Multicriteria Financial Portfolio Risk Management for International Projects

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Abstract: While opportunities for international construction firms have been growing with globalization, the risks involved with international construction projects are increasing significantly. However, due to the complex skein of various risks, it is difficult to evaluate the severity of risk variables at the corporate level and to examine key success factors in an attempt to maximize a firm's value under the challenging global business environment. This paper focuses on a financial portfolio risk management for international projects to integrate the risk hierarchy of both individual projects and at the corporate level, which applies a multicriteria decision making method to maximize the total value of firms. To demonstrate the approach, a case study is conducted based on real projects collected from a multinational general contractor. Finally, we present lessons learned as well as guidelines for the application of these lessons to future projects through a workshop with industry practitioners.

DOI: 10.1061/(ASCE)0733-9364(2004)130:3(346)

CE Database subject headings: International development; Corporate planning; Risk management; Financial management; Bids; Construction industry.

Introduction

International construction firms have increased their profit through overseas projects. However, the risk on international projects has also been increasing. Larger contract amounts, longer return periods of investment, and higher burdens of financing than those found in domestic markets are the major threats on international construction projects. In addition, international construction firms are exposed to a complex skein of risks such as currency and interest rates, inflation, credit, and other business risks (Lee and Walters 1989; He 1995; Han 1999). However, it is difficult to identify the risk variables affecting the bottom line and to examine key factors of success in order to reduce risks and maximize benefits under the rapidly changing global business environment. Furthermore, most multinational contractors use a profit-oriented criterion focused on the individual project level that does not reflect the overall risks at a corporate level and the ultimate goals of the company (Millman 1998).

To break through these impediments, strategic risk management is required to reduce turbulent risk exposures and maximize the total value of a firm. The fundamental goal of this paper is to introduce the framework of project-selection procedures for multinational contractors to integrate the risk hierarchies of both individual projects and at the corporate level. This paper focuses on financial risk factors such as currency exchange, interest, and inflation rates because they are inherent elements in international construction projects which can drastically influence a firm's return in the unsteady economic conditions. In addition, this paper aims at supporting the multinational contractors, especially those who are operating at least two international projects, so that they can select new projects on the basis of maximizing the value of a new portfolio. In order to achieve these goals, this paper focuses on the following questions:

1. What are the current approaches used for selecting international projects?
2. How can the tradeoff between risk and return be optimized in the international construction market?
3. What are the most important criteria for the optimal selection of new projects and how can a firm combine these criteria?
4. What are the essential benefits in using a multicriteria portfolio procedure to select potential international projects?

Review of Approaches for Overseas Project Selections

There are various approaches for the selection of international projects. Historically, these approaches have focused on risk at individual project level rather than risk at corporate level (Pouliquen 1970; Reutlinger 1970; Tanaka 1984; Demacopoulos 1989; Ahmad 1990; Messner 1994; Han 1999). However, the simple sum of individual project's risks can be significantly different from the total risks of enterprise-wide perspectives. As a result, the company can fail to choose optimal combinations of return and risk for the corporation.

Based on these limitations, portfolio management has been proposed (Vergara and Boyer 1977; Kangari and Boyer 1981; Minato 1994; Mullich 1998). The basic concept of portfolio man-

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Note. Discussion open until November 1, 2004. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this paper was submitted for review and possible publication on March 12, 2002; approved on April 23, 2003. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 130, No. 3, June 1, 2004. ©ASCE, ISSN 0733-9364/2004/3-346–356/$18.00.

agement is to reduce the overall risks associated with a portfolio of projects through diversification. If each project investment has a given risk and return, then by combining investments where the risks are not closely correlated, variance reduction and a lower risk level can result. This section discusses the principle of portfolio theory and the application of portfolio theory to the construction industry.

Principle of Portfolio Theory

Portfolio theory is closely related to the grouping of risks in the area of investment stocks, equities, or projects. Hypothetically, the investor can eliminate a specific risk, but the market risk remains. Since the efficient market will not offer rewards for specific risk, ''not keeping all of your eggs in one basket'' is the principle concept of portfolio theory (Flanagan and Norman 1993). The return on a portfolio of projects is simply a weighted average of the return on the individual projects. Hence, the expected value of the sum of various returns $[E(R_p)]$ is the sum of expected values, as described in the following expression (Elton and Gruber 1987):

$$E(R_p)=E\left(\sum_{i=1}^{N} X_i \cdot R_i\right)=\sum_{i=1}^{N} X_i \cdot E(R_i) \tag{1}$$

where R_p = return on the portfolio; R_i = ith individual project's return; and X_i = fraction of the investor's funds in the ith project.

Some techniques from portfolio theory have been used in the decision making process for construction projects. Vergara (1977) suggested the use of portfolio theory for bid/no-bid decision making, as well as help in timing the bid decision and rationalizing the decision to bid. He proposed four steps to attain the best set of projects in a new portfolio: (1) individual analysis of the existing project; (2) analysis of the combination of all existing projects and determination of the characteristics of the existing portfolio; (3) consideration of possible new projects on which a firm can bid; and (4) choice of the best portfolio for a firm and determination of the optimal bid price for the new project. These bid-strategy models and portfolio theory help the contractor to choose new projects and to determine bid prices. In addition, Minato (1994) suggested a methodology on the assumption that some covariable risks or corporate risks exist among a company's project portfolio. He also maintained the hypothesis that ''such risk could be diminished efficiently using strategies made at higher levels of corporate management.'' Minato's approach is simple and easy to understand because he uses a single criterion by adopting the beta concept. He defined beta as a covariance of overall project and a single project performance divided by a variance of the overall project performance. However, there are some limitations of his approach such as bias of historical data, difficulty of data collection, and the shortage of qualitative risk assessment. Finally, Mullich (1998) argued effective risk reduction might be possible by aligning project management with strategic planning. He presented a project portfolio management that helps firms choose projects with the highest market potential, set an achievable plan, more easily prove the highest return, and quickly respond to changing business needs.

Shortcomings of Existing Portfolio Methods

The previous traditional portfolio approach introduced and examined the possibility of portfolio theory application in construction. However, it focused on the single profit-oriented criteria of new projects, rather than considering multiple criteria that include not only quantitative but also qualitative points of view. In addition, it did not present adequately the measurement algorithm of a firm's total risk when a new project is added. Finally, the importance of a strategic decision making process, such as strategic alternatives and continuous monitoring procedures to mitigate the risk exposures at the corporate level, was not presented.

