USE OF UNCERTAINTY ANALYSIS FOR PROJECTS

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ABSTRACT

A project starts from idea to implementation, so it requires an in-depth study of its feasibility. To select or determine a project feasibility, future parking is required. Data which is often insufficient to carry out analysis requires an understanding of " **uncertainty"** involved in the analysis result limits such as: NPV, IRR or BC ratio.

Several ways of analysis that show the advantages and disadvantages, but necessary guidelines for decision makers are accepted. The accuracy of the method used really depends on the type of project being analyzed, the objectives to be achieved and the availability of existing resources, especially capital.

Keywords:

Uncertainty, Projects, probability.

1. Introduction

In deciding a project to be implemented is always faced with an uncertainty, therefore a guideline is needed for *decision makers* to ensure that their decisions can be accounted for.

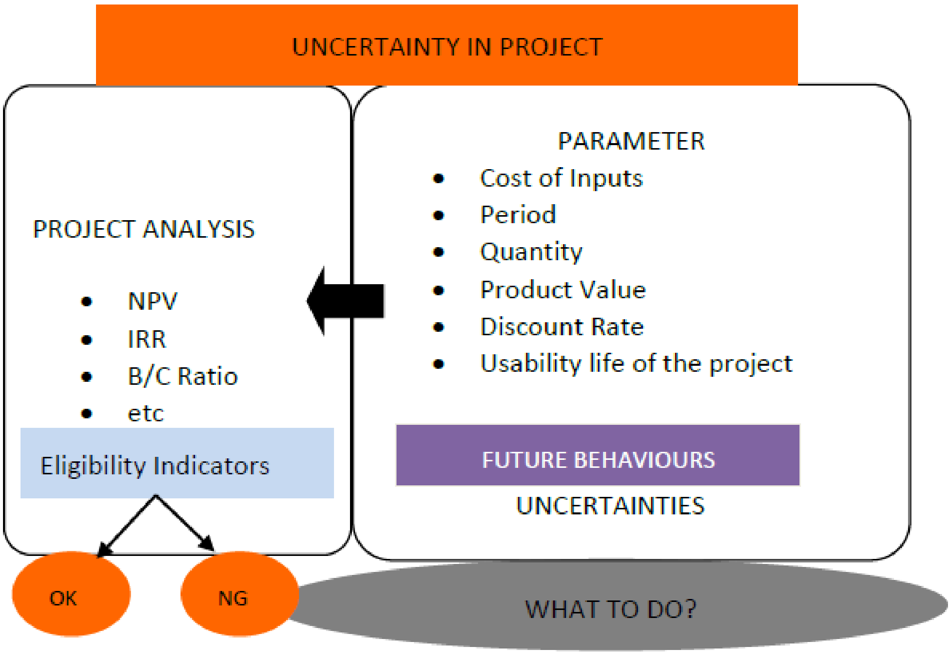

Figure 1: Uncertainty in the Project

"analysis ***Cost Benefit***" in a project planning uses a number of parameters and variables (for example; financing or cost of input, implementation period, product quantity and value, *rate of discount*, project useful life, etc.) and this process require information about these parameters and forecast future conditions or *forecasting future behaviors*. Existing data are often insufficient and there is also no available *data base* for future estimates.

Sources **"uncertainly"** is a lot, but to note in this regard is a combination of elements of risk or **"risk"** and **"uncertainly"** with an inside measurement of ***cost benefit*** analysis.

"Risk" is different from **"uncertain"** in the usual sense of ***cost benefit analysis*** with the following explanation:

RISK: is a situation where there is enough information to assess the assigned probabilities (assignment of probabilities) to different outcomes (different outcomes), so we can calculate the expected value of the outcomes.
UNCERTAINTY: is a situation where probabilities (although in a subjective condition) from various outputs or outcomes are difficult to assess.

