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FRAMEWORK FOR IMPLEMENTATION PROJECT PORTFOLIO SELECTION DECISION IN SHIPPING COMPANY

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ABSTRACT

Project portfolio selection is an activity to select proposal of projects either for a new project or project underway in order to accomplish the organization's objective without taking the existing restrictions. This paper focuses on the decision making process for project proposal selection currently applied by Shipping Company. First step is to identify the criterion used by the management team for project selection. Next step is to evaluate projects by means of scoring model. Further step is to do risk and financial analysis by using financial model and Monte Carlo simulation. Then, for selecting optimum portfolio, method 0-1 integer linear programming is used. Analysis result of this paper shows that the optimum evaluation steps taken in selecting a project portfolio are the decision to select project B and project C.

Keywords: Project portfolio selection, AHP, Simulasi Monte Carlo, Integer Programming

INTRODUCTION

Today, companies face an environment which is an increasingly dynamic environment and full of changes. In order to survive and thrive, companies must be able to adapt to several environmental conditions such as changes in services offered, the changes in information systems and other changes. Change is an activity that has a duration of certain time that requires resources such as manpower, money or other facilities so that can be said is a project.

Similarly, Shipping Company (PT XYZ) in Surabaya, which has *core businesses* in the area of *shipbuilding, ship repair, ship conversion* and ship building is a national shipbuilding company which has been internationally standardized and ISO 9001 standard since 1997. The sharp depreciation of the rupiah currency provides substantial opportunities of export markets for substantial national shipyards that have been national standard such as shipping company in Surabaya. By looking at the world needs new ships is growing at around 35 million BRT / year, while production capacity is only about 18 million BRT / year, including about 100,000 BRT / year that can be supported by the national shipbuilding industry. In addition to these opportunities, many challenges to be faced by the national shipbuilding industry such as shipping company in Surabaya

This paper aims to implement a project portfolio selection framework. Since the current required many changes to an organization or company can adapt and compete with their environment. And change is a project that has duration of time and limited resources to be able to implement the entire project.

Many models can be used to assist the selection of a portfolio of projects, but no one model that can assist in achieving an overall goal of portfolio management. That requires a wide range of models that are integrated through the framework of the project portfolio selection decisions.

The decision framework of project portfolio selection consists of four phases: strategic analysis, cost and risk analysis, optimal project portfolio selection and evaluation of the project portfolio. The model used in: strategies of analysis that is supported by the AHP model and *scoring models*. AHP model is used to determine the weight of each criterion strategy; while *scoring models* are used to provide an assessment of the project based on the criteria of the strategy. The both combinations gives a weighted value for each project which presents the project conformity with the strategy. Financial and risk analysis phase is supported by a financial model and Monte Carlo simulations. At this stage of the selection of the optimal portfolio is supported by the AHP model and

0-1 ILP *(integer linear programming)*. And the last stage of project evaluation is aided by a visual model, i.e. *bubble diagram.*

PROBLEM OF THE STUDY

Based on the background mentioned above, it can be formulated several problems which will be studied and searched its solutions in this study as follows:

Specifically, the purposes of this paper are:

1. To identify evaluation criteria for the selection of a strategy at this stage of the analysis strategy
2. How to make portfolio selection decisions based on the stage of strategic analysis and financial analysis and risk taking into account the criteria for both qualitative and quantitative evaluations?
3. How to develop an optimal multi-criteria decision model by using model of AHP *(Analytical Hierarchy Process) which* integrated with a model of ILP *(integer linear programming).?*
4. How to evaluate portfolio based on the balance of the reward, risk and project size?

In order for this research to achieve the desired objectives and does not deviate essence the issue raised, then this study have a limitation problem as follows:

1. The study was conducted at PT. Dock and Shipping Surabaya.
2. The data used in this study is the attribute data in the form of project data acquired during 2007.

By using some of the following assumptions:

1. The production process runs in stable condition.
2. The dollar is stable
3. Employees work in accordance with *Standard Operating Process* (SOP) which has been determined

REVIEW OF LITERATURE

The Basic Concepts of Decision Making

The issue of decision making is basically a form of selection of the various alternative actions that may be selected through a specific mechanism, in order to produce a good decision. The preparation of the decision model is a way to develop logical relationships that underlie the decision problem into a mathematical model that reflects the relationships that occur between the factors involved.

