

# ECONOMIC-PROBABILISTIC MODEL FOR RISK ANALYSIS IN PROJECTS

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**Keywords:** Risk analysis, Project management, Simulation.

**Abstract:** This paper presents an economic-probabilistic model to conduct risk analysis in projects. The model integrates risk and economic project analysis by quantifying both value and probability of occurrence of potential cash flow deviations, thus resulting in an economic-probabilistic analysis of the expected returns. The model allows calculating risk-adjusted values for cash flow groups and projecting net present value through stochastic simulation. As a result, the model provides both the risk-adjusted project economic return with the associated probability distribution to its NPV and the variability that each risk factor generates in the project return.

## 1 INTRODUCTION

Risk analysis is growing in importance in the current economy, as most economic decisions are taken in uncertainty-prone scenarios. Uncertainty sources are multiple and extensive, encompassing risks associated to markets, suppliers, weather, technology, etc. (Chavas, 2004).

Among the risk analysis models for project available in academic literature, few directly indicate the actual risks. Moreover, among the models that propose specific tools for risk analysis, most focus only on the success probability for the overall project itself, without considering their economic dimension. There are also models, such as Benaroch's (2002, 2007), that use real options to value IT projects given the assumed risks, but these models only conduct economic analysis and do not face the problem of identifying and quantifying the risks involved.

The objective of this paper is to present the application of an economic-probabilistic model for analysing risks in project investments. The model integrates risk and economic project analysis by quantifying both value and probability of occurrence of potential cash flow deviations, thus resulting in an economic-probabilistic analysis of the expected returns.

## 2 MODEL STRUCTURE

The model presented in this paper was based on the models by Karolak (1996), Foo and Muruganathan (2000) and Schimitz et al. (2006). The application of the model is conducted according to four steps: cash flow structure completion; risk assessment structure completion; determination of cash flow group risk-adjusted Net Present Value (NPV); and determination of risk-adjusted Net Present Value for the project.

In the step of cash flow structure completion, the benefit and cost items are distributed among nine cash flow groups. The groups are divided as follows: (i) Benefits, (ii) Financial costs, (iii) Infrastructure, (iv) Licensing and equipment, (v) Labor, (vi) Training, (vii) Outsourced services, (viii) Consumables and (ix) Other expenses.

The risk assessment structure completion is carried out through a questionnaire that combines the categories of risk with the project's cash flow. Risk categories and associated risk factors were identified through literature analysis coupled with expert opinions. The questionnaire is composed of six fields (Figure 1): (i) matching of cash flow groups and risk categories; (ii) assessment of risk factor impact; (iii) assessment of probability of occurrences for the risk factors' impact ranges; (iv) indication of analysts' knowledge level about each risk factor assessment; (v) indication of reasoning

Cash Flow Group A	Worst case		Best case		Worst case	Best case		High	Medium	Low	Reasoning base
	(-) Impact (\$)	(+)	(-) Probability (+)	Knowledge							
Risk Category I											
Risk Factor 1											
Risk Factor 2											
...											
Group A Value	\$ ...										

Figure 1: Risk Assessment Structure.

Assessment of Benefits	Worst case						Best case					
	(-) Impact (US\$/1.000)						(+) Probability (+)					
Risks associated to competitor actions												
Impact on benefits due to under/overestimated competitor response	-1.045	-627	-209	816	2.448	4.080	35%	40%	15%	7%	3%	
Impact on benefits due to under/overestimated introduction of substitute technologies	-1.700	-1.020	-340	0	0	0	20%	35%	45%	0%	0%	
...	...	...	...	...	...	...	...	...	...	...	...	
Benefits Value	US\$ 14.764 million											

\* Monetary values, in thousands

Figure 2: Risk Assessment Structure – Impact versus Probability.

base; and (iv) calculation of the cash flow group.

The completion of the questionnaire is carried out in four parts. First, the economic impact of the risk factor upon the cash flow group where it belongs is estimated. Analysts estimate values for the largest negative economic impact as well as the largest positive economic impact that each risk factor can produce upon the expected value for the cash flow group. From these values, the model generates four intermediate values, resulting in five probable economic impact ranges.

Secondly, analysts indicate the probability of occurrence for each range generated in the previous step. Figure 2 shows an example of this assessment for the risk category Risks associated to competitor actions. In the third part, the analysts indicate your knowledge level about each risk factor assessment. This allows analysing the opinion of several analysts, according to their knowledge levels. Finally, the analysts indicate the reasoning base, which ensures the traceability of the criteria used in the analysis and serve as a source of information to correct any discrepancies between the responses of different analysts.

