

**ANALYSIS OF SOURCING MITIGATION USING INTEGRATED HOUSE OF
RISK (HOR)
(CASE STUDY AT CEBONGAN BAMBOO CENTER, SLEMAN, YOGYAKARTA)**

Thesis

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By

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UNIVERSITAS ISLAM INDONESIA

YOGYAKARTA

March 2020

AUTHENTICITY STATEMENT

In the name of Allah SWT, the most gracious the most merciful, I hereby certify that this research of mine was conducted by my own work except the citation and summaries which those are already mentioned on references lists as source of this research. If someday this statement provided above is not right and violates the legal regulation of papers and intellectual property right, I agree Universitas Islam Indonesia to revoke my bachelor certificate.



Yogyakarta, March 2020



Muhammad Yudianto

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**ANALYSIS OF SOURCING MITIGATION USING INTEGRATED HOUSE OF
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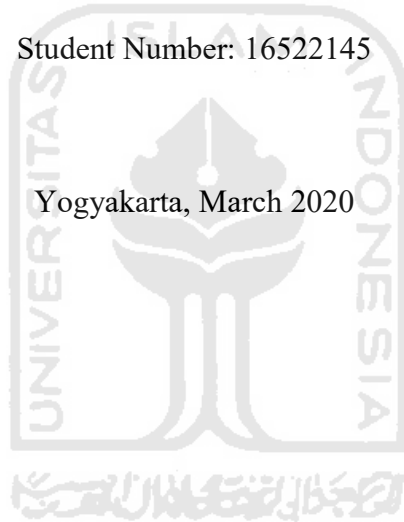
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(CASE STUDY AT CEBONGAN BAMBOO CENTER, SLEMAN, YOGYAKARTA)

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Acknowledge by,

Head of Undergraduate Program Department of Industrial Engineering
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DEDICATION PAGE

I am grateful for the love and encouragement from Dad and Mom, have always provided during every endeavor in my life.

Cebongan Bamboo Center, Sleman, Yogyakarta

My Thesis Supervisor, Muhammad Ridwan Andi Purnomo, ST., M.Sc., PhD.

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Assalamualaikum Wr. Wb.

Alhamdulillah, and gratitude is presented to Allah SWT as the strength and the guidance which blessing the author to complete the Thesis in “Cebongan Bamboo Center.” The report title is “Analysis of Sourcing Mitigation Using Integrated House of Risk (HOR).” Greeting devoted to our beloved Prophet Muhammad SAW, which has brought humankind to the world full of knowledge as it is today.

This report dedicated to all of the students, especially the Industrial Engineering Department as one of the collective knowledge. Therefore, the author would like to thank those who help and supports the author:

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Waalaikumsalam Wr. Wb.

Yogyakarta, March 2020



Muhammad Yudiarto

MOTTO

The strength of an alim from an 'abid (a lot of worship) is like the excess of the moon on the stars, from the fact that the scholars are the heirs of the prophets, they do not inherit money, only inherit knowledge, who takes it, then take it with a sufficient share.

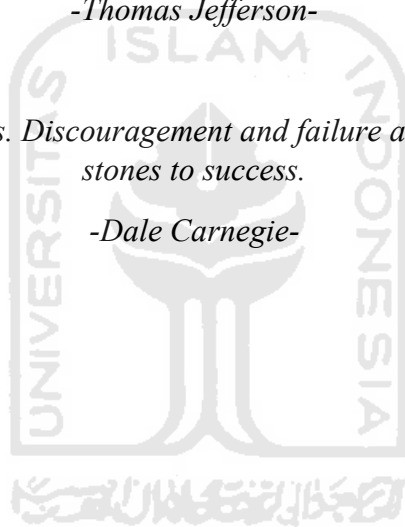
-HR. Abu Daud-

You want something you have never had, then you have to do something you have never done.

-Thomas Jefferson-

Develop success from failures. Discouragement and failure are two of the surest stepping stones to success.

-Dale Carnegie-



ABSTRACT

Cebongan Bamboo Center is one of the community industries engaged in bamboo in Sleman, Yogyakarta. The evaluation for suppliers needs to be determined by SMEs to solve the problem of delay in product delivery to the customer, the problem includes the absence of any agreement, sign on paper when negotiating, and problem of raw material delays from suppliers. So, to identify those problems, House of Risk (HOR) and Analytical Network Process (ANP) will be used.

To identify and measure the potential risks that exist and determine the priorities of the risks used House of Risk (HOR). In HOR, it was found that in the supply chain activity of bamboo materials, 23 risk events and 19 risk agents were identified. From the results of the HOR 1, it was obtained 4 selected risk agents related to sourcing that would be taken into consideration in mitigation actions. Then, from the results of the HOR 2, 5 mitigation actions can be used, with the hope of being able to mitigate risks in sourcing at Cebongan Bamboo Center.

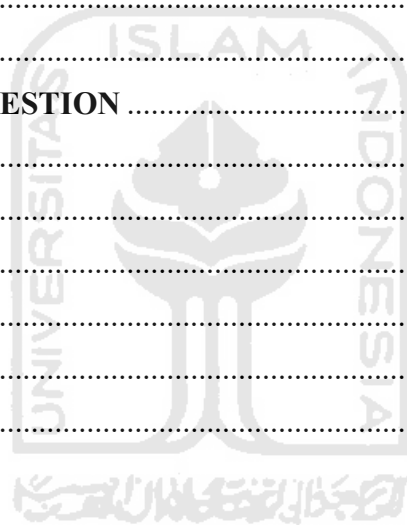
At the stage of ANP, the interview results and questionnaire that have been collected then obtained 5 criteria, 12 sub-criteria, and 5 alternatives. The result of the ideal alternative weight priority is Sleman supplier (Mr Heri) with 0.102054, Sleman supplier (Mr Aris) in the second position with 0.981747, Magelang supplier (Mr Yadi) in 3rd position with 0.838332, Kulon Progo supplier (Mr Jayus) in rank 4 with 0.833874, and Sleman supplier (Mr Ujang) last ranked with 0.782389.

Keywords: *supplier, sourcing, analytical network process, scor, house of risk, mitigation strategy*

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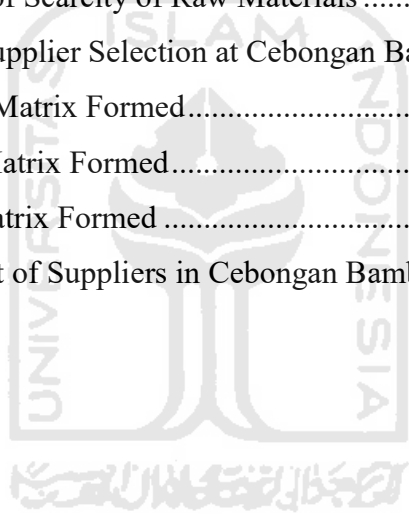
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CHAPTER 1

INTRODUCTION

1.1 Background

Over the past few years, business competition has increased fiercer, encouraging companies to expand their competitiveness in the form of effectiveness and efficiency. The essence of competition lies in the way companies implement processes in producing products or services that are better, cheaper, and faster than their competitors (Amit & Zott, 2010). Many companies have not yet succeeded in maximizing supply chain potential because it often fails to develop the performance measures and metrics needed to integrate supply chains in maximizing effectiveness and efficiency. According to (Rad & Nahavandi, 2018) one of the ways to increase the effectiveness and efficiency is by integrating the company's supply chain activities through optimizing the distribution of raw materials from suppliers, the flow of raw materials in the production process to the distribution of products to consumers.

Sourcing or procurement in supply chain describes several activities, among them are selecting suppliers, evaluating supplier performance, purchasing raw materials, maintaining good relationships with suppliers, and lastly monitoring the supply risk (Suryaningrat, 2016). A supplier is an organization that provides resources needed by customers in the form of material or non-material (service). In a company, the need for raw materials or components supplied by suppliers is one crucial factor in a production line. The selection of suppliers is a part that must be well managed and embedded in the supply chain; this relationship will affect the competitiveness of all supply chain activities (Bottani et al, 2018). Therefore, the issue of supplier selection becomes an essential issue for establishing the effectiveness of the supply chain system. With the right supplier, it can increase the company's competitiveness. Besides, in selecting suppliers can increase the productivity and quality of the products provided by the company (Nallusamy et al, 2016). So, companies must be selective and careful in choosing suppliers.

In the supply chain, uncertainty is the main factor that can affect the effectiveness of supply chain coordination. An uncertainty of unpredictable event that occurs in the company's supply chain will disrupt the flow of the production process (Tanjung et al, 2018). In sourcing, in general, risks can arise from each form of event. Risk is an opportunity that significantly impacts the achievement of objectives. Besides, sustaining the sourcing risks in a long-term will harm the company. Therefore, risk management is essential in managing risks mitigation to minimize the level of risk and the impact of these risks (Giannakis & Papadopoulos, 2016).

Business competition in the production process can be done in various sectors, and all have their risks, including the bamboo industry in Yogyakarta. Yogyakarta has a large area of land that is capable of running this bamboo business. It can be identified, there are facts taken from the Central Statistics Agency in the Special Region of Yogyakarta, out of 18 thousand hectares of forests in DIY, one third are bamboo forests. Based on data in 2011, the area of bamboo forests in DIY is 220 hectares, spread across four districts, covering 94.8 hectares in Sleman, 66.2 hectares in Bantul, 55.3 hectares in Kulonprogo, and 4.25 hectares in Gunungkidul.

The data above supported by data entered from Tribun Jogja and Detik Finance journalist from February 2019 to February 2020, bamboo products from Sleman increasingly show their ability to foreign markets. Bamboo handicraft products have become export commodities. Bamboo handicrafts such as household appliances, souvenirs, and home interior decoration, pegged at 5,000 to millions of rupiah. It has penetrated the export markets of Australia, Singapore, Philippines, Netherlands, Dubai, to Israel so that it is expected that SMEs in the future expected to be more innovative in creating bamboo products, since this bamboo product has a high potential for selling value in the future. No exception for SMEs Cebongan Bamboo Center in Yogyakarta.

Cebongan Bamboo Center is one of the community industries engaged in bamboo processing in Sleman, Yogyakarta. One of the risk incidents experienced by the Cebongan Bamboo Center is the delay in product delivery to the customer. Where the products sent by the company do not match the initial date desired by the customer, the company must re-

negotiate with the customer regarding the delivery date according to the number of products requested by the customer. In negotiating with customers, normally the company owner only communicates with customers by phone and WhatsApp application, because this habit has been done for a long time and even for decades. So, companies never use PO (Pre-order) and only rely on trust between companies and customers. Without a formal agreement with the signature attachment on paper, in this case, miscommunication often occurs at Cebongan Bamboo Center.

Then, the most significant risk, as well as the main problem that the company has experienced, is the delay in the delivery of raw materials that will be used in the production process so that the production process is hampered. According to company owner's estimation, in 2019 there were around 75% due to these delays. Bearing in mind that the Cebongan Bamboo Center does not yet have a standard for purchasing raw materials. According to a statement from the owner of SMEs, so far in selling bamboo, they have not collected data on the sales results. In this case, the Cebongan Bamboo Center in its bamboo sales during 2019 experienced a drastic decline due to an economy that began to be unstable and this sales decline supported by a lot of competition among SMEs, for instance SMEs with aluminum craft which was considered to be easier to obtain and faster in the process. While bamboo requires several weeks for processing in 1 batch of production. Also, the supply of bamboo does not only come from around Yogyakarta but also from Magelang, Wonogiri, and Klaten. Areas of supply of bamboo that far from Yogyakarta, also have the potential to cause delays in shipping. This condition will undoubtedly harm the company both in terms of time and cost. Therefore, it is necessary to conduct a risk analysis and design a risk mitigation strategy, to minimize risks or disturbances that are likely to arise in the sourcing. In addition to the problems mentioned, the table below is a list of complaints from suppliers to the owner of the company regarding the delay.

Table 1.1 Supplier Complaints Regarding the Delay

No.	Supplier Complaints Regarding the Delay
1	Areas of supply of bamboo that far from / outside Yogyakarta
2	Weather problems (heavy rain, strong winds)
3	Transport vehicles not yet / not available
4	An event in a village that involves suppliers
5	Human error (bamboo that should not be cut but intentionally cut)

Based on the problems faced by Cebongan Bamboo Center in the sourcing sector above, to identify and measure the potential risks that exist in the sourcing and determine the priorities of the risks that exist in the sourcing at the Cebongan Bamboo Center used the House of Risk (HOR) approach. This model is a framework developed by Laudine H. Geraldin and I. Nyoman Pujawan by developing the FMEA (Failure Mode and Effect Analysis) method and the QFD (Quality Function Deployment) method. HOR is a method that is focused on determining mitigation, reduction, and treatment strategies for risk causes (Pujawan & Geraldin, 2009). This method aims to determine the priority of the handling strategy, because so far, Cebongan Bamboo Center has never been to prioritize the risks faced in the sourcing. Also, there are many risk agents with a high probability of occurrence and cause many risk events with severe impacts at Cebongan Bamboo Center, including the delay in delivering raw materials, resulting in a delay in the production schedule mentioned above.

The HOR method is divided into 2 phases, namely, phase 1, which first starts from identifying supply chain activities based on the Supply Chain Operation Reference (SCOR). The SCOR model contains several sections and is organized around five main management processes, namely Plan, Source, Make, Deliver, and Return. The mapping process of SCOR in this research was taken in making process of bamboo crafts from raw materials to finished goods. With supply chains using these five processes, the model can be used to describe very simple or very complex supply chains using a set of almost all supply chains. Performance measurement using SCOR can measure companies from upstream to downstream. This reason is what makes the SCOR model superior to other methods that tend to measure the company internal, especially for sourcing.

After processing the HOR data for phase 1, HOR phase 2 is then carried out where in this stage, the risk management strategy is determined. Finally, to be able to know more deeply about the potential causes of the risk, fishbone tools are used. The function of a fishbone diagram here is to identify and organize the causes that might arise from a specific effect and then separate the root causes in Cebongan Bamboo Center from the result of HOR. The owner of the Cebongan Bamboo Center only knows the biggest problem, without seeing

the smallest cause of the problem. In fact, one problem can be broken down into various small problems to be clearer to see all possible causes and find the real root of the problem.

After identify, measure, and determine the priorities of the risks in HOR, the evaluation criteria for suppliers need to be determined by SMEs to solve or reduce the problem of raw material delays, supplier selection criteria based on quality, cost, delivery, flexibility, response, and innovation (Nair et al, 2015). Supplier selection is one of the essential things in purchasing activities for companies. Supplier selection is a multi-criteria problem that includes quantitative and qualitative factors. Several ways can be done by considering the advantages and disadvantages of each method. The methods can be used such as Promethee, Analytical Network Process (ANP), and Analytical Hierarchy Process (AHP). The Promethee method is a supplier ranking method for a limited number of alternatives and is chosen based on criteria that conflict with each other. The Promethee method has deficiencies in problem structuring and criteria weighting systems due to the unavailability of directives.

The ANP method is a relative measurement method that reflects the influence of interacting elements concerning control criteria. There are three types of interrelationships between control criteria in the ANP method, namely interrelationships in a set of elements (inner dependence), interrelationships between different elements (outer dependence), and reciprocal relationships (feedback). The Analytical Network Process (ANP) method is a development of the Analytical Hierarchy Process (AHP) method; the ANP method is able to correct weaknesses in the AHP including the ability in one element and the linkages between different elements and the AHP method there is only a mathematical method without testing, so there is no confidence in the model formed. In ANP analysis, it can be done by identifying the KPIs first. Below is the Cebongan Bamboo Center's KPI to all suppliers (five main suppliers) and suppliers's KPI to choose the companies as well.

Table 1.2 Cebongan Bamboo Center's KPI to All Supplier (Five Main Supplier)

Company's KPI	Description
Quality	<ol style="list-style-type: none"> 1. Compliance of goods with specifications that have been set 2. Supply of goods without defects 3. Ability to provide consistent quality
On-time Delivery	<ol style="list-style-type: none"> 1. The ability to deliver goods according to the agreed date 2. Ability in terms of handling the transportation system
Accuracy in Quantity	<ol style="list-style-type: none"> 1. Accuracy and appropriateness of supplies in shipment
Services	<ol style="list-style-type: none"> 1. Ease of contact 2. The ability to provide information clearly and easily understood 3. Speed in responding to customer requests 4. Quick response in resolving customer complaints
Price	<ol style="list-style-type: none"> 1. Price appropriateness with the quality of goods produced 2. The ability to give discounts on specific orders

Table 1.3 Suppliers's KPI to Choose the Companies

Supplier of Cebongan Bamboo Center	Criteria to Choose Companies (Including Cebongan Bamboo Center)
	Financial condition
	Demand fulfillment performance
Magelang (Mr. Yadi)	Response time and speed
Kulon Progo (Mr. Jayus)	Price
Sleman (Mr. Aris)	Guarantee agreement to suppliers
Sleman (Mr. Heri)	Geographical location (environmental conditions)
Sleman (Mr. Ujang)	The company's reputation in the eyes of customers
	Human resource management
	Company operational system

In Cebongan Bamboo Center, several sub-criteria have a relationship with each other; for example, from the quality criteria, there are sub-criteria for compliance of goods with the specification that have been set, this sub-criterion has a strong correlation with price appropriateness. Besides, there is a relationship in the on-time delivery sub-criteria with the

sub-criteria in services, and there are still several other interrelated and continuous relationships. From this explanation, the ANP method is considered abler to give a priority of the company in determining suppliers. ANP method is a weighting method that can do weighting not only on the basis of a hierarchical relationship between perspectives but also able to accommodate the nature of interdependent relationships between sourcing perspectives used as benchmarks for the design and measurement of company performance. The ANP method is expected to provide the best choice of scientific justification for suppliers at Cebongan Bamboo Center, Yogyakarta.

By using all of these methods and approaches, it will be expected to show risks that can arise in the company's risk in sourcing, find out handling strategies that can be done in dealing with the risks that occur in sourcing, and provide benefits to the company that can identify the suppliers desired by the Cebongan Bamboo Center.

1.2 Problem Formulation

From the background of the problem above, the problem can be formulated as follows:

1. What is the appropriate mitigation strategy for dealing with sources of risk in the sourcing at Cebongan Bamboo Center?
2. What is the priority handling of sources of risk from several suppliers in the sourcing at Cebongan Bamboo Center?

1.3 Research Objectives

The objectives of this study can be explained as follows:

1. Design the appropriate mitigation strategies to deal with sources of risk in the sourcing at Cebongan Bamboo Center.
2. Identify the priority handling of sources of risk in the sourcing at Cebongan Bamboo Center.

1.4 Research Limitation

Limitation of problems in this study can be described as follows:

1. The HOR method is applied to all SCOR business processes, yet the evaluation of risk mitigation strategies or action are focused on source only (not in plan, make, delivery (to the customer), and return).
2. The limitation lies in the problem to be analyzed, namely choosing suppliers for bamboo raw materials.
3. Do not see the process of advanced approaches (Fuzzy ANP).



CHAPTER 2

LITERATURES REVIEW

2.1 Deductive Study

2.1.1 Supply Chain Operations Reference (SCOR)

SCOR is a way that companies can use to communicate a framework about supply chains in detail, define, and categorize the processes that build the matrices or indicators needed in measuring supply chain performance. Thus, obtained measurements should be performed among suppliers, company internal, and consumers (Putri et al, 2017). The Supply Chain Operation Reference (SCOR) model is a conceptual model developed by the Supply Chain Council (SCC). The purpose of standardization by SCC is to facilitate understanding of the supply chain as a first step in order to obtain an effective and efficient supply chain management in sustaining the company's strategy (Dweekat et al, 2017).

According to (Milambo & Phiri, 2019) in the SCOR method, the main factors are plan, source, make, deliver, return. The SCOR framework provides a variety of performance measures for evaluating supply chains organized into several metric levels of size associated with one of the performance attributes, namely: Reliability, Responsiveness, Agility, Cost, and Asset based on (Sellitto et al, 2015). By analyzing and describing the process, the SCOR model can objectively measure supply chain performance based on data and can identify where improvements need to be made to create competitive advantage. Implementation of SCOR certainly requires a lot of effort to describe current business processes and define desired processes.

2.1.2 House of Risk (HOR)

Risk is defined as the probability of an event causing a loss and the potential magnitude of the event (Muhlbauer, 2004).

$$Risk = Event\ likelihood \times Event\ consequence \quad (2.1)$$

House of Risk (HOR) is the development of the two popular tools, namely quality function deployment (QFD) and the failure mode and effect analysis (FMEA) (Pujawan & Geraldin, 2009). In this research, the HOR model is used, because this model is different from the existing model in which HOR selected high risk Aggregate Risk Potentials, which means the risk agent has a high probability of occurrence and causes many risk events with severe impacts. Then mitigation measures are arranged for selected risk agents based on the ratio of total effectiveness to the level of difficulty and which mitigation measures can reduce many risk agents with high ARP values. HOR is divided into two phases:

1) First phase

- a. Identification of risk events (E_i) and risk agents (A_j)
- b. Calculation of occurrence and severity of variables E_i and A_j
- c. Construct a correlation matrix E_i and A_j with provisions, 0: no correlation, 1: weak correlation, 3: moderate correlation and 9: strong correlation.
- d. ARP (aggregate risk potential) value calculation of A_j using the formula:

$$ARP_j = O_j \cdot \sum S_i \cdot R_{ij} \quad (2.2)$$

Where O_j is the probability of occurrence of risk agent j , S_i is the severity of impact if risk event i occurred, and R_{ij} is the correlation between risk agent j and risk event i (which is interpreted as how likely risk agent j would induce risk event i).

- e. ARP rating of each A_j .
- f. Making a Pareto diagram A_j (priority selection A_j).

2) Second phase

- a. Preparation of mitigation or preventive action (PA_k) based on priority A_j .
- b. Correlation between A_j and PA_k with provisions 0, 1, 3 and 9.
- c. Calculation of the value of the total effectiveness of each PA_k with the formula:

$$TE_k = \sum (ARP_j \cdot E_{jk}) \quad (2.3)$$

Where ARP_j is the aggregate risk potential j and E_{jk} is each risk agent.

d. Measurement of degree of difficulty of application PA_k with a scale of difficulty of application 3: low, 4: medium and 5: high.

e. Effectiveness to difficulty ratio (ETD_k) calculation using the formula:

$$ETD_k = TE_k/D_k \quad (2.4)$$

Where TE_k is the total effectiveness of each action and D_k is the degree of difficulties in performing each action.

f. Priority ranking PA_k based on value ETD_k .

2.1.3 Fishbone Diagram

Fishbone diagram is one method/tool for improving quality. Too often, this diagram is called the Cause-effect diagram. The inventor was a Japanese scientist in the 60s named Dr. Kaoru Ishikawa. (Luca & Pasare, 2017) explained the fishbone diagram because it is indeed shaped similar to a fish bone that has a muzzle facing its right head. This diagram will show an impact or a result of a problem, with various causes. The effect is written as the muzzle of the head. Whereas the fish bones are filled with causes according to the approach of the problem.

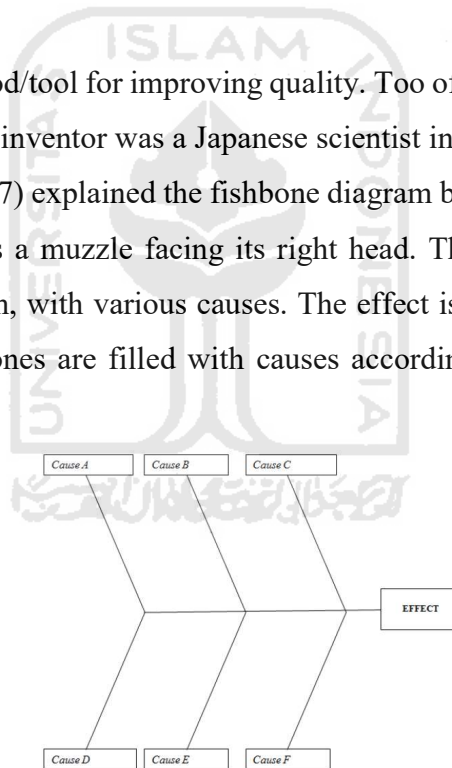


Figure 2.1 A Fishbone Diagram

2.1.4 Analytical Network Process (ANP)

Analytical Network Process (ANP) is a mathematical theory that allows a decision-maker to deal with factors that are interconnected (dependent) and feedback (systematic feedback).

ANP is one of the decision-making methods based on multiple criteria or Multiple Criteria Decision Making (MCDM) developed by Thomas L. Saaty. This method is a new approach to the qualitative way, which is a continued development of the previous method, the Analytical Hierarchy Process (AHP) (Aragónés-Beltrán et al, 2017). The figure below is a form of the interdependence of various components in the ANP structure.