Based on shortcomings of existing approaches, this paper presents a corporate risk management system that can integrate the multicriteria objectives (not limited to the single profit-oriented criteria) through continuous feedback from individual projects to the corporate level. The following section describes the multicriteria portfolio approach to making a strategic corporate level decision.

Basics for Corporate Risk Management

Description of Multicriteria Approach

Maximizing profit itself is not the ultimate goal of firms. Growing with stabilized return is also an essential objective for project selection. For this reason, Cardo and Wind (1985) and Segev (1995) utilize a risk–return model as the basic criteria for mapping business investments. The main goal of this model is to maximize the expected return for a given level of acceptable risk. However, this model cannot cover all the elements in the real business environment. In the real world, firms often eliminate inefficient projects with a higher project cost and a lower return prior to the initial bid stage even if it maintains the stability of risk variance. Accordingly, a firm should evaluate efficiency as one of the major factors in the selection of the optimal portfolio. Within the context of balancing the tradeoffs between conflicting values, this paper introduces the multicriteria portfolio approach at the corporate level, based on the three-dimensional criteria of portfolio management: maximizing expected value, minimizing risk variability, and maximizing efficiency.

Maximizing Expected Value

Maximizing the expected return is the most basic single element of considering optimal new projects. One of the best ways to choose among risky alternatives is to pick one with the highest expected value. In general, the importance of value creation is based on the net present value (NPV) of cash flow (Brigham 1989; Groppelli and Nikbakht 1995). Net present value is defined as the discounted uncertain cash flows at a required rate of return (RRR) [RRR is the minimum future receipts an investor will accept in choosing an investment (Groppelli and Nikbakht 1995)]. This paper employs the NPV in measuring the portfolio's expected return by using the scenario analysis (worst, normal, and best outcomes for risk variables considered) facing the project.

In developing the scenarios, the Pearson–Tukey method developed by Keefer and Bodily (1983) is used because this method works best for approximating systematic distributions for easy and simple measurement (Clemen 1996). This method adopts three-point approximation using the median and the 0.05 and 0.95 fractiles. This method assesses that the probability of normal scenario case is 0.63, and the probability of worst and best scenario is 0.185, respectively. Based on the approximation, this paper calculates the expected return by the following equation:

$$\text{expected return } (\overline{R})=\text{NPV}_w\times 18.5\%+\text{NPV}_n\times 63\% + \text{NPV}_b\times 18.5\% \tag{2}$$

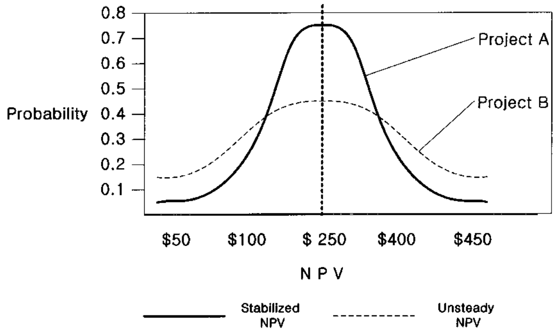

Fig. 1. Stabilizing expected return

where NPV_w, NPV_n, and NPV_b = worst, normal, and best NPV cases, respectively.

Minimizing Risk Variability

In corporate financial terms, risk is the deviation of expected outcomes from mean or expected value (Groppelli and Nikbakht 1995). The chance of loss or profit is unstable based on the degree of risk. Typically, there are two types of risk fluctuations. The vertical volatility is the fluctuations at any particular point of time that occur away from a denominator such as the mean or expected value. Statistically, stabilization means to minimize the variance of the expected return, as shown in Fig. 1. Fig. 1 indicates the risk of Project A is lower than that of Project B. That is explained by the fact that the former has a smaller standard deviation than that of the latter. This paper defines the vertical fluctuation as the variance of NPV using the three scenarios, as shown in the following equation:

$$\text{vertical fluctuation (VF)} = \sqrt{\sum_{n=1}^{N} (R-\overline{R})^2 \times P_i} \tag{3}$$

where N = number of observations (worst, normal, and best cases); R = returns of each case; $\overline{R}$ = expected return; and P_i = probability of each observation.

On the other hand, in the case of horizontal fluctuation in a time series, an irregular cash flow means that the coefficient of correlation is highly positively correlated (Vergara and Boyer 1977). If two projects show a perfect negative correlation in a time sequence (correlation $= -1.0$), then the standard deviation of portfolio of these two projects will be zero, which indicates that no risk exists.

Irregular cash flow in terms of both vertical variance at any particular point in time and horizontal variance in a time series for the whole project period makes maintaining financial soundness difficult. In some cases, it produces a negative cash flow at the corporate level that causes additional financing costs. Accordingly, in order to measure how much a portfolio can minimize risks and then stabilize the return, this paper adopts the concept of the total standard deviation by integrating vertical and horizontal fluctuations, as illustrated in the following equation. The concept of total standard deviation allows a firm to evaluate new potential projects, which can stabilize the cash flow at the corporate level and thus decrease unnecessary financing costs.

$$\text{total standard deviation} = \sqrt{\sum_{t=1}^{T} (\mathrm{VF}_t)^2} \tag{4}$$

where T = number of time periods and VF_t = vertical fluctuation at a time "t."

Efficiency: Maximizing Productivity of Investment

The financial goal of a firm is to get the highest efficiency and profitability from assets and, at the same time, keep the cost of capital as low as possible. Among the several financial ratio analyses such as internal rate of return (IRR) (IRR is a measure of the rate of profitability and the discount rate that makes the present value of cash flow equal to zero), weighted marginal cost of capital (WMCC) (WMCC is the additional rate of return that must be paid over the risk-free rate), and return on investment (ROI), ROI is widely used as a performance indicator to measure the overall effective use of assets (Groppelli and Nikbakht 1995). It is net profits after taxes divided by assets. If the assets are used effectively, ROI will be high; otherwise, it will be low. In this paper, the writers measure ROI in simple terms as the rate of NPV divided by the estimated total project cost.

