are useful in the context of an IT portfolio.

Regarding the limitation of our current approach, we did not include the interdependence of IT projects in this paper, and we plan to incorporate this feature in the following research progress. Instead of the simulated data, we would like to leverage real enterprise data to demonstrate our MTM valuation. In this regard, we have collected very granular data for a large firm's entire IT portfolio over the course of multiple years. We expect coding the data to begin soon, with the empirical study to follow.

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