An Integrated Approach to Managing IT Portfolio

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Abstract. As IT portfolio management (ITPM) has been increasingly regarded as solution to governing IT investment, enterprises are faced with the challenge to develop and manage IT portfolio. We argue that IT portfolio needs to additionally consider managerial flexibilities and interdependencies in terms of a balanced portfolio return and risk. Moreover, we propose an IT portfolio model that is capable of considering option and synergy to make decision. Finally, we demonstrate an example to show the use our proposed model.

Keywords: IT portfolio, synergy, managerial flexibility, options, interdependency.

1 Introduction

Increasingly, IT portfolio management (ITPM) has garnered significant attentions among enterprises. It is generally said that IT portfolio management is able to provide a portfolio-based approach to help manage various IT asset or project. Since McFarlan[20], the basic concept of IT portfolio has existed for almost 30 years. So far, however, the IT portfolio researches are still very limited in the Information Systems literature.

To a certain degree, IT portfolio management is seen as an extension of IT valuation and prioritization. In this regard, discounted-cash-flow based models and real-options based models are main financial modeling approaches. In contrast with discounted-cash-flow based models, real-options based models in recent years have developed a stream of research in information systems (IS) literature [3][4][5][8][9][26]. Nevertheless, real-options based models have their own limitations. For example, because of their complicated theoretical assumptions, some enterprises tend to see such models as the black-box model for managing IT investment. It is also one of reasons why the real-options based models are still precluded from being widely used and discounted-cash-flow based models are still dominant.

Actually, IT portfolio management should cover not only simply IT valuation and prioritization, but also portfolio analysis. Nonetheless, usually the IT portfolio-level analysis used to be overlooked, because the analogy between an IT portfolio and stock portfolio is not easily perceived. For instance, a stock portfolio can be composed of numerous different stocks from the public market, but an IT project portfolio can only be composed of IT projects proposed. Besides, each IT project is usually singular in an IT project portfolio, but same stock can be multiple in the stock portfolio. On the other hand, the value of a stock portfolio could not be influenced by any

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managerial flexibility, whereas the value of an IT project portfolio could. For instance, a senior IT manager could let some IT projects postpone for a while, or make them share some function with other IT projects in order to save certain cost. In other words, the value of the resultant IT project portfolio could change by IT manager's certain managerial action. Specifically, from our observation, managing IT project portfolio can exploit considerable possibilities of managerial flexibilities and interdependencies. With technology advancing, IT projects are often capable of benefiting from time because of Moore's law. For instance, because of the digital data and modular design, IT projects are relatively easy to share component with each other; because of the compatible managerial principles, IT projects are relatively feasible to be coordinated to support each other. Put simply, these nuances make managing IT portfolio very different from managing a traditional stock portfolio.

Accordingly, how to make the bridge between financial modeling approach and IT project context is one of main challenges in IT portfolio management. Although such researches in the Information Systems literature are stark, similar researches can be found in related research area. In the context of computer programming, Kersten and Verhoef employed the discounted-cash-flow based model and Markowitz's portfolio theory to optimize the IT product portfolio [10]. In the context of R&D management, Ong and Wu propose a descriptive IT investments portfolio framework incorporating real-options thinking [26]. In the context of operations research, Liesio et al. propose a project portfolio model which takes into account the project interdependency [13]. Clearly, however, more investigations are needed to explore the IT portfolio management in the Information Systems area.

In this paper we are to facilitate IT project portfolio management in a quantitative manner. Particularly, by providing a model for developing a balanced IT project portfolio, we are to improve the communication of IT investment decision. Also, we will demonstrate an example to illustrate the use of our proposed model. In this example, we will show how IT project deferral option and cost synergy could have impacts on IT project portfolio compositions. Finally, we will discuss this paper's managerial implications, research contribution, and future direction.

2 Related Literature

On the basis of real-options model, Luehrman proposes a two-parameters model to help deal with selecting projects embedded with a deferral option [15][16]. He creates an option space to help make strategy for projects under uncertainty. Basically, his model depends on the two logics. First, if we wait longer to make the decision for a project, we will have more uncertainties on its value. In other words, the project risk will increase. Second, if we wait some time to make decision for a project, the project's cost also needs to be discounted, since we should consider the interest that the money of the cost might accrue when we are waiting.