In this case the decision is seen as a process because it consists of a series of related activities and so is only considered a prudent action. In other words, the decision is a conclusion reached after consideration down. Consideration is that dimksud by analyzing several possibilities or alternatives and selecting one of them (Salusu, 1996).

Simon (1960) proposes a model that describes the decision making process. This process consists of three phases, namely:

a. *Intelligence*

This stage is the process of tracing and detection of problems and the scope of the problem recognition process. Data input is obtained, processed, and tested in order to identify any problems.

b. *Design*

This stage is the process of discovering, developing and analyzing alternative actions can be done. This stage includes the process to understand the problem, lowering the solution and test the feasibility of solutions.

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c. *Choice*

In this selection process was conducted among various alternative actions that may be executed. Election results are then implemented in the decision making process.

Simon's model also illustrates the contribution of the SIM (Information Systems Management) and Operational Research (OR) of decision making, as in figure 1.

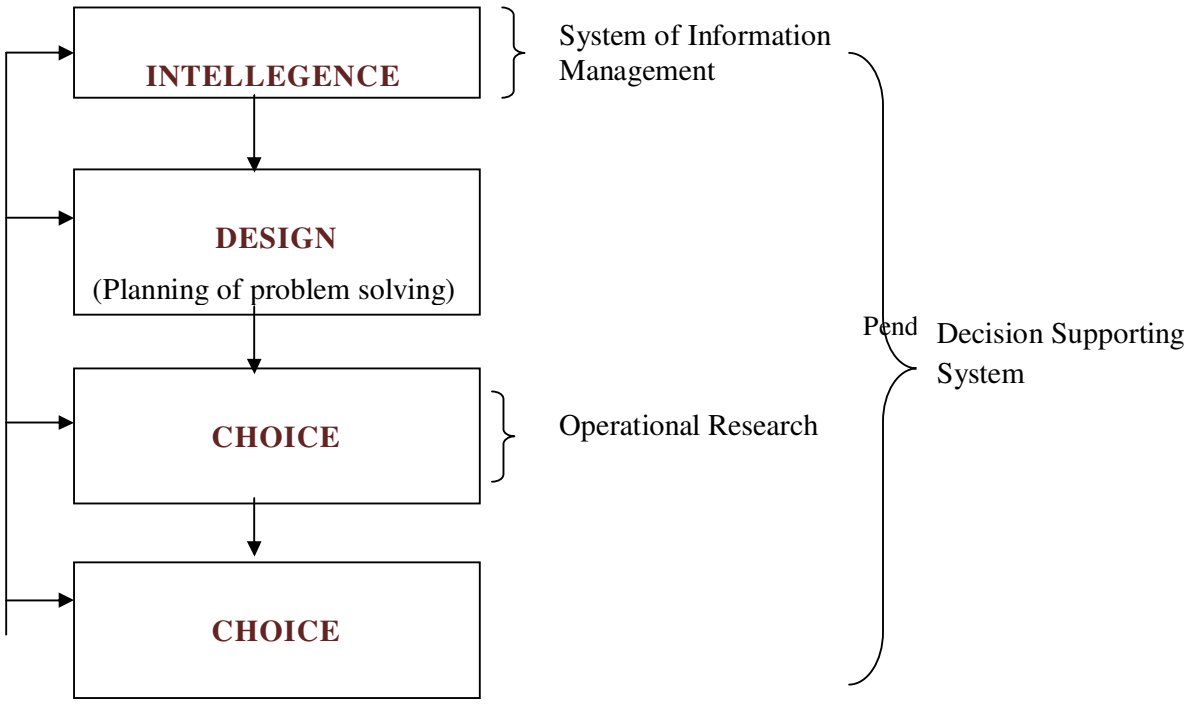

Figure 1. The Phase of Decision Making Process

The Determination of Decision Models of Project Portfolio Selection

The selection of the project portfolio is a periodic activity undertaken in selecting the portfolio, which is from the proposed available project and ongoing projects, which meet the organization goals without going through the available resources or breaking another barrier (Archer, 1999).

The output of one phase will be the input of another phase. The main input of this activity is a proposed project which will be considered either new project proposals or ongoing projects and has reached a certain development phase. The main input will be processed through the earlier phases in the portfolio selection activities. The output of this activity is the project composition which has met the portfolio target and the implementation schedule of these projects.

