DECISION MAKING OF RAW MATERIAL SUPPLIER FOR PRODUCT PP 10160104xx IN PT. KOMPINDO FONTANA RAYA USING FUZZY AHP APPROACH

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ABSTRACT

PT. Kompindo Fontana Raya is a knitting factory that produces main product PP 10160104xx. PP 10160104xx is a knit rope that is used for waist belt production. To produce this product, PT. Kompindo orders yarn as raw material and should choose the best supplier among 8 (eight) yarn suppliers. The choice of supplier is based on criteria as follows: term of payment, product quality, product price, delivery time, accuracy of order quantity, and delivery suitability. At that time, the decision choice of supplier is based on decision maker's intuition. Consequently, this leads to some suppliers can not satisfy some requirements of factory, such as low quality of yarn, lateness on delivery time, broken yarn, price too high, etc. These problems cause the company loss in time and cost. To overcome this problem, a Fuzzy Analytical Hierarchy Process (F-AHP) model was developed based on Fuzzy Synthetic Extent Analysis approach (Chang, 1996). The result from F-AHP model indicates that supplier PT. Evergreen has score 0.181 which is the highest score and it is recommended as the best supplier for raw material of prodzct PP 10160104xx in PT. Kompindo Fontana Raya.

***Keywords**: Decision Analysis, Analytical Hierarchy Process, Fuzzy AHP*

1. INTRODUCTION

PT. Kompindo Fontana Raya is a knitting company with main product is PP 10160104xx, which is a knit rope for waist belt. To produce this product, PT. Kompindo Fontana Raya should order yarn and select the best supplier from 8 (eight) suppliers of yarn. The choice of yarn supplier is based on some criteria as follow: *term of payment*, yarn quality, yarn price, delivery time, accuracy of order quantity, and delivery suitability. At that time, the decision of supplier is still based on intuition of decision makers and a quantitative method for selection of best supplier has not yet been applied.

Number of suppliers in PT. Kompindo is around 40 suppliers for all products. The high number of suppliers lead to difficulty for this company to determine the best supplier. The company may have wrong decision in selecting the best supplier. Consequently, this affects to production such as low quality of webbing, broken yarn, longer production time, lateness in delivery time, etc. All these problems have impact to increase the cost of the company.

As a consequent, a decision making model based on mathematical model needs to be developed to help decision makers in determining the best supplier based on company criteria. One of the models is Fuzzy Analytical Hierarchy Process (F-AHP). Fuzzy AHP model can reduce uncertainty in decision making because the structure of the model can give score to a criteria in a range value rather than a single value. This Fuzzy AHP model is based on *Fuzzy Synthetic Extent Analysis* approach that was developed by Chang (1996). This approach was selected because the determination of final weight using this approach is relatively easy as compared to other approaches.

The objective of this research is to propose a decision making model in selecting the best raw material supplier for product PP 10160104xx in PT. Kompindo Fontana Raya using Fuzzy AHP approach. It is expected the model can help decision makers in this company. Therefore, supply of raw material and production will be optimum.

2. THEORITICAL BACKGROUND

2.1. *Analytical Hierarchy Process* (AHP)

Analytical Hierarchy Process (AHP) was developed in 1970 by Thomas L. Saaty. AHP is a hierarchy functional model with the main input is human perception. AHP method enables to make an effective decision to complex problems whereas factors such as: logic, intuition, experiences, knowledge, data, emotion are optimised in a systematically (Therick, 2008).

Basic principals of AHP are analytical thinking that is based on human logic and are divided into 3 (three) parts as follow (Therick, 2008):

1. Hierarchy differences principle
   Establishment of problem hierarchy is a initial step to define the problem. Decision hierarchy is determined based on expert's knowledge
2. Priority principle
   Priority of criteria is represented as a weight or element contribution to the objective of decision making in AHP. AHP do priority analysis using pair wise comparison that compares two elements of criteria until all the elements are done.
3. Logic consistency principle
   Consistency of respondent answer to determine the element priority will affect to data validation and the result of decision making process. In general, respondent should be consistent in making comparison.

Decision hierarchy is the main tools of AHP. Using hierarchy, a complex and unstructured problem can be grouped into some sub categories and can be arranged into a hierarchy. The highest hierarchy is the goal of decision making. The second hierarchy is criteria that can be followed by sub criteria (optional). Alternatives are in the lowest hierarchy. Alternatives will be evaluated based on goal and criteria that have been set up by decision makers.