Measuring Corporate Risk Variability: Value at Risk

This paper uses the concept of value at risk (VaR) in an attempt to capture the degree of corporate risk variance. The use of VaR techniques in risk management has increased dramatically over the last few years (Millman 1998). Value at risk is "the worst expected loss over a target horizon within a given confidence interval. Value at risk summarizes in a single number the global exposure to market risks and the probability of adverse moves in financial variables" (Jorison 1996).

The VaR model shows the potential maximum loss that can happen on any given day with any position or portfolio positions, with a certain confidence level. Volatility of financial factors is usually calculated as the standard deviation of the percentage change in the risk factor over the relevant risk horizon. To define a portfolio's VaR, two quantitative factors must be determined: the confidence level and the length of the holding period. Value at risk can be measured directly from normal deviate at the specific confidence level, the standard deviation, and time interval, as shown in the following equation:

$$\mathrm{VaR} = W_0 \times \alpha \times \sigma \times \sqrt{\Delta t} \tag{5}$$

where W_0 = initial investment; α = normal deviate at the confidence level (z value); σ = standard deviation; and Δt = time interval.

First, the concept of confidence level relates to the definition of risk as the variability of the possible changes in the risk factors around an expected change. For example, α values of 95 and 99% confidence level are equivalent to 1.645 and 2.33, respectively. As presented, the higher the confidence level, the greater the VaR value.

In addition, VaR can be estimated based on a week, a month, or a year. The selection of the time horizon relates to the potential liquidation period of the position. In measuring risk, it is assumed that the relative risk of a position will be a function of time period: the longer the potential holding period, the greater the risk (Das 1997). Suppose that the VaR for 95% confidence level, and a 1 year holding period

$$\mathrm{VaR} = W_0 \times \alpha \times \sigma \times \sqrt{\Delta t} = W_0 \times 1.645 \times \sigma \times \sqrt{1} = W_0 \times 1.645 \times \sigma \tag{6}$$

The key point is that VaR is associated only with the standard deviation (Jorison 1996). For instance, as shown in Fig. 2, if one portfolio's average and standard deviation of the annual rate of

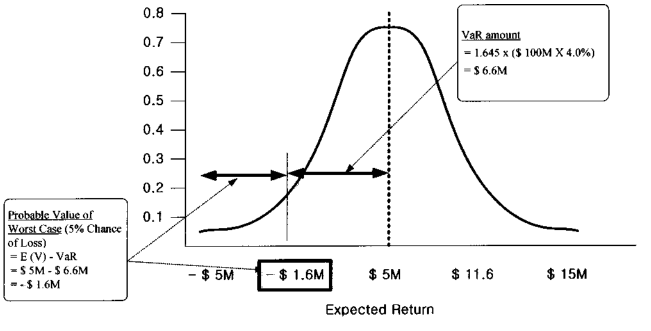

Fig. 2. Concept of value at risk

return is 5 and 4%, respectively and the initial investment is U.S. \$100 million, VaR accounts for U.S. \$6.6 million (U.S. \$100 million $\times$ 1.645 $\times$ 4%). It indicates that the portfolio would be expected to lose less than U.S. \$1.6 million (average expected return U.S. \$5 million minus VaR U.S. \$6.6 million) over 95% of the time.

In practice, two quantitative factors (confidence level and time interval) for estimating a VaR can be varied project to project and company to company. However, it is feasible in the real world business that the VaR of 95% confidence level and 1 year time interval are adopted for the purpose of a simplified measurement in a typical overseas project. Instead, if the projects face excessive uncertainties and relatively short durations, the firm can use a 98 (or 99%) confidence level and a quarterly (or monthly) based holding period.

Accordingly, we can apply VaR as a measurement of corporate risk, which derives from changes in market factors within an integrated risk framework. A number of writers have suggested a VaR application into the cash flow (Spinner 1990; Turner 1996). The most valuable benefit of VaR is that it imposes a structural methodology for critical thinking about the risk threshold. If a company can measure a candidate project's VaR amount, they can reasonably decide whether they will accept it as a potential portfolio for the new project selection.

Formalizing Multicriteria Integrated Portfolio Model

This paper develops a decision model to provide a powerful computational capability based on the well-balanced multicriteria for