The phase of strategic analysis is supported by the AHP model and scoring model. The AHP model is used to determine the weight of each strategy criteria. The scoring model is used to provide a project assessment based on the strategic criteria. The combination of AHP and scoring model gives a weighted value for each project which represents the project conformity level with the strategy. The weighted value can be used to filter the projects by comparing the specific value and can be input at the phase of optimal portfolio selection if the strategic criteria become one of the values which must be optimized.

The phase of cost and risk analysis is supported by a cost model and Monte Carlo simulation. The survey results in 1991 toward the use of techniques to evaluate the economic returns indicate a shift towards the use of NPV, a moderate decrease in the use of IRR (internal rate of return), a significant decrease in the use of the payback period compared to the survey results in 1978 (Archer, 1999). In this study, the cost model is used to estimate the net present value and combined with Monte Carlo

simulation to obtain the expected net present value and the variability of net present value. NPV or ENPV can be considered as a basis of screening the next project by only passing the project having ENPV NPV greater than or equal to 0. The variability indicates the risk level; the more variability gets greater the grater ENPV value is possible not reached. NPV and ENPV become inputs for the phase of optimal portfolio selection; the variability becomes the input of the phase of portfolio evaluation to see the risk balance.

At the phase of optimal portfolio selection, it uses the AHP method and 0-1 Integer Linear Programming. The goal is to obtain the project composition which optimizes the objectives by respecting the exist constraint.

The phase of project evaluation is much assisted by a visual model, i.e. Bubble diagram. This diagram shows a map of selected and unselected project composition based on the parameters such as risk, size and project duration. The purpose of this phase is to evaluate the portfolio balance based on certain parameters. From the evaluation results, it is possible to eliminate or add a project to improve the desired balance. If there is a project removal or addition, the phase of optimal portfolio selection can perform the recalculation to get the most recent portfolio value. The selected portfolio is possible to have a portfolio value which is not optimal.

Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) developed by Thomas L Saaty (Saaty, 1980) in the early 1970s, is a method of decision analysis with multiple criteria used to decrease ratio scales from the criteria paired comparison and alternatives both discrete and structured continuous in a multilevel hierarchy. This comparison can be drawn from the results of actual measurement or using the basic scale which shows the interest/relative strength based on the participants' preference.

In addition, AHP is a systematic procedure which can be used to describe the elements of a problem. AHP builds a rational basis of a problem by separating it into smaller element. Then, it is compared into a paired comparison to determine a priority in each hierarchy. Briefly, AHP procedures are as follows:

Step 1 : Define the problem and create a hierarchical structure. Start from the top to the bottom hierarchy.

Step 2 : Create a matrix of paired comparison for each level and determine a value for each comparison. Consistency is determined by using Eigenvalue.

Step 3 : Determine the relative weight by performing Eigenvector analysis for each criteria group which is in the same hierarchical level associated with the same criteria at the higher level.

Step 4 : Determine the consistency of the entire hierarchy.

The excellence of AHP is that the user is possible to enter all relevant aspects of the problem, either subjective or objective, into one model.

Monte Carlo Simulation

At the first time, Monte Carlo Simulation was developed by John Von Neumann, Stanislav Ulam, and Nicholas Metropolis in the late 1940s to solve the problems of particle physics. Its name is taken from the name of the gambling city in Monaco where the probability is a 'king'.

Briefly, Monte Carlo simulation can be said as a static simulation, i.e. the scheme of pseudo-random numbers use, which is distributed U (0,1), to solve the problems which are stochastic or deterministic in which the time does not play an important role (Law & Kelton, 2000).

The advantage of this method compared to the estimation method is that the Monte Carlo simulation provides an uncertainty measure, while the estimation method does not. Monte Carlo simulation is used in many statistical problems where the analytical solutions do not bring a result, the risk assessment related to the environmental impact, cost and engineering.

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Monte Carlo simulation uses random sampling from each uncertain variable's opportunities distribution in the model to perform hundred or thousand iterations. Each opportunities distribution is sampled in a certain manner which can reproduce the shape of distribution. The distribution of outcome model values reflects the value opportunity which may occur.

To generate a random variable, Monte Carlo simulation uses the inverse transformation method, as follows:

1. Raise U ~ U (0,1)
2. Calculate $X = F^{-1}(U)$

The process of raising random variety can be seen in the following picture. In the picture shows that a random number U_1 generates variables X_1 and U_2 generates X_2.