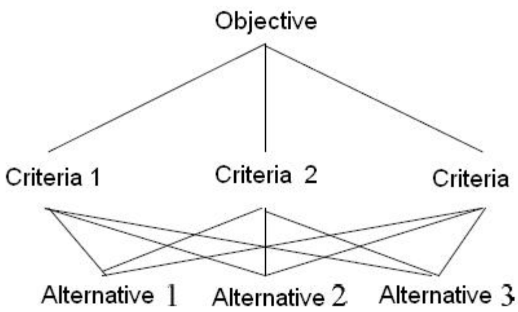

Figure 1. Hierarchy in AHP

A comparison between criteria in a sub system hierarchy with a criteria C and some elements A1 to Ai below that criteria can be described in a pair wise comparison matrix i × j as follow

C	A1	A2	…..	Aj
A1	a11	a12	…..	a1j
A2	a21	a22	…..	a2j
…..	…..	…..	…..	…..
Ai	ai1	ai2	…..	aij

Figure 2. Pair wise comparison matrix

Table 1. Pairwise comparison scale

Scale	Means
1	Criteria/alternative A is equally important to criteria/alternative B
3	A is weak important than B
5	A is essential important than B
7	A is very strong important than B
9	A is absolutely important than B
2,4,6,8	Intermediate values between adjacent scale values
Reciprocals	If criteria 1 is compared to criteria 2 has score 3, then criteria 2 is compared to criteria 1 has score 1/3.

In pair wise comparison matrix, diagonal element is equal to 1 that means the element is compared to itself. Other comparison is based on scale that is developed by Saaty that can be seen at Table 1.

2.2. Fuzzy Analytical Hierarchy Process (F-AHP)

Fuzzy AHP (F_AHP) is a method which developed from AHP method. Purpose of F-AHP is for reducing the inconsistency from AHP method. Chang (1992) introduced this new method by divided the pair wise comparison scale based on *Triangular Fuzzy Number* (TFN) using *extent analysis method*.

The step of F-AHP method according to (Chang, 1996) in (Jasril et al., 2011) as follow:

a. Establish problem hierarchy to be solved and determine pair wise matrix comparison using TFN scale.
b. Determine *fuzzy* synthesis prioritize value(*Si*) using formula,

$$Si = \sum_{j=1}^{m} M_i^j \times \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} M_i^j} \quad (1)$$

which:

$$\sum_{j=1}^{m} M_i^j = \sum_{j=1}^{m} lj, \sum_{j=1}^{m} mj, \sum_{j=1}^{m} uj \quad (2)$$

Whereas

$$\frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{m} M_i^j} = \frac{1}{\sum_{i=1}^{n} ui, \sum_{i=1}^{n} mi, \sum_{i=1}^{n} li} \quad (3)$$

c. Determine Vector value (V) and Ordinate *defuzzification value* (d').
If the result in each *fuzzy matrix*, $M_2 \geq M_1$ ($M_2 = (l_2, m_2, u_2)$ and $M_1 = (l_1, m_1, u_1)$) so the value vector can be calculated as follow::

$$V(M_2 \geq M_1) = \sup[\min(\mu M_1(x), \min(\mu M_2(y)))] \quad (4)$$

Or same with below function:

$$V(M_2 \geq M_1) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise \end{cases} \quad (5)$$

If the *fuzzy* value greater than k, M_i (i=1, 2,…, k) then, the vector value can be define as follow::
$V(M \geq M_1, M_2, \ldots, M_k) = V(M \geq M_1)$ and $V(M \geq M_2)$, and $V(M \geq M_k) = \min V(M \geq M_i)$. With assumption,

$$d'(A_i) = \min V(S_i \geq S_k) \quad (6)$$

For $k = 1, 2, \ldots, n$; $k \neq i$, the vector weight value will be

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \quad (7)$$

Which $A_i = 1, 2, \ldots, n$ is a decision element.

d. Normalization value of *fuzzy vector weight* (W)
After the normalization, then the vector weight value that has been normalized as follow:

$$W = d(A_1), d(A_2), \ldots, d(A_n))^T \quad (8)$$

Which W is a non *fuzzy* number.