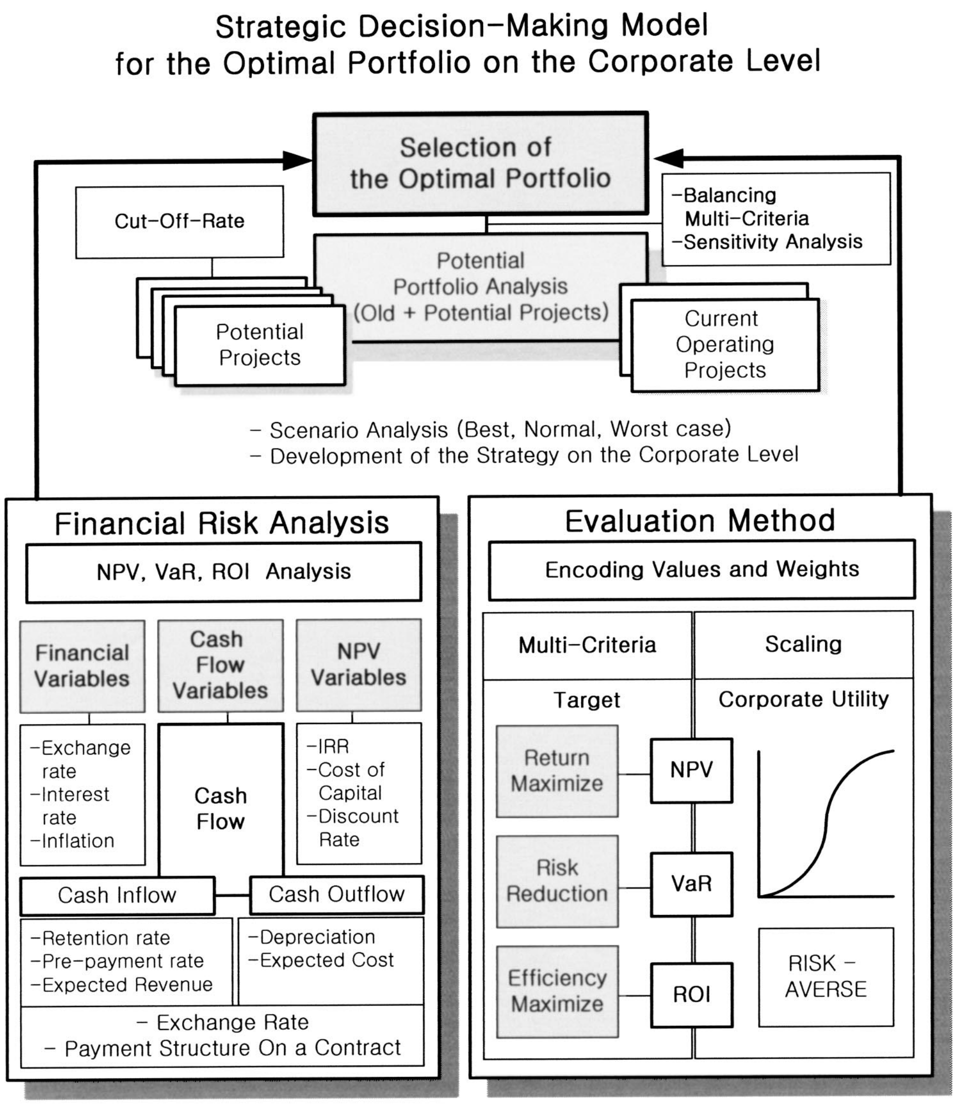

Fig. 3. Multicriteria integrated portfolio model

multinational contractors. It includes three categories, as shown in Fig. 3: (1) a financial risk analysis tool for analyzing cash flow and then estimating multicriteria values such as return (NPV), risk (VaR), and efficiency (ROI); (2) an evaluation and integration method for these multicriteria values; and (3) the selection method for an optimal portfolio of projects based on the integration of these values.

Financial Risk Analysis for Portfolio

International construction projects manifest more types of risks than domestic projects. Particularly, financial risks such as changes in exchange rates, interest rate, and inflation rate under the floating economic condition have drastic impacts on the cash flow and the expected return of overseas projects. Accordingly, the firm must assess how much these risk variables will affect the value of a project. Prior to the portfolio analysis, a firm should analyze the NPV through the financial risk measurements. Then, the three criteria (risk, return, and efficiency) can be accessed based on the NPV calculation. Fig. 4 illustrates the NPV calculation algorithm (details of the algorithm are shown in Appendix I).

Because this paper focuses on financial risks to estimate the NPV, other important risk factors that should be incorporated into the projection of the scenarios are quantified on the assumption that the variability of the cost and schedule that can influence the cash-in and cash-out flow of projects can be assessed using an approach similar to program evaluation and review technique, such as: (1) pessimistic, (2) optimistic, and (3) most likely value. In addition, more precise quantitative methods such as influence diagramming or the cross-impact analysis method was used to propagate the variance of cost and schedule, which considers all risk variables—including political, legal and environmental risks. This approach is explained in more detail in Han and Diekmann (2001).

When calculating NPV in accordance with the above algorithm, the basic condition—such as retention rate, preadvanced payment rate, depreciation rate, discount rate, confidence level, and time interval of VaR—should be provided. Additionally, the key factors are the contract revenue portion received in U.S. $, the budgeted cost structure paid in U.S. $, and the contract exchange rate. The variability of exchange rate is usually assessed using scenario analysis (worst, normal, and best case) based on the historical data or experts' review. Table 1 represents the basic conditions used to calculate the NPV for an illustrative U.S. $209 million contract in Indonesia and Table 2 shows the example of NPV calculations made in accordance with these basic conditions.

Combining and Evaluating Multicriteria Decision

Risk analysis using a multidimensional approach is performed through a systematic procedure for assessing the worth of potential projects. This worth assessment requires a quantitative approach throughout the process, but relies heavily upon subjective inputs. The first step is to calculate the relative changes in rates and values in order to access the contribution to the new portfolio to determine the added value of the new project, as summarized in Table 3.

The next step is to develop a comprehensive methodology for evaluating the potential utility curve of alternative proposals. According to Kahnemann and Tversky (1979), the utility curves for gains and losses are nonlinear, but in general are concave for opportunities and convex for threats. This paper proposes the utility curves for three multicriteria values based on this theory and based on experts' opinions. For example, utility value for a "64.6% increase in NPV [(new NPV − old NPV) ÷ old NPV] that is contributed by a new portfolio is assigned '79.5' points out of '100' by converting an increase in NPV" into the utility curve. Then, these values are combined for determining desirability of a project based on an additive multiattribute hierarchy method.

Optimal Portfolio Selection Procedures

Fig. 5 illustrates an integrated framework for optimal portfolio selection. It consists of six steps designed for a corporate level evaluation of new projects using multicriteria values with a NPV analysis. The first step requires input data for evaluating each individual project, such as the variance of currency exchange rate, discount rate, and depreciation rate. In this stage, management can use either historical data or consensus expert reviews.

The second step evaluates each individual candidate project's risk and return. This stage requires an expert's review of the input data. A multistaged screening process is useful in minimizing effort and eliminating candidate projects that are too risky or provide too low of a return (Han and Diekmann 2001). This paper conceptualizes the screening decision as one that is decided on VaR ratio (VaR divided by total project cost) and ROI. As an example, if a project fails to satisfy the minimum level of efficiency and risk criteria (for example, ROI is less than 15% and VaR ratio is in excess of 8%), it is abandoned prior to the portfolio analysis at a corporate level.

If the potential project passes the cutoff rates, the next step is developing a new set of portfolios. Through Steps 3 and 4, possible sets of portfolios are produced and evaluated based on the NPV analysis (risk, return, efficiency) and the firm's key targets. New portfolio selection is based primarily on comparison of the combined scores of three criteria. The weighting and scaling of each criterion is dependent upon the expected utility and the strategic goals of the company. If one portfolio is clearly optimal, the contractor can make a go-decision immediately. However, if there is no optimal portfolio, the company must develop a strategic alternative to increase the condition of the potential portfolio or decrease the tolerance level of risk (Step 5).

The final step provides the feedback to the portfolio analysis cycle. The environment and uncertainty of business, including the total tolerance of company risk, changes from time to time. Accordingly, it is essential to monitor at least monthly the total maximum tolerance of corporate level risk and to set up an "alarm system," proactively using statistical methods that determine whether the company's total risk tolerance is changing its long-term trend.