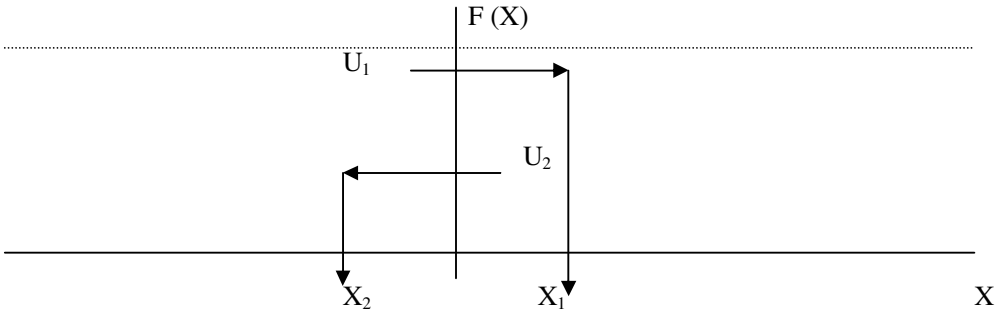

Figure 2. The transformation process to generate a random variable (Law & Kelton, 2000)

A simulation which uses random input will produce random output as well. When the random simulation output of a certain model construction compared to the other simulation output of other model construction, so if it is found any significant differences, such differences can arise from two sources, namely: different system construction or due to the use of different random variables. Therefore, it develops various methods to reduce variance. There are several methods which can be used to reduce the variance: Common Random Number (CRN), Control Variants' (CV), and Indirect Estimation and Conditioning (Law & Kelton, 2000).

Integer Linear Programming

Linear programming is one of methods which use mathematical model to represent the real world in a form of a model by using mathematical abstraction. The word “linear” indicates that all mathematical functions included in this model are a linear function. Then, the word “programming” refers to the meaning of planning. Thus, linear programming is activities planning to obtain optimum results among the possible alternatives (Taha, 1997).

In a linear programming, it has always found the existence of the decision variables, i.e. the variables which completely describe the decisions to be made: the objective function, which is a function of the decision variables to be optimized; and constraint functions, which is a barrier faced, so the variable prices do not vary in balance.

Integer linear programming is another form of linear programming where its divisibility assumption weakens or losses altogether. It means that a part of decision variables must be integer and some others may be fractional. Therefore, the integer linear programming is linear programming with the requirement addition that all or some of the decision variables is integer, not negative.

RESEARCH OBJECTIVES

The general objective of this study is to help the government program in restructuring State Owned Enterprises (BUMN) in terms of efficiency of BUMN, where by having the implementation of multi-criteria and multi-phase development on the selection of portfolio project in PT. Dok Dan Perkapalan Surabaya, one of the strategic BUMN in the field of marine will bring an impact on the optimization of

existing resources. Thus, the sustainable efficiency and performance improvement will be realized in such BUMN.

While the more specific objective of this study is to implement the development of a project portfolio selection framework through four phases, namely strategic analysis, cost and risk analysis, optimal project portfolio selection analysis, and project portfolio evaluation analysis.

PROPOSED METHODOLOGY

The proposed methodology for this problem composed of four main stages: (1) strategic analysis, (2) cost and risk analysis, (3) optimal project portfolio selection analysis, and (4) project portfolio evaluation analysis.

ANALYSIS AND DISCUSSION

Decision Hierarchy

The Decision Hierarchy of the Project Portfolio Selection problems is composed based on the aspects or criteria and their mentioned sub-criteria by using MS-Excel and Expert Choice software. The first level of the hierarchy is the Decision of Project Portfolio Selection. The second one consists of the aspects/criteria of project portfolio selection. The third one is sub-criteria of each mentioned criteria. The fourth level and the last level consist of the intensity rating of each sub-criterion. From several criteria, the problems hierarchy of the project portfolio selection can be created as follows:

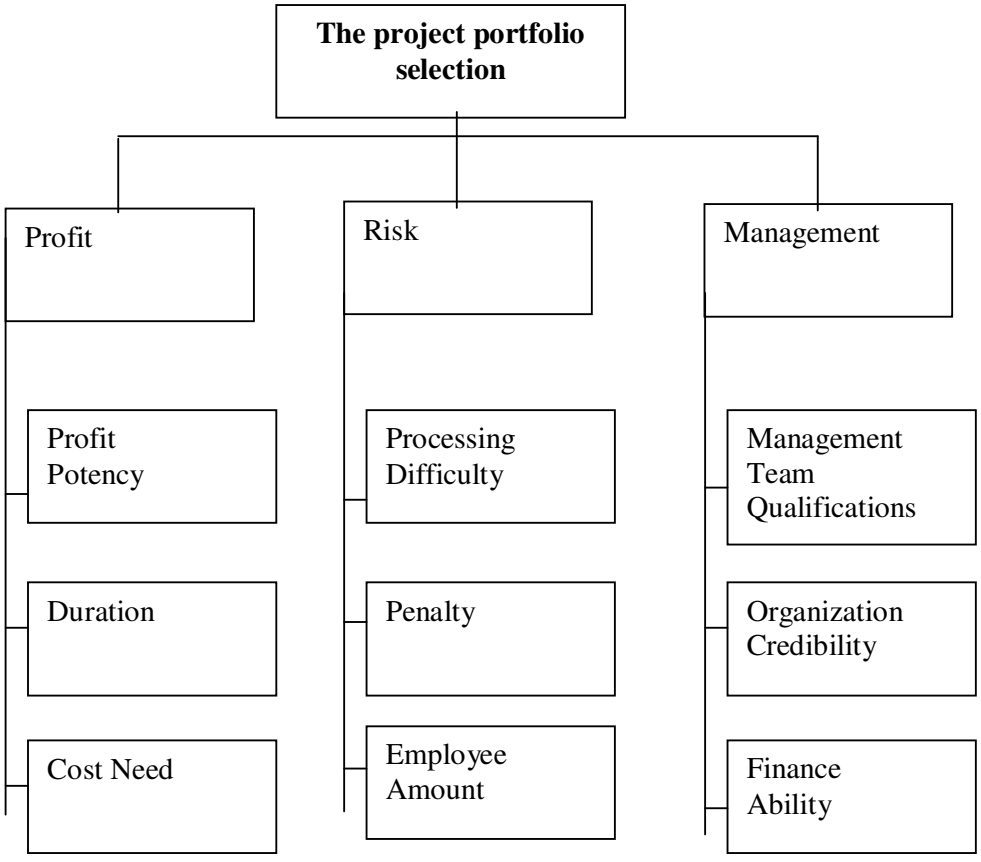

Figure 3. The Hierarchycal Structure of Project Portfolio Selection

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The Project Portfolio Selection

After spreading questionnaires, the next step is the weighting. From the processing by using the *Expert Choice V.9* software, the weight is obtained for each criterion, as follows:

Table 1. Normalization on the Sub-Criteria of Management

Sub-Criteria	Normalization
Management Team Qualifications	0.164
Organization's credibility	0.297
Finance Ability	0.104
Inconsistency Ratio = 0.02	

Table 2. Normalization on the Sub-Criteria of Risk

Sub-Criteria	Weight
Processing Difficulty	0.230
Penalty	0.648
Employee Amount	0.122
Inconsistency Ratio = 0.003	

Table 3. Normalization on the Sub- Criteria of Profit

Sub-Criteria	Weight
Profit Potency	0.724
Duration	0.193
Cost Need	0.083
Inconsistency Ratio = 0.0567	

From the processing above, it can be obtained the overall weight or aggregate weight of the alternatives toward the existing overall criteria (profit, risk, and management). The results of the aggregate weight of each criterion are as follows:

Table 4. The criteria weight on goals

Criteria	Weight
Management	0.123
Risk	0.320
Profit	0.557
Inconsistency Ratio = 0.016	

From the table above, it can be known that the profit criteria occupies the highest weight (0.557) when it is compared with two other criteria, i.e. management criteria (0,123) and risk criteria (0,320).

Strategy Evaluation Based on the Scoring Model

The next step is the weighting (scoring) toward the project portfolio which will be selected based on the weighted criteria. The parties of panel members/management are required to conduct assessments on each portfolio based on the weighted criteria which by using the AHP (Analytical Hierarchy Process) method. The scoring model is used to provide the project assessment based on the strategic criteria. The project portfolios to be assessed are as follows:

Project A: Manufacturing the "Tongkang Borge" ship, the status: new project, the project implementation: 2 years, the human resources need: 50 people, the project score: 70, 66 billion.