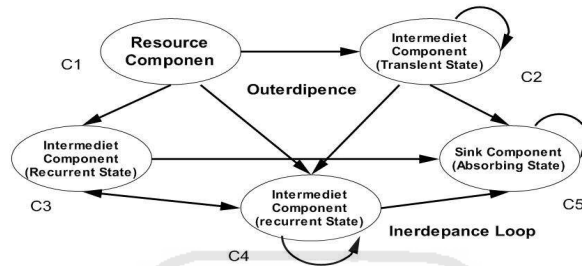


Figure 2.2 Interdependence Relationship

The steps in deciding with ANP are as follows:

1. Structure of the Problem and Develop a Relation Model

Determine the goals or objectives be achieved, determine the criteria that refer to the control criteria, and identify choices. If there are elements of equal quality, they are grouped into the same component (level or cluster).

2. Forming a Pairwise Comparison Matrix

The scale in the ANP uses the Saaty scale, where the ANP assumes that the decision-maker must make comparisons between all elements for each level in pairs. The comparison is transformed into a matrix. Comparisons can be made directly (with discussion) or through questionnaires.

3. Calculating the Element Weight

If the pairwise comparison is complete, the priority vector w called eVector is calculated by the formula:

$$A.w = \lambda \max. W \tag{2.5}$$

Where A is a paired comparison matrix and λ_{max} is the largest Eigen value of A. Whereas eVector or eigenvector is the priority weight of a matrix which is then used in the preparation of super matrices.

4. Calculating the Consistency Ratio

The consistency ratio (CR) provides a numerical assessment of how inconsistent an evaluation is. Consistency deviations are expressed by a consistency index (Consistency Index / CI), with the equation:

$$CI = \frac{\lambda_{maks} - n}{n - 1} \quad (2.6)$$

Where:

λ_{mak} = Maximum Eigen value of the pairwise comparison matrix n x n

n = Matrix size / number of items compared

To find out whether a certain amount of CI is good enough or not, we need to know the ratio that is considered good, i.e. if CR 0.1. If more than 0.1, a reassessment needs to be done.

The consistency ratio is obtained by comparing the consistency index (CI) with an appropriate value of a random consistency index number (RI), with the equation:

$$CR = \frac{CI}{RI} \quad (2.7)$$

RI values or random consistency indices of various matrix sizes (n) can be seen in the table issued by the Oarkride Laboratory.

5. Making the Super Matrices

Super matrix consists of 3 (three) stages, namely unweighted super matrix stage, weighted super matrix stage and limiting super matrix stage.

2.2 Previous Studies

Sevinç et al (2018) conducted research about industry 4.0 concept in Turkey, the objective of this research is to analyze the concept with the transition difficulties that exist in small and medium-sized enterprises (SMEs). Some methods are used that include a combination of AHP and ANP by distributing questionnaires to business managers. The process of preparing a hierarchy is based on four criteria, namely innovation, organization, environmental, and financial aspects, and from this we can get the weight of the criteria and sub-criteria which will be calculated further.

Gheshlaghi & Feizizadeh (2017) conducted research about landslide risk mapping in Iran. Based on the landslide mapping with various models and methods taken from various journals, the researchers of this study found an objective that is to test the combination of two models of MCDM, ANP and fuzzy logic in mapping landslide risk located in the Azarshahr Chay basin in northwestern Iran. The role of these two models is that fuzzy logic is used to weight sub-criteria, and ANP is applied to the criteria weights. Furthermore, the two are linked based on the GIS spatial analysis method and a landslide risk map. The results of this study are very useful for relevant agencies and a landslide prediction map can be used to mitigate hazards in the future.

Boonyanusith & Jittamai (2019) conducted research about blood supply chain management in Thailand. The purpose of this research is to explore possible risks that could occur in the blood supply chain and how to mitigate the risks. The method that used in this research is the HOR. The results indicate that there are 30 risk events and 16 risk agents identified and assessed in the case study. Based on these results, the recommendation is to improve a connection between blood service organizations by using management information systems (MIS) and technology to mitigate risks, complexities, as well as uncertainties in managing demand and supply in the blood supply chain.

Nugraheni et al (2017) conducted research about supply chain risk management in PT Suntory Garuda Beverage. PT SGB is one of the ready to drink (RTD) companies that

have increasing demand every year. The purpose of this study is to identify risk, cause of risk, and strategy to handle the risk that accordance with the current condition of PT. SGB. The method used in this research is SCOR and HOR. Based on the result on the Pareto chart, there are 63 identified risk events based on SCOR elements, 43 identified risk agents, and 15 recommended preventive strategies according to the most effective sequence of approaches applied in the PT SGB.

Zhang & Sun (2018) conducted research about risk assessment for railway special line shunting safety in China. The reason why they conduct this research is their traditionally risk assessment sometimes unable to deal with incomplete or uncertain data. This paper presents an integrated approach for conducting special-line shunting risk assessment, using fishbone diagram analysis, fuzzy reasoning approaches, and a fuzzy analytical hierarchy tool, which can evaluate both qualitative and quantitative risk data efficiently and effectively. The output of this research is risk degrees and risk levels that provides railway safety risk managers and engineers with tools to improve their safety standards in the future.

Wang et al (2015) conducted research about risk factors of oil drilling by Chinese construction in Ghana. The reason why they conduct this research is the recent interest of numerous Chinese companies in the Ghanaian economy cannot underestimate. There have been apparent benefits on both sides, but it's also accompanied by rising risk issues that need to address and pragmatic steps taken to curtail them. This research specifically showed the various environmental risk factors by Chinese firms with particular reference to the drilling of offshore oil and gas. Also, how they can be addressed with multiple recommendations by using a cause and effect diagram (fishbone diagram) method. One of the top suggestions was that Chinese nationals consult local chiefs in the community before embarking on any project to avoid land litigation problems and tension among locals.

Yu et al (2019) conducted research about OSH in Coal Chemical Enterprises. Based on the OSH principle, the four aspects examined in this study are humans, machines, the environment, and management. This is also based on research by previous researchers in the company is the presence of factors such as dust, toxins, and toxic gases that seriously limit

the safety and health of employees. Integration between fishbone diagrams, ANP, and dynamic systems is used in this study. Research results from this paper will increase OSH levels in all coal chemical companies throughout the world, both theoretical and practical applications.

Hossen et al (2017) conducted research about examining stoppage losses that taken from a textile case in Bangladesh. The spinning industry, which was again very competitive in Bangladesh, encouraged writers to make a study focusing on six stoppage losses. The aim is to calculate the Overall Equipment Efficiency (OEE) in the ring frame section of the spinning process. Several methods are used, such as Pareto Diagrams and Fishbone Diagrams to see the cause and effect that occurs. Finally, recommendations will be made for spinning industry owners to reduce stopping losses and to increase the productivity of the ring frame section.

Moons et al (2019) conducted research about performance indicator selection in the hospital logistics system. The author selects one hospital with poor inventory management, lack of standardization, and lack of coordination between departments, making the health care logistics process challenging to deal with, and ultimately produces a lot of waste. So, the Analytic Network (ANP) process is used as a Multi-Criteria Decision-Making (MCDM) technique to provide effective and efficient based on Key Performance Indicators (KPI). It is hoped that from the research results, the hospital logistics manager can make transparent and informed decisions to improve inventory and distribution policies.

Anggrahini et al (2015) conducted research about managing quality risk in a frozen shrimp. This research aims to analyze the quality of frozen shrimp product problems along the supply chain involving suppliers, companies, logistics providers, and customers. Company X has a problem that is a loss of product quality, which is often caused by production processes and external factors. The SCOR and HOR methods used in this study. The final results obtained from the two methods are that there are 12 proposed mitigation actions to be implemented in Company X.

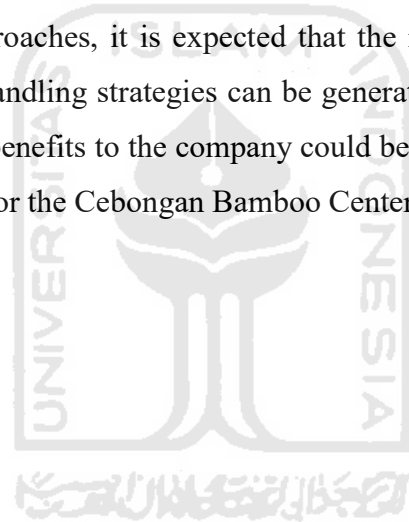
The rest of the literature can be seen in the table 2.1 below.

Table 2.1 Literature Review

No.	Author	Year	Object	Review			
				Supply Chain Operations Reference (SCOR)	House of Risk (HOR)	Fishbone Diagram	Analytical Network Process (ANP)
1	Ali Sevinç, Seyda Gür, & Tamer Eren	2018	SMEs Industries in Turkey				√
2	Hassan Abedi Gheshlaghi & Bakhtiar Feizizadeh	2017	Landslides in Iran				√
3	Wijai Boonyanusith & Phongchai Jittamai	2019	Blood Service Organizations in Thailand		√		
4	Silvyia Ratri Nugraheni, Rahmi Yuniarti, & Ratih Ardia Sari	2017	PT. Suntory Garuda Beverage	√	√		
5	Huafeng Zhang & Quanxin Sun	2018	Railway Special Line Shunting Safety			√	
6	Yousong Wang, Martin Henry Asare, Yufan Zhang, & Jing Kuang Liu	2015	People Working in the Coastal Community of Domunli			√	
7	Kai Yu, Lujie Zhou, Chen Hu, Linlin Wang, & Weiqiang Jin	2019	OSH in Coal Chemical Enterprises			√	√
8	Jamal Hossen, Nafis Ahmad, & Syed Mithun Ali	2017	Textile Case in Bangladesh			√	
9	Karen Moons, Geert Waeyenbergh, Liliane Pintelon, Paul Timmermans, Dirk De Ridder	2019	Materials logistics in hospitals	√			√
10	Dewanti Anggrahini, Putu Dana Karningsih, Martian Sulistiyono	2015	Company X (frozen shrimp) supply chain	√	√		
11	Titik Kusmantini, Adi Djoko Guritno, & Heru Cahya Rustamaji	2015	84 SMEs in the DIY Furniture.	√	√		

No.	Author	Year	Object	Review			
				Supply Chain Operations Reference (SCOR)	House of Risk (HOR)	Fishbone Diagram	Analytical Network Process (ANP)
12	Nur Eko Wahyudin & Imam Santoso	2016	Four expert respondents in CV.XYZ, located in Jurnorejo Village, Batu, East Java		√		
13	Mahdi Abolghasemi, Vahid Khodakarami, & Hamid Tehranifard	2015	Uncertain Metrics of SCOR Model & Bayesian Networks (BNs)	√			
14	Oleksandr Velychko	2015	Internal transportation of milk raw materials in the supply chain	√			
15	W Sutopo, DI Maryanie, & Yuniaristanto	2015	Industry and SMEs Activity for Palm Oil Derivative Building in Pelalawan Regency	√			
16	NLD Utami	2019	Chili traders at Traditional Market, Jatisrono District, Wonogiri Regency, Central Java	√	√		√
17	Kai Yu, Qinggui Cao, Changzhen Xie, Nannan Qu, & Lujie Zhou	2019	Chinese Coal Mine Enterprises			√	√
18	Piyanee Akkawuttiwanich & Pisal Yenradee	2018	Bottled Water Manufacturing	√			
19	Muhammad Firdaus Saputra	2018	PTPN X Unit PG. Modjopanggoong		√		
20	Tang Yingjia, Wang Xu, & Li Longxiao	2019	The Process from Airport to Hotel on the Basis of Traditional Air Travel	√		√	
*	Muhammad Yudiarto	2020	Cebongan Bamboo Centre	√	√	√	√

This research was conducted at Cebongan Bamboo Center. Cebongan Bamboo Center is one of the community industries engaged in bamboo processing in Sleman, Yogyakarta. The problems experienced by the Cebongan Bamboo Center is a delay in product delivery to the customer and a delay in the delivery of raw materials that will be used in the production process. Based on those problems, the author carries out this research. This study aims to design the appropriate mitigation strategies to deal with sources of risk in the sourcing and to know the priority handling of sources of risk in the sourcing at Cebongan Bamboo Center. The method used is the Supply Chain Operations Reference (SCOR), House of Risk (HOR) with the Fishbone Diagram approaches, and Analytical Network Process (ANP). By using all of these methods and approaches, it is expected that the risks can be identified in the company's risk in sourcing, handling strategies can be generated to deal with the risks that might occur in sourcing, and benefits to the company could be provided, in terms of finding out the appropriate suppliers for the Cebongan Bamboo Center.



CHAPTER 3

RESEARCH METHODOLOGY

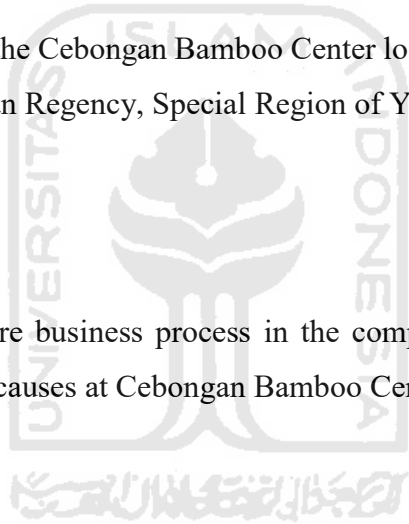
The methodology of this research is used as a guideline for researchers so as not to deviate from predetermined goals, and strive to solve the problem to be more systematic and directed so that it can meet the objectives to be achieved.

3.1 Research Subject

The subject of this research is the Cebongan Bamboo Center located at Jl. Cebongan No. 15, Mlati, Tirtoadi, Sleman, Sleman Regency, Special Region of Yogyakarta 55287.

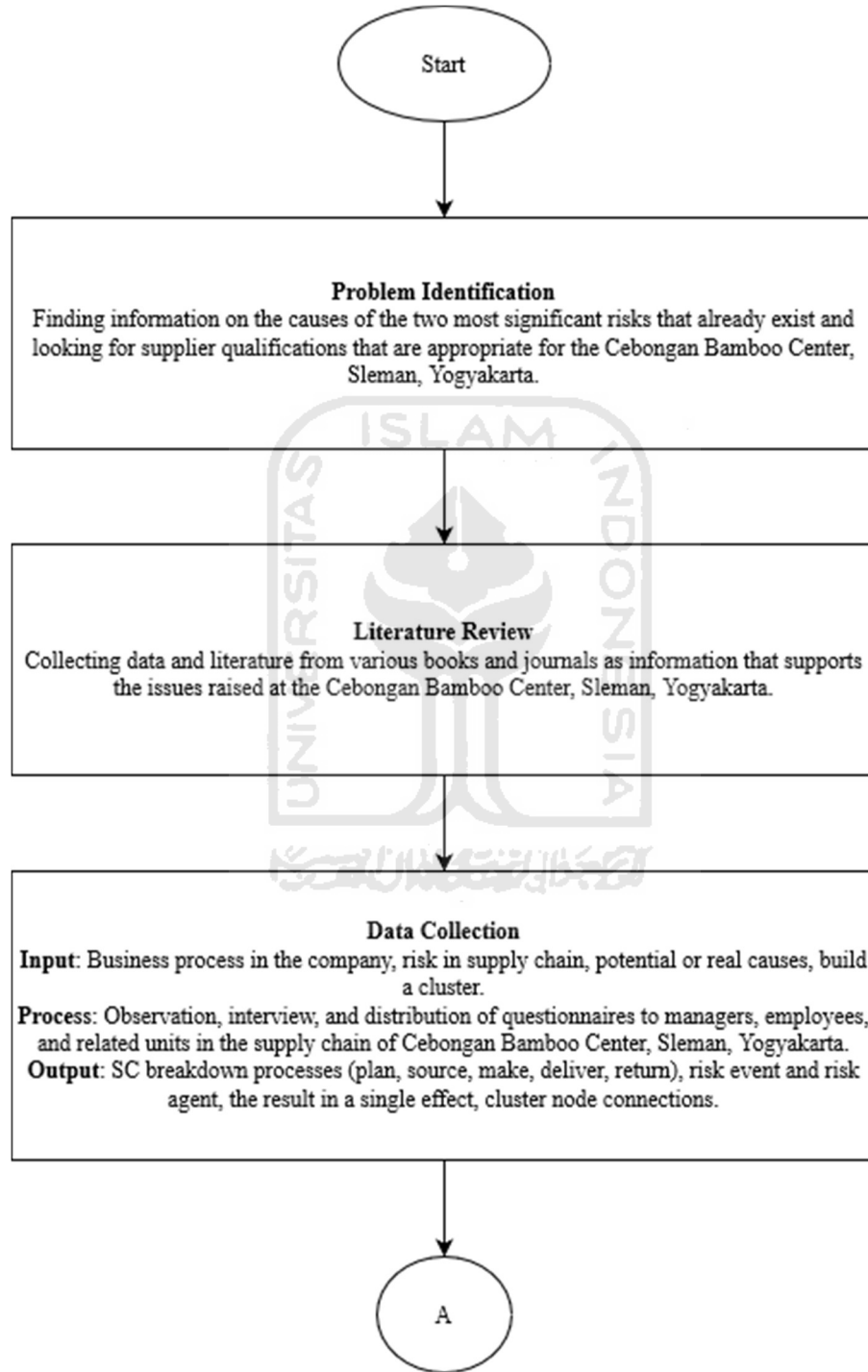
3.2 Research Object

The objects of this research are business process in the company, build a cluster, risk in supply chain, potential or real causes at Cebongan Bamboo Center Sleman, Yogyakarta.



3.3 Research Flow

The following is the research step displayed with a flow diagram from Figure 3.1.



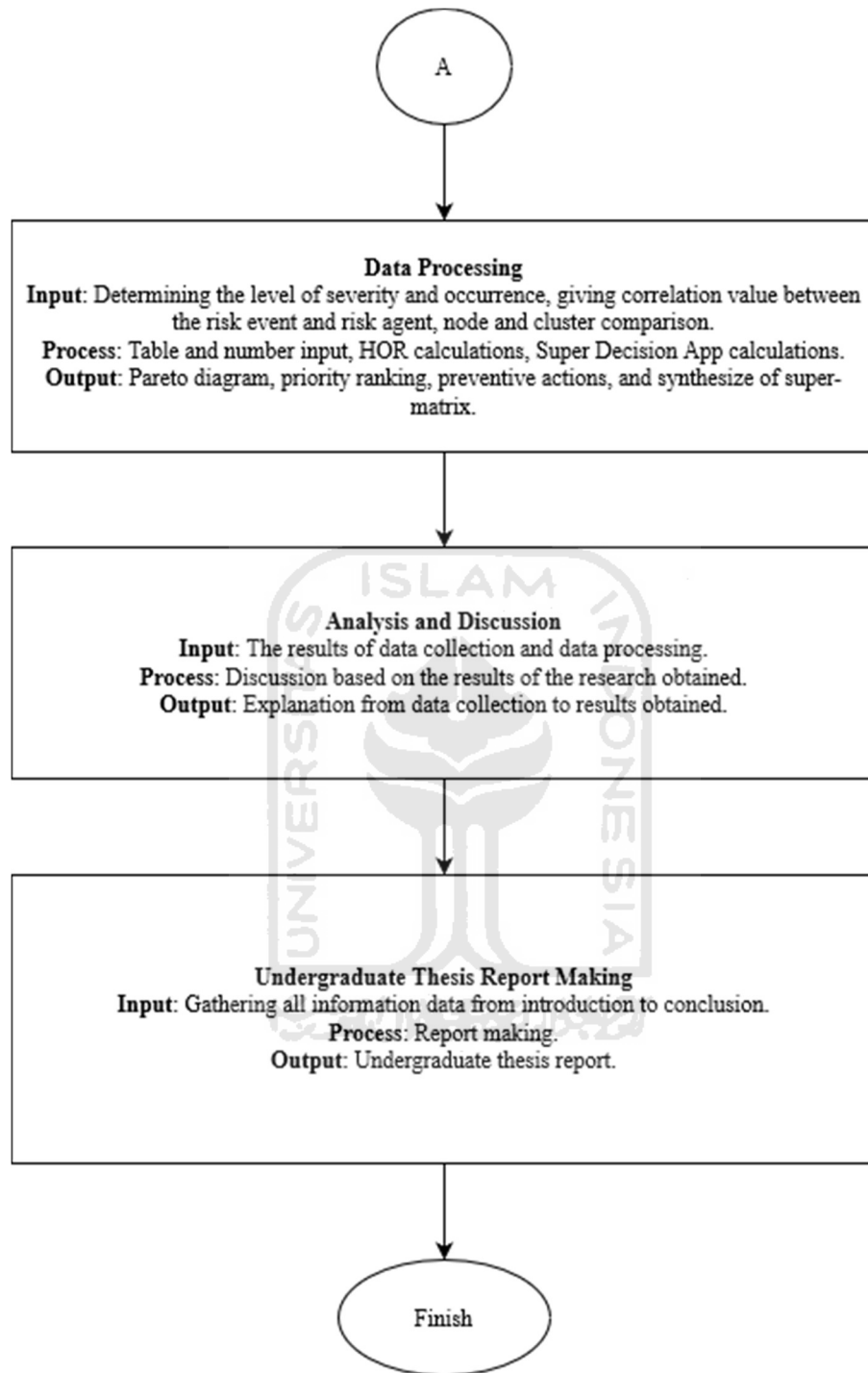


Figure 3.1 Research Flow

From the chart above, it can be illustrated that each flow has a relationship between each other which described in detail so that they can synergized to make this report complete. The following is a step in conducting this research.

1. Problem Identification

Problem identification is the initial field study process to identify problem outlines that will be the topic of this research. The method used is observation, and interview, then the output obtained at this stage is to get the problem formulation.

2. Research Objective

The purpose of the study is used as a basis for concluding. Each research objective is the answer to each predetermined problem formulation.

3. Literatures Review

A literature review is used as a secondary source of data relating to the research to be conducted. A literature study is divided into two, namely:

- a) Inductive study, a study that explains (reviewed) previous research in which the sources used in the form of journals.
- b) Deductive study, a study in which the sources used can be in the form of journals, books, official websites, and final project reports that discuss the same research object to serve as a theoretical basis.

4. Data Collection

The description or variables used in data collection are as follows.

- a) Business Process in the Company

A business process at the Cebongan Bamboo Center, which consists of mapping supply chain activities and identifying risks and risk agents. The mapping of bamboo supply chain activities is obtained by performing observation and derived from company

records. Later, the bamboo supply chain activities are mapped in the SCOR (Supply Chain Operations Reference) model to classify the supply chain activities. Risks and risk agents are identified based on supply chain activities that have been classified by brainstorming.

Table 3.1 Mapping of Bamboo Raw Material SC Activities into the SCOR Model

Plan	Production planning and control
	Calculation of material requirements
Source	Purchase of bamboo raw materials
	Removing, receiving, and storing bamboo raw materials
	Checking bamboo raw materials received
Make	Do the production process
	Perform checks and tests during the stages of the production process
	Submit the finished goods to the warehouse (according to the packing list)
Delivery	Shipping bamboo products to customer
Return	Return bamboo raw material to supplier

b) Risk in Supply Chain

The causes that have been reviewed are then differentiated into 23 risk events and 19 risk agents.

Table 3.2 Risk Event in Cebongan Bamboo Center

Code	Risk Event
E1	Sudden changes in production plans
E2	Error of inputted data and inventory
E3	Inaccurate owner estimate
E4	Supplier does not fulfill the order
E5	Delay in shipping of raw materials
E6	Requested products are not available
E7	Raw material prices are not according to the contract
E8	Product defect received from supplier
E9	The raw materials in the warehouse are still many
E10	The quality of raw materials is not appropriate
E11	Wrong items sent by suppliers
E12	Lack of coordination between workers
E13	Reworking the production process

Code	Risk Event
E14	The production process is hampered
E15	The delay in production scheduling
E16	Inaccuracy from workers
E17	Misplaced items that were not fully ready
E18	Delivery process is not timely
E19	Contract cancellation by customer
E20	Product defect received by customer
E21	Out of stock before delivery time
E22	Delay response of suppliers
E23	Rejected of submission

Table 3.3 Risk Agent in Cebongan Bamboo Center

Code	Risk Agent
A1	Inaccurate in forecasting
A2	Less competent workers
A3	Natural disasters
A4	Bad weather
A5	Vehicle accident
A6	Error in choosing supplier
A7	Quality of raw materials from suppliers is poor
A8	Weakness in memorandum of agreement
A9	Terrain delivery is difficult
A10	Transport equipment and machinery damaged
A11	Supplier is bankrupt
A12	Sudden request
A13	Supplier does not arrive on schedule
A14	Scarcity of raw materials
A15	Messiness in storage area
A16	Limitation of production
A17	Lack of supervision
A18	Seasonality factor
A19	Poor handling of goods

c) Potential or Real Causes

At Cebongan Bamboo Center, it can be defined there are two problems become the main risks in the company's sourcing activities, namely:

- Supply and Demand Risk
- Operational Risk

To be able to know deeper about the potential causes of the risk, fishbone tool is used. The primary function of a fishbone diagram is to identify and organize the causes that might arise from a specific effect and then separate the root causes.

d) Build a Cluster

From the preliminary interview, KPIs cluster (criteria) used in the selection of bamboo suppliers at Cebongan Bamboo Center, as follows:

1. Quality

Quality is the totality of the forms and characteristics of goods or services that demonstrate their ability to satisfy needs. The quality of products (bamboo) is measured by bamboo density, bamboo color, diameter, level of dryness, the presence or absence of disability, and bamboo straightness.