2. Analysis Method

The project analysis approach to overcome the unpredictable parameter value (Uncertain value) in practice can be done by:
a. Rule of thumb (simple)
b. Contingency Allowance
c. Systematic

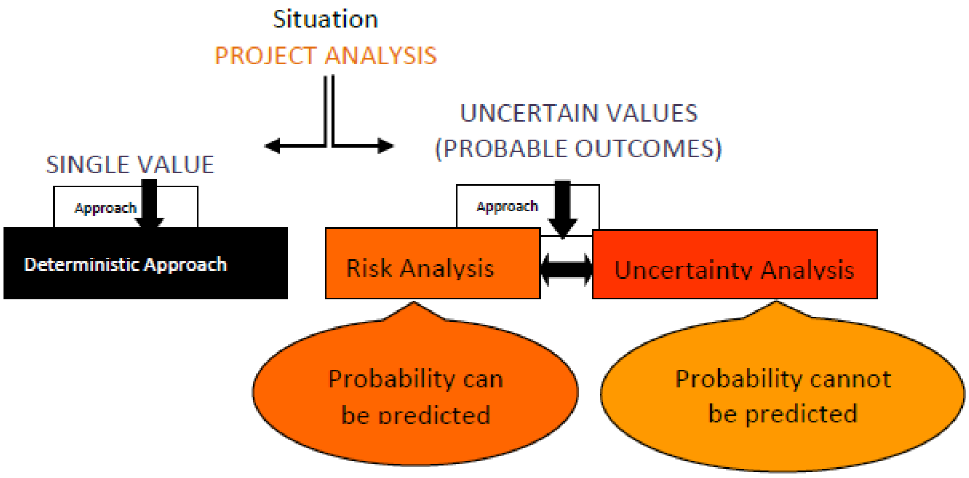

Figure 2. Analysis Method

There are several simple formulas, *rules of thumb*, and estimation methods as follows:
a) **Thumb Rules**

Adding a *"risk premium"* to the "*pure*" rate of discount in the calculation of NPV, IRR, etc. This causes the risk used to increase a "compound rate" with time and with increasing time, the condition of an item will have greater uncertainty. Nothing can be convincing and this method casts doubt between "uncertainty" and "under estimation" and the existence of under estimation of costs (or ocer estimation of benefits) that occurs when designing a project.

Increase "" items *COSTS* and / or reduce items *"BENEFITS"* that make "uncertain or uncertain" a certain number of percentages. This condition is also an ad hoc estimate with predominating assumptions by experts *over-optimistic*. iii Using a *project life* smaller than the formal economic life in general or a method of shortening the "pay-back" period of the appraisal, the short "pay-back" period method of appraisal.

b) **Contingency allowance**.

This method is often used in *project analysis*, especially when calculating “capital costs” including items that are not recognized but appear, as well as costs that are not expected to occur during construction, which are calculated as well as costs that are not expected to occur during construction. calculated based on previous experience. The amount of risk or *contingency allowances* for this is usually in the form of a single value estimate or normally a single value (5 or 19%) estimate.

Contingency allowances may also be made separately for price increases during the construction period.

However, this cannot be used as an "uncertainty" analysis because this calculation is intended for a specific purpose.

c) **A systematic approach (in "uncertainty analysis").**

The first step is to get a clear idea of the relative importance of the individual variables of the costs and benefit streams. Through sensitivity analysis, this can be done systematically.

The second step is to use a "probability analysis" or "risk analysis" to determine the amount of risk ("riskiness") of the project and then calculate the "expected value" of the NPV, IRR, etc. And also the estimated probability of a positive or negative NPV, etc. Finally, if the estimation of the probability output (outcomes) is not possible, it is necessary to make a decision through different criteria with "decision theory".

Step 1. Sensitivity analysis

Objective

Sensitivity analysis helps planners to understand the effect of various parameters (such as: initial costs, construction period, production and maintenance costs, capacity utilization) on the feasibility assessment of project implementation.

The principle of "sensitivity analysis" is to recognize parameters, which each change causes additional changes in the final outcome or outcome (eg NPV, IRR, and B: C). this means ascertaining the change in the parameter which causes the most sensitivity to the final outcome.

For example, if the initial cost is considered very sensitive to the NPV of a project, this will cause the project designer to go back to the "investigation and formulation" phase of the project to see if it is possible to reduce the "uncertainty elements" in the design by making changes to the design. the. On the other hand, if "sensitivity analysis" identifies "benefit" is very sensitive to the NPV of the project (which usually happens) the project designer will look back at the "market analysis" stage of the project study to see if it is possible to reduce uncertainties in the estimated "demand" of the expected product .

Sensitivity Analysis

To understand the parameter change towards project suitability.