Luehrman's model fits in with measuring IT project, since most of IT project are deferrable and therefore deferral options of IT investment are well regarded and investigated in the IT related literature [1][3][4][11][20]. Besides, Luehrman's model is compatible with discounted-current-flow based data, so that it is more likely to be accepted by decision makers in the enterprise. As Kleinmuntz states, for the resource allocation decision, a complex model will be in danger to be treated as a mysterious black box by decision makers, who will be reluctant to rely on it [12]. Since Luhrman's model has several merits and concise to use, we adopt similar measurements to evaluate the IT project.

Modern portfolio theory [18] has been successfully applied in several disciplines. In a way, this model is not only dominant in finance discipline, but also suitable for being applied in other disciplines [21]. Basically, Markowitz reasons that asset return, asset standalone risks, and correlated risks are three main constructs for determining portfolio efficiency. Further, he proposes to use expected value of the asset, the standard deviation of the asset, the correlation between assets, and mean-variance criteria (MV) to select the portfolio. Namely, it is stated that a portfolio can dominates the other portfolio, if it is of higher return, give the same risk for both portfolios. In the same vein, a portfolio can dominate the other portfolio, if it is of lower risk, given the same return for both portfolios. Accordingly, the famous efficient frontier curve can be derived and those dominant portfolios are also called efficienct portfolios. In many perspectives, certain adjustment of Markowitz's model is still needed to fit in with the various portfolio contexts. However, the basic logics can still be analogous and thus Modern portfolio theory can be so influential.

Synergy is generally believed to bring the advantage to the project portfolio. Further, interdependency is often associated with synergy, which is a synergistic effect to bring in the additional advantages for interdependent projects. For example, in the Engineering Management, Stummer and Heidenberger model the project interdependency in order to reflect the effect of synergism in R&D project portfolio [27]. In their example, this synergism not only can increase the value but also can save the cost in the portfolio. Similarly, in the Operations Research, Liesio et al. account for the project interdependency in order to reflect the effect of synergy, or cannibalization, in the project portfolio. In their definition, synergy means when overall value and, or the cost, of a set of projects differs from the sum of the individual projects' overall values and costs. In the Information Systems, Tanriverdi and Venkatraman define two types of synergy: super-additive value synergy and sub-additive cost synergy [22]. Super-additive value synergy refers to the phenomenon—Value (a, b) > Value (a) + Value (b). Sub-additive cost synergy refers to the phenomenon—Cost (a, b) < Cost (a) + Cost (b). Moreover, Tanriverdi argues that IT relatedness would induce sub-additive cost synergy and IT complementarity would lead to super-additive value synergy in the multi-business firm [24]. Overall, in the project level, synergy could mean positive effect in the project portfolio and usually results from the interdependency between the projects; in the firm level, IT synergy is related to IT resource relatedness and complementarity.

3 Proposed Solution

In order to foster a general understanding of our propose model, we firstly propose a method for analyzing IT project portfolio (figure 1). With it, we argue that we can have analysis layers to go through to evaluate an IT project portfolio: IT project common analysis, IT project managerial flexibility analysis, IT project interdependency analysis, IT portfolio analysis, and IT portfolio selection. In the first layer of IT project common analysis, IT project is estimated by the similar way we evaluate other non-IT project. For example, we need to analyze and project IT project value and cost. The derived analysis outputs, such as the IT project's net present value (NPV), can usually be found in the IT project proposal, IT project business case, and etc. In the next layer of IT project managerial flexibility analysis, we can consider how to exploit IT project options, such as the deferral option. In the layer of IT project interdependency analysis, synergy is our focus. For instance, we could think whether certain IT projects can work together to save the cost (i.e., sub-additive cost synergy). In the layer of IT portfolio analysis, we need to find a way to evaluate our IT projects in an aggregate view. For example, we might want to generate all possible IT project portfolio combinations and their respective returns and volatilities for making decision. Finally, in the layer of IT portfolio selection, we need to develop our selection criteria. Usually, the trade-off is unavoidable in this layer, such as a trade-off between the IT project portfolio return and risk. In our understanding, so far very few enterprises have touched on the last two layers, so that we propose this method for enterprise reference.