Quality here includes three sub-criteria:

- a. Compliance of goods with specifications that have been set
- b. Supply of goods without defects
- c. Ability to provide consistent quality

2. On-time Delivery

Delivery accuracy is the ability of suppliers to handle company requests so they can deliver goods.

The accuracy of shipping here includes two sub-criteria:

- a. The ability to deliver goods according to the agreed date
- b. Ability in terms of handling the transportation system

3. Accuracy in Quantity

Accuracy of quantities, namely the accuracy and appropriateness of supplies in shipment.

4. Services

Services are services, assistance, and facilities provided by suppliers to consumers (the company).

The service here includes four sub-criteria:

- a. Ease of contact
- b. The ability to provide information clearly and easily understood
- c. Speed in responding to customer requests
- d. Quick response in resolving customer complaints

5. Price

Prices are the value of objects/goods measured in units of money (rupiah).

Prices here include two sub-criteria:

- a. Price appropriateness with the quality of goods produced
- b. The ability to give discounts on specific orders

5. Data Processing

In conducting data processing, this research uses table and number input, House of Risks (HOR) 1 calculations, House of Risks (HOR) 2 calculations, and Super Decisions application calculations. At the end of HOR 1 will be Pareto diagram to mitigate preventive actions from risk event and risk agent that only related to the focus of this study, namely risk in sourcing of Cebongan Bamboo Center. After that, fishbone is used to find the detailed root of the problem in risk in sourcing from House of Risk (HOR) 2 at Cebongan Bamboo Center, Sleman, Yogyakarta.

6. Analysis and Discussion

In this section, a description of the results of this study is carried out. Also, the results of the House of Risk and Analytical Search Process data from Cebongan Bamboo Center will be explained.

7. Undergraduate Thesis Report Making

This final stage contains compilation of reports from all data and information obtained, ranging from introduction to conclusions and suggestions. Also, brief answers to the results of research on existing problems. In addition, in this section there will also be suggestions based on the results of research conducted at Cebongan Bamboo Center.



CHAPTER 4

DATA COLLECTING AND PROCESSING

4.1 Supply Chain Identification

4.1.1 Brief History of the Company

Cebongan Bamboo Center, Sleman, is one of the companies engaged in processing bamboo. Cebongan Bamboo Center was firstly established in 1950 by Mr. Kartodimejo. In that year, bamboo raw materials were very abundant in Sleman, so Mr. Kartodimejo had an idea that forwarded to the villagers so that the abundant bamboo could be used with added value. He proposed the first time to make a lounger called "lincak". After trying to make it, then he marketed it. Shortly after that, enthusiasts from this chair increased so that he invited all neighbors in his village to work together to use bamboo, which had not previously had any selling points. He taught the making of chairs and other bamboo handicraft materials until his neighbors were proficient. In the end, a community called the Cebongan Bamboo Center was formed, which has grown rapidly because the price is affordable by all levels of society. Cebongan Bamboo Center itself has a vision and mission that is that people understand bamboo crafts, introduce production from bamboo, so that people can have jobs, and get more income without being dependent on others.

4.1.2 Supply Chain Mapping in the Company

In making bamboo crafts from raw materials to finished goods, involves three main actors: suppliers, manufacturers, and distributors. First, the manufacturer orders bamboo material from the supplier; the supplier will process it. Then, after the agreement and payment activities are carried out, the delivery is done to the address designated by the

manufacturer. After getting bamboo orders from suppliers, bamboo is then processed. Bamboo is cut to the specified size, then washed using sand so that the fine hairs on the bamboo disappear, then bamboo is cleaned with detergent, and dried in the sun to dry. After the drying process, it enters the core stage, which is making the specified handicraft, for example, a guest chair with an angular model by creating a frame/trade, then given a woven rattan, adding a slide/batten, entering the sanding process. The guest chair is ready for sale. In all these bamboo handicraft products, the process is almost the same for all processes. Models or products from bamboo handicrafts include bamboo gazebos, bamboo buildings or restaurants, bamboo furniture, beds, reclining chairs, blinds, curtains, wicker, stilts, stairs, and so on.

Based on the supply chain activities in the company, the flow is managed. In the conceptual supply chain, there are usually 3 types of flow that must be managed. First is the flow of goods that flows from upstream to downstream. Second is the flow of money of the kind that flows from downstream to upstream. While the third is the flow of information that can occur from upstream to downstream or vice versa. For an overview of the supply chain activity framework from suppliers to end customers along with the flow that is managed by Cebongan Bamboo Center can be seen in Figure 4.1.

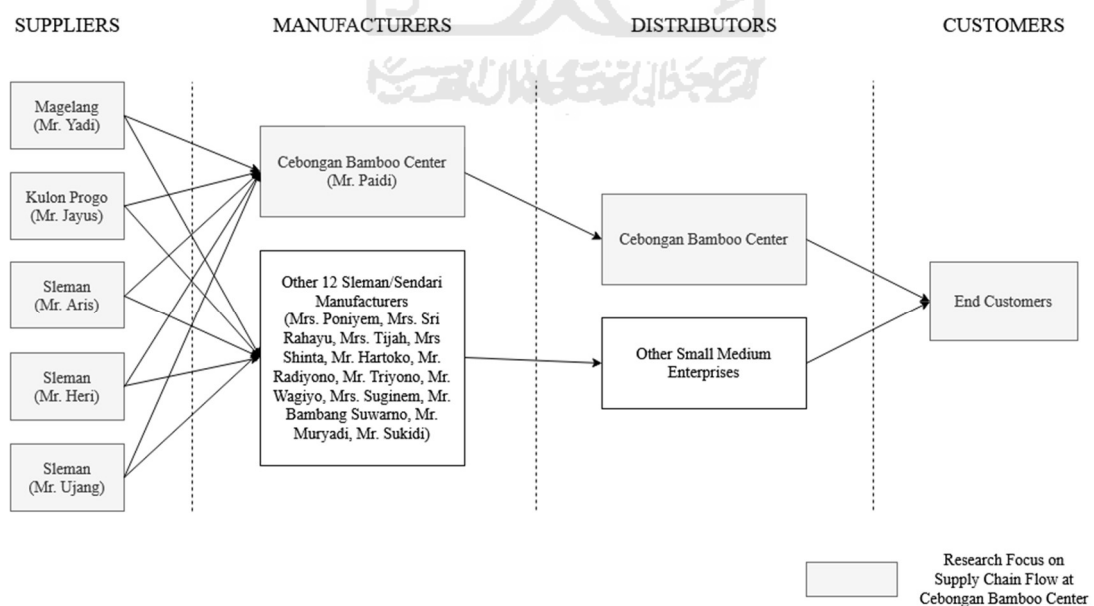


Figure 4.1 Supply Chain Mapping in Cebongan Bamboo Center

4.2 House of Risk (HOR)

To identify and measure the potential risks that exist in the supply chain and determine the priorities of the risks that exist in the sourcing at the Cebongan Bamboo Center used the House of Risk (HOR) approach. In using the HOR (House of Risk) method, there are several steps involved, including the following:

1. Identification of Bamboo Raw Material SC Activities

The first step in data collection begins with identifying the business processes within the departments being observed. A business process consists of a set of processes or sub-processes containing all activities related to one another and work together to produce a particular output. By identifying this business process can help analyze risk events and causes of risk that may occur in the department's business process that is observed. The identification of business processes follows the way of establishing SCOR by adopting five management processes: Plan, Source, Make, Deliver, and Return. The data collection was carried out by studying the Standard Operation Procedure (SOP) literature to get a better picture of the sub-processes that occur in the company.

The mapping process was carried out through interviews with the owner of the Cebongan Bamboo Center. Determination of the mapping results of SC activities that occurred at Cebongan Bamboo Center can be seen in Chapter 3 or the following table below.

Table 4.1 Mapping of SC Activities into SCOR Model Identification

Plan	Production planning and control
	Calculation of material requirements
Source	Purchase of bamboo raw materials
	Removing, receiving, and storing bamboo raw materials
	Checking bamboo raw materials received
Make	Do the production process
	Perform checks and tests during the stages of the production process
	Submit the finished goods to the warehouse (according to the packing list)
Delivery	Shipping bamboo products to customer
Return	Return bamboo raw material to supplier

2. Risk Identification Process

A risk is an event that results in losses while the event is still ongoing. A risk can produce one or more risk impacts, which will disrupt a business process. Various causes and vice versa also cause the risks that occur; one cause of risk can produce various risks. The cause of risk can be a trigger factor for risk. So, a risk event is an event when the deviation of objectives happened. While risk agent is the aspects causing the risk occurred. The table below represents the risk event in the business process.

Table 4.2 Risk Events Identified through Breakdown of Business Processes

Major Processes	Sub-processes	Risk Events (Severity)	Code
Plan	Production planning and control	Sudden changes in production plans (four)	E1
	Calculation of material requirement	Error of inputted data and inventory (eight)	E2
		Inaccurate owner estimate (three)	E3
	Purchase of bamboo raw materials	Supplier does not fulfill the order (seven)	E4
		Delay in shipping of raw materials (eight)	E5

Major Processes	Sub-processes	Risk Events (Severity)	Code	
Source		Requested products are not available (six)	E6	
		Raw material prices are not according to the contract (two)	E7	
	Removing, receiving, and storing bamboo raw materials	Product defect received from supplier (six)	E8	
		The raw materials in the warehouse are still many (two)	E9	
	Checking bamboo raw materials received	The quality of raw materials is not appropriate (four)	E10	
		Wrong items sent by suppliers (six)	E11	
	Make	Do the production process	Lack of coordination between workers (five)	E12
			Reworking the production process (six)	E13
			The production process is hampered (eight)	E14
			The delay in production scheduling (four)	E15
Perform checks and tests during the stages of the production process		Inaccuracy from workers (seven)	E16	
Submit the finished goods to the warehouse (according to the packing list)		Misplaced items that were not fully ready (three)	E17	
Delivery	Shipping bamboo products to customer	Delivery process is not timely (six)	E18	
		Contract cancellation by customer (six)	E19	
		Product defect received by customer (seven)	E20	

Major Processes	Sub-processes	Risk Events (Severity)	Code
		Out of stock before delivery time (six)	E21
Return	Return bamboo raw material to supplier	Delay response of suppliers (five)	E22
		Rejected of submission (eight)	E23

From the table above, it is found that there are 23 risk events at Cebongan Bamboo Center. The risk events have a different level of severity. The level of severity is defined in the form of number 1-10 which 1 has the lowest severity and 10 is the highest severity.

In this study, the main focus is on the risk agent. The risk agent is a triggering factor for risk so that by implementing a mitigation strategy on the risk agent, it can reduce the probability of risk causes to reduce the occurrence of risk events. Next, another aspect considered was the risk agent. The difference with the risk event in the risk agent was the probability of occurrence. Probability of occurrence is defined in number 1-10, which 1 is the lowest occurrence probability, and 10 is the highest occurrence probability. The stages in identifying the risk agent were carried out through interviews with the owner of the Cebongan Bamboo Center. The result reveals the existence of 19 risk agents in which one risk cause can cause one or more risk events. The following table below shows the causes of risk in the company.

Table 4.3 Risk Event with the Severity in Cebongan Bamboo Center

Code	Risk Event	Severity
E1	Sudden changes in production plans	4
E2	Error of inputted data and inventory	8
E3	Inaccurate owner estimate	3
E4	Supplier does not fulfill the order	7
E5	Delay in shipping of raw materials	8
E6	Requested products are not available	6
E7	Raw material prices are not according to the contract	2
E8	Product defect received from supplier	6
E9	The raw materials in the warehouse are still many	2
E10	The quality of raw materials is not appropriate	4
E11	Wrong items sent by suppliers	6
E12	Lack of coordination between workers	5

Code	Risk Event	Severity
E13	Reworking the production process	6
E14	The production process is hampered	8
E15	The delay in production scheduling	4
E16	Inaccuracy from workers	7
E17	Misplaced items that were not fully ready	3
E18	Delivery process is not timely	6
E19	Contract cancellation by customer	6
E20	Product defect received by customer	7
E21	Out of stock before delivery time	6
E22	Delay response of suppliers	5
E23	Rejected of submission	8

Table 4.4 Risk Agent with the Occurrence in Cebongan Bamboo Center

Code	Risk Agent	Occurrence
A1	Inaccurate in forecasting	4
A2	Less competent workers	3
A3	Natural disasters	1
A4	Bad weather	4
A5	Vehicle accident	2
A6	Error in choosing supplier	8
A7	Quality of raw materials from suppliers is poor	5
A8	Weakness in memorandum of agreement	7
A9	Terrain delivery is difficult	6
A10	Transport equipment and machinery damaged	5
A11	Supplier is bankrupt	1
A12	Sudden request	8
A13	Supplier does not arrive on schedule	8
A14	Scarcity of raw materials	6
A15	Messiness in storage area	4
A16	Limitation of production	5
A17	Lack of supervision	3
A18	Seasonality factor	6
A19	Poor handling of goods	4

3. Data Processing using HOR 1

From each risk event and risk agent, then it is followed by mapping the Aggregate Risk Potential (ARP) value with the House of Risk (HOR) Matrix Phase 1. This matrix maps the risk event correlation with each risk agent. The correlation values were carried out with a scale of 0, 1, 3, and 9. A value of 0 is given if there is no relationship between risk

agent and risk events; a value of 1 is given if there is a small correlation, a value of 3 is given if there is a moderate correlation, and a value of 9 is given if the relationship between the source of risk and the risk is very high.

The calculation of the ARP value is used to determine the priority of risk agents that need to be handled first and given precautionary measures against risk agents. Each ARP value is obtained through calculations using the formula:

$$ARP_j = O_j \cdot \sum S_i \cdot R_{ij} \quad (4.1)$$

The following is an example of ARP calculations and all the results of ARP calculations can be seen in the phase 1 HOR matrix:

$$ARP_I = 4 \times (9 \times 4 + 9 \times 8 + 9 \times 3 + 3 \times 2 + 3 \times 6) = 636 \quad (4.2)$$

Also, from the first house of risk, the aggregate risk potential will be identified and being ranked. The house of risk is represented as follows.

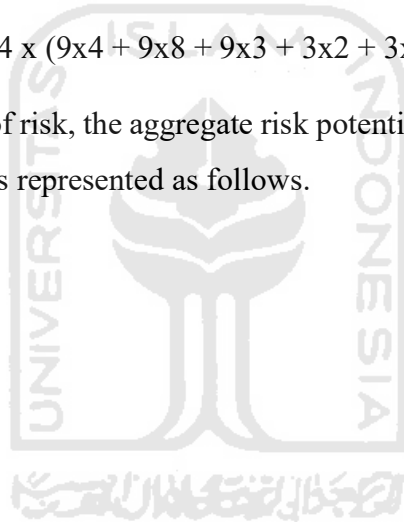


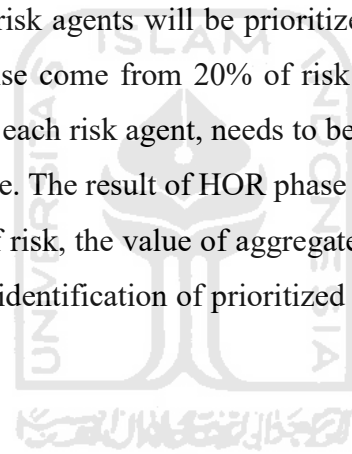
Table 4.5 Phase 1 of House of Risk

Risk Events	Risk Agents																			Si
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	
E1	9											9						9		4
E2	9																			8
E3	9																			3
E4					1	9		3			1									7
E5			1					9					9	9						8
E6						3								9		3				6
E7						3		9												2
E8						9	9	3												6
E9	3																	3		2
E10						3		1												4
E11						9		3			1									6
E12		3																		5
E13	3														3		3			6
E14						9				9		3	9							8
E15						9						3	9							4
E16		9																		7
E17															3		9			3
E18			1	3				9	9				9							6
E19						9		9					3		3					6
E20						1				3							9		9	7
E21																				6
E22						9		9					9							5
E23						9		3			1									8
Oj	4	3	1	4	2	8	5	7	6	5	1	8	8	6	4	5	3	6	4	

ARP _j	636	234	14	72	14	3944	270	2296	324	465	21	576	2376	756	108	180	324	252	252
P _j	5	13	18	16	18	1	10	3	8	7	17	6	2	4	15	14	8	11	11

4. Risk Evaluation

At this stage, the evaluation of the risk event is to determine which risk agent will be treated using the Pareto diagram. Pareto diagram establishment is aimed to determine which risk agents will be prioritized to be handled. The Pareto principle with the 80/20 rule describes that 80% of risk events that arise come from 20% of risk agents who cause them. To categorize, which prioritized and non-prioritized risk, the ARP value of each risk agent, needs to be ranked based on the weight or ARP value. The higher ARP value of risk agent, the higher rank will be. The result of HOR phase 1 is sorted from the highest ARP to the smallest ARP in Table 4.20 below. Based on the first house of risk, the value of aggregate risk potential will be used in the second house of risk. Before going to the second house of risk, the identification of prioritized risk agent is briefly visualized using this Pareto Diagram.



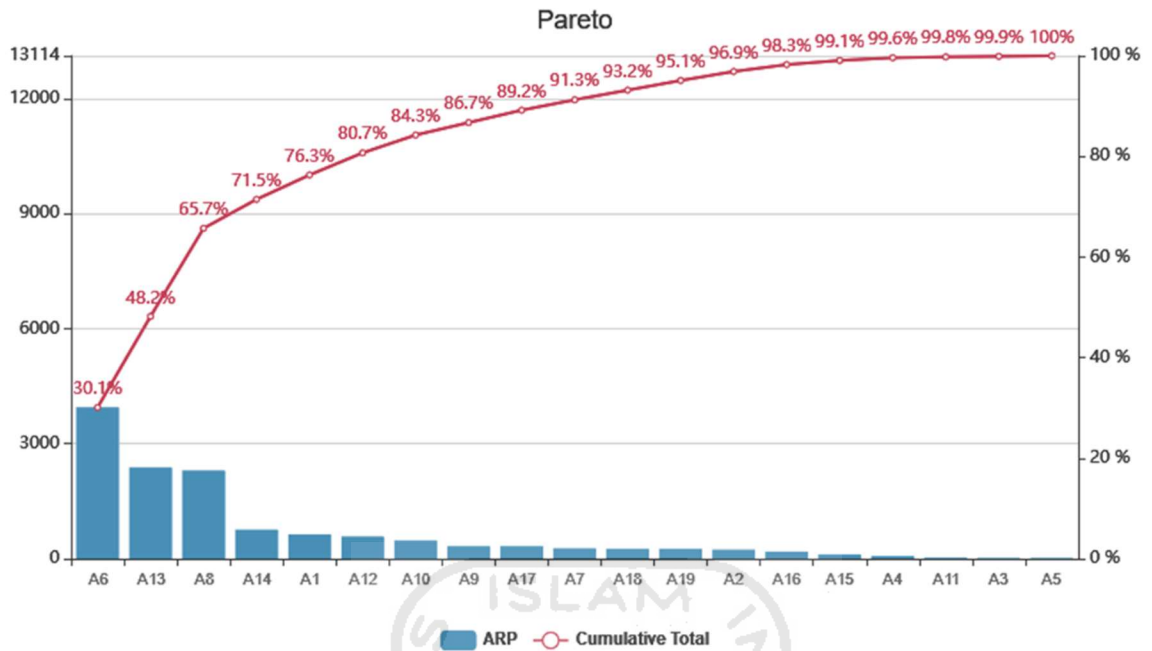


Figure 4.2 Pareto Diagram of HOR 1

From Figure 4.2 that using the Pareto 80/20 principle, the selected risk agent will be taken into consideration in the preparation of risk mitigation actions shown in the table below.

Table 4.6 The Selected Risk Agent based on Pareto Diagram

Risk Agents	Description	ARP Value	Cumulative Count	Cumulative Percentage
A6	Error in choosing supplier	3944	3944	30.1%
A13	Supplier does not arrive on schedule	2376	6320	48.2%
A8	Weakness in memorandum of agreement	2296	8616	65.7%
A14	Scarcity of raw materials	756	9372	71.5%
A1	Inaccurate in forecasting	636	10008	76.3%

From the table above, it can be seen for the priority order of handling risks originating from the sourcing of Cebongan Bamboo Center based on the Pareto Diagram. Due to the limitations in this study, the focus is on one of the processes in SCOR, namely

source. Table 4.6 shows that those associated with risk in sourcing are risk agents A6, A13, A8, A14 or showed in the highlight writing. For A1, it is related to the plan. The first highest ARP value is risk agent A6 or error in choosing suppliers with a total value of 3944 and a cumulative percentage of 30.1%. The second is the risk agent A13 or supplier does not arrive on schedule with a total ARP value of 2376 and a cumulative percentage of 48.2%, the third is the risk agent A8 or weakness in the memorandum of agreement with a total ARP value of 2296 and a cumulative percentage of 65.7%. Finally, the fourth is risk agent A14 or scarcity of raw materials with a total ARP value of 756 and a cumulative percentage of 71.5%.

Also, the risk agents in the table above will then be included in the phase 2 HOR model for designing mitigation actions. A mitigation action is an action to reduce the impact of a risk agent before the risk occurs. Alternative mitigation actions are obtained from brainstorming and references to related journals. The focus of designing this mitigation action is based on selected risk agents. Based on all known risk agents, some treatment strategy plans will be recommended that can allow us to eliminate or reduce the emergence of these risk agents. There are six recommended treatment strategies for Cebongan Bamboo Center that can be used to eliminate or reduce risk agents' appearance. The following is a table of strategy for handling mitigation actions.

Table 4.7 Strategy for Handling Mitigation Actions

M_k	Mitigation Strategy
M₁	Multi-optional trusted supplier
M₂	Construct a regulation with strict sanction
M₃	Implement an accurate calculation based on previous session
M₄	Create a safety stock
M₅	Make a scheduled coordination with supplier
M₆	Perform some work agreements at the beginning that agreed by all parties

5. Data Processing using HOR 2

The second stage in the House of Risk method is HOR Phase 2. At this stage, several treatment strategies will be selected, which are considered effective in reducing the probability of impact caused by the risk agent. The steps taken in this phase are starting with the design of a handling strategy, finding the relationship between the treatment

strategy and the risk agent, calculating the value of Total Effectiveness (TE_k), Degree of Difficulty (D_k) and the ratio of Effectiveness to Difficulty (ETD_k) to determine priority ranking of the existing strategy.

The first step is to measure the total effectiveness by multiplying the correlation value between the risk agent (j) and the preventive action (k). The total effectiveness calculation aims to assess the effectiveness of mitigation actions, with the following formula:

$$TE_k = \Sigma (ARP_j \cdot E_{jk}) \quad (4.3)$$

The following is an example of TE_k calculations and all the results of TE_k calculations can be seen in the phase 2 HOR matrix:

$$TE_1 = (9 \times 3944) + (3 \times 2376) + (3 \times 2296) + (3 \times 756) = 51780 \quad (4.4)$$

Table 4.8 Degree of Difficulty Rating Scale (D_k)

Weight	Description
3	Mitigation actions are easy to implement
4	Mitigation actions are somewhat difficult to implement
5	Mitigation actions are difficult to implement

The second step is to measure the effectiveness to difficulty ratio, by dividing the total value of effectiveness (TE_k) by the degree of difficulty taking action (Table 4.22). The calculation of the effectiveness of the degree of difficulty aims to determine the priority ranking of all actions, with the following calculation formula:

$$ETD_k = TE_k / D_k \quad (4.5)$$

The following is an example of TE_k calculations and all the results of TE_k calculations can be seen in the phase 2 HOR matrix:

$$ETD_1 = 51780 / 5 = 10356 \quad (4.6)$$

Table 4.9 Phase 2 of House of Risk

Code	Description of risk agents (A _j)	Multi-optional trusted supplier M ₁	Construct a regulation with strict sanction M ₂	Implement an accurate calculation based on previous session M ₃	Create a safety stock M ₄	Make a scheduled coordination with supplier M ₅	Perform some work agreements at the beginning that agreed by all parties M ₆	ARP _j
A6	Error in choosing supplier	9				3		3944
A13	Supplier does not arrive on schedule	3	9			9	3	2376
A8	Weakness in memorandum of agreement	3				3	9	2296
A14	Scarcity of raw materials	3			9			756
A1	Inaccurate in forecasting			9	1			636
Total effectiveness of proactive action k (TE_k)		51780	21384	5724	7440	40104	27792	
Difficulty of performing action k (D_k)		5	3	4	4	3	5	
Effectiveness to difficulty ratio of action k (ETD_k)		10356	7128	1431	1860	13368	5558.4	
Rank of proactive action k (R_k)		2	3	6	5	1	4	

The results of the Mitigation Action Priority Ranking in HOR phase 2 are shown in Table below.