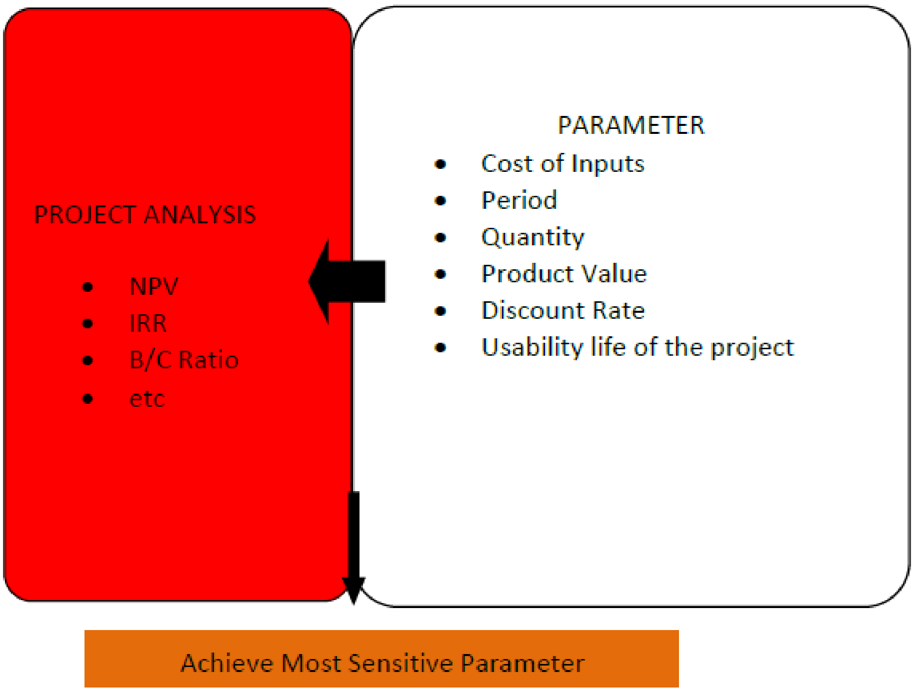

Figure 3. Sensitivity Analysis

Techniques and the percentage of "sensitivity analysis".

Change parameters (such as cost, benefit, life of project, etc., one at a time, one at a time, while other parameters are kept constant), with a set percentage (5%, 10%, 20%, etc.) and then calculate percentage change of the NPV, IRR and B: C ratio due to changes in these parameters. The most sensitive parameter is the parameter that causes the largest percentage change in the taken DCF criteria.

Before making changes to individual parameters, it is better to convert these parameters to their present value (present worth).

Another alternative sensitivity analysis can be done by "reducing the NPV to zero or reducing the NPV to zero". With this method, the calculations carried out to determine the percentage change of different variables affect and reduce the NPV to zero. Parameter that has the smallest percentage change but causes the NPV to change to zero is the most sensitive parameter.

An example of sensitivity analysis is given in Appendix 1.

Limitations of sensitivity analysis.

(i) This method is a partial analysis because only one parameter changes at a time. Therefore, it will be difficult to use for the selection of a project.

Step 2. Risk Analysis

The first step is to get a clear idea of the relative importance of different parameters (eg: **cost, benefit, project life** and **discount rate) from the Cost Benefit Analysis**. This can be done with ***"Sensitivity Analysis"***

The next step is to identify **a range of probable values** of the parameters (rather than a **single value**) which can be seen from previous experience or studies. - Analyze studies and assign probabilities to different values of parameters and calculate an ***"Expected Value***" of the NPV, together with calculating the **"Measures of Riskiness"** , such as *Probability of loss, standard deviation*, etc.

The stages of a risk analysis can be described as follows:

1) Determine with sensitivity analysis the parameters that cause *the* most sensitive outcomes. This limits the scope of the calculation.
2) Give a *Probability distribution* to a certain boundary value for each data set (based on previous experience)

If the project planner has sufficient information based on recorded data of a *probability distribution* (or *relative frequency*) of different values within the *range* taken, then these data can be used.

In general, planners often use the *"highest possible" value. lowest possible*, and "*most likely*" of each parameter, such as *cost, benefit*, age etc. In this case it is assumed that it tends to follow the *"beta distribution*".

3) Give the numbering from 00 to 99 to the value of each variable according to the assigned probability. In this case 00 to 99 represents 1 to 100.
4) *Monte Carlo Simulation*
   a. Using the " *Table Random Number*", select as many groups of 2 digits as the variable to be tested, then provide the value of the variable for one calculation *(a single trial*).
   b. For this single trial, do the calculation of the *outcome* such as NPV, IRR and others.
   c. Repeat this process using the *table random number a* few times (> 100 times), making sure the numbers selected in the table are continuous.
   d. Summarize the results in tabular form, then create a "*probability distribution diagram*"
   e. Draw a "histogram" *probability histogram*".