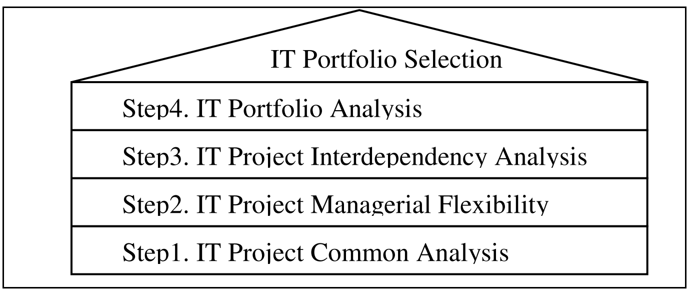

Fig. 1. Proposed Method for Analyzing IT Portfolio

3.1 Step 1: IT Project Common Analysis

Deriving IT project value and cost is the focus here. Most enterprises already have their financial practices to evaluate IT project value and cost, such as IT project's net present value (NPV). Thus, our proposed model assumes the IT project value and cost are already available for use.

3.2 Step 2: IT Project Managerial Flexibility Analysis

Analogous to Luehrman's model[15][16], our proposed model employs IT project return and IT project risk to further IT project common analysis into IT project managerial flexibility analysis. The deferral option of an IT project is our target to be considered in our proposed model. In other words, once an IT project is deferred, our model would consider the extra interest earning from the unused cost in the deferral time, as well as the accompanied risk. Basically, the return means a ratio of IT project value to its cost. The risk refers to the degree to which the IT project value would fluctuate in the deferral time. They are defined as follows.

$$Value\text{-}to\text{-}\cos t = S\frac{X}{(1+r)^t} \tag{1}$$

$$Volatility = \sigma\sqrt{t} \tag{2}$$

In the formula 1, we have S: IT project present value, X: IT project cost, r: risk-free interest rate, t: the time we can wait for making decision of the IT project, and actually traditional NPV = S – X. And in the formula 2, we haveσ: the standard deviation of IT project value in the deferral time, and t: the deferral time

3.3 Step 3: IT Project Interdependency Analysis

In our proposed model, we depend on IT project interdependency to approximate the value of IT project synergy. Moreover, we assume that we can estimate this interdependency by analyzing the degree to which IT projects are related. For example, whether IT projects are related to sharing similar tangible resources or utilizing the similar know-how, and whether they can be pooled for increase negotiation power for purchase. Since the research investigating the IT project interdependency and synergy is very sparse, we make our assumption mainly grounded on the finings of the sub-additive cost synergy and IT resource relatedness. According to Tanriverdi [24], the sub-additive cost synergy can be measured by four dimensions of IT resources relatedness. These dimensions are (1) shared tangible resources, (2) coordinated strategies, (3) pooled negotiating power, and (4) shared know-how. Besides, the conventional observation is also in support of our assumption. For instance, when thinking about reducing the total development cost of overall IT projects, the senior IT manager usually would consider whether there are some modules, functions, applications, software, and hardware which can be shared in these IT projects (i.e., shared tangible resource and shared know-how), or whether we can increase our bargain power by aggregating these IT projects' purchases (i.e., pooled negotiating power). Therefore, we reason analyzing IT project cost interdependency is a possible way for us to approximate the value of IT project cost synergy.

Accordingly, we assume that the cost-saving synergy (Syn_{ij}) is a function of the degree (%) to which two IT project are interdependent (Itd_{ij}). For instance, if the interdependency between IT project i and j is 0%, it is implied that both projects are independent and thus could hardily have any cost-saving synergy. On the contrary, if the degree of interdependency is 100%, there is likely a cost synergy for IT project i and j. Further, assuming today we can derive a function as $Syn_{ij} = 0.5(Itd_{ij})$ by either the expert judgment or by an educated guess, if we estimate two IT projects can have 10% interdependency on sharing certain cost component, we could project that there will probably be a cost synergy worth 5% of total cost of IT project i and j. In short, we assume the cost synergy magnitude of IT project i and j (Syn_{ij}) depends on the function of their interdependency (f (Itd_{ij}))

$$Syn_{ij} = f\left(Itd_{ij}\right) \tag{3}$$

In the formula 3, we have Syn_{ij} : synergy of IT project i and IT project j, and Itd_{ij} : interdependency between IT project i and project j.