Table 4.10 Mitigation Action Priority Ranking

Code	Mitigation Action	ETD _k	Priority Ranking
M ₅	Make a scheduled coordination with supplier	13368	1
M ₁	Multi-optional trusted supplier	10356	2
M ₂	Construct a regulation with strict sanction	7128	3
M ₆	Perform some work agreements at the beginning that agreed by all parties	5558.4	4
M ₄	Create a safety stock	1860	5
M ₃	Implement an accurate calculation based on previous session	1431	6

Just like HOR phase 1, due to the limitation in this study, the focus is on one of the processes in SCOR, namely source. Table 4.10 shows the highlight writing as mitigation risks associated with risk in sourcing are M₅, M₁, M₂, M₆, M₄ so that the attributes related to risk in sourcing will be further evaluated in the explanation below along with the fishbone diagram.

4.3 Fishbone Diagram

Before going into the discussion about mitigation actions from HOR 2, Cebongan Bamboo Center owner can analyze the problem to its root, a Fishbone Diagram analysis will be carried out first of the selected risk agents based on the Pareto diagram that related with sourcing. Four fishbone diagrams that related with sourcing are shown in the figure and explanation below.

Cause & Effect Error in Choosing Supplier

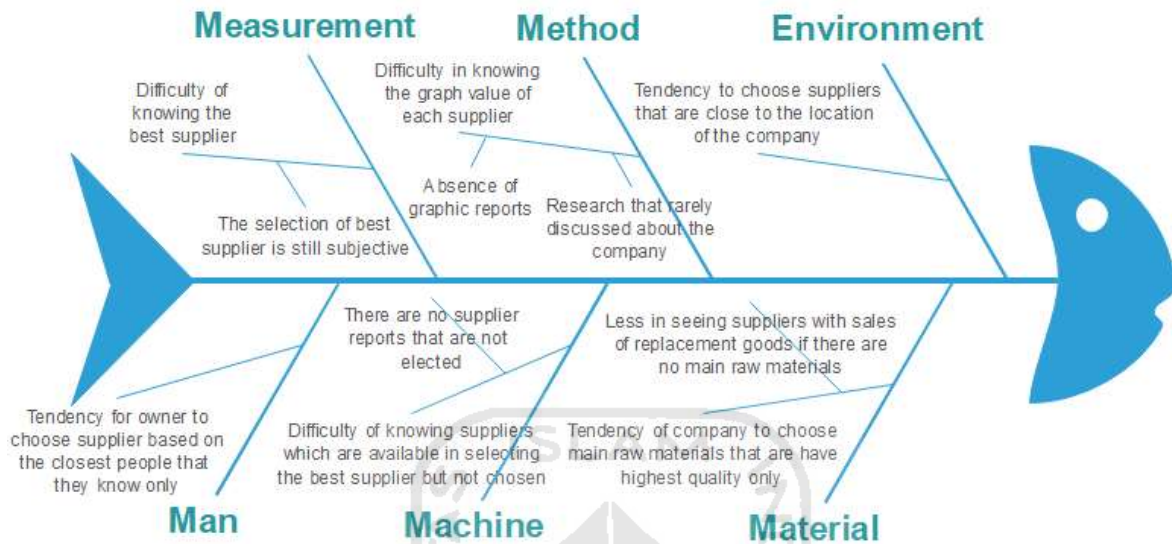


Figure 4.3 Fishbone Diagram of Error in Choosing Supplier

The fishbone analysis results above regarding the error in choosing suppliers found that six factors cause this to occur. The first is the material factor, where the Cebongan Bamboo Center has depended on the main product ordered. If there is no core product ordered, the owner will not order it and does not want to look for alternatives to other bamboo ordered items. Second is the machine factor, where the owner finds it difficult to choose the best supplier because five main suppliers are always a priority. Apart from these five main suppliers, there are still many other small suppliers that are often not considered by the owner. Even though there are small suppliers who have good potential to become permanent suppliers for Cebongan Bamboo Center. The third is the man factor, here the fault of Cebongan Bamboo Center is the dependence and tendency of the owner to choose suppliers based on the people closest to them. Even though there are still many small bamboo suppliers around the company's location who have sufficient and superior quality to meet the company's needs.

The fourth is measurement factor, the selection of suppliers, which is still subjective and only seen from a few sides. The fifth is the method factor, the difficulty in knowing each

supplier's quality, due to the lack of research on this company. Also, its ignorance of how to create, calculate and analyze measurement standards for the best suppliers. The last factor is the environmental factor, namely the tendency of companies to choose suppliers and prioritize the closest suppliers. This is best done if there is a sudden order from a customer. However, suppose it continues, for example. In that case, the closest supplier can run out of raw materials; the negative risk is that the company must think about a backup supplier and will need more time. Creating this waiting time can cause customers to be dissatisfied with the services provided by Cebongan Bamboo Center.

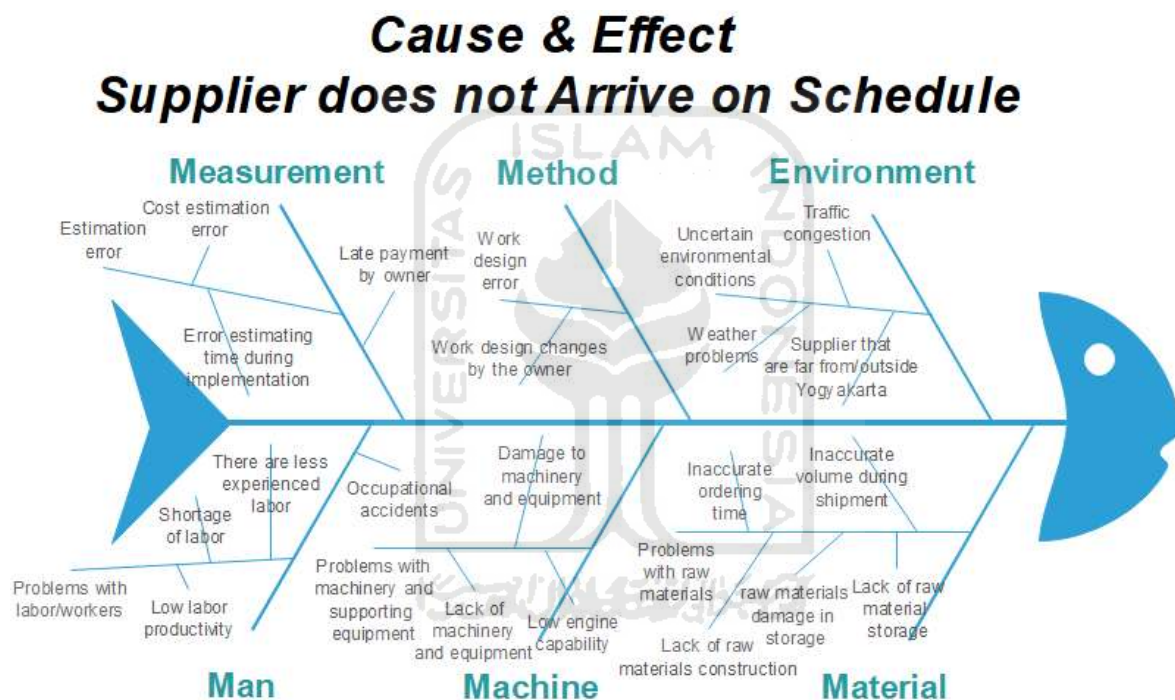


Figure 4.4 Fishbone Diagram of Supplier does not Arrive on Schedule

The fishbone analysis results above regarding the supplier do not arrive on schedule; it is found that six factors cause this to occur. First is the material factor. There are problems with raw materials, including inaccurate ordering time to the company, incorrect volume during shipment, lack of construction materials, raw materials damage in suppliers' storage, and lack of material storage. Second is the machine factor, where problems exist in the machinery and equipment system, the causes include lack of machinery and equipment, low engine capability due to old machines, and damage to several machinery and equipment. The

third is the man factor. This man factor is a problem initially from the worker. The causes include less labor productivity, less workers and workers who are still not very experienced, and frequent work accidents caused by the workers.

The fourth is factor measurement, where this problem stems from an inaccurate estimate of the price and time. Another problem is late payments by the owner, which results in the goods being supplied too late. The fifth is the method factor, where a work design error causes the problem by the owner. The last factor is environmental factors that are beyond human will. Uncertain environmental conditions such as traffic congestion, weather problems (heavy rain), and several suppliers that do come from outside the city of Yogyakarta, which causes the supply of materials to be slightly hampered by time.

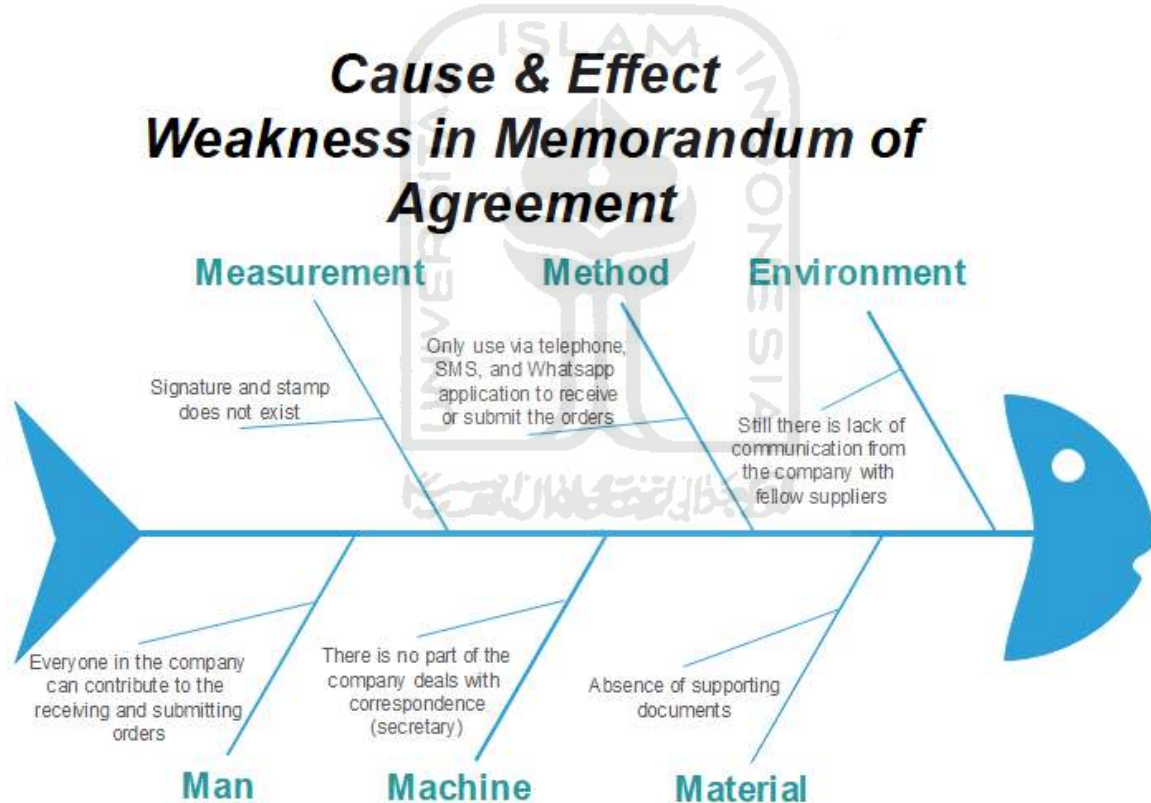


Figure 4.5 Fishbone Diagram of Weakness in Memorandum of Agreement

The fishbone analysis results above regarding weakness in the memorandum of agreement found that six factors cause this to occur. First is the material factor, where there is a problem with the absence of supporting documents in the contract. As it is previously identified, Cebongan Bamboo Center products can be ordered via the Whatsapp, SMS, and

telephone applications so that anyone, including suppliers, can easily break the rules for various reasons, such as not sending them on time. The second is the machine factor, where there is a problem in Cebongan Bamboo Center, which does not have a fixed organizational structure, especially for the secretary who is in charge of managing correspondence within the company.

The third is the man factor. As mentioned earlier, due to the absence of a fixed organizational structure, anyone from employees, owners, members, can take orders from suppliers. These people should be wrong because each person has their job description. These factors also can lead to miscommunication. The fourth is a measurement factor since there is no supporting documents for the agreement on paper; automatically, there is no company signature and seal. The fifth is the method factor, where the owner and the worker concerned only orders and receives via the Whatsapp, SMS, and telephone application. This factor is what causes weakness in the memorandum of agreement in the company. The last one is the environmental factor, namely the frequent miscommunication between the company and related suppliers due to the absence of an agreement on paper.

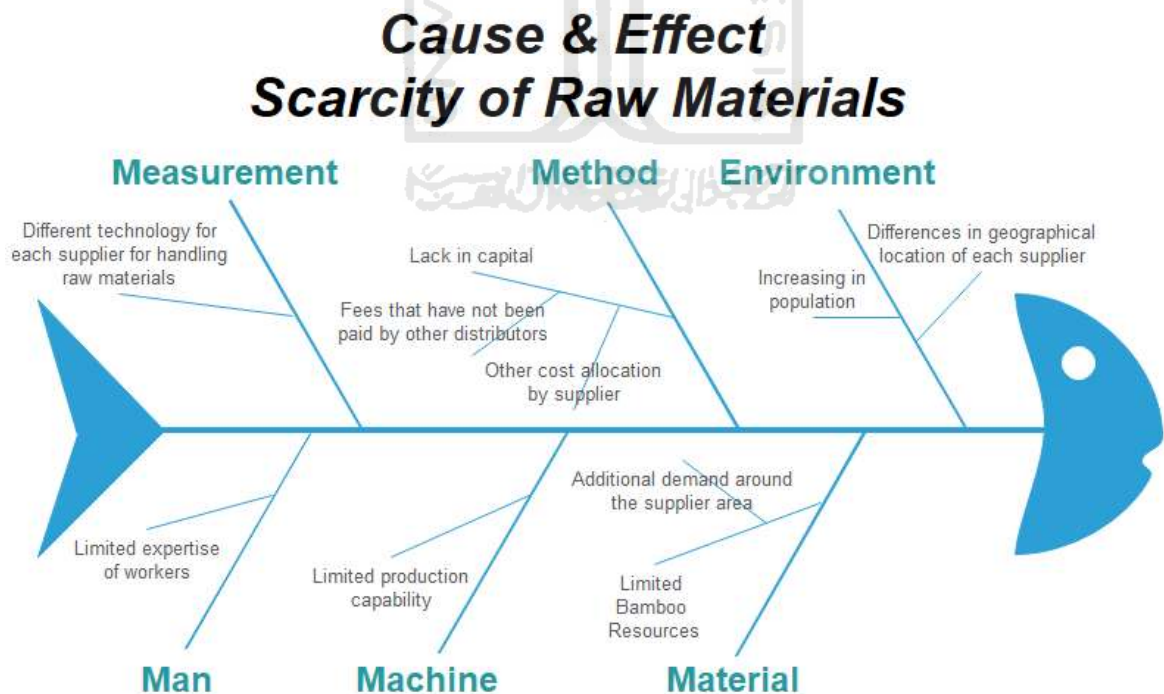


Figure 4.6 Fishbone Diagram of Scarcity of Raw Materials

The fishbone analysis results above regarding the scarcity of raw materials found that six factors cause this to occur. The first is the material factor, where there are problems with scarce bamboo resources. The main cause is the increase in demand from consumers and other small bamboo entrepreneurs so that the bamboo supply owned by suppliers is left little or even nonexistent. Second is the machine factor, which is due to suppliers' production restrictions; if consumer interest is low, this production limitation will automatically be implemented. The third is the man factor, where there are still some workers who are not proficient or still amateurs so that the work piles up on skilled workers. In this case, it will take a little longer to process, so that even though there are a lot of raw materials, there will be a small amount provided by the supplier on the market.

The fourth is a measurement factor, where there are problems, namely the difference in technology used by each supplier, some use machines, and some are manual. It will usually take a long time for manual ones to process the order so that it can cause scarcity. Furthermore, the fifth factor is the method factor; maybe this is a crucial problem, namely the problem in the capital. Several other companies place orders from one supplier, but they have not been fully paid for it, causing financial turnover to be disrupted. Finally, the supplier could not meet the demand for the Cebongan Bamboo Center because of the scarcity of raw materials. Besides, the allocation of funds for unexpected events in suppliers can also be a root cause. The last factor is the environmental factor, which is similar to the material factor, namely the density of the population and the difference in location between suppliers. The supply of bamboo will also be different for each supplier.

From the second phase of house of risk, the five highest preventive actions that related with sourcing will be explained in the next chapter. Based on the Pareto diagram above, the two attributes of risk agents, namely error in choosing supplier and supplier does not arrive on the schedule were in the top rank. In addition to providing fishbone diagram and some preventive actions, to give a priority of the company in determining suppliers, the researcher tries to help reduce the problem of risk in sourcing at Cebongan Bamboo Center using the Analytical Network Process (ANP) method as below.

4.4 Analytical Network Process

The researcher applies the ANP model in the case of selecting the best supplier. The name of the supplier is kept confidential to guarantee its confidentiality so that the writer gives the name of the owner and only the supplier's location which consists of the area of Magelang (Mr. Yadi), Kulon Progo (Mr. Jayus), Sleman (Mr. Aris), Sleman (Mr. Heri), and Sleman (Mr. Ujang). The ANP process is assisted by using Super Decision software to facilitate mathematical load calculations. The ANP method framework is illustrated as follows:

1. Determine Criteria, Sub-Criteria, and Alternatives

Criteria, sub-criteria, and alternatives are used as a basis for consideration in choosing the best supplier are obtained by conducting interviews with the owner of the Cebongan Bamboo Center as the decision-maker and the procurement division as the recipient of the goods. So, there are two parts involved. During this discussion, several criteria and sub-criteria from previous research were proposed, which would later adapt to the current situation at Cebongan Bamboo Center. The interview results and questionnaire process that have been collected then obtained 5 criteria, 12 sub-criteria, and 5 alternatives that will be presented in chapter 3 or table 4.11.

Table 4.11 Criteria and Sub-Criteria of Cebongan Bamboo Center

Criteria	Sub-Criteria
Quality	Q1. Compliance of goods with specifications that have been set Q2. Supply of goods without defects Q3. Ability to provide consistent quality
On-time Delivery	O1. The ability to deliver goods according to the agreed date O2. Ability in terms of handling the transportation system
Accuracy in Quantity	A1. Accuracy and appropriateness of supplies in shipment
Services	S1. Ease of contact S2. The ability to provide information clearly and easily understood S3. Speed in responding to customer requests

Criteria	Sub-Criteria
Price	S4. Quick response in resolving customer complaints
	P1. Price appropriateness with the quality of goods produced
	P2. The ability to give discounts on specific orders

Table 4.12 Alternatives of Supplier in Cebongan Bamboo Center

Alternatives
Magelang (Mr. Yadi)
Kulon Progo (Mr. Jayus)
Sleman (Mr. Aris)
Sleman (Mr. Heri)
Sleman (Mr. Ujang)

2. Determine the Relations between Criteria and Sub-Criteria

After determining the criteria and sub-criteria, the next step is to determine the relations to the criteria and sub-criteria. The relations between criteria or relation between criteria and sub-criteria is obtained from the owner of Cebongan Bamboo Center. Two relations occur, namely inner dependence and outer dependence. Inner dependence indicates that there is a dependency relation between sub-criteria in a criterion. Simultaneously, outer dependence is a dependency relation between criteria or between criteria with goals and alternatives.

Table 4.13 Relations between Criteria and Sub-Criteria of Cebongan Bamboo Center

Sub-Criteria	Quality			On-time Delivery		Accuracy in Quantity	Services				Price	
	Q1	Q2	Q3	O1	O2	A1	S1	S2	S3	S4	P1	P2
Quality	Q1	-	-	-	-	↑	-	-	-	-	↑	-
	Q2	-	-	↑	-	-	-	-	-	-	-	-
	Q3	-	-	-	-	-	-	-	-	-	-	-
On-time Delivery	O1	-	-	-	-	-	-	-	↑	-	-	-
	O2	-	-	-	-	-	-	-	-	-	-	-
Accuracy in Quantity	A1	-	-	-	-	-	-	-	-	-	-	-
	S1	-	-	-	-	-	-	↑	-	-	-	-

Sub-Criteria	Quality			On-time Delivery		Accuracy in Quantity	Services				Price	
	Q1	Q2	Q3	O1	O2	A1	S1	S2	S3	S4	P1	P2
Services	S2	-	-	-	-	-	-	-	-	-	-	-
	S3	-	-	-	-	-	-	-	-	-	-	-
	S4	-	-	-	-	-	-	-	-	-	-	-
Price	P1	-	-	-	-	-	-	-	-	-	-	↑
	P2	-	-	-	-	-	-	-	-	-	-	-

Compliance of goods with specifications that have been set is in line with price appropriateness. If the Cebongan Bamboo Center is satisfied with the bamboo that has been ordered, the supplier will feel good to make the right price. Conversely, if the goods obtained are not appropriate and below quality standards, it will not only have a bad impact on low prices. It will also harm for customers who are not satisfied with the Cebongan Bamboo Center.

Besides affecting the price, compliance with goods that have been set also affects the accuracy and appropriateness of supplies in shipment. The faster the product is selected, and the bamboo quality standards, the quicker the delivery to the Cebongan Bamboo Center. So that suppliers can use time effectively and efficiently to make deliveries to other places.

The importance of the supply of goods without defects is always expected of all companies, not least for suppliers of the Cebongan Bamboo Center. Costs incurred to repair defects will be minimized by always providing consistent quality. With suppliers who always maintain quality and choose the best bamboo, it is hoped that it will provide satisfaction for the owner and be one of the primary keys to the success of Cebongan Bamboo Center.

The ability to deliver goods according to the agreed date is no less influential with speed in responding to customer requests. The demand for bamboo from many customers requires company owners to have suppliers that can be relied on and on time. If some immediate orders or orders are many, the supplier must always be ready to accept orders that come from the company.

One that is not less important is the communication relationship between the two parties or commonly called ease to contact, a supplier who has a definite fast response relationship that the company will look for. This will give an output clear information conveyed, both from customers to the company and company to the supplier. Therefore, the company wants a critical component of the supplier, namely the ability to provide information clearly and easily understood.

Goods that have been confirmed safe and following the wishes will certainly enter the payment stage and be paid according to the quality provided by the supplier. This is included in the sub-criteria of price, namely price appropriateness with the quality of goods produced. Usually, the Cebongan Bamboo Center always gets discounted prices from bamboo that have been purchased from suppliers. The reason is buying in large quantities, and in a few months, the company orders the supplier repeatedly, and most importantly, according to what was ordered. Therefore, the company is looking for suppliers with the ability to give discounts on specific orders.

3. Inputting into the Super Decision Software

After completing the relationship between the criteria and sub-criteria, the next step is to make the ANP model into the Super Decision software. The model is divided into three groups which include:

- a. Goal or the main goal to be achieved. In this case, the goal is to choose the most suitable supplier. The goal is placed in the top/level 0 position.
- b. The criteria in which contain sub-criteria that are considered in choosing a supplier. Criteria and sub-criteria are below the goal or at level 1.
- c. An alternative is a group that will become a solution in choosing a supplier. The alternatives are below the criteria and sub-criteria or at level 2.

More details can be seen in Figure 4. Which has shown the composition of the model in which there are goals, criteria and sub-criteria, alternatives, and inner dependence & outer dependence.

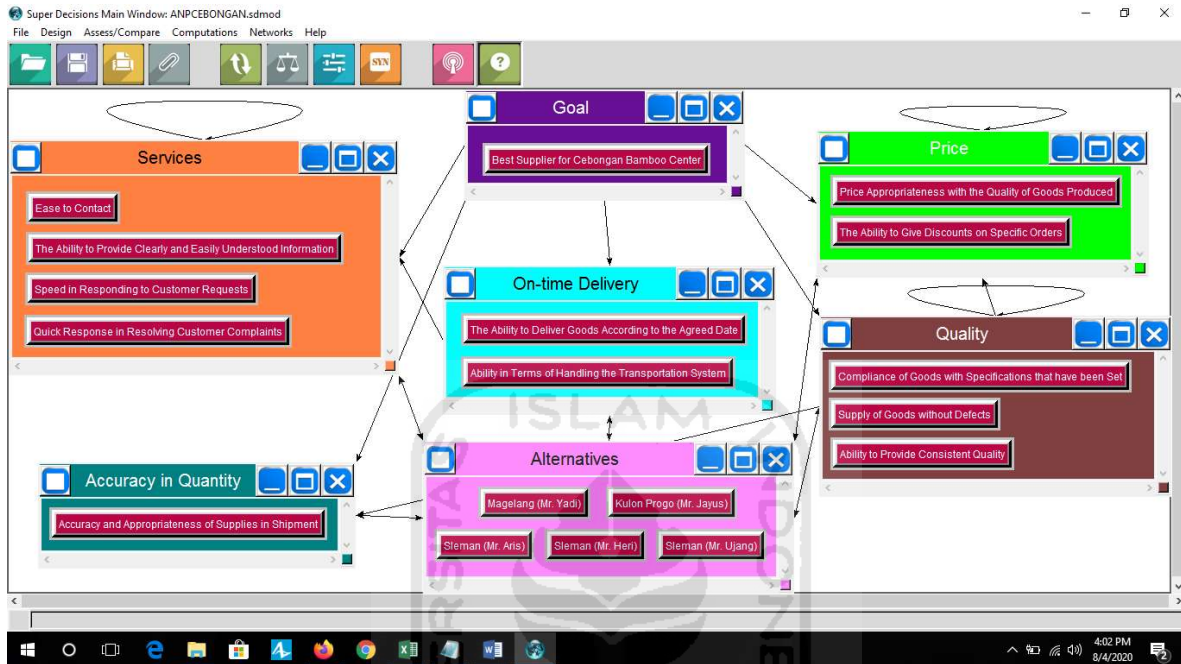


Figure 4.7 ANP Model Best Supplier Selection at Cebongan Bamboo Center

4. Make a Pairwise Comparison Matrix

Connections between clusters and nodes will form a comparison matrix. The matrix is given a value derived from the questionnaire contained in Appendices I as a weight for the matrix. The process of filling out the questionnaire takes a long time because of the large number of interaction interactions that must be filled. Expert respondents were asked to rate on the ANP 1-9 scale. The use of this scale is good, because the larger the measurement scale, the more accurate the results measured. The disadvantage is that due to the large-scale choice, respondents tend to be confused and bored in filling it out. Each expert respondent's questionnaire content is then tested for consistency by entering the data into the ANP model in software. This needs to be done to ensure that the raw data is consistent so that the geometric mean results will later provide consistent results as well. Geometric averages are used because the

values given by expert respondents are comparative, so they are more suitable to be used than arithmetic averages.

