(Check) Using analytic hierarchy process

by Rini Wongso

Submission date: 11-Jun-2020 03:26PM (UTC+0700)
Submission ID: 1341803947
File name: Using_analytic_hierarchy_process.pdf (205.91K)
Word count: 2564
Character count: 13132

Using Analytic Hierarchy Process and Decision Tree for a Production Decision Making

Sambudi Hamali, Rumondang Puji Nur Suci, Ami Fitri Utami, Hanisman
School of Business and Management
Bina Nusantara University
Jakarta, Indonesia
shamali@binus.edu, rsitorus@binus.edu,
autami@binus.edu, hanismanlim@gmail.com

Filia Arga
PhD Candidate in Economics
University of Illinois at Urbana
Champaign, Illinois, United States
arga2@illinois.edu

***Abstract*—Today, the light weight bricks are on high demand in the market, where "X" is considering to expand its' business to produce this product. However, expanding business to a new business lines requires a comprehensive considerations. Complexity of decision-making not only lies in the uncertainty or the imperfections of information, but involves many criteria and sub-criteria used to rank the alternatives of a decision. The purpose of this study is to understand the best solution on whether or not the light weight bricks being produced by "X". Hence, this study applied the analytic hierarchy process (AHP) and Decision Tree Analysis (DTA) as the rational decision making tools may help "X" to decide whether or not to invest in the new business line. The results based on data processing AHP of directors and general managers indicate that the "X" has a tendency to decide to make the light weight bricks. While based on the DTA shows that the "X" will benefit if it decides to make the light weight bricks.**

Keywords—Multi-criteria, Expected Monetary Value, Analytic Hierarchy Process, Decision Tree Analysis, Light weight bricks

I. INTRODUCTION

In today's era, the massive development of constructions are leveraging the needs of its' basic materials which boost the consumptions. In this case, one of the materials which most currently used is the white light weight brick which has a smooth and well-flattened surface. This light weight bricks were invented for various aims includes lightened the structure's load of a construction, fasten the development execution, and minimize the material residue which often occur on the wall installation process.

"X" is a company which runs its' business in producing and selling concrete block as the product. Understanding the fact that the light weight bricks are on high demand in the market, "X" is now considering to expand its' business to produce the product. However, expanding business to a new business lines requires a comprehensive considerations. Especially in this case, adding the light weight bricks as their new product line will also load the company with a huge capital investment includes new machine, new land, and new suppliers.

Based on previous discussions, the use of Analytic Hierarchy Process (AHP) and Decision Tree Analysis (DTA) as the rational decision making tools may help "X" to decide whether or not to invest in the new business line. AHP as one of a basic decision making tools is developed by Thomas L. Saaty, one of professor in the Wharton School of Economics (1971-1975). The AHP itself designed to encounter both the rational and intuitive notions to choose the best alternatives above all [1]. On the other hands, the DTA is a form of graphical decision process which indicates various factors includes the decision alternatives, the natural conditions and possibilities, and the payoffs for each alternatives combinations and natural conditions [2]. In DTA, the expected monetary value (EMV) being used to measures the attractiveness of alternatives. AHP and DTA has been used in various settings to make decisions [3,4,5,6].

This study aimed to understand the best solution on whether or not the light weight bricks being produced by "X" by using AHP and DTA as the analytical tools. Moreover, this paper composed of several parts includes the literature review of the AHP and DTA, the methodology on how this study use AHP and DTA as analytical tools, and the conclusion about what is the best solutions based on the tools.

II. THEORETICAL REVIEW

A. Analytic Hierarchy Process (AHP)

Analytical Hierarchy Process is a decision analysis method with a compound criteria that used to lower the ratio of the paired comparisons of criteria and alternatives, both discrete and continuous that will arranged in a multilevel hierarchy. This comparison can be drawn from the actual measurements or using the basic scale that shows interest / relative strength based on the preferences of participants [1].

There are four steps in AHP method that will explain as follows [7] :

1) Developing hierarchy: In order to create the hierarchy structure, we need to decide the main goals. The main objective will be structured as a top-level hierarchy. The criteria that matched to assess our alternatives will be

978-1-5090-3352-2/16/$31.00 ©2016 IEEE

structured below the top level. Each criterion has a different intensity. The last level of a hierarchy is called sub-criteria (if it may be required).