e. Consistency Evaluation
Consistency evaluation is done by changing *fuzzy* scale to become single value first by using *defuzzification* every alternative and criteria. *Defuzzification* is process that change *fuzzy* output single value output (*crips*) (Marimin, 2007) in (Suharjito, 2011). There are many methods of de*fuzzi*fication, but the most common that used was centroid method and maximum. De*fuzzi*fication also can be performing by geometric average methods; the process of this de*fuzzi*fication is as follow:

- Calculate average geometric value from lower limit value (BB), middle limit value (BT), and top limit value (BA) from the scoring from each expert to get aggregate of lower limit value, middle limit value, and top limit value from expert scoring count by using below formula:

$$\overline{BB} = \sqrt[n]{\prod_1^n BB} \qquad \overline{BT} = \sqrt[n]{\prod_1^n BT} \qquad \overline{BA} = \sqrt[n]{\prod_1^n BA} \quad (9)$$

- Calculate single value (crisp) using average geometric from above value using formula:

$$N_{crisp} = \sqrt[3]{\overline{BB} * \overline{BT} * \overline{BA}} \quad (10)$$

Calculation of Consistency Index / CI is use to know the consistency from the answer which will affect the result validity, using formula:

$$CI = \frac{\lambda_{\max} - n}{n-1} \quad (11)$$

$$CR = \frac{CI}{RI} \quad (12)$$

From 500 random matrix sample with comparison scale 1 – 9, for some matrix order, Saaty get average value RI as follow :

Tabel 2. Random Index Value

Matrix Order	RI	Matrix Order	RI
1	0.00	9	1.45
2	0.00	10	1.49
3	0.58	11	1.51
4	0.90	12	1.48
5	1.12	13	1.56
6	1.24	14	1.57
7	1.32	15	1.59
8	1.41		

Source: Saaty (1994)
Which: RI = Random Index

From the research done by Saaty, the matrix comparison categorized as consistent if CR value not greater than 0.1.

3. RESEARCH METHOD

The flow for fuzzy AHP start from determine hierarchy structure, determine TFN scale, criteria evaluation, develop pairwise comparison matrix based on TFN scale, determine fuzzy synthesis value, determine vector and ordinate defuzzification, normalized weight value, alternative rank and consistency evaluation. The flow model of Fuzzy AHP can be seen in Figure 4.

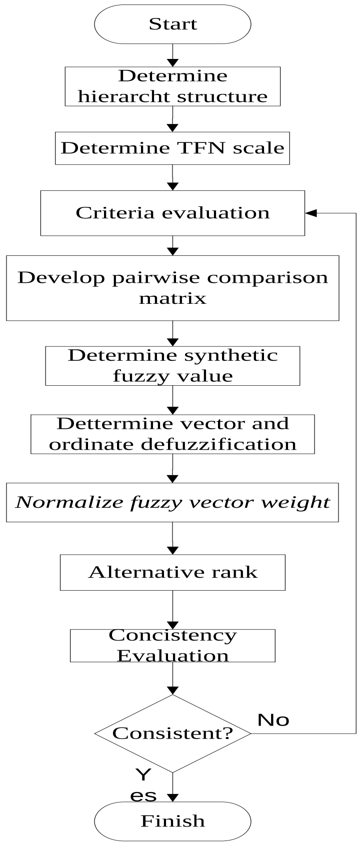

Figure 4. Flow Chart Fuzzy AHP

4. RESULTS AND DISCUSSION

From the interview, we got 6 factors that affected in process of selecting supplier, which are *term of payment* (time to settle the payment), quality, price, on time delivery, accuracy of order quantity stock, and delivery suitability.
Factors that have sub criteria is quality factors, because in order to determine the quality of the goods were affected from colour, number of defects, and yarn strength. There are 8 suppliers which are, *Jie Yang Guangdong, Shaoxing Super Special*, *Quanzhou Sanhong*, PT Prima Politek, PT. Indonusa, PT. Evergreen, PT. Sugilindo, and Omiyatek. Hierarchy Structure in supplier selection can be shown in figure 5.
Calculations of decision making in PT. Fontana Kompindo Utama for one against other criteria in pricewise comparison matrix were made in triangular fuzzy number (TFN) model. Pair wise comparison matrix in decision making can be seen in Table 3.