The results of checking the consistency in each expert respondent's questionnaire found that all expert respondents were consistent in filling out the questionnaire. Several matrix that appear for ANP models can be designed in the application or can be created manually. The researcher also made a pair comparison matrix calculation contained in Appendices II and III.

The CR value for each comparison matrix between a goal in each criterion shows a value below 0.1 ($CR \leq 0.1$). This value indicates that the owner's assessment of the goal in each criterion is consistent because all of the value is equally important based on the respondent's questionnaire, so the results that the researcher does not need any calculations. Then it can be concluded that the respondents' assessment is following the real conditions. Meanwhile, below is the following recap value of the Consistency Ratio (CR) of sub-criteria in each alternative in comparison matrix based on the manual calculation in Appendices II.

Table 4.14 Sub-Criteria in Alternatives Magelang (Mr. Yadi) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Quality (Q)	0	Consistent
2	Between Sub-criteria in On-time Delivery (O)	0	Consistent
3	Between Sub-criteria in Accuracy in Quantity (A)	0	Consistent
4	Between Sub-criteria in Services (S)	0	Consistent
5	Between Sub-criteria in Price (P)	0	Consistent

Table 4.15 Sub-Criteria in Alternatives Kulon Progo (Mr. Jayus) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Quality (Q)	0.046255	Consistent
2	Between Sub-criteria in On-time Delivery (O)	0	Consistent
3	Between Sub-criteria in Accuracy in Quantity (A)	0	Consistent
4	Between Sub-criteria in Services (S)	0.045011	Consistent
5	Between Sub-criteria in Price (P)	0	Consistent

Table 4.16 Sub-Criteria in Alternatives Sleman (Mr. Aris) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Quality (Q)	0	Consistent
2	Between Sub-criteria in On-time Delivery (O)	0	Consistent
3	Between Sub-criteria in Accuracy in Quantity (A)	0	Consistent
4	Between Sub-criteria in Services (S)	0	Consistent
5	Between Sub-criteria in Price (P)	0	Consistent

Table 4.17 Sub-Criteria in Alternatives Sleman (Mr. Heri) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Quality (Q)	0.046255	Consistent
2	Between Sub-criteria in On-time Delivery (O)	0	Consistent
3	Between Sub-criteria in Accuracy in Quantity (A)	0	Consistent
4	Between Sub-criteria in Services (S)	0.022419	Consistent
5	Between Sub-criteria in Price (P)	0	Consistent

Table 4.18 Sub-Criteria in Alternatives Sleman (Mr. Ujang) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Quality (Q)	0	Consistent
2	Between Sub-criteria in On-time Delivery (O)	0	Consistent
3	Between Sub-criteria in Accuracy in Quantity (A)	0	Consistent
4	Between Sub-criteria in Services (S)	0	Consistent
5	Between Sub-criteria in Price (P)	0	Consistent

In the Table 4.14 until 4.18, it can be seen that the CR value for each comparison matrix between sub-criteria in each alternative shows a value below 0.1 ($CR \leq 0.1$). This value indicates that owner's assessment of the sub-criteria of each alternative is consistent. Then it can be concluded that the respondents' assessment is following the real conditions.

The following is the recap value of the Consistency Ratio (CR) of alternatives in each sub-criterion in comparison matrix based on the manual calculation in Appendices III.

Table 4.19 Alternatives in Sub-criteria Quality (Q) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Compliance of Goods with Specifications that have been Set (Q1)	0.095567	Consistent
2	Between Sub-criteria Supply of Goods without Defects (Q2)	0.082615	Consistent
3	Between Sub-criteria Ability to Provide Consistent Quality (Q3)	0.085016	Consistent

Table 4.20 Alternatives in Sub-criteria On-time Delivery (O) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria The Ability to Deliver Goods According to the Agreed Date (O1)	0.094155	Consistent
2	Between Sub-criteria Ability in Terms of Handling the Transportation System (O2)	0.093373	Consistent

Table 4.21 Alternatives in Sub-criteria Accuracy in Quantity (A) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Accuracy and Appropriateness of Supplies in Shipment (A1)	0.035635	Consistent

Table 4.22 Alternatives in Sub-criteria Services (S) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Ease of Contact (S1)	0.045538	Consistent
2	Between Sub-criteria The Ability to Provide Information Clearly and Easily Understood (S2)	0.05307	Consistent
3	Between Sub-criteria Speed in Responding to Customer Requests (S3)	0.066168	Consistent
4	Between Sub-criteria Quick Response in Resolving Customer Complaints (S4)	0.017288	Consistent

Table 4.23 Alternatives in Sub-criteria Price (P) Consistency Ratio Value

No	Matrix	Value of CR	Explanation
1	Between Sub-criteria Price Appropriateness with the Quality of Goods Produced (P1)	0.05343	Consistent
2	Between Sub-criteria The Ability to Give Discounts on Specific Orders (P2)	0.022764	Consistent

In the Table 4.19 until 4.23, it can be seen that the CR value for each comparison matrix between alternatives in each sub-criteria shows a value below 0.1

($CR \leq 0.1$). This value indicates that owner's assessment of the alternatives of each sub-criterion is consistent. Then it can be concluded that the respondents' assessment is following the real conditions.

5. Form a Supermatrixes

After entering all comparative value data, an unweighted matrix, weighted matrix, and limit matrix are obtained. The value in the limit matrix is a priority value that shows the weight of each sub-criterion. Reduction or addition of criteria or sub-criteria will significantly affect the weighing results. There are three supermatrixes formed, namely, unweighted, weighted, and limit. The process of research data processing carried out with the help of Super Decisions software.

a. Unweighted Super Matrix

Unweighted Super Matrix is transformation of each pairwise comparison matrix value into one large matrix form. Unweighted Super Matrix formed can be seen in the figure below.

Cluster Node Labels		Accuracy in Quantity	Alternatives					Goal	On-time Delivery
Accuracy and Appropriateness of Supplies in Shipment		Accuracy and Appropriateness of Supplies in Shipment	Kulon Progo (Mr. Jayus)	Magelang (Mr. Yadi)	Sleman (Mr. Aris)	Sleman (Mr. Heri)	Sleman (Mr. Ujang)	Best Supplier for Cebongan Bamboo Center	Ability in Terms of Handling the Transportation System
Accuracy in Quantity	Accuracy and Appropriateness of Supplies in Shipment	0.000000	1.000000	1.000000	1.000000	1.000000	1.000000	0.000000	
Alternatives	Kulon Progo (Mr. Jayus)	0.193812	0.000000	0.000000	0.000000	0.000000	0.000000	0.161298	
	Magelang (Mr. Yadi)	0.193812	0.000000	0.000000	0.000000	0.000000	0.000000	0.223304	
	Sleman (Mr. Aris)	0.233323	0.000000	0.000000	0.000000	0.000000	0.000000	0.153564	
	Sleman (Mr. Heri)	0.204897	0.000000	0.000000	0.000000	0.000000	0.000000	0.210309	
	Sleman (Mr. Ujang)	0.173956	0.000000	0.000000	0.000000	0.000000	0.000000	0.251526	
Goal	Best Supplier for Cebongan Bamboo Center	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
On-time Delivery	Ability in Terms of Handling the Transportation System	0.000000	0.500000	0.666667	0.333333	0.666667	0.500000	0.000000	

Figure 4.8 Unweighted Super Matrix Formed

b. Weighted Super Matrix

The Weighted Super Matrix's value is obtained by increasing the weight of each comparison node with the eigenvector value in each cluster connected; the shape of this matrix can be seen in the figure.

Cluster Node Labels		Accuracy in Quantity	Alternatives					Goal	On-time Delivery
		Accuracy and Appropriateness of Supplies in Shipment	Kulon Progo (Mr. Jayus)	Magelang (Mr. Yadi)	Sleman (Mr. Aris)	Sleman (Mr. Heri)	Sleman (Mr. Ujang)	Best Supplier For Cebongan Bamboo Center	Ability in Terms of Handling the Transportation System
Accuracy in Quantity	Accuracy and Appropriateness of Supplies in Shipment	0.000000	0.200000	0.200000	0.200000	0.200000	0.200000	0.200000	0.000000
Alternatives	Kulon Progo (Mr. Jayus)	0.193812	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.161298
	Magelang (Mr. Yadi)	0.193812	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.223304
	Sleman (Mr. Aris)	0.233523	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.153564
	Sleman (Mr. Heri)	0.204897	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.210309
	Sleman (Mr. Ujang)	0.173956	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.251526
Goal	Best Supplier for Cebongan Bamboo Center	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
On-time Delivery	Ability in Terms of Handling the Transportation System	0.000000	0.100000	0.133333	0.066667	0.133333	0.133333	0.100000	0.000000

Figure 4.9 Weighted Super Matrix Formed

c. Limiting Super Matrix

The results obtained in the Weighted Super Matrix are then increased by the weight with the overall eigenvalue vector cluster so that the results obtained are shown in the figure.

Cluster Node Labels		Accuracy in Quantity	Alternatives					Goal	On-time Delivery
		Accuracy and Appropriateness of Supplies in Shipment	Kulon Progo (Mr. Jayus)	Magelang (Mr. Yadi)	Sleman (Mr. Aris)	Sleman (Mr. Heri)	Sleman (Mr. Ujang)	Best Supplier For Cebongan Bamboo Center	Ability in Terms of Handling the Transportation System
Accuracy in Quantity	Accuracy and Appropriateness of Supplies in Shipment	0.101363	0.101363	0.101363	0.101363	0.101363	0.101363	0.101363	0.101363
Alternatives	Kulon Progo (Mr. Jayus)	0.085100	0.085100	0.085100	0.085100	0.085100	0.085100	0.085100	0.085100
	Magelang (Mr. Yadi)	0.085555	0.085555	0.085555	0.085555	0.085555	0.085555	0.085555	0.085555
	Sleman (Mr. Aris)	0.100191	0.100191	0.100191	0.100191	0.100191	0.100191	0.100191	0.100191
	Sleman (Mr. Heri)	0.102054	0.102054	0.102054	0.102054	0.102054	0.102054	0.102054	0.102054
	Sleman (Mr. Ujang)	0.079846	0.079846	0.079846	0.079846	0.079846	0.079846	0.079846	0.079846
Goal	Best Supplier for Cebongan Bamboo Center	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
On-time Delivery	Ability in Terms of Handling the Transportation System	0.050850	0.050850	0.050850	0.050850	0.050850	0.050850	0.050850	0.050850

Figure 4.10 Limiting Super Matrix Formed

d. Analysis of Sub-Criteria Weights and Supplier Priorities

The weight of the sub-criteria determines the priority of each of the existing sub-criteria. Where the sub-criteria that has the highest weight gets the most top priority while the sub-criteria with the lowest weight will not be the priority or the last consideration by the company. The weight of the sub-criteria and alternatives can be seen in the limiting value column in the table 4.24. On the table 4.24, weights consist of two types, namely global weights (limiting value) and cluster weights (normalized by cluster). The global weight (limiting value) indicates the weight of the sub-criteria compared to other sub-criteria in the model as a whole. In contrast, the cluster weight is the normalization result of the global weight which shows the weight of the sub-criteria in the cluster.

Table 4.24 Sub-Criteria Weights and Alternative Suppliers

Cluster	Sub-Criteria	Sub-Criteria Weights	
		Normalized by Cluster	Limiting
Quality	Compliance of goods with specifications that have been set	0.31000	0.032441
	Supply of goods without defects	0.26945	0.028197
	Ability to provide consistent quality	0.42055	0.044010
On-time Delivery	The ability to deliver goods according to the agreed date	0.43843	0.039699
	Ability in terms of handling the transportation system	0.56157	0.050850
Accuracy in Quantity	Accuracy and appropriateness of supplies in shipment	1.00000	0.101363
Services	Ease of contact	0.18321	0.022266
	The ability to provide information clearly and easily understood	0.25326	0.030779
	Speed in responding to customer requests	0.36827	0.044756
	Quick response in resolving customer complaints	0.19527	0.023731
Price	Price appropriateness with the quality of goods produced	0.43046	0.055600
	The ability to give discounts on specific orders	0.56954	0.073563
Alternatives	Magelang (Mr. Yadi)	0.18897	0.085555
	Kulon Progo (Mr. Jayus)	0.18796	0.085100
	Sleman (Mr. Aris)	0.22130	0.100191
	Sleman (Mr. Heri)	0.22541	0.102054
	Sleman (Mr. Ujang)	0.17636	0.079846

Based on the results of data processing with Super Decision software, it is known that the sub-criteria that has the highest weight is accuracy and appropriateness of supplies in shipment with a value of 0.101363. In contrast, ease of contact has the lowest weight with a value of 0.022266. The accuracy and appropriateness of supplies in the shipment has the highest weight in sub-criteria for Cebongan Bamboo Center. Cebongan Bamboo Center considers that the accuracy and appropriateness of supplies in shipment is the first thing that suppliers must pay attention. It relates to the raw material procurement process, especially related to the production process of making bamboo crafts, determining the purchase price, and the customer demand for bamboo products. The ease of contact sub-criteria has the lowest weight because on average, all suppliers from Cebongan Bamboo Center are easy to contact; it is rare not to be approached except suppliers who have something urgent.

The weight of the sub-criteria is assessed based on its effect on other sub-criteria in the same or different clusters. Each criterion has a different overall weight so that it will affect the weight of the sub-criteria in it and also the alternative cluster. Based on the results of ANP data processing shown in the table 4.24, it is known that Sleman supplier (Mr Heri) has the highest limiting value among other suppliers, namely 0.102054; then consecutively the highest to lowest values were Sleman suppliers (Mr Aris) with a value of 0.100191, Magelang suppliers (Mr Yadi) with a value of 0.085555, suppliers of Kulon Progo (Mr Jayus) with a value of 0.085100, and finally, suppliers of Sleman (Mr Ujang) with a value of 0.079846.

e. Solution on Super Decision

A comprehensive calculation that has been carried out by Super Decision will be displayed on a form called synthesise, so it can be seen the ranking of each alternative. Synthesis can be shown in the Figure below.

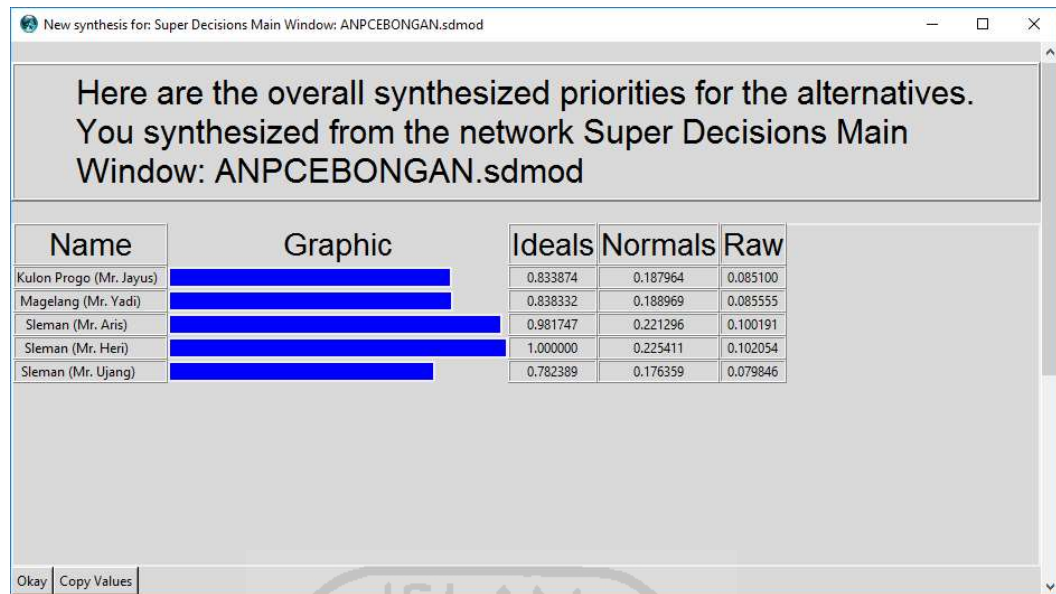


Figure 4.11 Synthesized Result of Suppliers in Cebongan Bamboo Center

From the weighted value that has been obtained, each alternative is ranked. When looking for alternative ranking weights from suppliers, starting from finding the global weight which is the eigenvector value of the super matrix limiting normalization, then looking for the cluster weight obtained from the global weight value of the alternatives divided by the total number of global weights. While the last one is looking for the ideal weight obtained from the results for the cluster weight of the alternative with the highest cluster weight, then the result of the ideal alternative priority weight is Sleman supplier (Mr Heri), namely raw = 0.102054, normal = 0.225411 and ideal = 1. The alternative ranking is seen from the value in the ideal column, which has the highest value, so he is the best alternative according to the Analytical Network Process (ANP) method. Alternative rankings can be seen in the Figure 4.12.

Based on the Figure, it appears that the Sleman supplier (Mr Heri) is the first ranking alternative with the highest value of 1; then Sleman supplier (Mr Aris) in the second position with a value of 0.981747; Magelang supplier (Mr Yadi) in 3rd position with a value of 0.838332; Kulon Progo supplier (Mr Jayus) in rank 4 with a value of 0.833874; and Sleman supplier (Mr Ujang) was ranked last with a value of 0.782389.

Furthermore, after doing and obtaining priority results from several suppliers of Cebongan Bamboo Center, to determine the maximum potential loss estimate for a certain period with a certain confidence level and in normal market conditions, the VaR is calculated or often called value at risk. VaR is the largest loss that may occur within a certain time span predicted with a certain level of confidence (Taylor, 2016). This loss can be anticipated by allocating reserve funds.

The VaR value can be calculated by the following formula.

$$\text{VaR} = \bar{x} + z \left(\frac{s}{\sqrt{n}} \right) \quad (4.7)$$

Where:

- VaR = the impact of losses caused by risky events
- \bar{x} = the average value of the loss due to risky events
- z = z value taken from normal distribution table with alpha 5%
- s = standard deviation of losses due to risky events
- n = the number of risk events

To calculate the z value using the value of the z score, the z score is the standard normal variable value of the probability of the level of confidence in the risk. The value on the z score can be seen in the table below.

Table 4.25 Z Score's Level of Confidence

	Level of Confidence (%)			
α	99 ($\alpha = 1$)	97.5 ($\alpha = 2.5$)	95 ($\alpha = 5$)	90 ($\alpha = 10$)
Z score	2.326	1.960	1.645	1.282

There are several instruments that must be considered by companies to prioritize suppliers, including transportation cost, staffing (HR) management, document management, sample products, value creation, standardizations, continuous monitoring and customer confidence. Some of the above instruments have been done before prioritizing suppliers (under normal conditions), but among others there have not been done optimally. The

following table is a breakdown of the costs of investing before prioritizing the suppliers and after prioritizing the suppliers.

Table 4.26 Cost Breakdown in Cebongan Bamboo Center

Event (Code)	Description	Investment in Rupiah (Before Prioritizing Suppliers)	Investment in Rupiah (After Prioritizing Suppliers)
P1	Transportation Cost	2,500,000	700,000
P2	Staffing (HR) Management	60,000	320,000
P3	Document Management	50,000	200,000
P4	Sample Products	520,000	380,000
P5	Value Creation	500,000	1,200,000
P6	Standardizations	410,000	960,000
P7	Continuous Monitoring	180,000	540,000
P8	Customer Confidence	880,000	600,000
	Total Investment	5,100,000	4,900,000
	Average (\bar{x})	637,500	612,500
	Standard Deviation (σ)	801,797.09	335,676.29

It can be seen from the table above that the biggest investment is the investment made before prioritizing suppliers, for the total comparison there is only a difference of 200,000 rupiah. In the table after prioritizing suppliers, several investment cuts were made, such as in transportation costs, product sample, and customer confidence because after prioritizing suppliers was considered more orderly with clearer company, good supplier systems and procedures. Before doing a mathematical calculation, the table below will show several components needed in the calculation, including investment value, expected return, standard deviation, return, and n.

Table 4.27 Components Needed in VaR Calculation

	Investments Before Prioritizing Suppliers	Investments After Prioritizing Suppliers
Investment value (I)	5,100,000	4,900,000
Expected Return (ER)	20%	20%
Standard Deviation (σ)	801,797.09	335,676.29
Return ($x = I.ER$)	1,020,000	980,000
n	1	1

$$\begin{aligned} \text{Investments before prioritizing suppliers} &= 1,020,000 + 1.645 \left(\frac{801,797.09}{\sqrt{8}} \right) \\ &= 1,486,321.44 \end{aligned}$$

$$\begin{aligned} \text{Investments after prioritizing suppliers} &= 980,000 + 1.645 \left(\frac{335,676.29}{\sqrt{8}} \right) \\ &= 1,175,227.76 \end{aligned}$$

From the results of the VaR calculation above, the best investment is after prioritizing suppliers, because it produces a smaller VaR value, meaning that Cebongan Bamboo Center has to provide less reserves to anticipate risks. So that the results of VaR investments after prioritizing suppliers can become a company's reference for the possibility or probability of incurring losses that are greater than the predetermined rate of losses.



CHAPTER 5

DISCUSSION

The evaluation for suppliers needs to be determined by SMEs to solve the problem of delay in product delivery to the customer, the problem in without any agreement and sign on paper when negotiating with customers, and the problem of raw material delays from suppliers Cebongan Bamboo Center. If this evaluation is not implemented, it will undoubtedly harm the company both in terms of time and cost. So, measure the potential risks that exist in the supply chain, determine the priorities of the risks that exist in the sourcing, and to identify supplier criteria at the Cebongan Bamboo Center uses the House of Risk (HOR) and Analytical Network Process (ANP) methods.

House of Risk method is a renewable method for carrying out risk mapping and risk mitigation plans within the appropriate to be applied for observations. At the stage of HOR, the first step in data collection begins with identifying the business processes within the departments being observed. A business process consists of a set of processes or sub-processes containing all activities related to one another and work together to produce a particular output. The identification of business processes follows the way of establishing SCOR by adopting five management processes. Previously, the objective analysis was carried out at each stage of the operational business process. The purpose of the formulation of goals to be achieved at each step of the business process is to identify events that can hinder or affect company goals. The next step is identifying the risk event and risk agent process in the company. A risk event is an event when the deviation of objectives happened. While risk agent is the aspects causing the risk occurred. It is found that there are 23 risk events at Cebongan Bamboo Center. The risk events have a different level of severity. The level of severity is defined in the form of number 1-10 which 1 has the lowest severity and 10 is the highest severity. Next, another aspect considered was the risk agent. Probability of occurrence is defined in number 1-10, which 1 is the lowest occurrence probability, and 10 is the highest occurrence probability. The result obtained is that there are 19 risk agents in which one risk cause can cause one or more risk events in Cebongan Bamboo Center.

From each risk event and risk agent, then it is followed by mapping the Aggregate Risk Potential (ARP) value with the House of Risk (HOR) Matrix Phase 1. The correlation values were carried out with a scale of 0, 1, 3, and 9. A value of 0 is given if there is no relationship between risk agent and risk events; a value of 1 is given if there is a small correlation, a value of 3 is given if there is a moderate correlation, and a value of 9 is given if the relationship between the source of risk and the risk is very high. The calculation of the ARP value is used to determine the priority of risk agents that need to be handled first and given precautionary measures against risk agents. Also, from the first house of risk, the aggregate risk potential will be identified and being ranked. The next step is risk evaluation. There are two steps at the risk evaluation stage, namely determining the risk agent rating according to the calculated ARP value and determining the priority of the risk agent to be reduced by predetermined mitigation actions. At this stage, the evaluation of the risk event is to determine which risk agent will be treated using the Pareto diagram. The result of HOR phase 1 is sorted from the highest ARP to the smallest ARP. Before going to the second house of risk, the identification of prioritized risk agent is briefly visualized using Pareto Diagram. The first highest ARP value is risk agent A6 or error in choosing suppliers. The second is the risk agent A13 or supplier does not arrive on schedule. The third is the risk agent A8 or weakness in the memorandum of agreement. Finally, the fourth is risk agent A14 or scarcity of raw materials.