2) Making the pairwise comparison matrix. This method aimed to set the priorities that depicts the relative contribution or influence of each element against the objectives and criteria on the previous level. Pairwise matrix made by comparing each pair of alternatives against the criteria tested. In the assessment of the relative importance of the two elements applied reciprocal axioms, meaning that if the elements of a rated three times more important than b, then the element b must be equal to 1/3 times the importance compared to the a element. In addition, comparison of the two elements that are the same will generate a number 1, meaning equally important. Two different elements can be assessed equally important. If there are n elements, it will obtain the pairwise comparison matrix of size n x n. The number of scoring required in preparing this matrix is n (n-1) / 2 due to reciprocal matrix and diagonal elements equal to 1.

3) Synthesizing. This method aimed to Make a synthesis to produce a single number that indicates the priority of each element

4) Logical Consistency Tests. In this stage, we try to determine whether the provision in the comparison between the value of the object has been done consistently. Consistency ratio (CR) indicates to which extent the analysis is consistent in delivering value to the comparison matrix. In general the results of the analysis to be considered as consistent is when the rate of CR $\leq$ 10%. If CR> 10% it is necessary to conduct a re-evaluation consideration in preparing the comparison matrix. Furthermore, below are the scale priorities and the example of pairwise comparison matrix based on [7].

TABLE I. SCALE PRIORITIES

Intensity of importance	Definition
1	Both elements are important.
3	One element slightly favor over another.
5	One element strongly favor over another.
7	One element favored very strongly over another.
9	One element favored absolute over another.
2,4,6,8	The value of two elements when compared each other would be too small.

Source: Harjanto (2009)

TABLE II. THE EXAMPLE OF PAIRWISE COMPARISON MATRIX

Criteria	A	B	C
A	1	o	o
B	x	1	o
C	x	o	1

Source: Harjanto (2009)

B. The Decision Tree

The decision tree (decision tree) is a graphical display indicating the decision process of alternative decisions, natural conditions and opportunities, and payoffs for each combination of alternative decisions and natural conditions [2].

There are five steps to analyze problems using a decision tree [2].

1) Define the problem.
2) Draw a decision tree.
3) Determine opportunities for natural conditions.
4) Estimate of payoffs.
   This step aimed to estimate the payoffs for each combination of alternative decisions and natural conditions as possible.
5) Solving problem.
   The step tries to solve the problem by counting the EMV for each point in the natural condition. It can be done by working from back to front (backward), which expands from the right side of the trees, continue to get to a decision point on the left.

III. METHODOLOGY

This section presents the case of decision making carried out at the "X". This study use descriptive survey as its' method where both primary and secondary data are being gathered. The primary data were gathered by interviewing & spreading questionnaires to managers and directors of "X". On the other hands, the secondary data were gathered by analysing company's report, histories, and the previous research.

Furthermore, the detailed methods of this study may inferred as below steps:

1) *Determining Criteria*: This process implemented by discussing & interviewing what criteria are needed by the company on deciding whether to or not to produce a new product. In this case, the discussions & interviews were ran with the company's stakeholders include managers and directors. Based on the interviews and discussions there are four main criteria found includes cost, location, basic material, and management. After the criteria were extracted, the hierarchy of criteria being developed in order to make the decision. The criteria hierarchy are able to see in below fig.1 :

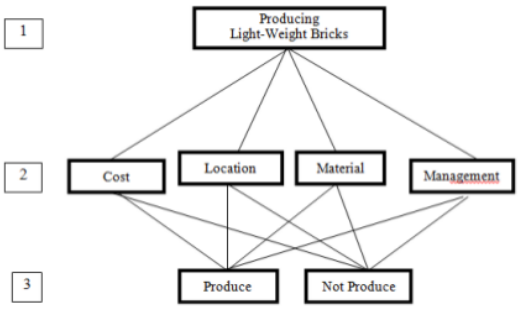

Fig. 1. Production Hierarchy of Light Weight Bricks

2) Developing & spreading questionnaire, The questionnaire development process implemented based on the pairwise comparison in order to understand the load of each criteria and alternative. Furthermore, the questionnaires were spread to the decision makers.