Case Study

To demonstrate the methodology proposed, we have conducted a case study. The basic assumptions applied to the case study are: (1) the basic contract currency is the U.S. dollar, while the local currency portion will vary from project to project; (2) the total contract amount including the ongoing projects and new candidate projects will be limited to 1 billion U.S. dollars due to financial credit limitations (ongoing projects = U.S. $500 million, new projects = U.S. $500 million); (3) RRR of U.S. $1 billion is 12%, which will be used as a discount rate and guideline to screen the

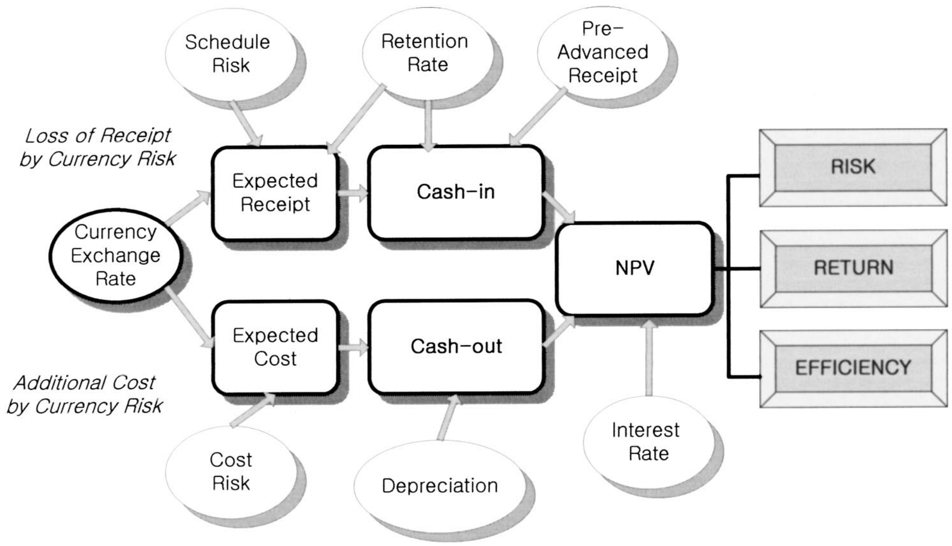

Fig. 4. Net present value calculation algorithms

Table 1. Basic Conditions to Calculate Net Present Value for Indonesia Case

Variables	Conditions	Amounts
Contract revenue[a]	Total	\$209 million
	% of U.S. dollars	80%
Planned budgeted cost	% to revenue	89.2%
	% of U.S. dollars	60%
Rate	Depreciation percent	5.0%
	Discount rate	12.0%
	Prepayment ratio	10.0%
VaR Test	Confidence level	95%
	Time interval	1 year
Scenario probability	Worst case	18.5%
(Pearson–Tukey method)	Normal case	63.0%
	Best case	18.5%
Schedule variance[b]	Worst	−8.0%
	Normal	0.0%
	Best	5.0%
Cost variance[c]	Worst	10.0%
	Normal	0.0%
	Best	−5.0%
Exchange rate variance[d]	Worst	152%
(contract exchange rate:	Normal	0.0%
1 dollar = 3,923.7 local)	Best	−45%

[a]This project is to be paid 80% in U.S. dollars and 20% in local currency.

[b]Schedule variance fluctuates between −8 and 5% of the base case based on the historical data and experts' consensus opinion.

[c]Cost variance fluctuates between 10 and −5% of the base case.

[d]Based on real historical data for last 10 years and expert reviews, the local currency exchange rate fluctuates between 152 and −45% of the rate at the time the contract was made. The normal case is the same as the contractual currency exchange rate. The worst case is the highest devaluated exchange rate (152%) and the best case is the lowest strong exchange rate (−45%).

potential projects. Table 4 lists seven sample projects that are selected among real projects from around the world. Libya and Pakistan projects (Projects Nos. 1 and 2) are fixed as two ongoing projects, and five projects are added as new candidate projects.

The right project selection should be made as early as possible after the owner initiates a project. During the early stages of the project, however, there is insufficient information available to measure the project viability. The projection of a go/no-go decision, in consequence, becomes a matter of subjective judgment based on the contractors' experience, historical data, or consensus opinion. A company can improve the chances of deciding viable projects if they have a methodical formalism that can guide them to systematically analyze the critical risk factors inherent in the project environment and their impact on project feasibility.

Accordingly, we can measure the output of existing portfolio and new candidate projects by eliciting the appropriate information based on both historical data and an expert's assessment and applying the NPV prediction algorithm, as presented in Table 2. As specified, the company can select two new projects with a combined value of 500 million U.S. dollars, as shown in Table 5. The main question of this case study is "Which new projects should we choose as an optimal portfolio to maximize the firm's value?" Typically, one would assume that the firm would select "portfolio No. 1 (Projects Nos. 3 and 4)" because the profit of these projects is the highest among five new candidate projects. However, the firm cannot always choose the best projects due to factors such as competitiveness to win the contract, their ability to perform, or the strategic importance to the future of the company. In reality, the firm usually has the dilemma of choosing between projects from the good "A" group (Projects Nos. 3 and 4) and projects from the bad "B" group (Projects Nos. 5, 6, and 7). If this is the case, a company that adopts a traditional project selection approach ("single maximum profit") may choose portfolio No. 2 (Projects Nos. 3 and 5) as new projects, simply because these projects have higher profit than other "A+B" portfolio combinations.

By contrast, the proposed multicriteria integrated portfolio model is superior in selecting candidate projects by maximizing the firm's overall value. To measure the integrated contributions of new sets of portfolios to the ongoing existing portfolio, the

Table 2. Example of Net Present Value (NPV) Calculation (Unit: Thousand U.S. Dollars)

Scenario		Period (year)								
Cases	Probability (%)	1	2	3	4	5	Total NPV	Total standard deviation	Value at risk	Return on investment
Worst	18.5	(22,743)	(83,526)	(27,040)	(1,511)	9,080	(125,740)	—	—	—
Normal	63	16,025	(2,760)	(2,166)	(303)	11,875	22,671	—	—	—
Best	18.5	29,146	25,271	6,432	109	8,727	69,685	—	—	—
Expected NPV		11,280[a]	(12,516)	(5,177)	(451)	10,776	**3,912**	—	—	—
Standard deviation		16,952	35,454	10,912	529	1,439	—	40,814[b]	**67,139**[c]	**1.9%**[d]

Note: Bold faced: three multicriteria values for optimal portfolio selection; ( ): negative cash flow.