5) Calculate the "*Expected Value*" of the NPV based on the table or histogram, also the probability of the Negative NPV and positive NPV, *variance*, etc.

Calculation 5);

Expected NPV = $\sum_{NPV} = \sum (NPV_i^+)(P_i^+) - \sum (NPV_i^-)(P_i^-)$

Size Of Loss = $\sum (NPV_i^-) / \sum P_i^-$

Variance = $\sum (NPV_i - E_{NPV})^2 \times (P_i)$

Std Deviation = $\sqrt{\sum (NPV_i - E_{NPV})^2 \times (P_i)^2}$

Calculating Riskiness

Risk can be taken as several or many aspects of the *probability distribution,* such as:

i. *Variance* (and standard` deviation)
ii. *probability* of negative NPV (or loss)
iii. *Expected size* of a negative NPV (or loss)

If the NPV distribution shows a *"variance"* (or *standard* deviation)which is greater than the expected NPV *(Expected* NPV), then *uncertainty* of the project into very high. *The probability of loss is* also high.

For a "*Standardized Variate" (V / σ = E_{NPV} / Std-Dev)*of 0.83 the *probability of loss* is ± 20%, and if the value is low = 0.53 the *probability of loss* becomes 30% (the *probability of loss value* 20% -30% is a very high value to be able to accept risk in a project)

Step 3 Decision Criteria (Pure Uncertainty Analysis)

a. *Technique*

"*Decision Problem", in a* situation where the decision maker cannot determine at all the probability of various events that can affect activities, can be overcome by using a device similar to that used on the "Game Theory"

b. *matrix example*

example *"Pay Off"* can be shaped *matrix-monetary* or *Utility, for* example:

	Alternatives or *Strategy* or *Decisions*	*Change Events`* or *State of Nature*
industry	Introduces industrial products or its level, Different products: A, B, C and D	*Level of Demand*- Increasing constantly, decreasing
Agriculture	Alternative products; corn, beans, rice and cotton	Changing *Events* of the rainy season, dry, slightly, many ff.

c. *Decision Criteria*

To determine the *choice of projects* apart from the different alternatives shown in the "*pay off matrix"*, the calculation is carried out using the *decision criteria* following:

(i) *Maximin Criteria* (Wald)
Select actions from the alternative / project that can maximize the *minimum pay-off* .

(ii) *Maximax Criteria* (Hurwicz)
Select a project to maximize *the maximum pay-off* (an optimistic approach or *Gamble's strategy.*

(iii) *Index of Pessimism Criteria* (Hurwicz)
is a combination of the two methods above, but with the *"index of pessimism,* as probability used and the *weighted average* day *pay-off* calculated

(iv) *Principle of Insufficient Criteria* (Bayes and La Place)
This criterion uses an *equi-probability* for all projects or alternatives before calculating the *weighted average* of the *pay-off*

(v) *Maximax regred Criteria* (Savage)
Choosing an alternative / project that minimizes the *maximum potential losses (opportunity cost).* This means creating a matrix with *potential losses,* such as a *regret matrix* by subtracting the *actual pay-off* from the *potential pay-off*

3. Analysis Results

3.1 Formulation of the Rules of thumb

- Adding a risk premium to the discount rate makes the discount factor become :

$1 / (1 + r + p)^t$ as a substitute for the normal discount rate of $1 / (1 + r)^t$, where r = rate of discount, t = time and p = risk premium,
where the value increases monotonically with time. But in many cases the condition can turn out to be better or worse than expected.

- Using a method of increasing the item *cost* and *reducing* item *benefit,* will be difficult to replace a thorough and systematic approach in which costs disintegration and benefits in the project appraisal, besides many types of *RISK over-optimism* mouth.
- Using the *project life* method, this method also harms projects a lot with its "*benefits*" occurring at a later stage in *project life*.

Therefore, the three methods above are very inaccurate (rough), so they are not ***recommended for Project Analysis***

3.2 *Contingency Allowance*

This method is intended for a purpose, so it cannot be used

3.3 Sensitivity Analysis The

following is an example of calculations on an Irrigation for Agriculture project, obtained results are as follows:

i. From Figure 4, the effect of NPV with an 8% discount rate of the irrigation system, which varies between 19% and 29%, is very sensitive, because a change of 2.1% can make NVP = 0.