Project B: Manufacturing the Conventional Tug ship, the status: new project, the project implementation: 1 year, the human resources needed: 50 people, the project value: 26 billion.

Project C: Manufacturing the oil tanker ship, the status: new project, the project implementation: 2 years, the human resources needed: 99 people, the project value: 100 billion.

Project D: Manufacturing the White product ship, the status: new project, the project implementation: 2 years, the project value: 120 billion.

After each project is assessed by the panel members based on the scoring model using questionnaires, the results obtained are as follows:

Table 5. Result of Scoring Models

Criteria	Value	Scoring			
	Weight	Project A	Project B	Project C	Project D
Cost	0.123	0.981	0.736	0.490	0.368
Risk	0.320	0.961	2.562	2.242	1.601
Management	0.557	2.786	3.343	5.014	2.229
Total		4.727	6.640	7.746	4.198

The combination of AHP and scoring model gives a weighted value for each project which presents the project conformity level with the strategy. From the data processing, it obtains the ranking of project selection, namely Project C, Project B, Project A, and Project D.

Cost Evaluation by using Monte Carlo Simulation

The next step is the cost evaluation which is supported by cost model and Monte Carlo simulation. The cost approach is used in this project portfolio selection. This approach arranges the project priority based on the cost value, namely the ENPV ratio toward the deviation standard of NPV. The project having a high worth is first priority to be implemented. Then, if the required sources are still sufficient for the projects which have priority underneath, it will be selected and so on until the required sources are not sufficient to implement the project.

Each project will give some costs which consist of development cost (the project cost itself) and the next costs as the project result implementation impact, i.e. the project preparation cost, administrative cost, marketing cost, and production cost. Moreover, each implemented project will get profit from the sale. Each project has several development alternatives.

The component of cost and profit is probabilistic. Other components are treated deterministically. The value of each component is estimated in each period. The number of periods is analyzed depending on each project and each development alternative.

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The component values of cost and profit will be used to calculate the NPV with the growth rate which is probabilistic per period. The NPV calculation is conducted by using Monte Carlo simulations due to some of its components are probabilistic. The random variable of probabilistic components will be raised depending on the distribution and its parameters. Each iteration will produce one NPV, and the simulation can be done repeatedly. The formula used to calculate NPV (Net Present Value) is as follows:

$$NPV = \sum_{i=1}^{N} \frac{PI_i}{(1+r)^i} - Cost_0$$

PI_i = Project net income in year i
N = Number of years over which project income occurs
r = Discount rate
$Cost_0$ = Project cost (assumed to be in year 0)

The NPV calculation result using Monte Carlo simulation and simulated by using the MS Excel software can be seen in the table below:

Table 6. The table of NPV simulation for Project A (in Billion IRD) for 1000 simulations

	1	2	3	4	5	6	7	8	9	10
Mean	7.158	7.165	7.143	7.146	6.894	7.148	7.155	7.125	7.152	7,149
St Dev	17.113	18.324	17.956	17.765	17.023	17.648	17.652	17.256	17.725	17.802
Min	-14.136	-14.687	-14.568	-14.963	-12.364	-14.698	-14.635	-15.462	-14.234	-14.354
Max	42.964	41.004	40.693	40.231	39.698	41.436	46.287	45.285	46.865	40.758

Table 7. The table of NPV simulation for Project B (in Billion IRD) for 1000 simulations

	1	2	3	4	5	6	7	8	9	10
Mean	28.66	29.99	29.45	27.84	27.69	25.48	30.77	30.02	39.804	29.88
St Dev	10.47	12.64	14.98	11.12	12.64	11.75	12.88	13.46	15.48	12.64
Min	8.467	8.234	8.467	7.968	8.267	8.234	8.794	8.234	8.251	8.654
Max	45.542	49.326	49.236	45.698	49.231	48.631	46.987	47.24	49.596	49.534

Table 8. Table table of NPV simulation for Project C (in Billion IRD) for 1000 simulations

	1	2	3	4	5	6	7	8	9	10
Mean	213.44	213.25	214.87	212.889	213.18	215.63	219.87	213.25	214.46	213.19
St Dev	87.234	86.126	88.783	87.149	85.458	85.234	84.156	86.178	86.184	86.179
Min	70.124	69.897	71.454	69.456	67.489	69.874	69.852	70.253	70.005	69.981
Max	352.04	351.44	354.23	350.26	352.76	352.23	351.56	352.86	354.26	351.43