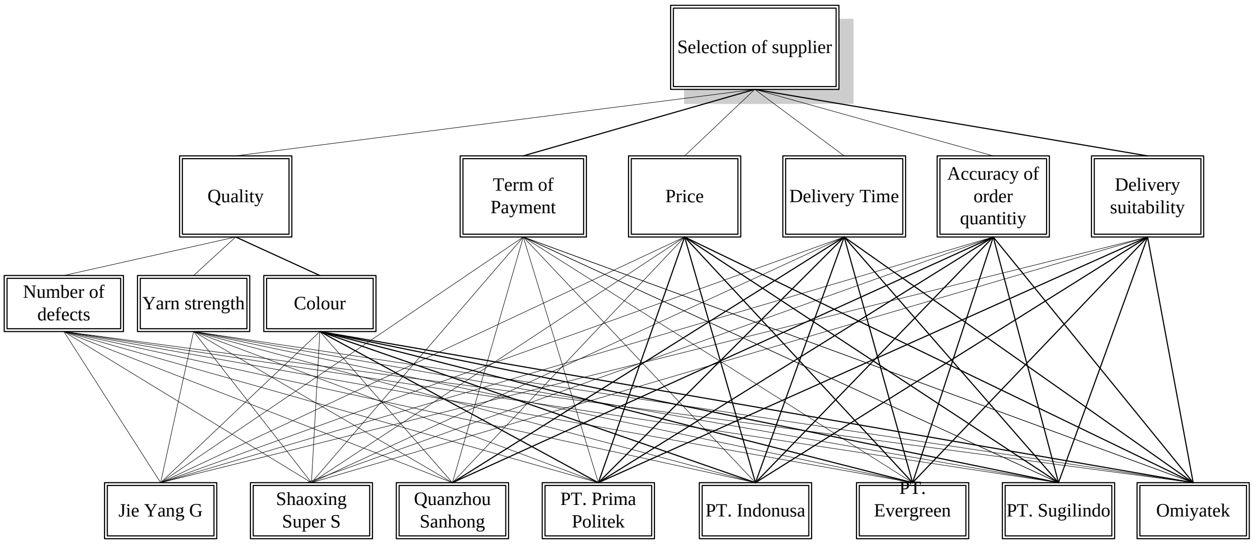

Figure 5. Hierarchy Structure

Table 3. Pricewise Comparison Matrix between F-AHP Criteria

Factor Criteria A	Factor Criteria B					
	Term of Payment	Quality	Price	Delivery Time	Accuracy of Order Quantity	Delivery Suitability
Term of Payment	[1, 1, 1]	[0.2, 0.33, 1]	[0.11, 0,11, 0.14]	[0.11, 0,11, 0.14]	[0.11, 0,11, 0.14]	[0.11, 0,11, 0.14]
Quality	[1, 3, 5]	[1, 1, 1]	[0.2, 0.33, 1]	[1, 1, 2]	[1, 1, 2]	[1, 1, 2]
Price	[7, 9, 9]	[1, 3, 5]	[1, 1, 1]	[0.5, 1, 1]	[0.5, 1, 1]	[0.5, 1, 1]
Delivery Time	[7, 9, 9]	[0.5, 1, 1]	[1, 1, 2]	[1, 1, 1]	[1, 1, 2]	[0.5, 1, 1]
Accuracy of Order Quantity	[7, 9, 9]	[0.5, 1, 1]	[1, 1, 2]	[0.5, 1, 1]	[1, 1, 1]	[1, 1, 2]
Delivery Suitability	[7, 9, 9]	[0.5, 1, 1]	[1, 1, 2]	[1, 1, 2]	[0.5, 1, 1]	[1, 1, 1]

After that weight pricewise comparison each criteria by using below steps:

- Step 1:
  Calculate value

$$\sum_{j=1}^{m} M_i^j = \sum_{j=1}^{m} lj, \sum_{j=1}^{m} mj, \sum_{j=1}^{m} uj$$

  By adding every fuzzy triangular value in each row.

$$\begin{array}{ccc} l & m & u \end{array}$$
$$\left|\begin{array}{ccc} 1.64 & 1.78 & 2.57 \\ 5.20 & 7.33 & 13 \\ 10.50 & 16 & 18 \\ 11 & 14 & 16 \\ 11 & 14 & 16 \\ 11 & 14 & 16 \end{array}\right|$$

- Step 2:
  Calculate $\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_i^j\right]$ value by adding every fuzzy triangular value in pricewise comparison matrix.

