

# Risk-based project value analysis – contributed value and procurement cost

Sato T

JGC Corporation, Yokohama, Kanagawa, Japan

## Abstract

In this paper the author proposes a theoretical framework for the risk-based project value analysis. Based on cash flows and risk factors (probabilities of failure) of all tasks in a project, this analysis method enables to calculate risk-based project value (RPV) at any starting moment of tasks. RPV analysis has three areas of powerful application: (1) contributed value analysis, (2) procurement cost analysis, and (3) project portfolio management. Contributed value of a task to the project can be derived as RPV increase between start and finish of the task, thus enabling more appropriate basis for earned value analysis for product development projects. Procurement decisions should be made based on 'Critical cost' of the source which is calculated with cost and associated risk factor. Summation of all the planned and ongoing projects' RPV represents project portfolio value of a company. Project priority should be given based on value of 'Extended DIPP', remaining RPV divided by cost ETC.

*Keywords* Risk, RPV, contributed value, procurement, project portfolio

## 1. Basic concept of Risk-based project value (RPV)

In the previous paper presented at ProMAC 2004 Tokyo [1], the author proposed a new criteria for project evaluation called "Risk-based Project Value", or in short, RPV. RPV represents expected monetary value of a project throughout its life cycle. A project is an endeavour to deliver products or services in order obtain income values with some initial cost expenditure. Any projects, however, have risks of failure with in their tasks. RPV is calculated based on the project cash flow and risk factors.

Let us illustrate concept of RPV with a simple example. Suppose "Project Z" is comprised of two tasks A and B (product development and sales, for example) as shown in Figure 1. Task A requires initial cost of \$20. At completion of Task B, \$100 income is expected. Task A has 50% of probability of failure ('risk factor' hereinafter), and Task B has 20% risk. Task A is more difficult to complete than B.

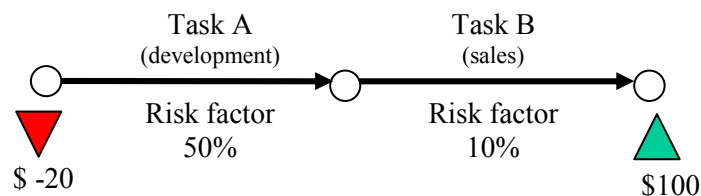


Figure 1 Diagram of Project Z

Probability of overall project success is  $50\% \times 90\% = 45\%$ . Expected value of income is  $\$100 \times 45\% = \$45$  at the beginning of Task A. Therefore, the project value is  $\$45 - \$20 = \$25$ , based on its risk factors.

If the risky Task A is successfully completed, then expected income becomes  $\$100 \times 90\% = \$90$ . Therefore, project value increases to;  $\$90 - \$20 = \$70$ . When Task B is also completed successfully, project value is realized as  $\$100 - \$20 = \$80$ . These values, \$25, \$70, and \$80, are Risk-based Project Values (RPV) at the project start, beginning of Task B, and at the project completion, respectively.

Value of a task is defined as the increase of RPV after successful completion of the task. For the above case, contributed value of Task A (product development) is \$45, while Task B (sales) is only \$10 as shown in Figure 2. Although Task A just spends cost (=cost center function) and Task B earns money (=profit center function), Task A has more value contribution than B. This is because Task A is more difficult, and thus its success greatly increases project expectation. In general, the higher the risk is, the more value is contributed to the project (see details in the section 2).

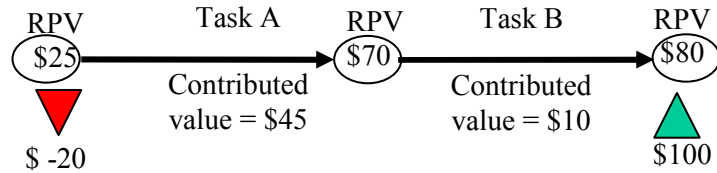


Figure 2 Risk-based value of Project Z

For a project which is comprised of a series of task 1..N, RPV at the beginning of Task number  $i$  can be calculated by the following equation [1],

$$RPV_i = \frac{-\sum_{k=i+1}^N C_k Q_{k+1} + \sum_{k=i}^N S_k Q_k}{Q_i} - \sum_{k=1}^i C_k + \sum_{k=1}^{i-1} S_k \quad Q_i = \prod_{j=1}^i (1-r_j) \quad (1)$$

where  $S_i$ ,  $C_i$  and  $r_i$  are income, expense and risk factor (= probability of failure) at task number  $i$  respectively. The first term of the right-hand side of this equation represents anticipated future cash flow of the project, which are discounted by future risk factors. The second and third term is costs and incomes of the past tasks. Risk factor  $r_i$  indicates subjective probability of uncertain events in each task that lead to termination of the project in the Bayesian statistics context. This is obtained in the risk management planning phase [2][3].