3.4 Step 4: IT Portfolio Analysis

On the basis of Markowitz portolio model, we develop our model to measure the return and riks of an IT project portfolio. The cost synergy is also taken into account in this model. In a sense, a stock portfolio return is analogous to our IT project portfolio $return_p$. So, it is derived as follows.

$$return_p = \sum_{i=1}^{n} w_i \left(S_i \frac{(1+r)^{ti}}{X_i - \sum_{j=i+1}^{n} Syn_{ij}} \right) \tag{4}$$

In the formula 4, we have w_i : the weight of IT project i in the portfolio, Syn_{ij} : the synergy of IT project i and IT project j in the portfolio, X_i : the cost of IT project i in the portfolio, S_i : the value of IT project i in the portfolio, r : the risk-free interest rate, and ti : the deferral time for IT project i.

The stock portfolio risk is analogous to our IT project portfolio $risk_p$, and it is derived as follows.

$$risk_p = \sqrt{\left(\sum_{i=1}^{n} (w_i \sigma_i)^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j \neq i}}^{n} w_i w_j \rho_{ij} \ \sigma_i \ \sigma_j \right)} \tag{5}$$

In the formula 5, we have w_i : the weight of IT project i in the portfolio, w_j : the weight of IT project j in the portfolio, ρ_{ij} : the correlation between IT project i and j, σ_j : the standard deviation of IT project *j*, and σ_i : the standard deviation of IT project *i*.

3.5 IT Portfolio Selection

We follow Markowitz's mean-variance criterion to select IT project portfolio. This criterion is well-regarded in financial portfolio analysis and also found effective in other non-financial areas. Its basic logic is that, given the same risk, a portfolio A with a higher return will be dominant than a portfolio B with a lower return, and vice versa. Moreover, this mean-variance criterion can lead to a so-called efficient frontier where the portfolio risk is minimized and return is maximized. Following the same logic, we adopt this mean-variance criterion to determine whether an IT project portfolio A is more efficient than an IT project portfolio B. In our model, the efficient IT portfolio frontier will be defined as the following rule.

$$\text{\textit{IT project portfolio A is more efficient than IT project portfolio B, if}} \quad return_A > return_B \text{ and } risk_A \le risk_B \tag{6}$$

4 An Illustrative Example

In this section, we illustrate a simplified example to further the understanding of our proposed model. Hypothetically, we have only three IT projects A, B, and C to select (Table 2). Thus, initially there will be only three IT project choices a, b, c to make decision in order to develop the IT project portfolio. In addition, we assume we can also decide to defer these decisions to the next year. Thus, we can add choice a1, b1 and c1 to represent choices when the original projects are deferred for one year to make decision. For example, we can decide to invest IT project A, B, and C at the current time (i.e., choices a, b, and c), or defer to decide them until the next year (i.e. choices a1, b1, and c1). Noticeably, since a and a1, b and b1, and c and c1 are physically the same project, they are precluded from being selected concurrently. Consequently, with the 6 choices (i.e., a, b, c, a1, b1, and c1), we will have many different portfolio compositions to determine whether they are efficient IT portfolios.

Table 1. IT project profiles

Heading level	IT project A	IT project B	IT project C
IT project present value (S)	\$102	\$99	\$97
IT project cost (X)	\$100	\$100	\$100
The deferral time (t) (per year)	1	1	1
Standard deviation (per year) (σ)	0.3	0.2	0.1
Risk-free interest rate(r_f)	0.06	0.06	0.06

Moreover, we design 3 scenarios to verify the importance of taking the options and synergy in into the consideration of an IT project portfolio. In the first scenario, the base case, we consider neither options nor synergy. And we depend on the traditional net-present-value to determine the efficient IT project portfolio. In other words, in this way what we do will be similar to prioritizing IT project based on its net-present-value only. In the second scenario, the case 1, we add options consideration. In the last case, case 2, we consider both options and synergy. To this end, we assume the IT project B and IT project C have the 10% interdependency on sharing certain cost component. In addition, we assume the correlation between two IT projects will also be half of the IT projects' interdependency. Similarly, we assume the amount of we can save from both IT projects' total cost (synergy) will be half of the IT projects' interdependency. Namely, in this case the correlation between IT project B and C will be set as 0.05, and 5% of their total cost will be saved as cost synergy benefit.