- Step 3:
  From pricewise comparison matrix, calculate *fuzzy synthetic extent value* for each main criteria:

  $S_1 = (1.64, 1.78, 2.57) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right) =$

  (0.02, 0.027, 0.051)

  $S_2 = (5.20, 7.33, 13) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right)$

  =

  (0.064, 0.109, 0.258)

  $S_3 = (10.50, 16, 18) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right)$

  =

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(0.129, 0.238, 0.358)

$S_4 = (11, 14, 16) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right) =$

(0.135, 0.209, 0.318)

$S_5 = (11, 14, 16) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right) =$

(0.135, 0.209, 0.318)

$S_6 = (11, 14, 16) \otimes \left(\frac{1}{81.57}, \frac{1}{67.11}, \frac{1}{50.34}\right) =$

(0.135, 0.209, 0.318)

- Step 4:
  Compare *fuzzy synthetic extent* value with its minimum value.

- $V(S_1 \geq S_2) = \frac{0.064-0.051}{(0.027-0.051)-(0.109-0.064)} = -0.181 = 0$

  $V(S_1 \geq S_3) = \frac{0.129-0.051}{(0.027-0.051)-(0.238-0.129)} = -0.578 = 0$

  $V(S_1 \geq S_4) = \frac{0.135-0.051}{(0.027-0.051)-(0.209-0.135)} = -0.852 = 0$

  $V(S_1 \geq S_5) = \frac{0.135-0.051}{(0.027-0.051)-(0.209-0.135)} = -0.852 = 0$

  $V(S_1 \geq S_6) = \frac{0.135-0.051}{(0.027-0.051)-(0.209-0.135)} = -0.852 = 0$
- $V(S_2 \geq S_1) = 1$

  $V(S_2 \geq S_3) = \frac{0.129-0.258}{(0.109-0.258)-(0.238-0.129)} = 0.501$

  $V(S_2 \geq S_4) = 0.554$; $V(S_2 \geq S_5) = 0.554$; $V(S_2 \geq S_6) = 0.554$
- $V(S_3 \geq S_1) = 1$; $V(S_3 \geq S_2) = 1$; $V(S_3 \geq S_4) = 1$; $V(S_3 \geq S_5) = 1$; $V(S_3 \geq S_6) = 1$
- $V(S_4 \geq S_1) = 1$; $V(S_4 \geq S_2) = 1$; $V(S_4 \geq S_3) = 0.864$;
  $V(S_4 \geq S_5) = 1$; $V(S_4 \geq S_6) = 1$
- $V(S_5 \geq S_1) = 1$; $V(S_5 \geq S_2) = 1$; $V(S_5 \geq S_3) = 0.864$;
  $V(S_5 \geq S_4) = 1$; $V(S_5 \geq S_6) = 1$
- $V(S_6 \geq S_1) = 1$; $V(S_6 \geq S_2) = 1$; $V(S_6 \geq S_3) = 0.864$;
  $V(S_6 \geq S_4) = 1$; $V(S_6 \geq S_5) = 1$

Table 4. Fuzzy Synthesis Result

S	S_1	S_2	S_3	$S_4 \geq$	$S_5 \geq$	$S_6 \geq$
S_1		1	1	1	1	1
S_2	0		1	1	1	1
S_3	0	0.501		0.864	0.864	0.864
S_4	0	0.554	1		1	1
S_5	0	0.554	1	1		1
S_6	0	0.554	1	1	1	
Minimum	0	0.501	1	0.864	0.864	0.864

- Step 5:
  Then calculate the weight and normalized vector weight by dividing each element vector weight with its total so we got the main criteria weight value.
  $W' = (0, 0.501, 1, 0.864, 0.864, 0.864)^T$
  $W = (0, 0.122, 0.244, 0.211, 0.211, 0.211)^T$

From the five steps above, we got the weight of each supplier seen in Table 5. Table 5 shows that the biggest weight was 0.182 from PT. Evergreen.