Con Example NSITIVITY ANALYS IRIGATION ROJECT FOR AGRICULTURE

NPV= 9.939 – (7826+1988) = 125

no	BENEFIT & COST	PRESENT VALUE 8% discount rate
I	CAPITAL	(xRp. 000.000)
1.1	Irigation system	-5.064
1.2	Disposal system	-1.594
1.3	Contingency (5% (1+2))	-332
1.4	Dept.Charges (12%(1+2+3))	-836
	SUB-TOTAL	-7.826
II	OPERATING	
2.1	Salaries	-530
2.2	Electricity	-1.278
2.3	Repairs, etc.	-180
	SUB-TOTAL	-1.988
III	BENEFIT	9.939
	SUB-TOTAL	9.939
	NPV dari Proyek	125

Figure 4. Examples of calculation of sensitivity analysis

Cost Change

Δ BIAYA	Δ NPV	NPVbaru	% Δ NPV
+ 10 %	- 595,5 *	-471,0	-476
+ 20 %	- 1.191,0	-1.066,0	-953
- 10 %	595,5	721,0	476
- 20 %	1.191,0	1.316,0	953

* 10%x5.064 + 5%(Z) + 12%(Z+Y) = 595,5
(Z) (Y)

Due to cost change, direct and indirect cost

New NPV = Initial NPV + delta NPV

%delta NPV = delta NPV divided by initial NPV

% Cost change in irrigation system to make NPV = 0

(100%/476%) x 10% = 2.1% (only with 2.1% change can make NPV = 0)

→ Cost change is VERY SENSITIVE

Figure 5. Sensitivity of changes in costs

Through the calculation of Risk Analysis, the expected NPV value is obtained, at the worst value = -1.884 and the best = +1.616. With the most optimistic probability of 16.67% and the most pessimistic also 16.67%, with this value the decision maker will be able to take guidelines to ensure the feasibility of the project is feasible or not.

Example

RISK ANALYSIS IRIGATION PROJECT FOR AGRICULTURE

no	BENEFIT & COST	PRESENT VALUE 8% discount rate
I	CAPITAL	(xRp. 000.000)
1.1	Irigation system	-5.064
1.2	Disposal system	-1.594
1.3	Contingency (5% (1+2))	-332
1.4	Dept.Charges (12%(1+2+3))	-836
	SUB-TOTAL	-7.826
II	OPERATING	
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2.2	Electricity	-1.278
2.3	Repairs, etc.	-180
	SUB-TOTAL	-1.988
III	BENEFIT	9.939
	SUB-TOTAL	9.939
	NPV from Project	125

BERI PROBABILITY DISTRIBUTION
- ML (most likely)=
- HP (highest prob)=
- LP (lowest prob)=

Figure 6. Example of Calculation of Risk Analysis

RISK ANALYSIS

PROBABILITY DISTRIBUTION — Numbering [0 - 99

NILAI		Benefit	Sewerage	Disposal	Operating	RN
LP	(1/6)	9.442	-5.646	-1.781	-1.889	00 - 16
ML	(4/6)	9.939	-5.944 *	-1.875 *	-1.988	17 - 82
HP	(1/6)	10.933	-6.537	-2.062	-2.187	83 - 99

→ Calculate Expected NPV

Worst Condition NPV= 9.442-(6.537+2.602+2.187=-1.884

Best Condition NPV= 10.933-(5.657+1.781+1.889=1.606

*(add charges)

The Estimator use 3 extreme values and need several distributions for the 3 values. Distribution that usually use is "Beta Distribution" with relative frequencies (a probability):

Most Optimistic	1/6 (→ 16.67 %)
Most Likely	4/6(→ 66.67 %)
Most Pessimistic	1/6 (→ 16.67 %)
Total	1

Figure 7. Probability Risk Analysis

Example

MONTE CARLO SIMULATION

NIL	RN	Benefit	Sewerage	Disposal	Operating
LP	00 — 16	9.442	5.646	1.781	1.889
ML	17 — 82	9.939	5.944	1.875	1.988
HP	83 — 99	10.933	6.537	2.062	2.187