Consequently, for each scenario we can derive the efficient portfolios from its overall IT project portfolio combinations. In the figure 2, we can see there are 3 groups of efficient portfolios, each of which will be presented with the same color, the same shape, and the same first digit. For example, the green-diamond-0a means that, in the base case, a portfolio composed of the choice a is derived as efficient, the blue-triangle-1a means that, in the case 1, a portfolio composed of the choice a is derived as efficient, and the red-square-2bc means that, in the case 2, a portfolio composed of the choice b and c is derived as efficient.

As for the base case, the most efficient portfolio is only the portfolio (a), i.e., doing the IT project A now. This result is actually not surprised, since only IT project A is of a positive net-present-value (i.e., 2$). According to the mean-variance criteria, other portfolio combinations could generate only the worse return, given the same risk in each IT project choice (i.e., a, b, and c) in the base case. In the case 1 where we begin to consider the IT project deferral option, we will have 7 efficient portfolios (i.e., a1, a1b1, a1c1, b1c1, ab1, ac1, and a). Among these efficient portfolios, the portfolio (a1), i.e., doing the IT project A 1-year later, will be of the highest return as well as highest risk. And the portfolio (a), i.e., doing the IT project A now, will be of the lowest return as well as highest risk. Clearly, the results together reflect the trade-off between the portfolio return and risk. That is, the deferral option could bring in not only additional advantage but also additional risk. This is also why the portfolio (a) is the efficient portfolio either in the base case or case 1. It is the efficient portfolio with lowest risk, given the no-synergy situation. In the case 2 of example where we consider both IT project deferral option and cost synergy, the situation change and we will have 3 efficient portfolios (i.e., bc, a1bc, b1c1). Currently, the efficient portfolio

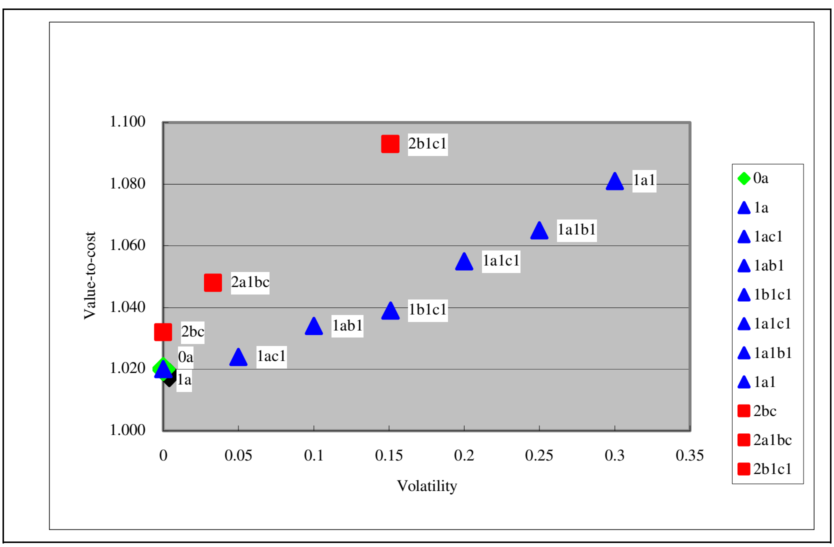

Fig. 2. Efficient portfolio frontier of illustrative example scenarios

with lowest return and risk is the portfolio (bc), i.e., doing the IT project B and C now, the in-between efficient portfolio is the portfolio (a1bc), i.e., doing IT project B and C now and doing IT project 1-year later, and the efficient portfolio with highest risk as well as highest return is the portfolio (b1c1), i.e., doing the IT project B and C 1-year later. Noticeably, the interdependency between IT project B and C have the impact on the efficient portfolio composition, since each of three efficient portfolios comprise choices originated from both IT project B and C (i.e., bc and b1c1). If we contrast the efficient portfolios in the three cases, we will find the efficient portfolio in base case happens to be one of the efficient portfolios in case 1. And the efficient portfolios in case 2 of example are better than those in the base 1 and base case.