Table 9. Table table of NPV simulation for Project D (in Billion IRD) for 1000 simulations

	1	2	3	4	5	6	7	8	9	10
Mean	121.41	120.89	121.03	124.21	122.86	121.87	108.94	120.56	121.56	120.99
St Dev	46.585	42.981	46.242	43.479	43.624	45.22	47.43	41.235	48.721	45.201
Min	-84.37	-66.51	-154.14	-95.74	-161.3.8	-69.45	-54.56	-64.23	-59.36	-60.38
Max	61.55	146.26	61.55	67.57	153.79	84.15	253.10	85.264	87.623	87.623

Evaluation of Optimal Portfolio Selection

This evaluation of the optimal project portfolio is to make the project portfolio selection appropriate with the objective criteria without violating the existing barrier. The processing is assisted by 0-1 integer linear programming (ILP).

The formulation of 0-1 Integer Linear Programming Model

System Constraint/Constraint System

Each project/proposal can only be selected once/duplication is prohibited.

$$\sum_{j=1}^{J} X_j + d_j^- - d_j^+ = 1 \quad ; \quad j = 1,2,\ldots\ldots,J$$

The general form of the formulation for the ILP is:

$$\text{Max/ Min} \quad Z = \sum_{j=1}^{n} cjxj$$

$$\text{Constrain :} \quad \sum_{j=11}^{n} aijxj \leq \geq bi \quad untuk\, i = 1,2,3,\ldots\ldots,m \qquad \text{b}$$

$$xj \geq 0 \; and \; integer, \quad untuk\, j = 1,2,3,\ldots\ldots,n$$

The following is the calculation formulation of 0-1 integer linear programming:

$$X1 = \begin{cases} 1 & \text{if there is an investment on project j} \\ 0 & \text{if there is no investment} \end{cases}$$

Table 9. The table NPV for 4 Projects (in Billion IRD)

Project	NPV	year 1st	year 2nd	year 3rd
A	7.1	20	21	22.05
B	29.88	12	12.6	13.23
C	213.19	50	52.5	55.125
D	120.99	45	47.25	49.6

From the results of cost evaluation, it is reached an equation formulation of 1-0 ILP as follows:

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The objective function maximizes NPV:

Maximize 7,1 X1 + 29,88 X2 + 213,19 X3 + 120,99 X4

The constraint is as follows:

$$20\ X1 + 12\ X2 + 50\ X3 + 45\ X4 \leq 30$$

$$21\ X1 + 12{,}6\ X2 + 52{,}5\ X3 + 47{,}25\ X4 \leq 25$$

$$22{,}05\ X1 + 13{,}23\ X2 + 55{,}13\ X3 + 49{,}6\ X4 \leq 4$$

Based on the calculation results using MS Excel, it obtains the following results:

Table 10. The calculation results of 0-1 ILP

			Capital requirements (Billion IDR)		
Project A	**Decision**	**Return (Billion IDR)**	**1**	**2**	**3**
A	0	7.1	20	21	22.05
B	1	29.88	12	12.6	13.25
C	1	213.19	50	52.5	55.125
D	0	120.99	45	47.25	49.6
Available capital (Billion IDR)			100	75	75
		Capital Used	62	65.1	68.375
Objective	243.27				

From the table above, it can be seen that the selected suitable project portfolio is project B and C.

CONCLUSION

Based on the analysis of research results and discussion, it can be concluded:

1. The AHP and Scoring models provide a logical, structured and coherent framework in evaluating a process of group decision-making where the project portfolio is evaluated on a various criteria which have been prioritized.
2. The cost evaluation of improvement plan of the QFD results which has been done and based on the results of brainstorming with an expertise team can be seen in Table 5.16.
3. The Development Model of Project Portfolio Selection Decision Framework becomes important for three reasons:
   - Such model combines and weights the Qualitative and Quantitative Criteria by using AHP.
   - Such model uses the weighting model score to order the alternative portfolio by using an AHP / Rating Model of Expert Choice software.
   - Such model integrates the Integer Linear Programming to determine the selected suitable projects by using MS Excel software.
4. From the four project portfolios based on the last phase in the model of decision development is obtained the selected suitable projects, namely Project B and Project C.

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