If all the tasks have the same duration period and risk factors are all constant, RPV at the beginning of the project equals to Net Present Value (NPV) defined in Discounted Cash Flow (DCF) method. Cut-off rate  $R$  for discounting is defined by the risk factor  $r$  in the following relationship.

$$R = \frac{r}{1-r} \quad (2)$$

DCF method is used only in the planning phase, however [4]. RPV can be obtained at start timing of any tasks during the project life cycle. We'll discuss this advantage in Section 3.3 for project portfolio management.

## 2. Calculation of RPV for complex project task networks

Ordinary projects have multiple parallel and serial tasks in their network diagrams. Following Figure 3 is a typical example of product development project. Numbers in parentheses are risk factors of tasks. This section describes how to obtain RPV for these projects having complex task networks.

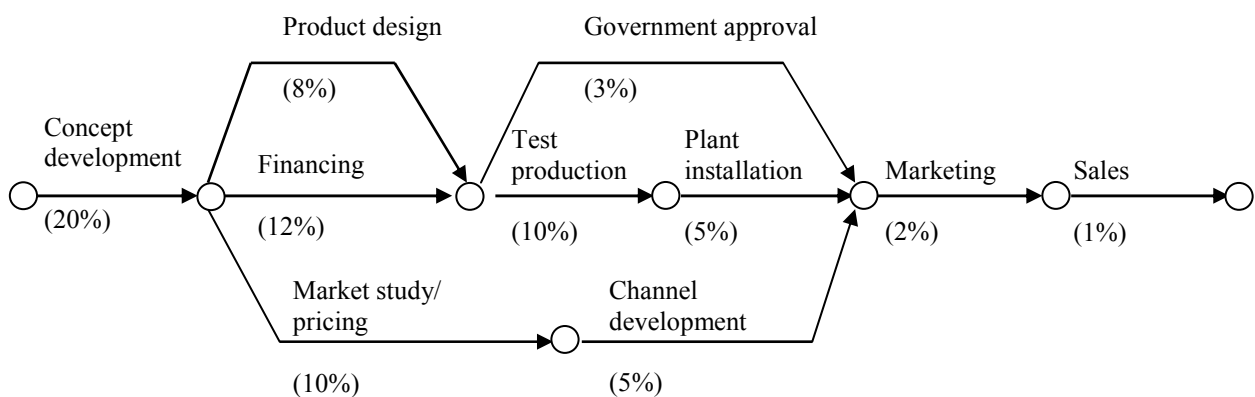


Figure 3 Example of product development project diagram

If there are two parallel tasks  $j$  and  $k$ , combine them to make a single task as shown in Figure 4.

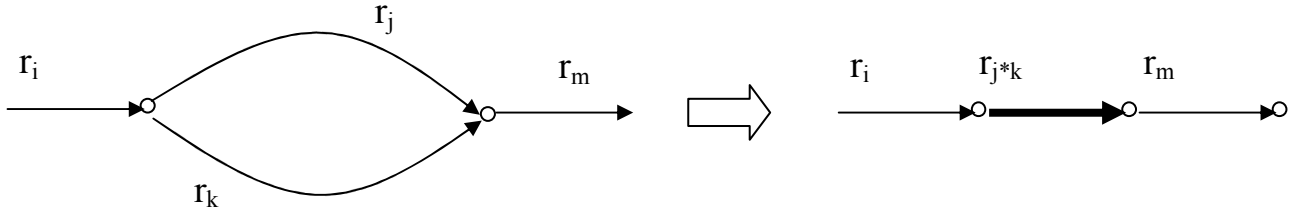


Figure 4 Combination of two parallel tasks

Income and expense for the combined task (j\*k) :  $S_{j*k} = S_j + S_k$ ,  $C_{j*k} = C_j + C_k$  (3)

Risk factor for the combined task (j\*k) :  $r_{j*k} = 1 - (1 - r_j)(1 - r_k) = r_j + r_k - r_j r_k$  (4)

Two serial tasks can also be combined into one task as shown in Figure 5.