In the step of determination of cash flow group risk-adjusted net present value, average values for the probable economic impact ranges and their respective probabilities of occurrence are used to generate a probability distribution for the economic impact that translates the risk associated to each factor. This distribution probabilistically describes the impact of the considered factor on the monetary value for the cash flow group in question.

Risk-adjustment was carried out by summing up the deterministic value for the group, indicated in the cash flow, and the probability distribution of the risk factor that impact the group at hand, through stochastic simulation using the Monte Carlo sampling technique. Figure 3 shows an example of the probability distributions for the cash flow groups Benefits and Financial costs and budgeting.

The determination of risk-adjusted net present value for the project is carried out by summing up the probability distributions for the cash flow groups through a new stochastic simulation. Figure 4 presents an example of the probability distribution for the project NPV with an average NPV of US\$ 1,862,568.20.

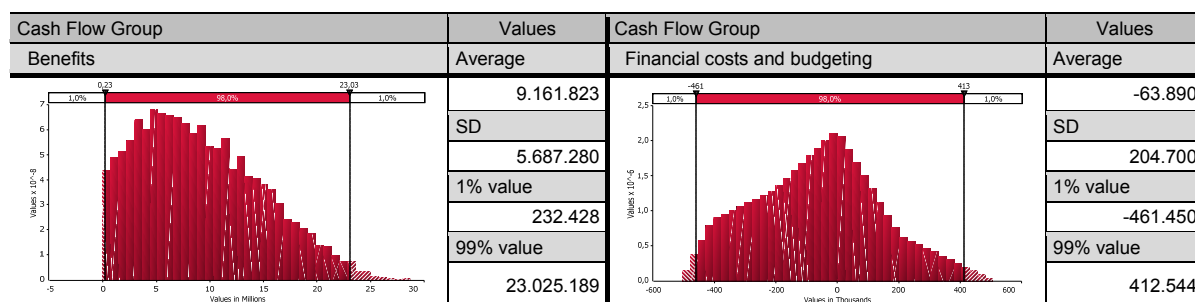


Figure 3: Summary of the probabilistic cash flow.

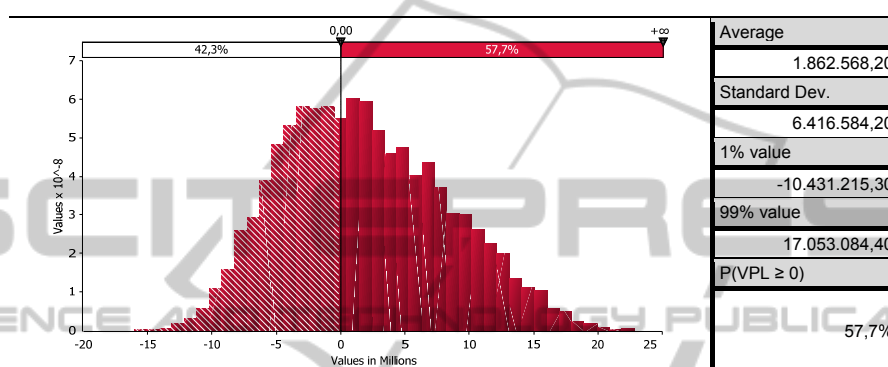


Figure 4: Probabilistic risk-adjusted NPV.

Figure 4 also shows the NPV standard deviation, a 98% confidence interval for NPV and the probability of a positive NPV. This information provides a complete view of the economic risk involved in the project in a language accessible to both analysts and decision makers.

After completing the risk assessment structure completion, it is also possible to rank the risk factors according to their impact on the project. This allows identifying which factors represent the greatest threats and the best opportunities to the project, enabling the analysis of new options.

This model fills a literature gap by integrating risk and economic project analysis. It offers decision support translating the different types of risks in financial results providing a clearer view of the project's economic viability to decision makers.

### 3 CONCLUSIONS

The proposed model guides the elaboration of the project cash flow, identifies the risks involved and quantifies the risks by mapping the potential economic impacts and their probabilities of occurrence. As its final result, the model provides the project risk-adjusted economic return in the form of a probability distribution for its NPV.

The presentation of the economic-probabilistic risk analysis as a project NPV probability distribution facilitates the comprehension of the subtleties involved in the risk analysis for the decision makers. Moreover, the probabilistic NPV allows decision makers without technical knowledge to easily assess the project risk level and the impact of alternative scenarios by themselves, whilst other risk analysis solutions usually require the support of specialists for this type of evaluation.

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