Input	I		II		III		IV		V	
	RN		RN		RN		RN		RN	
Ben	8	9442	53	9939	93	10933	90	10933	95	10933
Sew	42	-5944	19	-5944	03	-5646	25	-5944	33	-5944
Dis	26	-1875	64	-1875	23	-1875	60	-1875	47	-1875
Opr	89	-2187	50	-1988	20	-1988	15	-1889	64	-1988
NPV		-564		132		1424		1225		1126

Figure 8. Montecarlo Simulation

Random Numbers =RAND()

0.08	0.96	0.66	0.76	0.82	0.51	0.33	0.11	0.85	0.14	0.54
0.91	0.53	0.21	0.03	0.96	0.56	0.63	0.39	0.10	0.47	0.74
0.20	0.49	0.16	0.32	0.53	0.66	0.70	0.15	0.22	0.27	0.37
0.97	0.59	0.37	0.37	0.93	0.52	0.40	0.98	0.69	0.17	0.46
0.90	0.12	0.49	0.60	0.37	0.25	0.51	0.56	0.60	0.27	0.70
0.37	0.38	0.78	0.02	0.30	0.75	0.41	0.31	0.59	0.06	0.85
0.97	0.97	0.71	0.33	0.73	0.07	0.39	0.30	0.77	0.03	0.49
0.54	0.90	0.96	0.21	0.73	0.39	0.74	0.62	0.75	0.72	0.77
0.72	0.65	0.91	0.04	0.66	0.23	0.94	0.75	0.75	0.05	0.51
0.21	0.12	0.62	0.97	0.26	0.30	0.20	0.07	0.17	0.70	0.45
0.59	0.81	0.72	0.21	0.76	0.27	0.12	0.64	0.36	0.33	0.84
0.49	0.55	0.88	0.05	0.92	0.18	0.24	0.91	0.05	0.40	0.92
0.90	0.12	0.28	0.89	0.15	0.71	0.31	0.75	0.89	0.70	0.88
0.91	0.61	0.64	0.73	0.33	0.82	0.62	0.14	0.27	0.25	0.34
0.89	0.98	0.35	0.28	0.90	0.11	0.60	0.85	0.47	0.75	0.78
0.71	0.03	0.39	0.98	0.02	0.42	0.86	0.20	0.04	0.79	0.20
0.44	0.56	0.00	0.60	0.50	0.54	0.15	0.08	0.18	0.48	0.27
0.16	0.36	0.94	0.23	0.17	0.37	0.56	0.40	0.30	0.67	0.19
0.03	0.75	0.53	0.49	0.21	0.88	0.15	0.37	0.72	0.96	0.31
0.71	0.66	0.78	0.46	0.42	0.46	0.41	0.11	0.96	0.99	0.91
0.13	0.30	0.67	0.28	0.94	0.23	0.12	0.73	0.41	0.64	0.54
0.53	0.63	0.83	0.67	0.64	0.64	0.81	0.78	0.76	0.40	0.16
0.93	0.09	0.15	0.25	0.04	0.34	1.00	0.02	0.12	0.37	0.42
0.96	0.77	0.52	0.23	0.65	0.66	0.59	0.38	0.61	0.37	0.41

Figure 9. Random Number

Example

TABEL OUTCOME

RANGE NPV	JLH INPUT	%	
1501-2000	3	0.028	PROB OF GAIN (+) 0.743
1001-1500	16	0147	
501-1000	6	0.055	
0-500	56	0.513	
0-500	22	0.202	PROB OF LOSS (-) 0.257
501-1000	3	0.028	
1001-1500	3	0.027	
	109	1	