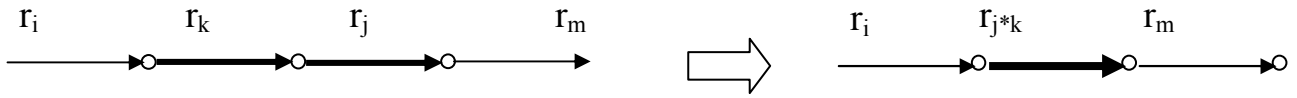


Figure 5 Combination of two serial tasks

Income and expense for the combined task (j\*k) :  $S_{j*k} = S_j$ ,  $C_{j*k} = C_j - S_k + C_k$  (5)

Risk factor for the combined task (j\*k) :  $r_{j*k} = r_j + r_k - r_j r_k + \frac{r_k (S_k - C_k)}{S_j}$  (6)

If tasks do not have income, then (3) also applies.

$$r_{j*k} = 1 - (1 - r_j)(1 - r_k) = r_j + r_k - r_j r_k$$

Please note that task combination operation for serial and parallel cases both require multiplied probability unlike in Fault Tree Analysis. This is because success of project relies on completion of two tasks anyway.

Using these operations, more complex task networks can be simplified into series of tasks as shown in Figure 6. Then, apply equation (1) to calculate RPV.

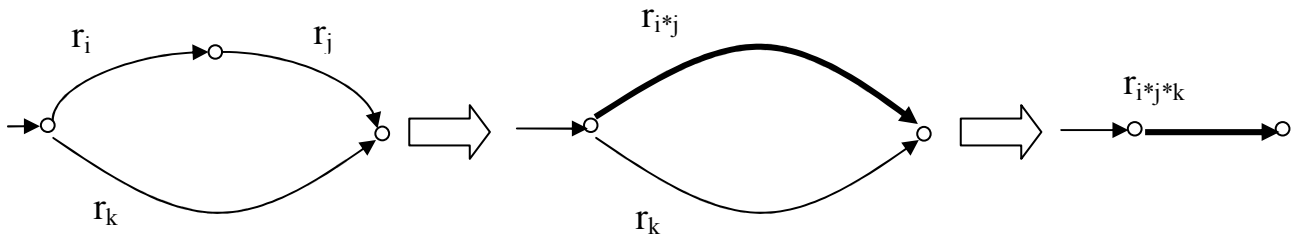


Figure 6 Simplification of complex task network

### 3. Application areas of RPV

RPV can be valuated at any timing during the project life cycle, unlike NPV in DCF method. Taking advantage of this feature, the author proposes three areas of application of RPV in project evaluation:

#### 3.1 Contributed value analysis of tasks

After successful completion of each task having some risk, RPV normally increases (see also Figure 2). This increment can be regarded as the value contributed, or “earned”, by the task [1]. This contributed value can be used to determine rewards or incentives to members dedicated to project tasks.

Equation (1) can be rewritten in the following form.

$$RPV_i = (1 - r_i) RPV_{i+1} - r_i C_i \quad (7)$$

Therefore,  $RPV_{i+1} - RPV_i = \Delta RPV_i = r_i (RPV_i - C_i)$  (8)

Or, if we denote

$$H_i = \frac{-\sum_{k=i+1}^N C_k Q_{k+1} + \sum_{k=i}^N S_k Q_k}{Q_i}, \quad (9)$$

then,  $RPV_{i+1} - RPV_i = \Delta RPV_i = r_i (H_{i+1} + S_i)$ . (10)

Equation (8) and (10) shows RPV increment, or value contributed by a task, is proportional to its risk factor. This means there is no value contribution if the task has no risk. The higher the risk is, the greater the contributed value to project. Or, in more familiar expression, “high risk, high return”.

Sometimes we combine two parallel tasks into one for RPV calculation as shown in Figure 4. In such cases, RPV increment of the combined task should be distributed to the original tasks by the following equation.

$$\Delta RPV_j = \Delta RPV_{j^*k} \frac{r_j (RPV_{j^*k+1} - C_j)}{r_j (RPV_{j^*k+1} - C_j) + r_k (RPV_{j^*k+1} - C_k)} \quad (11)$$

Conventional Earned Value Analysis (EVA) has regarded the budgeted cost of each task (BCWS) as its value [5]. In product development project as shown in Figure 1, budgeted costs are normally small for early “soft tasks” such as concept development or product design, and they become large for “hard tasks” such as plant implementation. Successful development of product concept earns only very small value. Progress measurement by the conventional EVA method, thus, does not match to the project managers’ common sense.