[a]Expected NPV $= -22{,}743 \times 18.5\% + 16{,}025 \times 63\% + 29{,}146 \times 18.5\%$.

[b]Total standard deviation $= \sqrt{(16{,}952^2 + 35{,}454^2 + 10{,}912^2 + 529^2 + 1{,}439^2)}$.

[c]VaR $= 1.645 \times$ standard deviation $= 1.645 \times 40{,}814$.

[d]ROI = total NPV ÷ total cost = 3,912 ÷ 209,000.

case study developed a portfolio analysis summary as shown in Table 6. Among these portfolios, Nos. 1, 8, 9, and 10 either dominate others deterministically or are deterministically dominated by other portfolios, which make it possible to decide ''absolutely go'' or ''absolutely no-go.'' Instead, this analysis focuses on the remaining six portfolios that are more difficult to choose from in the case that one will fail to pursue a dominant portfolio.

The case study uses three different weighting sets to evaluate the sensitivity of how much the combined scores fluctuate if the different weighting ratios (such as 70% weight preference on return; risk; or efficiency, respectively) are applied. Table 7 illustrates that portfolio No. 4 shows consistent scoring regardless of significantly different sets of weighting ratios.

As stated above, the firm may choose the portfolio ''No. 2'' if they focus only on profit. However, the case study recommends No. 4 as an optimal portfolio despite its smaller expected profit. This portfolio exposes the contractor to reduced risk because Project No. 7 (Saudi Arabia) maintains a stable currency exchange rate. On the other hand, Project No. 5 (Indonesia) exposes the contractor to increased risk due to the extreme variance of currency risk. The exposure to this currency risk induced lower NPV (return), higher VaR (risk), and lower ROI (efficiency) even though the profit was higher than other projects.

In the process of selecting an optimal portfolio, we have based this case study on the assumption that the company will obtain each project it pursues. Accordingly, if the firm will not obtain the recommended potential projects, the firm's decision also should be adapted. For example, if the company does not obtain project No. 3 (Philippines), the portfolio No. 7 or No. 6 can be a next alternate consecutively based on the various evaluations of the possible portfolio sets (see Table 7). Similarly, in the case where the firm will fail to obtain a project from the best candidates (Projects Nos. 3 and 4), the company may select only one new project such as Projects Nos. 7 or 6 regardless of their financial credit capacity because ''B'' portfolio combinations (Projects Nos. 8, 9, and 10) do not contribute significantly to the firm's overall value.

Application to Future Projects

We conducted the case study mainly to demonstrate the multicriteria approach. The case study used project data gathered from one company. In lieu of clear validation by applying it to the actual situation encountered by the company, the writers have added a workshop held with industry experts in order to assess the value of this approach as well as to identify its application to actual situations.

The workshop panel consists of 15 industry experts who have worked on marketing and managing overseas projects for a number of years. The writers asked them to validate the portfolio approach in comparison to other individual project-basis selection methods. In order to examine the quality of the approach, participants provided a critical review of the proposed portfolio model structure, appropriateness of the concept, and usefulness and effectiveness of the model. The following is a summary of the workshop:

1. The panel members indicated that the case presented is very analogous to the ones that often take place in actual situations. They pointed out that although risk management at a corporate level is necessary, they typically use the traditional approach based on the evaluation of individual projects. Subsequently, 13 experts responded that a multicriteria portfolio model to quantify the international risks at a corporate level could be useful by improving the decision quality, as demonstrated in the case study.
2. Panelists perceived that possible profitability, amounts of country/currency risks, ability to perform, possibility of future markets, and well-defined project scope are generally considered important factors in making a project selection decision. They agreed that the multicriteria integrated model platform incorporates these important factors—such as return, risk, and effectiveness.
3. Panelists agreed with the comprehensiveness, usefulness, and effectiveness of the proposed approach. Questions were

Table 3. Scaling Method for Contribution of New Portfolio

Criteria	Subcriteria (%)	Target	Equation
Return	Relative change in NPV	Maximize	Increased NPV ÷ old NPV = (new NPV − old NPV) ÷ old NPV
Risk	Relative change in VaR	Minimize	Increased VaR ÷ old VaR = (New VaR − old VAR) ÷ old VaR
Efficiency	Relative change in ROI	Maximize	Increased ROI ÷ RRR = (new ROI − RRR) ÷ RRR