3) *Calculating the loads of each criterion & Making decision.* This process aimed to calculates the loads of each criteria in the AHP frames. In this case, the results of calculation will be differed among each decision maker. Thus, different load are given to both managers and directors with 70% and 30% in sequent

4) *Estimating cost for each alternative*

5) Measuring probability and the failure levels of each alternatives

6) Structuring decision tree

7) Deriving the Expected Monetary Value

8) Selecting the best option

IV. Results & Discussion

A. AHP Results

After the questionnaires are submitted, the result of the questionnaires will be described into the Pairwise Comparison Matrix as follows:

TABLE III. Pairwise Comparisson Matriks for The Criteria from the Director

	Budget	Location	Raw Material	Management
Budget	1	2	3	5
Location	0.5	1	0.5	2
Raw Material	0.33	2	1	2
Management	0.2	0.5	0.5	1
Total	2.03	5.5	5	10

Source: Data Analysis Result, 2016

TABLE IV. Pairwise Comparisson Matriks of the Criteria from the General Manager

	Budget	Location	Raw Material	Management
Budget	1	2	4	4
Location	0.5	1	0.5	2
Raw Material	0.25	2	1	2
Management	0.25	0.5	0.5	1
Total	2	5.5	6	9

Source: Data Analysis Result, 2016

TABLE V. Final Assessment Result from The Director

Criteria	Weight	Produce	Not To Produce
Budget	0.493	0.37*	0.12
Location	0.179	0.12	0.06
Raw Material	0.23	0.19	0.04
Management	0.097	0.06	0.03
Total		0.75	0.25

Source: Data Analysis Result, 2016

TABLE VI. Final Assessment Result from The General Manager

Criteria	Weight	Produce	Not To Produce
Budget	0.507	0.41	0.10
Location	0.177	0.13	0.04
Raw Material	0.214	0.17	0.04
Management	0.101	0.08	0.03
Total		0.79	0.21

Source: Data Analysis Result, 2016

The following step is to multiply the total of each final assessment with the value of the decision maker. The value of the decision maker is decided by a thorough discussion between the Director and the General Manager. The result can be visualized in the next table.

TABEL VII. Final Calculation

	Weight of decision maker	Produce	Not To Produce
Director	0.70	0.525[a]	0.175
General Manager	0.30	0.237	0.063
Total	1.00	0.762	0.238

Source: Data Analysis Result, 2016

[a] As a result from weight of decision maker x Weight of each decision = 0.70 x 0.75 = 0.525

Based on the result gained by AHP Data analysis from the director and the general manager, there are two results of the calculation; 0.763 for producing and 0.238 for not producing. This shows that "X" has the tendency to produce the white lightweight concrete.

B. The Decision Tree Results

Next, is the probability data and the value of the decision for the available alternatives based on the interview with the director of "X". The director has been in the construction business since 1997 as a director and he has also gathered knowledge based on the information from his colleagues in the lightweight concrete business.

TABEL VIII. Probability Data And Decision Result Of Decision Tree

No	Criteria	Probabilities for natural condition			Decision Result (In Million Rupiah)		
		Good Economy	Poor Economy	Normal Economy	Good Economy	Poor Economy	Normal Economy
1.	To Produce	0.4	0.1	0.5	500	-100	200
2	Not To Produce	0	0	0	0	0	0

Source: Data Analysis Result, 2016

From Table VIII we shall continue to the decision tree as follows,

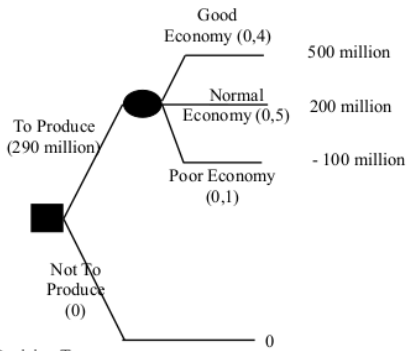

Fig. 2. Decision Tree

After the decision tree is made, the calculation is conducted by looking at the odds and the result set by the director of "X" based on each branch; to produce and not to produce.