On the other hand, RPV increment represents real task contribution to the project. This method gives greater values to early soft tasks with higher risks. Progress measurement should base on contributed value, enabling more meaningful progress control.

$$\text{Progress (\%)} = \frac{EV}{\sum EV} = \frac{\Delta RPV_i}{\sum_{k=1}^{N-1} \Delta RPV_k} = \frac{\Delta RPV_i}{RPV_N - PRV_0} \quad (12)$$

For example, consider “Project Z” depicted in Figure 1 and 2. If Task A successfully completes, project progress =  $45 / (80 - 25) = 81.8 \%$ .

Performance appraisal and rewarding of project personnel is one of difficult problem in human resource management. If any task fails, the whole project stops. In this sense, contributions can be regarded as logic of multiplication. Meanwhile, rewarding requires logic of addition. Equation (8) and (11) can solve this logic gap issue. Appraisal of members engaged in each task should base on this value contributed by the task.

### 3.2 Procurement cost analysis

Procurement cost analysis is always very important for project management. Common practice of project procurement is to compare multiple vendors’ proposal and to select the best source. For the purpose of fair comparison, RFQ should be prepared to describe scope of work and technical specifications. Vendor

inquiry is done with the RFQ, aiming at “apple to apple” comparison. Normally, we select the vendor who is technically acceptable and with the least price.

However, this process lacks the aspect of procurement risk. Outsourced work is always associated with execution risks such as fatal schedule delay, unacceptable product quality, or even bankruptcy. We often observe these kinds of risk with offshore outsourcing. It is not always optimal decision to select cheapest vendor [6].

Suppose there are two vendors A and B, and their proposal prices are  $C_a$  and  $C_b$ . We estimate risks of their work performance are  $r_a$  and  $r_b$ . We neglect  $S$  because it is a procurement task. With equation (7) and (9), we can derive:

$$RPV_{i+1} = \frac{H_{i+1} - C_i}{1 - r_i} \quad (13)$$

Please note that  $H_{i+1}$  is not dependent on  $C_i$ . Therefore, condition to select vendor A should be;

$$\frac{H_{i+1} - C_a}{1 - r_a} > \frac{H_{i+1} - C_b}{1 - r_b} \quad (14)$$

Conventional vendor selection is based on price comparison (condition  $C_a < C_b$ ). Equation (14) shows risk factors should also be taken into consideration.

In real business scenes, however, it is not a practical assumption for each buyer to calculate  $H_{i+1}$  on procurement stage. Therefore, the author proposes much simpler approach [6].

Consider  $C^*$  as the maximum cost payable to the procurement task. From equation (7) and (9), condition of maximum procurement cost is;

$$(1 - r_i)H_{i+1} - C_i^* \geq 0 \quad (15)$$

For vendor A and B, this condition equally applies.

$$C_a^* = (1 - r_a)H_{i+1}, \text{ and } C_b^* = (1 - r_b)H_{i+1}$$

Hence,  $H_{i+1} = \frac{C_a^*}{1 - r_a} = \frac{C_b^*}{1 - r_b}$  (16)

From the above equation (16), we can define a new criteria  $C_r$ , “Critical Cost”, as follows:

$$C_r = \frac{C}{1 - r} \quad (17)$$

In comparison of more than one vendors, evaluate each Critical Cost  $C_r$  and select the smallest one. This does not require  $H$  calculation any more.  $C_r$  comparison is simple but powerful.

Equation (8) means that the contributed value of a task is proportional to its risk factor. For simple manpower service tasks, it is appropriate to assume probability of failure  $r$  is constant at any moments.

$$\frac{dr}{dt} = \text{const.} \quad (18)$$

Hence,  $r \propto t$ , or,

$$\Delta RPV \propto t \quad (19)$$

This means contributed value by a task depends on its time duration and risk factor. This gives the rational for paying wages to people based on working time and difficulty (speciality) of the work.

### 3.3 Portfolio management

As explained in section 1, RPV at the beginning of a project has a similar meaning of NPV in DCF method. If RPV is positive, the project is worth doing, and if negative, it has no worth. RPV gives a simple basis for go/no-go decision. If there are project plan alternatives which are mutually exclusive, the plan with the highest RPV should be chosen [1].