Next, in HOR phase 2, there is a mitigation action which is the main requirement. A mitigation action is an action to reduce the impact of a risk agent before the risk occurs. Alternative mitigation actions are obtained from brainstorming and references to related journals. There are five recommended treatment strategies for Cebongan Bamboo Center that can be used to eliminate or reduce risk agents' appearance, including multi-optional trusted supplier, construct a regulation with strict sanction, create a safety stock, make a scheduled coordination with supplier, and perform some work agreements at the beginning that agreed by all parties. Based on the risk agent's priority problems based on the Aggregate Risk Potential value and the Pareto Diagram, several preventive actions can be considered a solution to the problem. The calculations in HOR phase 2 have provided direction regarding the priority of mitigation actions that the company should take. At this stage, several

treatment strategies will be selected, which are considered effective in reducing the probability of impact caused by the risk agent. The steps taken in this phase are starting with the design of a handling strategy, finding the relationship between the treatment strategy and the risk agent, calculating the value of Total Effectiveness (TE_k), Degree of Difficulty (D_k) and the ratio of Effectiveness to Difficulty (ETD_k) to determine priority ranking of the existing strategy. The level of difficulty is measured using a likert scale of 3 to 5. A scale of 5 indicates the most difficult level in implementing preventive action, then a scale of 3 means the easiest level in implementing preventive action. The degree/level of difficulty of implementing preventive action can be determined by several factors, including the design of the costs to be issued, the resources needed, and the required time. The second step is to measure the effectiveness to difficulty ratio, by dividing the total value of effectiveness (TE_k) by the degree of difficulty taking action. Before going into the discussion about mitigation actions from HOR 2 and Cebongan Bamboo Center owner can analyze the problem to its root, a Fishbone Diagram analysis will be carried out first of the selected risk agents based on the Pareto diagram.

After that, the preventive action sequence will be calculated as a direction for the company to improve the sourcing system. Preventive action is calculated based on historical data that carried out or planned by the Cebongan Bamboo Center. From the second phase of house of risk, the risk mitigation action with the highest ranking is make a scheduled coordination with a supplier which has a total effectiveness value (TE_k) of 40104, a degree of difficulty effectiveness value (ETD_k) of 13368 and value of the degree of difficulty (D_k) is 3 which means this action is easy to implement. A supply chain is an organizational system in which there are roles and perform various activities, including information, funds, and other resources that are interrelated in the movement of a product or service from supplier to customer. With the achievement of coordination of the company's supply chain, including suppliers, each channel of the company's supply chain will not experience a shortage of goods nor too many excess goods.

The second-highest-ranking risk mitigation action is a multi-optional trusted supplier, which has a total effectiveness value (TE_k) of 51780, a degree of difficulty effectiveness value (ETD_k) of 10356 and a degree of difficulty (D_k) value of 5 which means this action is

difficult to implement. Cebongan Bamboo Center cannot be separated from the suppliers. Having only a few suppliers to supply certain products might cause some risks to the company, such as the risk of getting out of stock. The fixed delivery schedule agreed by both owner and the supplier is sometimes not suitable for the real demand condition. In this case, the choosing of a multi optional supplier can be used. By having some optional suppliers, the owner can be free to adjust the stock with real demand conditions (Yao & Minner, 2017). The choice of a trusted supplier is also essential. A careless supplier will cause some risks to the company, such as the risk of a defective product, late delivery product, etc.

The third-highest-ranking risk mitigation action is the construct a regulation with strict sanctions, which has a total effectiveness value (TE_k) of 21384, a degree of difficulty effectiveness value (ETD_k) is 7128, and a value of the degree of difficulty (D_k) is 3 which means this action is easy to implement. The human error contributes high effect to the risk event. Disciplinary of the owner to workers or suppliers is needed to control the business (O'Connell et al, 2017). Construct a regulation with strict sanctions can facilitate the objectives of disciplinary the stakeholder. For the worker, the regulation will increase the awareness to do the job properly and decrease some risk events, such as the error of inputting inventory data in the company. For the supplier, the regulation with a strict sanction is needed to apply suppliers to decrease the probability of risk events, such as the breach of a supplier contract agreement.

The fourth-highest-ranking risk mitigation action is to perform some work agreements at the beginning that agreed by all parties which have a total effectiveness value (TE_k) of 27792, a degree of difficulty (ETD_k) of 5558.4 and value of the degree of difficulty (D_k) of 5 which means this action is difficult to implement. The company shall establish and maintain written procedures for carrying out contract reviews and for coordinating these activities to all relevant parties. In this day and age, many companies that do business and do work only with "trust". This condition usually often happens when there is a business collaboration with friends or family. This trust capital is often a problem in business. Work agreements serve as a factor to increase company revenue and maintain good relationships with clients (Mioch et al, 2018). In the work agreement contract, it can be written what the parties have agreed upon and will happen if the parties violate the contract. Not only making

contracts, to manage this risk, the owner of Cebongan Bamboo Center must also understand the contents of the agreement before signing the contract.

The risk mitigation action with the fifth-highest-ranking is creating a safety stock which has a total effectiveness value (TE_k) of 7440, a degree of difficulty (ETD_k) effectiveness value of 1860 and a degree of difficulty (D_k) is 4 which means this action is rather difficult to implement. Customer demand sometimes cannot be predicted accurately. Decreasing demand can be prevented by having good marketing to increase the sell. If demand is very high, it can cause the risk of out of stock in Cebongan Bamboo Center. Creating a safety stock can be used to prevent the risk (RĀDĀŞANU, 2016).

In addition to providing fishbone diagram and some preventive actions, to give a priority of the company in determining suppliers, the researcher tries to help reduce the problem of risk in sourcing using the Analytical Network Process (ANP) method. At the stage of ANP, a basis for consideration in choosing the best supplier are obtained by conducting interviews with the owner of the Cebongan Bamboo Center as the decision-maker and the procurement division as the recipient of the goods. So, there are two parts involved. During this discussion, several criteria and sub-criteria from previous research were proposed, which would later adapt to the current situation at Cebongan Bamboo Center. The interview results and questionnaire process that have been collected then obtained 5 criteria, 12 sub-criteria, and 5 alternatives. After determining the criteria and sub-criteria, the next step is to determine the relations to the criteria and sub-criteria. The relations between criteria or relation between criteria and sub-criteria is obtained from the owner of Cebongan Bamboo Center. After completing the relationship between the criteria and sub-criteria, the next step is to make the ANP model into the Super Decision software. Super Decisions is an application that implements the Analytical Network Process (ANP), which is useful as a decision-maker with dependence and feedback. By entering the weighting questionnaire data distributed to the Super Decisions application, this application can determine the weighting for each data that has been inputted. Next step is make a pairwise comparison matrix. The process of filling out the questionnaire takes a long time because of the large number of interaction interactions that must be filled. Expert respondents were asked to rate on the ANP 1-9 scale. All of CR value for each comparison matrix between goal in each criteria, sub-criteria in each

alternatives, and alternatives in each sub-criteria shows a value below 0.1 ($CR \leq 0.1$). This value indicates that owner's assessment is consistent. Then it can be concluded that the respondents' assessment is following the real conditions.

After entering all comparative value data by using the computation command, next, an unweighted matrix, weighted matrix, and the limit matrix will be obtained. The unweighted matrix is made based on pairwise comparisons between clusters, criteria, and alternatives by entering the column's priority vector (eigenvector) into the matrix corresponding to the cell. After that, the weighted matrix is obtained by multiplying all the weighted matrix elements by the values contained in the appropriate cluster matrix. Each column has the sum of one. The limit matrix is obtained by multiplying the matrix by itself several times. The weight of the sub-criteria determines the priority of each of the existing sub-criteria. Where the sub-criteria that has the highest weight gets the most top priority while the sub-criteria with the lowest weight will not be the priority or the last consideration by the company. Based on the results of data processing with Super Decision software, it is known that the sub-criteria that has the highest weight is accuracy and appropriateness of supplies in shipment. The accuracy and appropriateness of supplies in the shipment has the highest weight in sub-criteria for Cebongan Bamboo Center. The weight of the sub-criteria is assessed based on its effect on other sub-criteria in the same or different clusters. Each criterion has a different overall weight so that it will affect the weight of the sub-criteria in it and also the alternative cluster. The weight of importance of the sub-criteria shows the order of priority or the sub-criteria's influence in evaluating and determining supplier priorities. The greater the weight of a sub-criteria, the higher the priority or, the greater the sub-criteria's influence in the evaluation process and determining supplier priorities, and vice versa. Based on the results of ANP data processing, it is known that Sleman supplier (Mr Heri) has the highest limiting value among other suppliers; then consecutively the highest to lowest values were Sleman suppliers (Mr Aris), Magelang suppliers (Mr Yadi), suppliers of Kulon Progo (Mr Jayus), and finally, suppliers of Sleman (Mr Ujang).

A comprehensive calculation that has been carried out by Super Decision will be displayed on a form called synthesise, so it can be seen the ranking of each alternative. In synthesise there is ideal weight. Ideal weight obtained from the results for the cluster weight

of the alternative with the highest cluster weight, then the result of the ideal alternative priority weight is Sleman supplier (Mr Heri); then Sleman supplier (Mr Aris) in the second position; Magelang supplier (Mr Yadi) in 3rd position; Kulon Progo supplier (Mr Jayus) in rank 4; and Sleman supplier (Mr Ujang) was ranked last. This supplier performance evaluation is periodic; the company can, at any time, assess the supplier's performance. The evaluation results can be used as a proposed decision by the owner, especially the operational division, to determine the number of orders for raw materials because it will be affected by each supplier's performance. Suppliers who have better performance than other suppliers will get a higher number of orders. Based on the supplier evaluation results, it gives the result that all suppliers can be declared to have passed the evaluation even though they have different performances.



CHAPTER 6

CONCLUSION AND SUGGESTION

This chapter describes the conclusions based on the results of the analysis and discussion referring to the research objectives and suggestions as input.

6.1 Conclusion

From the results of this study regarding the objective of chapter 1, there are several conclusions obtained, including:

1. The five appropriate mitigation strategy for dealing with sources of risk from the result of HOR 2 include:
 - a. First, making a scheduled coordination with supplier. The risk mitigation action with the highest ranking is make a scheduled coordination with a supplier which has a total effectiveness value (TE_k) of 40104, a degree of difficulty effectiveness value (ETD_k) of 13368 and value of the degree of difficulty (D_k) is 3 which means this action is easy to implement. With the achievement of coordination of the company's supply chain, including suppliers, each channel of the company's supply chain will not experience a shortage of goods nor too many excess goods.
 - b. The second is multi-optional trusted supplier. The second-highest-ranking risk mitigation action is a multi-optional trusted supplier, which has a total effectiveness value (TE_k) of 51780, a degree of difficulty effectiveness value (ETD_k) of 10356 and a degree of difficulty (D_k) value of 5 which means this action is difficult to implement. In the ANP method that the author has done above, there are recommendations for the Cebongan Bamboo Center with the ideal alternative priority. The fixed delivery schedule agreed by both owner and the supplier is sometimes not suitable for the real demand condition. In this case, the choosing of a multi optional supplier can be used.

- c. The third is to construct a regulation with strict sanction. The third-highest-ranking risk mitigation action is the construct a regulation with strict sanctions, which has a total effectiveness value (TE_k) of 21384, a degree of difficulty effectiveness value (ETD_k) is 7128, and a value of the degree of difficulty (D_k) is 3 which means this action is easy to implement. Construct a regulation with strict sanctions can facilitate the objectives of disciplinary the stakeholder. For the worker, the regulation will increase the awareness to do the job properly and decrease some risk events, such as the error of inputting inventory data in the company. For the supplier, the regulation with a strict sanction is needed to apply suppliers to decrease the probability of risk events, such as the breach of a supplier contract agreement.
 - d. The fourth is to perform some work agreements at the beginning that agreed by all parties. The fourth-highest-ranking risk mitigation action is to perform some work agreements at the beginning that agreed by all parties which have a total effectiveness value (TE_k) of 27792, a degree of difficulty (ETD_k) of 5558.4 and value of the degree of difficulty (D_k) of 5 which means this action is difficult to implement. In the work agreement contract, it can be written what the parties have agreed upon and will happen if the parties violate the contract. Not only making contracts, to manage this risk, the owner of Cebongan Bamboo Center must also understand the contents of the agreement before signing the contract.
 - e. The fifth is to create a safety stock. The risk mitigation action with the fifth-highest-ranking is creating a safety stock which has a total effectiveness value (TE_k) of 7440, a degree of difficulty (ETD_k) effectiveness value of 1860 and a degree of difficulty (D_k) is 4 which means this action is rather difficult to implement. Customer demand sometimes cannot be predicted accurately. Decreasing demand can be prevented by having good marketing to increase the sell. If demand is very high, it can cause the risk of out of stock in Cebongan Bamboo Center.
2. The priority order of handling risks originating from the sourcing of Cebongan Bamboo Center based on the Pareto Diagram. Risk in sourcing are the risk agents with attribute A6, A13, A8, A14. For A1, it is related to the plan. The first highest

ARP value is risk agent A6 or error in choosing suppliers with a total value of 3944 and a cumulative percentage of 30.1%. The second is the risk agent A13 or supplier does not arrive on schedule with a total ARP value of 2376 and a cumulative percentage of 48.2%, the third is the risk agent A8 or weakness in the memorandum of agreement with a total ARP value of 2296 and a cumulative percentage of 65.7%. Finally, the fourth is risk agent A14 or scarcity of raw materials with a total ARP value of 756 and a cumulative percentage of 71.5%. Then, the result of the ideal alternative priority weight based on ANP is Sleman supplier (Mr Heri), namely raw = 0.102054, normal = 0.225411 and ideal = 1. ; then Sleman supplier (Mr Aris) in the second position with a value of 0.981747; Magelang supplier (Mr Yadi) in 3rd position with a value of 0.838332; Kulon Progo supplier (Mr Jayus) in rank 4 with a value of 0.833874; and Sleman supplier (Mr Ujang) was ranked last with a value of 0.782389.

6.2 Suggestion

Based on the assessment of the results of research in the field, the author intends to provide suggestions that hopefully can be useful for the company (SMEs), for the next researcher, and the faculty, as follows:

1. For the next researchers

As for some suggestions that need to be considered for further researchers who are interested in researching about this research are:

- a. Future researchers are expected to review more sources and references related to the HOR and ANP methods so that the results of their research can be better and more complete.
- b. Future researchers are expected to better prepare themselves in the collection process so that research can carry out better. The next researcher is expected to be supported by interviews with sources who are competent in the HOR and ANP studies more deeply.

- c. The interviewees used in this study was only 3 peoples in the company. Future research is expected to increase the number of interviewees to use so that it will approach results that are accurate to the actual conditions.
 - d. It is expected that in future studies to use other types of companies as research objects.
 - e. Besides, it is necessary to conduct supplier review and risk in sourcing mitigation periodically and continuously, so that it will be expected to provide benefits to the company from time to time. Because of the risk, the company's supply chain flow, and handling strategies are growing along with the development of time.
2. For the Faculty of Industrial Technology UII
- a. These results are expected to become reference material for other students who want to carry out practical work and/or undergraduate thesis.



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APPENDICES I

Analytical Network Process (ANP) Questionnaire Question Attributes (Has Been Filled in by Owner of Cebongan Bamboo Center)

LAMPIRAN – Kuisisioner Analytical Network Process (ANP)

KUISISIONER ANALYTICAL NETWORK PROCESS (ANP)

Dalam rangka melengkapi penulisan skripsi di Universitas Islam Indonesia, saya Muhammad Yudiarto ingin mengajukan permohonan pengisian kuisisioner. Tujuan dari pengisian kuisisioner ini adalah mengetahui prioritas penanganan sumber risiko dalam rantai pasokan di UKM Bambu Cebongan dan dapat merancang strategi mitigasi yang tepat untuk menangani sumber risiko dalam rantai pasokan di UKM Bambu Cebongan. Pada akhirnya, diharapkan akan memberikan manfaat bagi UKM untuk dapat mengetahui pemasok yang diinginkan, dapat mengidentifikasi risiko yang dapat timbul dalam aliran rantai pasokan UKM, dan dapat mengetahui strategi penanganan yang dapat dilakukan dalam menangani risiko yang terjadi di UKM Bambu Cebongan.

Adapun data yang akan diperoleh dari kuisisioner ini hanya untuk penelitian. Untuk informasi lebih lanjut Anda bisa menghubungi saya Muhammad Yudiarto di nomor 081364060864.

Profil Responden

Jawaban diisi di tempat yang telah disediakan, untuk jawaban pilihan mohon dilingkari salah satu jawaban yang benar.

Nama Lengkap (beserta gelar) : Paidi
Jenis Kelamin : L / P
Usia : 40 tahun
No Telp / Hp : 081328834435
Alamat : Sendon, Sleman, Yogyakarta
Jabatan (saat ini) : Pemilik UKM Bambu Cebongan
Pangkat / Golongan : -

Petunjuk Pengisian:

1. Untuk memberikan penilaian terhadap elemen-elemen permasalahan dari setiap tingkat yang sedang diteliti prioritasnya, penilaian dituliskan dalam skala numerik (skala 1 hingga 9) dengan keterangan seperti di tabel berikut:

Intensitas Kepentingan	Keterangan
1	Kedua elemen sama pentingnya
3	Elemen yang satu sedikit lebih penting daripada elemen yang lainnya
5	Elemen yang satu lebih penting daripada yang lainnya
7	Satu elemen sangat lebih penting daripada elemen lainnya
9	Satu elemen mutlak lebih penting daripada elemen lainnya
2,4,6,8	Nilai-nilai antara dua nilai pertimbangan-pertimbangan yang berdekatan

2. Kuisisioner ini menggunakan metode ranking untuk menilai besarnya pengaruh antara satu elemen dengan elemen lainnya (beri tanda checklist pada kotak skala).
3. Jika elemen pada kolom sebelah **kiri** lebih penting dari elemen pada kolom sebelah **kanan**, nilai perbandingan ini diisikan pada kolom sebelah **kiri**, dan sebaliknya, jika elemen pada kolom sebelah **kanan** lebih penting maka diisikan pada sebelah **kiri**, nilai perbandingan ini diisikan pada kolom sebelah **kanan**. (lihat contoh di bawah ini).

Contoh pengisian kuisisioner:

Kriteria	Skala																		Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
Pak Jayus									✓									Pak Yadi	

Artinya: Pak Jayus **sama pentingnya** Pak Yadi

Kriteria	Skala																		Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
Pak Jayus			✓															Pak Yadi	

Artinya: Pak Jayus **sangat lebih penting** dari Pak Yadi

Kriteria	Skala																	Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus																	✓	Pak Yadi

Artinya: Pak Jayus **mutlak lebih penting** dari Pak Yadi

Sub-Kriteria dalam Alternatif Magelang (Pak Yadi)

Sub-Kriteria	Skala																	Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Q1								✓										Q2
Q1									✓									Q3
Q2										✓								Q3
O1										✓								O2
S1									✓									S2
S1									✓									S3
S1									✓									S4
S2									✓									S3
S2									✓									S4
S3								✓										S4
P1								✓										P2

Sub-Kriteria dalam Alternatif Kulon Progo (Pak Jayus)

Sub-Kriteria	Skala																	Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Q1									✓									Q2
Q1									✓									Q3
Q2								✓										Q3
O1									✓									O2
S1								✓										S2

Sub-Kriteria	Skala																		Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
S1										✓								S3	
S1									✓									S4	
S2										✓								S3	
S2									✓									S4	
S3									✓									S4	
P1									✓									P2	

Sub-Kriteria dalam Alternatif Sleman (Pak Aris)

Sub-Kriteria	Skala																		Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
Q1								✓										Q2	
Q1									✓									Q3	
Q2										✓								Q3	
O1								✓										O2	
S1									✓									S2	
S1									✓									S3	
S1									✓									S4	
S2									✓									S3	
S2									✓									S4	
S3									✓									S4	
P1										✓								P2	

Sub-Kriteria dalam Alternatif Sleman (Pak Heri)

Sub-Kriteria	Skala																		Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9		
Q1									✓									Q2	

Sub-Kriteria	Skala																			Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9			
Q1									✓										Q3	
Q2								✓											Q3	
O1										✓									O2	
S1									✓										S2	
S1									✓										S3	
S1										✓									S4	
S2									✓										S3	
S2										✓									S4	
S3									✓										S4	
P1									✓										P2	

Sub-Kriteria dalam Alternatif Sleman (Pak Ujang)

Sub-Kriteria	Skala																			Sub-Kriteria
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9			
Q1									✓										Q2	
Q1									✓										Q3	
Q2									✓										Q3	
O1										✓									O2	
S1								✓											S2	
S1									✓										S3	
S1									✓										S4	
S2									✓										S3	
S2									✓										S4	
S3									✓										S4	
P1									✓										P2	

Alternatif dalam Sub-kriteria Bagian Q1 → Kualitas Supplier Berdasarkan: Kesesuaian Barang dengan Spesifikasi yang Telah Ditetapkan

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus										✓								Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi										✓								Pak Aris
Pak Yadi								✓										Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris										✓								Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian Q2 → Kualitas Supplier Berdasarkan: Persediaan Barang Tanpa Cacat

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus								✓										Pak Aris
Pak Jayus										✓								Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi										✓								Pak Aris
Pak Yadi									✓									Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris								✓										Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri									✓									Pak Ujang

Alternatif dalam Sub-kriteria Bagian Q3 → Kualitas Supplier Berdasarkan: Kemampuan Untuk Memberikan Kualitas yang Konsisten

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus								✓										Pak Yadi
Pak Jayus										✓								Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi										✓								Pak Heri
Pak Yadi								✓										Pak Ujang
Pak Aris								✓										Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri									✓									Pak Ujang

Alternatif dalam Sub-kriteria Bagian O1 → Pengiriman Tepat Waktu Supplier Berdasarkan: Kemampuan untuk Mengirimkan Barang Sesuai dengan Tanggal yang Disepakati

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus										✓								Pak Aris
Pak Jayus										✓								Pak Heri
Pak Jayus								✓										Pak Ujang
Pak Yadi										✓								Pak Aris
Pak Yadi									✓									Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris									✓									Pak Heri
Pak Aris							✓											Pak Ujang

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Heri										✓								Pak Ujang

Alternatif dalam Sub-kriteria Bagian O2 → Pengiriman Tepat Waktu Supplier Berdasarkan: Kemampuan dalam Hal Menangani Sistem Transportasi

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus									✓									Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus										✓								Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi								✓										Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris									✓									Pak Heri
Pak Aris											✓							Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian A1 → Akurasi dalam Kuantitas Supplier Berdasarkan: Ketepatan Pasokan dalam Pengiriman

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus									✓									Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi									✓									Pak Heri

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Yadi									✓									Pak Ujang
Pak Aris								✓										Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian S1 → Pelayanan Supplier Berdasarkan: Kemudahan Kontak dengan Supplier

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus							✓											Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi									✓									Pak Heri
Pak Yadi										✓								Pak Ujang
Pak Aris										✓								Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri									✓									Pak Ujang

Bagian S2 → Pelayanan Supplier Berdasarkan: Kemudahan Memberikan Informasi dengan Jelas dan Mudah Dipahami

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus									✓									Pak Aris
Pak Jayus								✓										Pak Heri

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi										✓								Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris										✓								Pak Heri
Pak Aris										✓								Pak Ujang
Pak Heri									✓									Pak Ujang

Alternatif dalam Sub-kriteria Bagian S3 → Pelayanan Supplier Berdasarkan: Kecepatan dalam Menanggapi Permintaan Pelanggan

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus										✓								Pak Yadi
Pak Jayus								✓										Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi										✓								Pak Heri
Pak Yadi								✓										Pak Ujang
Pak Aris									✓									Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian S4 → Pelayanan Supplier Berdasarkan: Respon Cepat dalam Menyelesaikan Keluhan Pelanggan

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus									✓									Pak Yadi
Pak Jayus									✓									Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi										✓								Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris									✓									Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian P1 → Harga Supplier Berdasarkan: Kesesuaian Harga dengan Kualitas Barang yang Diproduksi

Alternatif	Skala																	Alternatif
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Pak Jayus										✓								Pak Yadi
Pak Jayus									✓									Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi									✓									Pak Aris
Pak Yadi								✓										Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris								✓										Pak Heri
Pak Aris									✓									Pak Ujang
Pak Heri								✓										Pak Ujang

Alternatif dalam Sub-kriteria Bagian P2 → Harga Supplier berdasarkan: Kemampuan untuk Memberikan Diskon pada Pesanan Tertentu

Alternatif	Skala																Alternatif	
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8		9
Pak Jayus									✓									Pak Yadi
Pak Jayus										✓								Pak Aris
Pak Jayus									✓									Pak Heri
Pak Jayus									✓									Pak Ujang
Pak Yadi										✓								Pak Aris
Pak Yadi										✓								Pak Heri
Pak Yadi									✓									Pak Ujang
Pak Aris									✓									Pak Heri
Pak Aris								✓										Pak Ujang
Pak Heri							✓											Pak Ujang

~ Terima Kasih atas Partisipasi Anda dalam Mengisi Kuisisioner Ini ~

APPENDICES II

Pairwise Comparison Matrix Manual Calculation between Sub-Criteria in Alternatives

Pairwise Comparison Matrix between Sub Criteria Q in Alternatives Magelang (Mr. Yadi)

Sub-Criteria	Pairwise Comparison			In Decimal		
	Q1	Q2	Q3	Q1	Q2	Q3
Q1	1	2	1	1	2	1
Q2	1/2	1	1/2	0.5	1	0.5
Q3	1	2	1	1	2	1
Total				2.5	5	2.5

Pairwise Comparison Average Matrix between Sub Criteria Q in Alternatives Magelang
(Mr. Yadi)

Sub-Criteria	Q1	Q2	Q3	Total	Average
Q1	0.4	0.4	0.4	1.2	0.4
Q2	0.2	0.2	0.2	0.6	0.2
Q3	0.4	0.4	0.4	1.2	0.4

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|} \hline & 1 & 2 & 1 \\ \hline \text{Criteria} & 0.5 & 1 & 0.5 \\ \hline & 1 & 2 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.4 \\ \hline 0.2 \\ \hline 0.4 \\ \hline \end{array} = \begin{array}{|c|} \hline 1.2 \\ \hline 0.6 \\ \hline 1.2 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.2 & 0.6 & 1.2 \\ 0.4 & 0.2 & 0.4 \end{matrix}}{\begin{matrix} 3 & 3 & 3 \end{matrix}}$$

$$D = \begin{matrix} 3 & 3 & 3 \end{matrix}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{3+3+3}{3} = 3$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(3-3)}{(3-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 3x3 order, then the matrix value index used is 0.58.