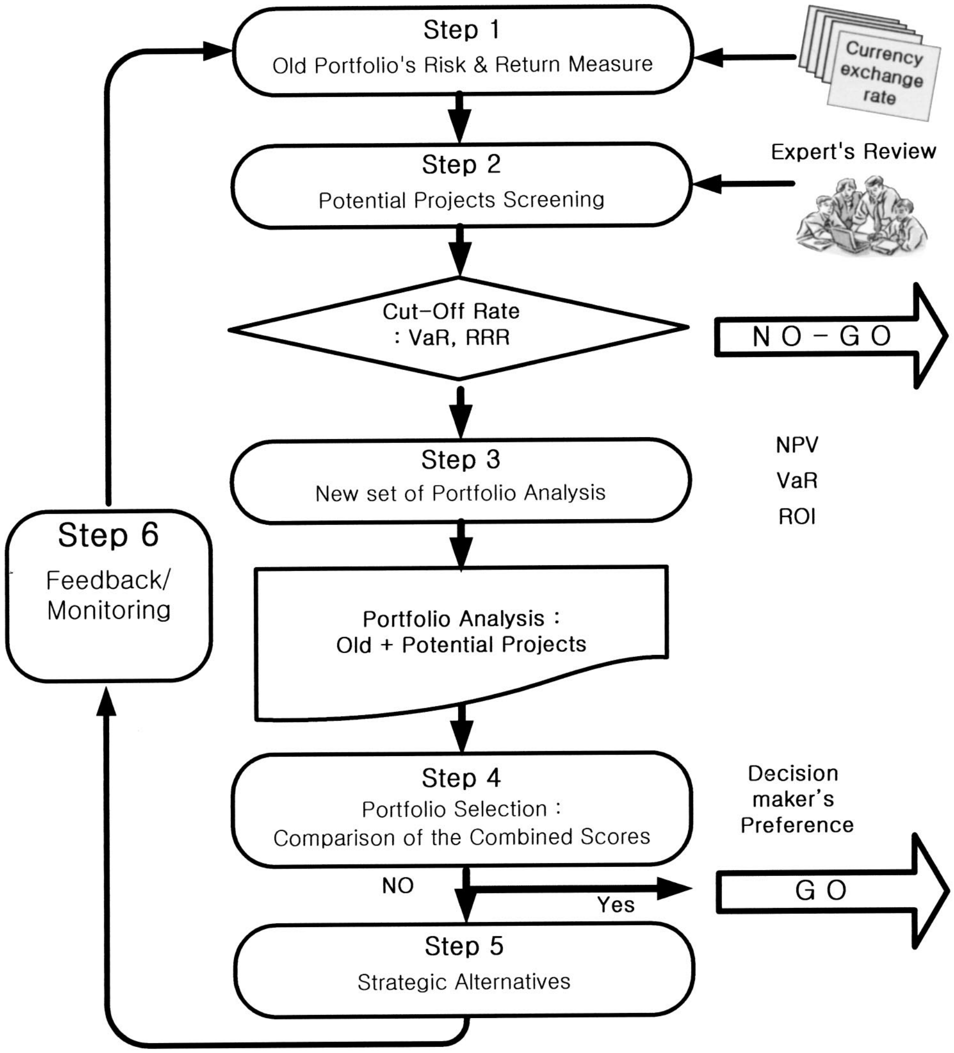

Fig. 5. Optimal portfolio selection procedure

arranged to evaluate the support for decision making of the portfolio model. The index numbers ranging from 1 to 7 were used to express how well the model described the actual problem domain. Five items are involved in the chain as the significant factors to obtain a quality decision: (1) appropriate content of model, (2) representation of risk variables, (3) clear multicriteria outcome and their tradeoff, (4) usefulness of model, and (5) effectiveness in terms of simplicity and ease of model. The end result showed that the model achieved approximately 90% of agreement as a decision support tool.

4. However, the panelists reviewed the model critically and then provided several important suggestions. In particular, most experts asked for the decision system as a general

Table 4. List of Sample Projects

Project No.	Country	Revenue (thousand dollars)	Contractor's cost (%)	Profit (%)	Remarks
1	Libya	293,000	91.0	9.0	Ongoing
2	Pakistan	207,000	84.2	15.8	Ongoing
3	Philippines	213,000	81.1	18.9	Good candidate
4	Vietnam	197,000	84.2	15.8	Good candidate
5	Indonesia	209,000	89.2	10.8	Bad candidate
6	Malaysia	238,000	97.4	2.6	Bad candidate
7	Saudi	117,000	101.0	−1.0	Bad candidate

Note: Project Nos. 1 and 2 are ongoing projects. Project Nos. 3 and 4 are good candidate projects, while Nos. 5, 6, and 7 are bad candidates.

Table 5. Matrix of Possible Sets of New Projects

Potential projects No.	3	4	5	6	7
3	—	Portfolio No. 1: 3 + 4	No. 2: 3 + 5	No. 3: 3 + 6	No. 4: 3 + 7
4	—	—	No. 5: 4 + 5	No. 6: 4 + 6	No. 7: 4 + 7
5	—	—	—	No. 8: 5 + 6	No. 9: 5 + 7
6	—	—	—	—	No. 10: 6 + 7
7	—	—	—	—	—

Note: Portfolio No. 1 indicates the combination of the candidate projects Nos. 3 and 4.

guideline in the process of practical implementation. We summarize this guideline for practical implementation in Appendix II.

Summary and Conclusions

This paper discussed the basic framework of risk management systems to integrate the process and the risk hierarchy of projects at the corporate level. The writers tested the proposed approach to demonstrate the model using the sample projects of a global contractor. Major findings include:

1. Among the three main criteria, return (NPV) emphasized the strategy of volume and qualitative evaluation measures, while efficiency (ROI) focused on the productivity of capital and qualitative factors. In addition, risk (VaR) emphasized the stability of NPV and corporate tolerance for risk.
2. Higher profit ratios did not always guarantee a higher NPV. The optimal portfolio selection results from a well-balanced multicriteria approach rather than from a single profit criterion.
3. Among the purposes for conducting risk management, stabilizing NPV was an essential element for corporate risk management because it lowered the standard deviation and VaR.
4. The contribution of new potential projects to the new portfolio was an important factor in selecting appropriate candidate projects. A company can make more inclusive decisions with the portfolio concept rather than selecting projects on an individual basis.

Primarily, this paper provides a practical method applicable to the selection of new sets of overseas projects. However, there are some limitations. This model targeted multinational contractors that were running at least two international projects. It assumes that the contractor applying this model will be a relatively large company such as one of the top 100 contractors in the world. Given these limitations, future procedural research will concentrate on a model to evaluate risks at both the corporate and the individual project levels. With an integrated sequential model, even small to medium sized firms can select valuable overseas projects regardless of their existing portfolios. Finally, proper allocation of risk is very important in the risk management cycle. The contractor must consider its risk tolerance and existing risk exposure. The risk level varies from project to project and from country to country. Developing a methodology to provide a contingency against total risk exposure will be the main area for future research.

Appendix I. Description of Net Present Value Calculation Algorithm

1. Calculate the loss of receipt (LR_t) and the additional project cost (AC_t) due to the change of currency exchange rate in period "t." These values are obtained by multiplying the periodic revenue or cost, change of currency exchange rate, and the portion paid in local currency as follows:

$$LR_t = EV_t \times LC_r \times (1 - 1/ER_t) \quad (7)$$

$$AC_t = BC_t \times LC_c \times (ER_t - 1) \quad (8)$$

where EV_t = earned value schedule in period "t" (periodic revenue); LC_r = local currency portion of contract revenue; ER_t = change of exchange rate (%); BC_t = budgeted cost in period "t"; and LC_c = local currency portion of budgeted cost.