A company normally has more than one project – some running and some still in planning. RPV can also be calculated for ongoing projects. Summation of all the planned and ongoing projects' RPV represents total portfolio value of the company.

Introduction of a new project plan of positive RPV into the project portfolio usually increases portfolio value. However, a company's resources are limited. Addition of a project sometimes means removing key manpower from ongoing projects. The resource relocation may increase execution risks of ongoing projects, resulting decrease of their RPV values. Therefore, introduction of a new project does not always mean simple addition of RPV.

For the purpose of priority analysis in project portfolio, comparison of RPV itself is not adequate because it contains past cash flow value. Steven A. Devaux has proposed a criterion called "Simple DIPP" [7]. Simple DIPP of a project can be calculated by its expected (income) monetary value divided by its cost ETC. If Simple DIPP is high, the project has higher priority to continue and complete. The key concept of Simple DIPP is to obtain ratio of expected income to cost ETC, neglecting sunk costs in the past.

Using RPV instead of expected income, the author proposed a criterion "extended DIPP" as defined below:

$$\frac{RPV_N - RPV_i}{\sum_{k=i}^N C_k} \quad (20)$$

This represent ratio of remaining RPV to cost ETC. If there are project alternatives which are mutually independent, the one with the highest extended DIPP should be chosen. In product development projects as shown in Figure 3, extended DIPP usually becomes highest just before the sales task [1]. To maximize the project portfolio value of a company, extended DIPP can be used as criteria for prioritisation.

#### 4. Further aspects

Risk factor  $r$  is defined as probability of failure in a project task. However, project task is usually a temporary endeavour not possible to retry or to observe statistics in the same situation. In this sense, risk factor  $r$  is subjective probability in Bayesian inference.

Project management itself is a task requiring manpower and time duration. However, it is difficult to locate project management activity in the project task network. Although it is possible to draw an arrow for management task from the project start to the finish point, it does not help to assess risk associated with it. A good project manager's contribution should be valued by how much he/she could reduce risks of the whole project, instead of calculation from equation (8) or (10). Calculation method to for manager's contribution value is still required.

#### 5. Conclusion

Theoretical framework of risk-based project value (RPV) analysis is proposed. RPV is a summation of realized cash flows in past and expected cash flows discounted by risk factors in the future. RPV equals to NPV of DCF method when all tasks are supposed to have the same duration and risk factors. RPV calculation method is described for projects having more complex project networks with serial and parallel tasks. Risk-based project value analysis can provide three application fields. (1) Contributed value of tasks: RPV increase between start and finish of a task represents its value contribution to the project. (2) Procurement cost analysis: sourcing decisions should be made based not only on costs but also risk factors associated. (3) Portfolio management: summation of all the projects' RPV represents portfolio value of the company. Companies should allocate resources in order to increase total RPV. Prioritization should be given based on 'Extended DIPP' index value. Further development with real project case studies is essential, and the author is glad to have any collaboration opportunities.

## Nomenclature

$i, j, k$	task number indicator
$RPV_i$	Risk-based project value at the beginning of task number $i$
$C_i, S_i$	Expense at the beginning of and income at the end of task number $i$
$r_i$	Risk factor (subjective probability of failure) of task number $i$
$N$	Total number of tasks in a project
$R$	Cut-off rate used in NPV calculation in DCF method
$Cr$	Critical cost
$Cost ETC$	Cost estimated to complete

## References

- [1] Sato, T., "Maximizing Project Portfolio Value using Simple Index under Resource Constraints - Risk-based Value Analysis", Proceedings for *ProMAC Tokyo*, 2004, J067.
- [2] Royer, P. S., "Project Risk Management: A Proactive Approach", Project Management Institute, 2001.
- [3] Kanba, H., "Considerations for Risk management planning", *Journal of the Society of Project Management*, Vol. 7, No. 3, 2005, pp8-13 (in Japanese)
- [4] Senju, S. "Fundamentals of Economics Engineering" Revised edition, Nihon Nouritsu Kyokai Management Centre, 1994 (in Japanese)
- [5] Fleming, Q. W. and Koppelman, J. M. "Earned Value Project Management", Project Management Institute, 2000.
- [6] Sato, T., "Risk-based Project Cost Analysis", Proceedings for *Japan Industrial Management Association Spring Conference*, 2006, B-02 (in Japanese).
- [7] Devaux, Stephen A., "Total Project Control", John Wiley & Sons, Inc., 1999