Random Index

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

Source: (Saaty, 1990)

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for $n = 3$, $RI = 0.58$

Consistency Ratio = $0/0.58 = 0$

The Consistency Ratio of Sub Criteria O in Alternatives Magelang (Mr. Yadi) is 0

because the RI for $n = 2$, $RI = 0.00$. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria S in Alternatives Magelang (Mr. Yadi)

Sub-Criteria	Pairwise Comparison				In Decimal			
	S1	S2	S3	S4	S1	S2	S3	S4
S1	1	1	1	1	1	1	1	1
S2	1	1	1	1	1	1	1	1
S3	1	1	1	1	1	1	1	1
S4	1	1	1	1	1	1	1	1
				Total	4	4	4	4

Pairwise Comparison Average Matrix between Sub Criteria S in Alternatives Magelang (Mr. Yadi)

Sub-Criteria	S1	S2	S3	S4	Total	Average
S1	0.25	0.25	0.25	0.25	1	0.25
S2	0.25	0.25	0.25	0.25	1	0.25
S3	0.25	0.25	0.25	0.25	1	0.25
S4	0.25	0.25	0.25	0.25	1	0.25

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	1
	1	1	1	1
	1	1	1	1
	1	1	1	1

 \times

0.25
0.25
0.25
0.25

 $=$

1
1
1
1

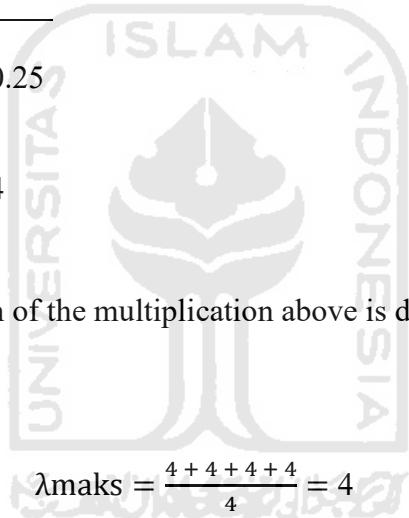
2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1 & 1 & 1 & 1 \end{matrix}}{\begin{matrix} 0.25 & 0.25 & 0.25 & 0.25 \end{matrix}}$$

$$D = \begin{matrix} 4 & 4 & 4 & 4 \end{matrix}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).



$$\lambda_{maks} = \frac{4 + 4 + 4 + 4}{4} = 4$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(4-4)}{(4-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according

to the number n. The criteria comparison matrix used is a matrix with a 4x4 order, then the matrix value index used is 0.9.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 4, RI = 0.9

Consistency Ratio = 0/0.9 = 0

The Consistency Ratio of Sub Criteria P in Alternatives Magelang (Mr. Yadi) is 0 because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria Q in Alternatives Kulon Progo (Mr. Jayus)

Sub-Criteria	Pairwise Comparison			In Decimal		
	Q1	Q2	Q3	Q1	Q2	Q3
Q1	1	1	1	1	1	1
Q2	1	1	2	1	1	2
Q3	1	1/2	1	1	0.5	1
			Total	3	2.5	4

Pairwise Comparison Average Matrix between Sub Criteria Q in Alternatives Kulon Progo (Mr. Jayus)

Sub-Criteria	Q1	Q2	Q3	Total	Average
Q1	0.333333	0.4	0.25	0.983333	0.327778
Q2	0.333333	0.4	0.5	1.233333	0.411111
Q3	0.333333	0.2	0.25	0.783333	0.261111

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|} \hline & 1 & 1 & 1 \\ \hline \text{Criteria} & 1 & 1 & 2 \\ \hline & 1 & 0.5 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.327778 \\ \hline 0.411111 \\ \hline 0.261111 \\ \hline \end{array} = \begin{array}{|c|} \hline 1 \\ \hline 1.261111 \\ \hline 0.794444 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{array}{ccc} 1 & 1.261111 & 0.794444 \\ 0.327778 & 0.411111 & 0.261111 \end{array}}{\begin{array}{ccc} 3.050847 & 3.067568 & 3.042553 \end{array}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{3.050847 + 3.067568 + 3.042553}{3} = 3.053656$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(3.053656 - 3)}{(3 - 1)} = 0.026828$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 3x3 order, then the matrix value index used is 0.58.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 3, RI = 0.58

Consistency Ratio = $0.026828/0.58 = 0.046255$

The Consistency Ratio of Sub Criteria O in Alternatives Kulon Progo (Mr. Jayus) is 0 because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria S in Alternatives Kulon Progo (Mr. Jayus)

Sub-Criteria	Pairwise Comparison				In Decimal			
	S1	S2	S3	S4	S1	S2	S3	S4
S1	1	2	1/2	1	1	2	0.5	1
S2	1/2	1	1/2	1	0.5	1	0.5	1
S3	2	2	1	1	2	2	1	1
S4	1	1	1	1	1	1	1	1
				Total	4.5	6	3	4

Pairwise Comparison Average Matrix between Sub Criteria S in Alternatives Kulon Progo (Mr. Jayus)

Sub-Criteria	S1	S2	S3	S4	Total	Average
S1	0.222222	0.333333	0.166667	0.25	0.972222	0.243056
S2	0.111111	0.166667	0.166667	0.25	0.694444	0.173611
S3	0.444444	0.333333	0.333333	0.25	1.361111	0.340278
S4	0.222222	0.166667	0.333333	0.25	0.972222	0.243056

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	2	0.5	1
	0.5	1	0.5	1
	2	2	1	1
	1	1	1	1

 \times

0.24306
0.17361
0.34028
0.24306

 $=$

1.003472
0.708333
1.416667
1

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.003472 & 0.708333 & 1.416667 & 1 \\ 0.24306 & 0.17361 & 0.34028 & 0.24306 \end{matrix}}{\begin{matrix} 4.128571 & 4.08 & 4.163265 & 4.114286 \end{matrix}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{4.128571 + 4.08 + 4.163265 + 4.114286}{4} = 4.121531$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(4.121531 - 4)}{(4-1)} = 0.04051$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 4x4 order, then the matrix value index used is 0.9.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 4, RI = 0.9

Consistency Ratio = $0.04051/0.9 = 0.045011$

The Consistency Ratio of Sub Criteria P in Alternatives Kulon Progo (Mr. Jayus) is 0 because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Aris)

Sub-Criteria	Pairwise Comparison			In Decimal		
	Q1	Q2	Q3	Q1	Q2	Q3
Q1	1	2	1	1	2	1
Q2	1/2	1	1/2	0.5	1	0.5
Q3	1	2	1	1	2	1
			Total	2.5	5	2.5

Pairwise Comparison Average Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Aris)

Sub-Criteria	Q1	Q2	Q3	Total	Average
Q1	0.4	0.4	0.4	1.2	0.4
Q2	0.2	0.2	0.2	0.6	0.2
Q3	0.4	0.4	0.4	1.2	0.4

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|} \hline & 1 & 2 & 1 \\ \hline \text{Criteria} & 0.5 & 1 & 0.5 \\ \hline & 1 & 2 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.4 \\ \hline 0.2 \\ \hline 0.4 \\ \hline \end{array} = \begin{array}{|c|} \hline 1.2 \\ \hline 0.6 \\ \hline 1.2 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{array}{ccc} 1.2 & 0.6 & 1.2 \\ \hline 0.4 & 0.2 & 0.4 \end{array}}{\begin{array}{ccc} 3 & 3 & 3 \end{array}}$$

$$D = \begin{array}{ccc} 3 & 3 & 3 \end{array}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{3+3+3}{3} = 3$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(3-3)}{(3-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 3x3 order, then the matrix value index used is 0.58.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 3, RI = 0.58

Consistency Ratio = 0/0.58 = 0

The Consistency Ratio of Sub Criteria O in Alternatives Sleman (Mr. Aris) is 0 because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria S in Alternatives Sleman (Mr. Aris)

Sub-Criteria	Pairwise Comparison				In Decimal			
	S1	S2	S3	S4	S1	S2	S3	S4
S1	1	1	1	1	1	1	1	1
S2	1	1	1	1	1	1	1	1
S3	1	1	1	1	1	1	1	1
S4	1	1	1	1	1	1	1	1
				Total	4	4	4	4

Pairwise Comparison Average Matrix between Sub Criteria S in Alternatives Sleman (Mr. Aris)

Sub-Criteria	S1	S2	S3	S4	Total	Average
S1	0.25	0.25	0.25	0.25	1	0.25
S2	0.25	0.25	0.25	0.25	1	0.25
S3	0.25	0.25	0.25	0.25	1	0.25
S4	0.25	0.25	0.25	0.25	1	0.25

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|c|} \hline & 1 & 1 & 1 & 1 \\ \hline \text{Criteria} & 1 & 1 & 1 & 1 \\ \hline & 1 & 1 & 1 & 1 \\ \hline & 1 & 1 & 1 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.25 \\ \hline 0.25 \\ \hline 0.25 \\ \hline 0.25 \\ \hline \end{array} = \begin{array}{|c|} \hline 1 \\ \hline 1 \\ \hline 1 \\ \hline 1 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{array}{cccc} 1 & 1 & 1 & 1 \end{array}}{\begin{array}{cccc} 0.25 & 0.25 & 0.25 & 0.25 \end{array}}$$

$$D = \begin{array}{cccc} 4 & 4 & 4 & 4 \end{array}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{maks} = \frac{4 + 4 + 4 + 4}{4} = 4$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(4-4)}{(4-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 4x4 order, then the matrix value index used is 0.9.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 4, RI = 0.9

Consistency Ratio = 0/0.9 = 0

The Consistency Ratio of Sub Criteria P in Alternatives Sleman (Mr. Aris) is 0

because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Heri)

Sub-Criteria	Pairwise Comparison			In Decimal		
	Q1	Q2	Q3	Q1	Q2	Q3
Q1	1	1	1	1	1	1
Q2	1	1	2	1	1	2
Q3	1	1/2	1	1	0.5	1

Sub-Criteria	Pairwise Comparison			In Decimal		
	Q1	Q2	Q3	Q1	Q2	Q3
			Total	3	2.5	4

Pairwise Comparison Average Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Heri)

Sub-Criteria	Q1	Q2	Q3	Total	Average
Q1	0.333333	0.4	0.25	0.983333	0.327778
Q2	0.333333	0.4	0.5	1.233333	0.411111
Q3	0.333333	0.2	0.25	0.783333	0.261111

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|} \hline & 1 & 1 & 1 \\ \hline \text{Criteria} & 1 & 1 & 2 \\ \hline & 1 & 0.5 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.327778 \\ \hline 0.411111 \\ \hline 0.261111 \\ \hline \end{array} = \begin{array}{|c|} \hline 1 \\ \hline 1.261111 \\ \hline 0.794444 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{array}{ccc} 1 & 1.261111 & 0.794444 \\ 0.327778 & 0.411111 & 0.261111 \end{array}}{\begin{array}{ccc} 3.050847 & 3.067568 & 3.042553 \end{array}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{3.050847 + 3.067568 + 3.042553}{3} = 3.053656$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(3.053656 - 3)}{(3 - 1)} = 0.026828$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 3x3 order, then the matrix value index used is 0.58.

Consistency Ratio = CI / RI , where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for $n = 3$, $RI = 0.58$

$$\text{Consistency Ratio} = 0.026828 / 0.58 = 0.046255$$

The Consistency Ratio of Sub Criteria O in Alternatives Sleman (Mr. Heri) is 0 because the RI for $n = 2$, $RI = 0.00$. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria S in Alternatives Sleman (Mr. Heri)

Sub-Criteria	Pairwise Comparison				In Decimal			
	S1	S2	S3	S4	S1	S2	S3	S4
S1	1	1	1	1/2	1	1	1	0.5
S2	1	1	1	1/2	1	1	1	0.5
S3	1	1	1	1	1	1	1	1
S4	2	2	1	1	2	2	1	1
				Total	5	5	4	3

Pairwise Comparison Average Matrix between Sub Criteria S in Alternatives Sleman (Mr. Heri)

Sub-Criteria	S1	S2	S3	S4	Total	Average
S1	0.2	0.2	0.25	0.166667	0.816667	0.204167
S2	0.2	0.2	0.25	0.166667	0.816667	0.204167
S3	0.2	0.2	0.25	0.333333	0.983333	0.245833
S4	0.4	0.4	0.25	0.333333	1.383333	0.345833

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|c|} \hline & 1 & 1 & 1 & 0.5 \\ \hline \text{Criteria} & 1 & 1 & 1 & 0.5 \\ \hline & 1 & 1 & 1 & 1 \\ \hline & 2 & 2 & 1 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.204167 \\ \hline 0.204167 \\ \hline 0.245833 \\ \hline 0.345833 \\ \hline \end{array} = \begin{array}{|c|} \hline 0.827083 \\ \hline 0.827083 \\ \hline 1 \\ \hline 1.408333 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{array}{cccc} 0.827083 & 0.827083 & 1 & 1.408333 \end{array}}{\quad}$$

$$D = \begin{matrix} & 0.204167 & 0.204167 & 0.245833 & 0.345833 \\ 4.05102 & 4.05102 & 4.067797 & 4.072289 \end{matrix}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{4.05102 + 4.05102 + 4.067797 + 4.072289}{4} = 4.060532$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(4.060532 - 4)}{(4 - 1)} = 0.020177$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 4x4 order, then the matrix value index used is 0.9.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 4, RI = 0.9

$$\text{Consistency Ratio} = 0.020177/0.9 = 0.022419$$

The Consistency Ratio of Sub Criteria P in Alternatives Sleman (Mr. Heri) is 0

because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Ujang)

Pairwise Comparison				In Decimal		
Sub-Criteria	Q1	Q2	Q3	Q1	Q2	Q3
Q1	1	1	1	1	1	1
Q2	1	1	1	1	1	1
Q3	1	1	1	1	1	1
Total				3	3	3

Pairwise Comparison Average Matrix between Sub Criteria Q in Alternatives Sleman (Mr. Ujang)

Sub-Criteria	Q1	Q2	Q3	Total	Average
Q1	0.333333	0.333333	0.333333	1	0.333333
Q2	0.333333	0.333333	0.333333	1	0.333333
Q3	0.333333	0.333333	0.333333	1	0.333333

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|} \hline & 1 & 1 & 1 \\ \hline \text{Criteria} & 1 & 1 & 1 \\ \hline & 1 & 1 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.333333 \\ \hline 0.333333 \\ \hline 0.333333 \\ \hline \end{array} = \begin{array}{|c|} \hline 1 \\ \hline 1 \\ \hline 1 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1 & & 1 & & 1 \\ 0.333333 & & 0.333333 & & 0.333333 \end{matrix}}{\quad}$$

$$D = \begin{matrix} 3 & & 3 & & 3 \end{matrix}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{3+3+3}{3} = 3$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(3-3)}{(3-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 3x3 order, then the matrix value index used is 0.58.

Consistency Ratio = CI / RI , where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for $n = 3$, $RI = 0.58$

$$\text{Consistency Ratio} = 0/0.58 = 0$$

The Consistency Ratio of Sub Criteria O in Alternatives Sleman (Mr. Ujang) is 0 because the RI for n = 2, RI = 0.00. The results of calculating data can be justified.

Pairwise Comparison Matrix between Sub Criteria S in Alternatives Sleman (Mr. Ujang)

Sub-Criteria	Pairwise Comparison				In Decimal			
	S1	S2	S3	S4	S1	S2	S3	S4
S1	1	1	1	1	1	1	1	1
S2	1	1	1	1	1	1	1	1
S3	1	1	1	1	1	1	1	1
S4	1	1	1	1	1	1	1	1
				Total	4	4	4	4

Pairwise Comparison Average Matrix between Sub Criteria S in Alternatives Sleman (Mr. Ujang)

Sub-Criteria	S1	S2	S3	S4	Total	Average
S1	0.25	0.25	0.25	0.25	1	0.25
S2	0.25	0.25	0.25	0.25	1	0.25
S3	0.25	0.25	0.25	0.25	1	0.25
S4	0.25	0.25	0.25	0.25	1	0.25

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

$$\begin{array}{|c|c|c|c|c|} \hline & 1 & 1 & 1 & 1 \\ \hline \text{Criteria} & 1 & 1 & 1 & 1 \\ \hline & 1 & 1 & 1 & 1 \\ \hline & 1 & 1 & 1 & 1 \\ \hline \end{array} \times \begin{array}{|c|} \hline 0.25 \\ \hline 0.25 \\ \hline 0.25 \\ \hline 0.25 \\ \hline \end{array} = \begin{array}{|c|} \hline 1 \\ \hline 1 \\ \hline 1 \\ \hline 1 \\ \hline \end{array}$$

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1 & 1 & 1 & 1 \\ 0.25 & 0.25 & 0.25 & 0.25 \end{matrix}}{\quad}$$

$$D = \begin{matrix} 4 & 4 & 4 & 4 \end{matrix}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{4 + 4 + 4 + 4}{4} = 4$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(4-4)}{(4-1)} = 0$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 4x4 order, then the matrix value index used is 0.9.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 4, RI = 0.9

Consistency Ratio = 0/0.9 = 0

The Consistency Ratio of Sub Criteria P in Alternatives Sleman (Mr. Ujang) is 0
because the RI for $n = 2$, $RI = 0.00$. The results of calculating data can be justified.



APPENDICES III

Pairwise Comparison Matrix Manual Calculation between Alternatives in Sub-Criteria

Pairwise Comparison Matrix between Alternatives in Sub Criteria Q1

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1/2	2	1	1	1	0.5	2	1
Mr. Jayus	1	1	1/2	1	1	1	1	0.5	1	1
Mr. Aris	2	2	1	1/2	1	2	2	1	0.5	1
Mr. Heri	1/2	1	2	1	2	0.5	1	2	1	2
Mr. Ujang	1	1	1	1/2	1	1	1	1	0.5	1
Total						5.5	6	5	5	6

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria Q1

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.18181818	0.16666667	0.1	0.4	0.16666667	1.01515152	0.203030303
Mr. Jayus	0.18181818	0.16666667	0.1	0.2	0.16666667	0.81515152	0.163030303
Mr. Aris	0.36363636	0.33333333	0.2	0.1	0.16666667	1.16363636	0.232727273
Mr. Heri	0.09090909	0.16666667	0.4	0.2	0.33333333	1.19090909	0.238181818
Mr. Ujang	0.18181818	0.16666667	0.2	0.1	0.16666667	0.81515152	0.163030303

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	0.5	2	1	X	0.203030303	=	1.121818182
	1	1	0.5	1	1		0.163030303		0.883636364
	2	2	1	0.5	1		0.232727273		1.246969697
	0.5	1	2	1	2		0.238181818		1.294242424
	1	1	1	0.5	1		0.163030303		0.880909091

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.121818182 & 0.883636364 & 1.246969697 & 1.294242424 & 0.880909091 \\ 0.203030303 & 0.163030303 & 0.232727273 & 0.238181818 & 0.163030303 \end{matrix}}{\begin{matrix} 5.525373134 & 5.420074349 & 5.358072917 & 5.433842239 & 5.403345725 \end{matrix}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{5.525373134 + 5.420074349 + 5.358072917 + 5.433842239 + 5.403345725}{5} = 5.428141673$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

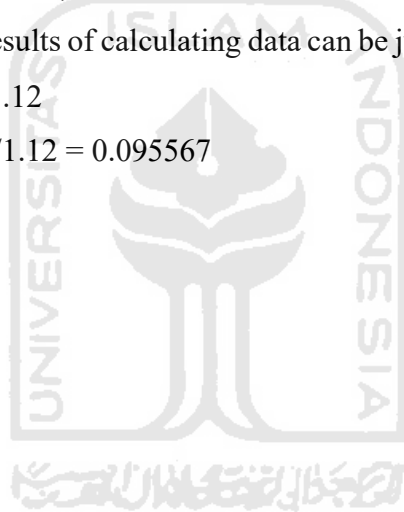
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.428141673-5)}{(5-1)} = 0.107035$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.107035/1.12 = 0.095567$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria Q2

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1/2	1	1	1	1	0.5	1	1
Mr. Jayus	1	1	2	1/2	1	1	1	2	0.5	1
Mr. Aris	2	1/2	1	2	1	2	0.5	1	2	1
Mr. Heri	1	2	1/2	1	1	1	2	0.5	1	1
Mr. Ujang	1	1	1	1	1	1	1	1	1	1
	Total					6	5.5	5	5.5	5

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria Q2

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.16666667	0.18181818	0.1	0.181818182	0.2	0.83030303	0.166060606
Mr. Jayus	0.16666667	0.18181818	0.4	0.090909091	0.2	1.03939394	0.207878788
Mr. Aris	0.33333333	0.09090909	0.2	0.363636364	0.2	1.18787879	0.237575758
Mr. Heri	0.16666667	0.36363636	0.1	0.181818182	0.2	1.01212121	0.202424242
Mr. Ujang	0.16666667	0.18181818	0.2	0.181818182	0.2	0.93030303	0.186060606

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	0.5	1	1
	1	1	2	0.5	1
	2	0.5	1	2	1
	1	2	0.5	1	1
	1	1	1	1	1

 \times

0.166060606
0.207878788
0.237575758
0.202424242
0.186060606

 $=$

0.881212121
1.136363636
1.264545455
1.089090909
1

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.881212121 & 1.136363636 & 1.264545455 & 1.089090909 & 1 \\ 0.166060606 & 0.207878788 & 0.237575758 & 0.202424242 & 0.186060606 \end{matrix}}{5.306569343 \quad 5.466472303 \quad 5.322704082 \quad 5.380239521 \quad 5.374592834}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.306569343 + 5.466472303 + 5.322704082 + 5.380239521 + 5.374592834}{5} = 5.370115617$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

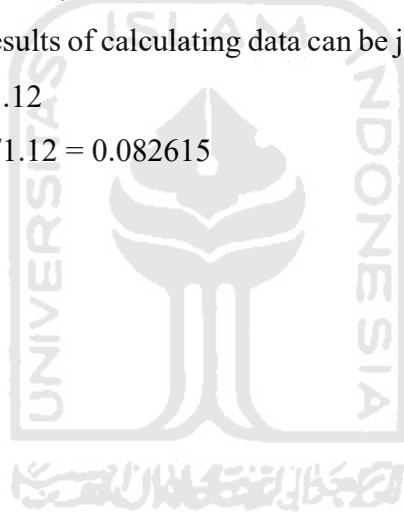
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.370115617-5)}{(5-1)} = 0.092529$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.092529/1.12 = 0.082615$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria Q3

Alternatives	Pairwise Comparison					In Decimal				
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1/2	1	1/2	2	1	0.5	1	0.5	2
Mr. Jayus	2	1	1/2	1	1	2	1	0.5	1	1
Mr. Aris	1	2	1	2	1	1	2	1	2	1
Mr. Heri	2	1	1/2	1	1	2	1	0.5	1	1
Mr. Ujang	1/2	1	1	1	0.5	1	1	1	1	1
	Total					6.5	5.5	4	5.5	6