5 Discussion and Conclusion

Thus far, we can see if we consider IT project managerial flexibility and interdependency, more and better portfolio choices might emerge. In our case 2 of example, the derived efficient IT project portfolios are obviously better than those in the base 1 and base case. Specifically, in our case 2, if an enterprise is conservative (i.e., risk-averser), it is likely that portfolio (bc) is favored because it has lowest risk. Conversely, if the enterprise is comfortable with high risk (e.g., risk-seeker), the portfolio (a1bc) becomes a good choice because it has the largest the return as well as risk. In between, the portfolio (b1c1) could be good portfolio choice because its risk is neither lowest nor highest. Even if there is no IT project interdependency to exploit, there still could be better choices if we have some IT managerial flexibility to utilize. In our case 1 of example, portfolio (a1), portfolio (a1b1), portfolio (a1c1), portfolio (b1c1), portfolio (ab1), and portfolio (ac1) are all efficient, as long as we are willing to bear certain risk in our IT project portfolio.

Another important point reflected in this paper is that we need to pay attention to the balance between the return and risk in the IT project portfolio. If we fully rely on real-options based models to select IT projects, we could unconsciously constitute an IT project portfolio with very high risk. Besides, there is also a possibility of a synergy risk, although it is beyond the scope of this paper. In our example, the portfolio (a1) is better than portfolio (a) because it is with a higher return, whereas portfolio (a) can be better than portfolio (a1) because it is with a lower risk. Therefore, although we have shown that additional return could be brought by considering managerial flexibility and interdependency, we want to underlie that we also have to consider the additional risk. It is very risky to make IT project portfolio without a balance consideration.

Additionally other than options, the IT interdependency and synergy are crucial to the IT project portfolio decision. Although such investigations in the literature are still stark, we argue the IT project interdependency is a helpful index to approximate the synergy effect. For example, if we find that several independent IT projects actually more or less need to get some hardware from the same vendor, it would be sensible if we estimate their cost synergy by evaluating the degree to which their hardware cost are interdependent.

Moreover, considering IT interdependency and synergy could really make difference in the IT portfolio decision making. Only considering discounted-based-models and real-options-models are sometimes not sufficient. For example, initially we could just decide to defer an IT project because of its low net-present-value (NPV) but high future risk, ex: a costly and advanced IT platform project. However, after considering this IT platform's possible interdependencies with other IT application projects, we could decide not to defer it due to the cost synergy. Actually, it is also very likely to have the value synergy in the IT portfolio, although we have not addressed it in this paper. Therefore, the consideration of interdependency and synergy really matter in the IT project portfolio.

On the other hand, this paper provides a useful implication for further investigation of the relationship between synergies and options. In our case 2 of example, we can find one of efficient portfolios is portfolio (b1c1). Actually, it is not a surprised result because we assume IT project B and C have the interdependency. And resultant synergy could also be exploited even if the two projects are deferred for 1 year later, i.e., the choice b1 and c1, as long as the two projects were not dropped off. In this regard, we make a conjecture that there an interesting relationship between synergy and option, a right, instead of the obligation, to utilize the IT project interdependency. Moreover, if we combine it with the deferral option, this relationship could be treated as the enterprise discretion to exploit the IT project interdependency now or later. For example, when two similar IT projects are proposed by two different units, enterprise usually would think of whether to integrate, or merge them to the unified one. However, the timing of doing so could very depend. It could be in their development processes, or we can wait until they have both been successfully developed.

Overall, this paper makes contributions. First, we demonstrate how to manage IT portfolio in a quantitative manner. Besides, our proposed approach is fully compatible with financial data and can easily be understood by other non-IT departments, executive levels, or even other enterprise shareholders. Additionally, in the information systems literature, most related papers investigating IT portfolio management are still focused on the discounted-based-model and real-options based model. In this paper, we point out we need to consider managerial flexibility influence, interdependency influence, and their mutual influences in the IT portfolio decision, bring out an promising research area in terms of a more integrated IT portfolio management.

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