Table 5. Supplier Alternative Weight Calculation

	Term of Payment	Quality	Price	Delivery Time	Accuracy of order quantity	Delivery Suitability	Final Weight	Rank
W_{Q1}	0	0.122	0.244	0.211	0.211	0.211		
				Alternative				
Jie Yang G	0.333	0.291	0.348	0	0.125	0.125	0.173	2
Shaoxing Super	0.333	0	0.320	0	0.125	0.125	0.131	3
Quanzhou Sanhong	0.333	0	0.319	0	0.125	0.125	0.131	4
PT. Prima Politek	0	0	0.012	0.2	0.125	0.125	0.098	5
PT. Indomusa	0	0	0	0.2	0.125	0.125	0.095	6
PT. Evergreen	0	0.709	0	0.2	0.125	0.125	0.182	1
PT. Sugilindo	0	0	0	0.2	0.125	0.125	0.095	7
Omiyatek	0	0	0	0.2	0.125	0.125	0.095	8

From the supplier alternative weight calculation we got that PT. Evergreen has the biggest value compare to other suppliers. But this result is still not valid, because we still don't count the consistency test from all comparison matrixes. The result will be valid if the consistency test fall below 0.1.

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Consistency test shown that all of the matrixes are consistent, because CR falls below 0.1 which respondent valuation in determine the comparison and priority are valid, so there's no need to revise the opinion.

5. CONCLUSION

From analyze and calculation of Supplier Selection Decision Making using *Fuzzy Analytical Hierarchy Process* approach in PT. Kompindo Fontana Raya, we got the conclusion as follow:

- To solve the decision making problem, Chang algorithm can be applied in simple calculation but still have high accuracy.
- F-AHP grading with *fuzzy extent analysis* method (Chang, 1996) show result as follow: from 8 alternative suppliers, , PT. Evergreen became the 1st supplier with 0.182 weight, in the 2nd is 2 Jie Yang Guangdong with 0.173 weight, the 3rd is Shaoxing Super with 0.131 weight, the 4th is Quanzhou Sanhong 0.131 weight, the 5th is PT. Prima Politek with 0.098 weight, the 6th is PT. Indonusa with 0.095 weight, the 7th is PT. Sugilindo with 0.095 weight, and the 8th is Omiyatek with 0.095 weight.
- From *fuzzy* AHP calculation, we can make decision for yarn order in making knitting rope type PP 10160104xx in PT. Kompindo,

6. REFERENCE

(a) Chang, D. Y. 1996. "Applications of the Extent Analysis Method on Fuzzy AHP,"*European Journal of Operational Research*, 95, 649-655.

(b) Jasril, Elin Haerani, dan Iis Afrianty. "Sistem Pendukung Keputusan (SPK) Pemilihan Karyawan Terbaik Menggunakan Metode Fuzzy AHP (F-AHP)". *Seminar Nasional Aplikasi Teknologi Informasi 2011.*

(c) Kabir, Golam and Dr. M. Ahsan Akhtar Hasin. "Comparative Analysis of AHP and Fuzzy AHP Models for Multicriteria Inventory Classification". *Journal of Fuzzy Logic Systems*, Vol. 1, No.1, Oct 2011.

(d) Kusumadewi S. 2003. *Artificiall Intelligence : Teknik dan Aplikasinya*. Yogyakarta : Graha Ilmu.

(e) Shega, H. Nia H, Rita Rahmawati, dan Hasbi Yasin, " Penentuan Faktor Prioritas Mahasiswa dalam Memilih Telepon Seluler Merk Blackberry dengan Fuzzy AHP". *Jurnal Gaussian,* Vol. 1, No. 1, 2012: 73-82

(f) Suharjito.*"Pemodelan Sistem Pendukung Pengambilan Keputusan Cerdas Manajemen Risiko Rantai Pasok Produk/ Komoditi Jagung".* Disertasi, Institut Pertanian Bogor, 2011.

(g) Tang, Y. C and Malcom J. Beynon. "Application and Development of a Fuzzy Analytic Hierarchy Process within a Capital Investment Study", *Journal of Economics and Management,* Vol 1, No. 2, 2005: 207-230.

(h) Therick, Hendry Leonardo.*"Peningkatan Produktivitas Departemen Sewing dengan Perbaikan Lingkungan Kerja Menggunakkan Fuzzy AHP pada PT. Bina Busana Internusa".* Skripsi Jurusan Teknik Industri Universitas B