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria Q3

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.15384615	0.09090909	0.25	0.09090909	0.33333333	0.91899767	0.183799534
Mr. Jayus	0.30769231	0.18181818	0.125	0.18181818	0.16666667	0.96299534	0.192599068
Mr. Aris	0.15384615	0.36363636	0.25	0.36363636	0.16666667	1.29778555	0.25955711
Mr. Heri	0.30769231	0.18181818	0.125	0.18181818	0.16666667	0.96299534	0.192599068
Mr. Ujang	0.07692308	0.18181818	0.25	0.18181818	0.16666667	0.85722611	0.171445221

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	0.5	1	0.5	2	X	0.183799534	=	0.978846154
	2	1	0.5	1	1		0.192599068		1.054020979
	1	2	1	2	1		0.25955711		1.385198135
	2	1	0.5	1	1		0.192599068		1.054020979
	0.5	1	1	1	1		0.171445221		0.908100233

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.978846154 & 1.054020979 & 1.385198135 & 1.054020979 & 0.908100233 \\ 0.183799534 & 0.192599068 & 0.25955711 & 0.192599068 & 0.171445221 \end{matrix}}{\begin{matrix} 0.183799534 & 0.192599068 & 0.25955711 & 0.192599068 & 0.171445221 \end{matrix}}$$

$$D = \begin{matrix} 5.325618263 & 5.472617247 & 5.336775932 & 5.472617247 & 5.296736914 \end{matrix}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{5.325618263 + 5.472617247 + 5.336775932 + 5.472617247 + 5.296736914}{5} = 5.38087312$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

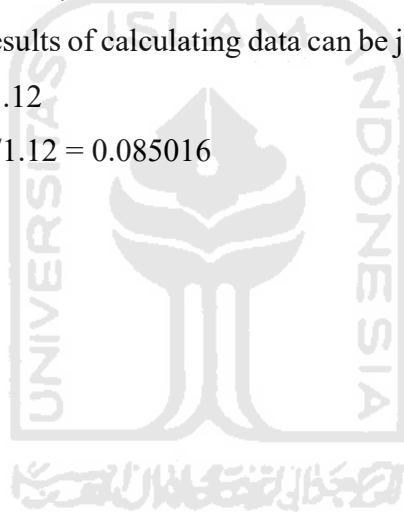
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.8087312-5)}{(5-1)} = 0.095218$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.095218/1.12 = 0.085016$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria O1

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1/2	1	1	1	1	0.5	1	1
Mr. Jayus	1	1	1/2	1/2	2	1	1	0.5	0.5	2
Mr. Aris	2	2	1	1	3	2	2	1	1	3
Mr. Heri	1	2	1	1	1/2	1	2	1	1	0.5
Mr. Ujang	1	1/2	1/3	2	1	0.5	0.5	0.333	2	1
Total						6	6.5	3.333	5.5	7.5

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria O1

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.16666667	0.15384615	0.150015002	0.181818182	0.133333333	0.78567934	0.157135867
Mr. Jayus	0.16666667	0.15384615	0.150015002	0.090909091	0.266666667	0.82810358	0.165620716
Mr. Aris	0.33333333	0.30769231	0.300030003	0.181818182	0.4	1.52287383	0.304574765
Mr. Heri	0.16666667	0.30769231	0.300030003	0.181818182	0.066666667	1.02287383	0.204574765
Mr. Ujang	0.16666667	0.07692308	0.099909991	0.363636364	0.133333333	0.84046943	0.168093886

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	0.5	1	1	X	0.157135867	=	0.847712617
	1	1	0.5	0.5	2		0.165620716		0.913519121
	2	2	1	1	3		0.304574765		1.658944356
	1	2	1	1	0.5		0.204574765		1.081573773
	1	0.5	0.333	2	1		0.168093886		0.918613039

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.847712617 & 0.913519121 & 1.658944356 & 1.081573773 & 0.918613039 \\ 0.157135867 & 0.165620716 & 0.304574765 & 0.204574765 & 0.168093886 \end{matrix}}{\begin{matrix} 5.394774798 & 5.515729817 & 5.446755758 & 5.286936401 & 5.464880722 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.394774798 + 5.515729817 + 5.446755758 + 5.286936401 + 5.464880722}{5} = 5.421815499$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

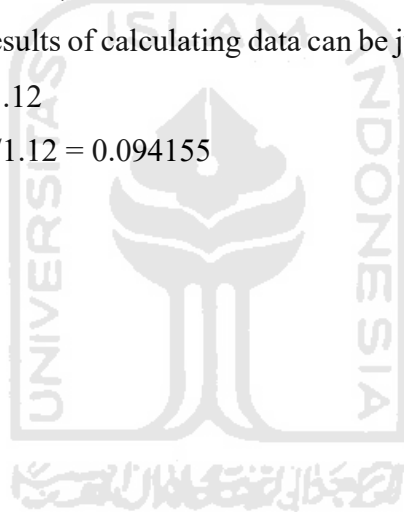
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.421815499-5)}{(5-1)} = 0.105454$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.105454/1.12 = 0.094155$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria O2

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1	2	1	1	1	1	2	1
Mr. Jayus	1	1	1	1	1/2	1	1	1	1	0.5
Mr. Aris	1	1	1	1	1/3	1	1	1	1	0.333
Mr. Heri	1/2	1	1	1	2	0.5	1	1	1	2
Mr. Ujang	1	2	3	1/2	1	2	3	0.5	1	1
	Total					4.5	6	7	5.5	4.833

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria O2

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.22222222	0.16666667	0.142857143	0.363636364	0.206910821	1.10229322	0.220458643
Mr. Jayus	0.22222222	0.16666667	0.142857143	0.181818182	0.103455411	0.81701962	0.163403925
Mr. Aris	0.22222222	0.16666667	0.142857143	0.181818182	0.068901304	0.78246552	0.156493103
Mr. Heri	0.111111111	0.16666667	0.142857143	0.181818182	0.413821643	1.01627475	0.203254949
Mr. Ujang	0.22222222	0.33333333	0.428571429	0.090909091	0.206910821	1.2819469	0.256389379

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	2	1
	1	1	1	1	0.5
	1	1	1	1	0.333
	0.5	1	1	1	2
	1	2	3	0.5	1

 \times

0.220458643
0.163403925
0.156493103
0.203254949
0.256389379

 $=$

1.203254949
0.87180531
0.828988284
1.146160058
1.374762657

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.203254949 & 0.87180531 & 0.828988284 & 1.146160058 & 1.374762657 \\ 0.220458643 & 0.163403925 & 0.156493103 & 0.203254949 & 0.256389379 \end{matrix}}{\begin{matrix} 5.457962231 & 5.335277663 & 5.297283177 & 5.639026567 & 5.362010942 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.457962231 + 5.335277663 + 5.297283177 + 5.639026567 + 5.362010942}{5} = 5.418312116$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

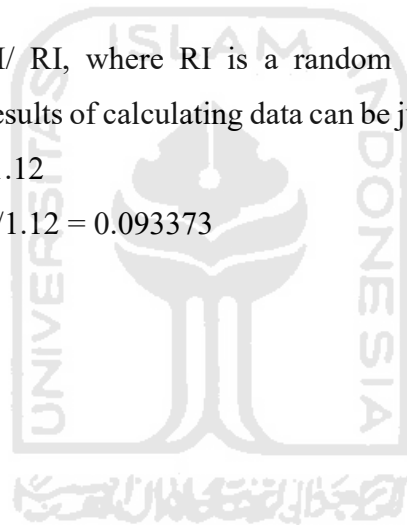
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.418312116-5)}{(5-1)} = 0.104578$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.104578/1.12 = 0.093373$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria A1

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1	1	1	1	1	1	1	1
Mr. Jayus	1	1	1	1	1	1	1	1	1	1
Mr. Aris	1	1	1	2	1	1	1	1	2	1
Mr. Heri	1	1	1/2	1	2	1	1	0.5	1	2
Mr. Ujang	1	1	1	1/2	1	1	1	1	0.5	1
Total						5	5	4.5	5.5	6

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria A1

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.2	0.2	0.22222222	0.18181818	0.16666667	0.97070707	0.19414141
Mr. Jayus	0.2	0.2	0.22222222	0.18181818	0.16666667	0.97070707	0.19414141
Mr. Aris	0.2	0.2	0.22222222	0.36363636	0.16666667	1.15252525	0.23050505
Mr. Heri	0.2	0.2	0.11111111	0.18181818	0.33333333	1.02626263	0.20525252
Mr. Ujang	0.2	0.2	0.22222222	0.09090909	0.16666667	0.87979798	0.17595959

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	1	1
	1	1	1	1	1
	1	1	1	2	1
	1	1	0.5	1	2
	1	1	1	0.5	1

 \times

0.194141414
0.194141414
0.230505051
0.205252525
0.175959596

 $=$

1
1
1.205252525
1.060707071
0.897373737

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1 & 1 & 1.205252525 & 1.060707071 & 0.897373737 \\ 0.194141414 & 0.194141414 & 0.230505051 & 0.205252525 & 0.175959596 \end{matrix}}{\begin{matrix} 5.150884495 & 5.150884495 & 5.228746713 & 5.167814961 & 5.099885189 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.150884495 + 5.150884495 + 5.228746713 + 5.167814961 + 5.099885189}{5} = 5.159643171$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

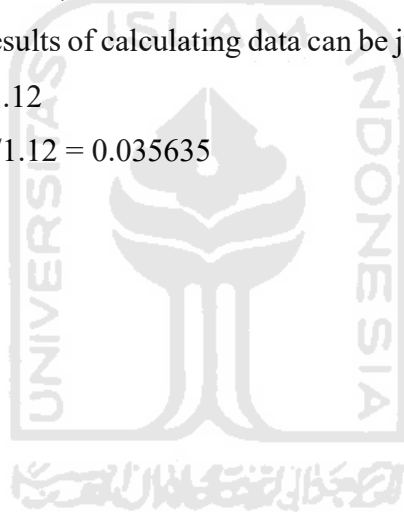
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.159643171-5)}{(5-1)} = 0.039911$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.039911/1.12 = 0.035635$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria S1

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1	1	1/2	1	1	1	1	0.5
Mr. Jayus	1	1	3	1	1	1	1	3	1	1
Mr. Aris	1	1/3	1	1/2	1	1	0.333	1	0.5	1
Mr. Heri	1	1	2	1	1	1	1	2	1	1
Mr. Ujang	2	1	1	1	1	2	1	1	1	1
Total						6	4.333	8	4.5	4.5

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria S1

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.16666667	0.23078698	0.125	0.22222222	0.11111111	0.85578698	0.171157397
Mr. Jayus	0.16666667	0.23078698	0.375	0.22222222	0.22222222	1.21689809	0.243379619
Mr. Aris	0.16666667	0.07685207	0.125	0.11111111	0.22222222	0.70185207	0.140370413
Mr. Heri	0.16666667	0.23078698	0.25	0.22222222	0.22222222	1.09189809	0.218379619
Mr. Ujang	0.33333333	0.23078698	0.125	0.22222222	0.22222222	1.13356476	0.226712952

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	1	0.5	X	0.171157397	=	0.886643524
	1	1	3	1	1		0.243379619		1.280740826
	1	0.333	1	0.5	1		0.140370413		0.728475985
	1	1	2	1	1		0.218379619		1.140370413
	2	1	1	1	1		0.226712952		1.171157397

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.886643524 & 1.280740826 & 0.728475985 & 1.140370413 & 1.171157397 \\ 0.171157397 & 0.243379619 & 0.140370413 & 0.218379619 & 0.226712952 \end{matrix}}{\begin{matrix} 5.180281664 & 5.262317493 & 5.189669023 & 5.221963563 & 5.165816002 \end{matrix}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{5.180281664 + 5.262317493 + 5.189669023 + 5.221963563 + 5.165816002}{5} = 5.204009549$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.204009549-5)}{(5-1)} = 0.051002$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.051002/1.12 = 0.045538$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria S2

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1	2	1	1	1	1	2	1
Mr. Jayus	1	1	1	2	1	1	1	1	2	1
Mr. Aris	1	1	1	1/2	1/2	1	1	1	0.5	0.5
Mr. Heri	1/2	1/2	2	1	1	0.5	0.5	2	1	1
Mr. Ujang	1	1	2	1	1	1	1	2	1	1
Total						4.5	4.5	7	6.5	4.5

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria S2

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.22222222	0.22222222	0.142857143	0.307692308	0.222222222	1.11721612	0.223443223
Mr. Jayus	0.22222222	0.22222222	0.142857143	0.307692308	0.222222222	1.11721612	0.223443223
Mr. Aris	0.22222222	0.22222222	0.142857143	0.076923077	0.111111111	0.77533578	0.155067155
Mr. Heri	0.11111111	0.11111111	0.285714286	0.153846154	0.222222222	0.88400488	0.176800977
Mr. Ujang	0.22222222	0.22222222	0.285714286	0.153846154	0.222222222	1.10622711	0.221245421

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	2	1
	1	1	1	2	1
	1	1	1	0.5	0.5
	0.5	0.5	2	1	1
	1	1	2	1	1

 \times

0.223443223
0.223443223
0.155067155
0.176800977
0.221245421

 $=$

1.176800977
1.176800977
0.800976801
0.931623932
1.155067155

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.176800977 & 1.176800977 & 0.800976801 & 0.931623932 & 1.155067155 \\ 0.223443223 & 0.223443223 & 0.155067155 & 0.176800977 & 0.221245421 \end{matrix}}{\begin{matrix} 5.266666667 & 5.266666667 & 5.165354331 & 5.269337017 & 5.220750552 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.266666667 + 5.266666667 + 5.165354331 + 5.269337017 + 5.220750552}{5} = 5.237755046$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

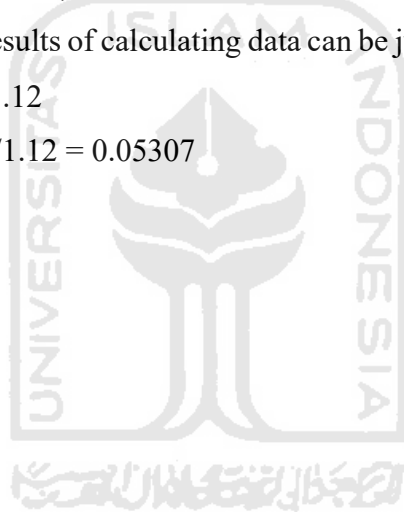
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.237755046-5)}{(5-1)} = 0.059439$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.059439/1.12 = 0.05307$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria S3

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	2	1	1/2	2	1	2	1	0.5	2
Mr. Jayus	1/2	1	2	1	1	0.5	1	2	1	1
Mr. Aris	1	1/2	1	1	1	1	0.5	1	1	1
Mr. Heri	2	1	1	1	2	2	1	1	1	2
Mr. Ujang	1/2	1	1	1/2	1	0.5	1	1	0.5	1
Total						5	5.5	6	4	7

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria S3

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.2	0.36363636	0.16666667	0.125	0.285714286	1.14101732	0.228203463
Mr. Jayus	0.1	0.18181818	0.33333333	0.25	0.142857143	1.00800866	0.201601732
Mr. Aris	0.2	0.09090909	0.16666667	0.25	0.142857143	0.8504329	0.17008658
Mr. Heri	0.4	0.18181818	0.16666667	0.25	0.285714286	1.28419913	0.256839827
Mr. Ujang	0.1	0.18181818	0.16666667	0.125	0.142857143	0.71634199	0.143268398

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	2	1	0.5	2
	0.5	1	2	1	1
	1	0.5	1	1	1
	2	1	1	1	2
	0.5	1	1	0.5	1

 \times

0.228203463
0.201601732
0.17008658
0.256839827
0.143268398

 $=$

1.216450216
1.055984848
0.899199134
1.371471861
0.757478355

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.216450216 & 1.055984848 & 0.899199134 & 1.371471861 & 0.757478355 \\ 0.228203463 & 0.201601732 & 0.17008658 & 0.256839827 & 0.143268398 \end{matrix}}{\begin{matrix} 5.330551077 & 5.237975091 & 5.286714177 & 5.33979437 & 5.287127965 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.330551077 + 5.237975091 + 5.286714177 + 5.33979437 + 5.287127965}{5} = 5.296432536$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

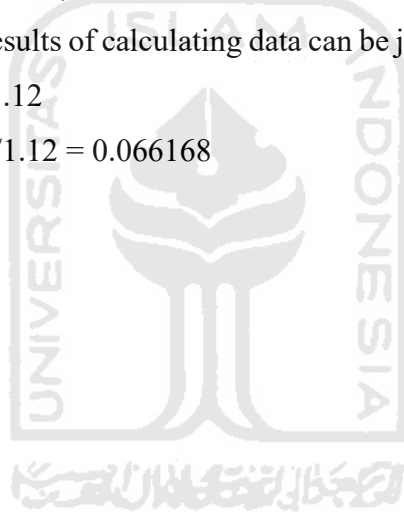
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.296432536-5)}{(5-1)} = 0.074108$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.074108/1.12 = 0.066168$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria S4

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1	1/2	1	1	1	1	0.5	1
Mr. Jayus	1	1	1	1	1	1	1	1	1	1
Mr. Aris	1	1	1	1	1	1	1	1	1	1
Mr. Heri	2	1	1	1	2	2	1	1	1	2
Mr. Ujang	1	1	1	1/2	1	1	1	1	0.5	1
Total						6	5	5	4	6

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria S4

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.16666667	0.2	0.2	0.125	0.16666667	0.85833333	0.17166667
Mr. Jayus	0.16666667	0.2	0.2	0.25	0.16666667	0.98333333	0.19666667
Mr. Aris	0.16666667	0.2	0.2	0.25	0.16666667	0.98333333	0.19666667
Mr. Heri	0.33333333	0.2	0.2	0.25	0.33333333	1.31666667	0.26333333
Mr. Ujang	0.16666667	0.2	0.2	0.125	0.16666667	0.85833333	0.17166667

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	1	0.5	1
	1	1	1	1	1
	1	1	1	1	1
	2	1	1	1	2
	1	1	1	0.5	1

 \times

0.171666667
0.196666667
0.196666667
0.263333333
0.171666667

 $=$

0.868333333
1
1
1.343333333
0.868333333

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.868333333 & & & & \\ & 1 & & & \\ & & 1 & & \\ & & & 1.343333333 & \\ & & & & 0.868333333 \end{matrix}}{\begin{matrix} 0.171666667 & 0.196666667 & 0.196666667 & 0.263333333 & 0.171666667 \end{matrix}}$$

$$D = \begin{matrix} 5.058252427 & 5.084745763 & 4.084745763 & 5.101265823 & 5.058252427 \end{matrix}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.058252427 + 5.084745763 + 4.084745763 + 5.101265823 + 5.058252427}{5} = 5.077452441$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.077452441-5)}{(5-1)} = 0.019363$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.019363/1.12 = 0.017288$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria P1

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	2	1	2	1	1	2	1	2	1
Mr. Jayus	1/2	1	1	1	1	0.5	1	1	1	1
Mr. Aris	1	1	1	2	1	1	1	1	2	1
Mr. Heri	1/2	1	1/2	1	2	0.5	1	0.5	1	2
Mr. Ujang	1	1	1	1/2	1	1	1	1	0.5	1
Total						4	6	4.5	6.5	6

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria P1

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.25	0.33333333	0.22222222	0.307692308	0.166666667	1.27991453	0.255982906
Mr. Jayus	0.125	0.16666667	0.22222222	0.153846154	0.166666667	0.83440171	0.166880342
Mr. Aris	0.25	0.16666667	0.22222222	0.307692308	0.166666667	1.11324786	0.222649573
Mr. Heri	0.125	0.16666667	0.11111111	0.153846154	0.33333333	0.88995726	0.177991453
Mr. Ujang	0.25	0.16666667	0.22222222	0.076923077	0.166666667	0.88247863	0.176495726

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	2	1	2	1	X	0.255982906	=	1.344871795
	0.5	1	1	1	1		0.166880342		0.872008547
	1	1	1	2	1		0.222649573		1.177991453
	0.5	1	0.5	1	2		0.177991453		0.937179487
	1	1	1	0.5	1		0.176495726		0.911004274

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 1.344871795 & 0.872008547 & 1.177991453 & 0.937179487 & 0.911004274 \\ 0.255982906 & 0.166880342 & 0.222649573 & 0.177991453 & 0.176495726 \end{matrix}}{\begin{matrix} 5.25375626 & 5.225352113 & 5.290786948 & 5.265306122 & 5.161622276 \end{matrix}}$$

3. Calculating λ_{\max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{\max} = \frac{5.25375626 + 5.225352113 + 5.290786948 + 5.265306122 + 5.161622276}{5} = 5.239364744$$

4. Calculating the Consistency Index (CI) = $(\lambda_{\max} - N) / (N - 1)$

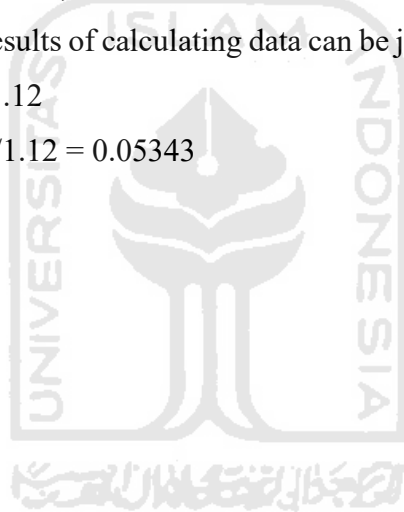
The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.239364744-5)}{(5-1)} = 0.059841$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.059841/1.12 = 0.05343$$



Pairwise Comparison Matrix between Alternatives in Sub Criteria P2

Alternatives	Pairwise Comparison						In Decimal			
	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang
Mr. Yadi	1	1	1/2	1/2	1	1	1	0.5	0.5	1
Mr. Jayus	1	1	1/2	1	1	1	1	0.5	1	1
Mr. Aris	2	2	1	1	2	2	2	1	1	2
Mr. Heri	2	1	1	1	3	2	1	1	1	3
Mr. Ujang	1	1	1/2	1/3	1	1	1	0.5	0.333	1
Total						7	6	3.5	3.833	8

Pairwise Comparison Average Matrix between Alternatives in Sub Criteria P2

Criteria	Mr. Yadi	Mr. Jayus	Mr. Aris	Mr. Heri	Mr. Ujang	Total	Average
Mr. Yadi	0.14285714	0.16666667	0.142857143	0.130446126	0.125	0.70782708	0.141565416
Mr. Jayus	0.14285714	0.16666667	0.142857143	0.260892252	0.125	0.8382732	0.167654641
Mr. Aris	0.28571429	0.33333333	0.285714286	0.260892252	0.25	1.41565416	0.283130831
Mr. Heri	0.28571429	0.16666667	0.285714286	0.260892252	0.375	1.37398749	0.274797498
Mr. Ujang	0.14285714	0.16666667	0.142857143	0.08687712	0.125	0.66425807	0.132851614

Calculating Consistency Ratio

1. Multiplying matrices with corresponding priority.

The first step in testing the consistency of a matrix is to determine the Eigen Vector first. The Eigen Vector is obtained from the initial matrix multiplication with the weight obtained. Following is the calculation of Eigen Vector in the comparison matrix between criteria.

Criteria	1	1	0.5	0.5	1
	1	1	0.5	1	1
	2	2	1	1	2
	2	1	1	1	3
	1	1	0.5	0.333	1

 \times

0.141565416
0.167654641
0.283130831
0.274797498
0.132851614

 $=$

0.721035835
0.858434584
1.442071671
1.407268644
0.675144653

2. Divide the results from the calculation above with Priority Weight.

After getting the Eigen Vector value, the next step is to divide the results that have been obtained on step 1 with weight criteria (priority weight).

$$D = \frac{\begin{matrix} 0.721035835 & 0.858434584 & 1.442071671 & 1.407268644 & 0.675144653 \\ 0.141565416 & 0.167654641 & 0.283130831 & 0.274797498 & 0.132851614 \end{matrix}}{\begin{matrix} 5.093304973 & 5.120255427 & 5.093304973 & 5.121111564 & 5.081945418 \end{matrix}}$$

3. Calculating λ_{max} (The sum of the multiplication above is divided by the number of elements).

$$\lambda_{max} = \frac{5.093304973 + 5.120255427 + 5.093304973 + 5.121111564 + 5.081945418}{5} = 5.101984471$$

4. Calculating the Consistency Index (CI) = $(\lambda_{max} - N) / (N - 1)$

The maximum value of Eigen that has been obtained is then used in calculating the value of the Consistency Index (CI). The following is a calculation of the Consistency Index (CI).

$$CI_1 = \frac{(5.101984471-5)}{(5-1)} = 0.025496$$

The value of the Consistency Index that has been obtained is then used to calculate the value of Consistency Ratio (CR). The value of Consistency Ratio is the result of the division between the value of the Consistency Index (CI) and the index value of the matrix according to the number n. The criteria comparison matrix used is a matrix with a 5x5 order, then the matrix value index used is 1.12.

Consistency Ratio = CI/ RI, where RI is a random index of consistency. If the consistency ratio is ≤ 0.1 , the results of calculating data can be justified. From the RC random table obtained for n = 5, RI = 1.12

$$\text{Consistency Ratio} = 0.025496/1.12 = 0.022764$$