EMV calculation:

EMV (to produce) = (0.4 x 500) + (0.1 x -100) + (0.5 x 200)

= 200 + (-10) + 100 = 290 million

EMV (not to produce) = 0

From the result of the calculation above, "X" will gain profit if they decide to produce the white lightweight concrete.

V. Conclusions

As a whole, this paper elaborates an AHP and DTA-based methodology and measure to understand the best solution on whether or not the light weight bricks being produced by "X". The results suggest that based on data processing AHP of directors and general managers indicate that the "X" has a tendency to decide to make white light brick. While based on the DTA shows that the "X" will benefit if it decides to make white light brick. However, this study could not be generalized because the study to a decision to produce or not the light weight bricks.

References

[1] T. L. Saaty and L. G. Vargas, *Models, Methods, Concepts & Applications of the Analytic Hierarchy Process*, International Series in Operations Research & Management Science 175, Springer Science+Business Media New York, 2012.

[2] J. Heizer & B. Render, "Operation Management,", 10th ed., New Jersey, 2011.

[3] L-A. Vidal, F. Marle, and J-C. Bocquet. "Using a Delphi process and the Analytic Hierarchy Process (AHP) to evaluate the complexity of projects." *Expert systems with applications* 38.5, pp. 5388-5405, 2011.

[4] PK. Dey, "Project risk management: a combined analytic hierarchy process and decision tree approach." *Cost Engineering*, 44.3, pp. 13-27, 2002.

[5] E. Battistoni, AF. Colladon, L. Scarabotti, MM. Schiraldi, "Analytic hierarchy process for new product development." *International Journal of Engineering Business Management* 5 (2013).

[6] Liao, Wen-Hwa, and Wan-Li Qiu. "Applying analytic hierarchy process to assess healthcare-oriented cloud computing service systems." *SpringerPlus*5.1 (2016): 1030.

[7] E. Harjanto, "Manajemen Operasi,", Cetakan Ketujuh, Jakarta, 2008.

(Check) Using analytic hierarchy process

ORIGINALITY REPORT

12%	10%	6%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.e3s-conferences.org Internet Source	3%
2	www.jurnal.stmikpontianak.ac.id Internet Source	2%
3	yunus.hacettepe.edu.tr Internet Source	1%
4	Angtyasti Jiwasiddi, Rumondang Puji Nur Suci, Roberttus Tang Herman, Paul Weiss. "News website perceived quality; a comparative study for news websites in Indonesia", 2016 International Conference on Information Management and Technology (ICIMTech), 2016 Publication	1%
5	Sudaryono, Untung Rahardja, Masaeni. "Decision Support System for Ranking of Students in Learning Management System (LMS) Activities using Analytical Hierarchy Process (AHP) Method", Journal of Physics: Conference Series, 2020 Publication	1%

6	hrcak.srce.hr Internet Source	1%
7	sinta3.ristekdikti.go.id Internet Source	1%
8	Wen-Hwa Liao, Wan-Li Qiu. "Applying analytic hierarchy process to assess healthcare-oriented cloud computing service systems", SpringerPlus, 2016 Publication	1%
9	cual.openrepository.com Internet Source	1%
10	pegadaian.co.id Internet Source	<1%
11	ejournal.poltektegal.ac.id Internet Source	<1%
12	Sulistyo Heripracoyo, Fenny Meilia, Candra Ronny, Umar Eko Prasetyo. "Model of measuring the influence of Knowledge Management system to IT complaints, case study in telecomunication company", 2016 International Conference on Information Management and Technology (ICIMTech), 2016 Publication	<1%
13	edoc.pub Internet Source	<1%

14	Tri Pujadi, Ahmad Fathurrozi, Selvyna Theresia. "Using Analytical Hierarchy Process for the decision support system in teacher placement", 2016 International Conference on Information Management and Technology (ICIMTech), 2016 Publication	<1%

Exclude quotes	Off	Exclude matches	Off
Exclude bibliography	On		

(Check) Using analytic hierarchy process

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4