2. Calculate the cash-in in period "t" (CI_t) by cumulating all of the periodic revenue, preadvanced payment, retention, and loss of revenue due to the currency exchange risk as follows:

$$CI_t = PR + EV_t \times (1 - RR) - LR_t - PR$$

Table 6. Results of New Portfolio Analysis[a]

New portfolios No.	Expected value (ongoing+new)			Contribution of new portfolios		
	Net present value	Value at risk	Return on investment	Net present value	Value at risk	Return on investment
1	104,327	53,907	13.3%	112.3%	79.5%	33.9%
2	80,878	101,088	9.8%	64.6%	236.5%	−30.0%
3	78,295	68,836	9.1%	59.4%	129.2%	−41.3%
4	77,817	43,357	10.5%	58.4%	44.3%	−18.7%
5	80,406	108,586	9.9%	63.7%	261.5%	−29.5%
6	77,823	71,425	9.2%	58.4%	137.8%	−41.1%
7	77,344	48,085	10.6%	57.4%	60.1%	−17.8%
8	54,374	117,692	6.2%	10.7%	291.8%	−90.1%
9	53,895	96,548	7.1%	9.7%	221.4%	−87.6%
10	51,312	61,614	6.4%	4.4%	105.1%	−94.9%

[a]Unit: thousand U.S. dollars.

Table 7. Total Scoring and Sensitivity Analysis

Portfolio No.	Return		Risk		Efficiency		Total		
	Net present value	Point	Value at risk	Point	Return on investment	Point	Weight set No. 1[a]	Weight set No. 2[b]	Weight set No. 3[c]
2	64.6%	79.5	236.5%	0	−30.0%	30.0	58.6	13.9	36.9
3	59.4%	72.8	129.2%	25.1	−41.3%	28.4	58.8	30.6	37.0
4	58.4%	71.3	44.3%	91.3	−18.7%	50.0	73.1	81.0	58.4
5	63.7%	78.3	261.5%	0	−29.5%	42.4	59.0	16.3	45.3
6	58.4%	71.3	137.8%	19.4	−41.1%	28.7	56.7	26.5	36.3
7	57.4%	69.8	60.1%	85.4	−17.8%	50.0	70.9	76.7	57.5

[a]Return:risk:efficiency = 70%:20%:10% (weight priority on return).

[b]Return:risk:efficiency = 10%:70%:20% (weight priority on risk).

[c]Return:risk:efficiency = 20%:10%:70% (weight priority on efficiency).

$$\times \text{Percent completed } (\%) \quad (9)$$

where PR = preadvanced payment at the beginning of project; EV_t = earned value schedule in period "t" (progress payment); RR = retention rate; and LR_t = loss of receipt by currency risk in period "t" [from Eq. (7)].

3. Calculate the cash-out in period "t" (CO_t) by cumulating all of the periodic budgeted cost, depreciation cost, and additional cost due to the currency exchange risk as follows:

$$CO_t = BC_t + AC_t - DC_t = BC_t + AC_t - (BC_t \times DR)$$
$$= BC_t \times (1 - DR) + AC_t \quad (10)$$

where BC_t = budgeted cost in period "t"; AC_t = additional cost by currency risk in period "t" [from Eq. (8)]; DC_t = depreciation cost in period "t"; and DR = depreciation rate.

4. Calculate the NPV by cumulating the net cash flow, which takes off cash-out from cash-in and then discounts it by the present value index as follows:

$$NPV = \sum [NCF_t/(1+RRR)^t]$$
$$= \sum [(CI_t - CO_t)/(1+RRR)^t] \quad (11)$$

where NCF_t = net cash flow in period "t"; CI_t = cash-in in period "t" [from Eq. (9)]; CO_t = cash-out in period "t" [from Eq. (10)]; and RRR = required rate of return.

5. Calculate the expected NPV based on the Pearson–Tukey method to develop the three scenarios (worst, normal, and best outcomes)

$$E(NPV) = NPV_w \times 18.5\% + NPV_n \times 63\% + NPV_b \times 18.5 \quad (12)$$

where NPV_w, NPV_n, and NPV_b are estimated through steps 1–4 based on the worst, normal, and best case scenario, respectively.

Appendix II. Guidelines for Practical Implementation

Based on the workshop, the following suggestions are made regarding the appropriate application of the portfolio approach to the future projects:

1. The model requires both historical data and an expert's subjective assessment to evaluate the new sets of portfolios. Often, it is difficult to get the appropriate information due to the possibility of personnel bias. Accordingly, the expert panelists identified three categories of input data to support the elicitation of project conditions: (1) boundary conditions (i.e., discount rate, depreciation percentage, discount rate); (2) deterministic variable (i.e., percent of U.S. $ to be paid, estimated budget ratio to the revenues, contractual currency exchange rate, preadvanced payment ratio, period of project); and (3) probabilistic variables (i.e., variance of cost and schedule, fluctuation range of exchange rate). In particular, the company should estimate the probabilistic variables using both available historical data and expert judgments to lessen any possible biases.
2. To measure the VaR value, a 95% confidence level and 1 year time interval are acceptable for simplification. However, if a firm requires more reliable and accurate analysis, the company can adopt a 98% confidence level and quarterly based time interval. In general, as the project assumes more risks, higher confidence level and shorter time intervals are desirable.
3. The model proposed focuses on the financial risks to estimate the variance of cash flow and subsequently, other risk variables are assumed to be relatively stable. For practical implementation, the variability of the cost and schedule that involves the influence of other risk variables can be assessed by drawing the scenarios such as pessimistic, optimistic, and most likely value based on the analysis of similar projects and consensus expert opinions.
4. Because the utility function varies from company to company, a firm needs to develop the appropriate utility curves for the scaling of risk, return, and efficiency. The following are general procedures: (1) determining the value scores for a single attribute according to a firm's preference, which is transformed into scales from 1 to 100; (2) designing a utility curve, normally concave for opportunity and convex for threat against the strategic goals of the company; and (3) assigning "0" value below the lower limit (i.e., percent of increased NPV = 0%) and "100" values beyond the upper limit (i.e., percent of increased NPV = 100%) to avoid the possibility of negative values.
5. A firm should develop strategic alternatives to improve project conditions in real situations. For example, if a firm can make strategic risk allocations or hedging tools to reduce the currency risks of an Indonesia project (Project No. 13), the firm could choose portfolio No. 2 (Projects Nos. 3 and 13) or portfolio No. 5 (Projects Nos. 4 and 13) as an optimal portfolio.
6. Finally, it is desirable for a firm to set up at least a quarterly based monitoring system for updating the risk variables and

providing a contingency against total risk tolerance, even though the firm measures the NPV on a yearly basis.

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