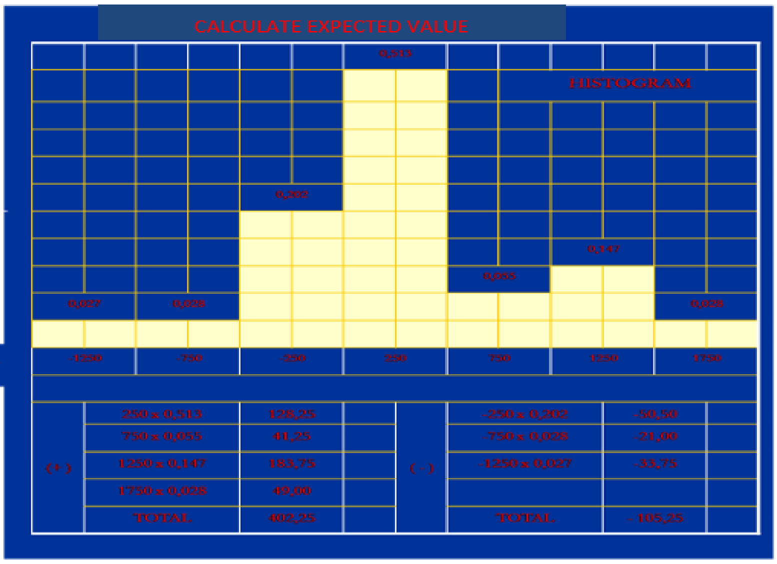

Figure 10. Outcome Table

Some examples of analysis results in the following figure show;

1. PAY-OFF MATRIX

PROJECT DEVELOPMENT

Alternative level of product	Change Events (level of demand)			
	Less 15%	as forcasted	more 15%	20%
A	70	170	250	270
B	150	160	200	230
C	80	140	180	210
D	150	120	160	160

Example

PAY-OFF MATRIX

Facility to Construct	PROFIT (Rp.000)		
	Strong Market	Fair Market	Poor Market
Large size	550.000	110.000	- 310.000
Medium size	300.000	129.000	- 100.000
Small size	200.000	100.000	- 32.000
No	0	0	0

Figure 11. Pay Off Matrix

a. *Maximin Criteria*, the approach tends to be more defensive with the approach *pessimism*

b. *Maximax Criteria*, *it*is very lucky that you will experience problems if a very serious / urgent decision is needed.

MAXIMAX CRITERION

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market
Large size	550.000	110.000	- 310.000
Medium size	300.000	129.000	- 100.000
Small size	200.000	100.000	- 32.000
No	0	0	0

Decision maker chose "Large size" due to maximum pay-off
Decision maker is optimistic about future

If coefficient of optimism = 0.6

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market	
Large size	550.000(0.6)	110.000	- 310.000(0.4)	206.000
Medium size	300.000(0.6)	129.000	- 100.000(0.4)	140.000
Small size	200.000(0.6)	100.000	- 32.000(0.4)	107.200
No	0(0.6)	0	0(0.4)	0
	maximum pay-off		minimum pay-off	

α= 0.4

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market	
Large size	550.000(0.4)	110.000	- 310.000(0.6)	34.000
Medium size	300.000(0.4)	129.000	- 100.000(0.6)	60.00[illegible]
Small size	200.000(0.4)	100.000	- 32.000(0.6)	60.8[illegible]
No	0(0.4)	0	0(0.6)	0

Figure 12. Maximum Criterion

LaPlace CRITERION

(equal likelihood criterion)

If 3 state of nature than each is 1/3

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market	
Large size	550.000(1/3)	110.000(1/3)	-310.000(1/3)	116.666
Medium size	300.000(1/3)	129.000(1/3)	-100.000(1/3)	109.666
Small size	200.000(1/3)	100.000(1/3)	-32.000(1/3)	89.333
No	0(1/3)	0(1/3)	0(1/3)	0

Figure 13 Laplace Criterion

MINIMAX REGRET CRITERION

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market
Large size	550.000	110.000	- 310.000
Medium size	300.000	129.000	- 100.000
Small size	200.000	100.000	- 32.000
No	0	0	0

regret (opportunity loss) table

Facility to Construct	PROFIT (Rp.000) Strong Market	Fair Market	Poor Market
Large size	0	19.000	310.000
Medium size	250.000	0	100.000
Small size	350.000	29.000	0
No	550.000	129.000	0

Figure 14. Minimum Regret Criterion

c. *Index of Pessimism Criteria*,values (arrows) are not formulated and subjective
d. *Principle of Insufficient Reason Criteria,* there are weaknesses in probablity which are not formulated in unclear situations.
e. *Minimax Regred Citeria,* there is a conservative bias, where the fact about the *pay-off* that may occur losses is like the *regret matrix* which includes either "0" or *positive entries.*

4. Conclusion

- Uncertainty or *uncertainty* needs to be taken into account in analyzing a project.
- In order to be able to make a project choice, it can be done in several ways, from various ways it turns out that none of them is the most perfect, one with the other has advantages and disadvantages.
- The use of the most suitable method / method is very much influenced by the nature / type of the project and the objectives to be achieved in accordance with the resources owned by the project actors.

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