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## REVIEW OF SUBCONTRACTOR SELECTION CRITERIA IN CONSTRUCTION SERVICES USING ANALYTIC NETWORK PROCESS (ANP) - BENEFIT COST RISK (BCR)

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### Abstract

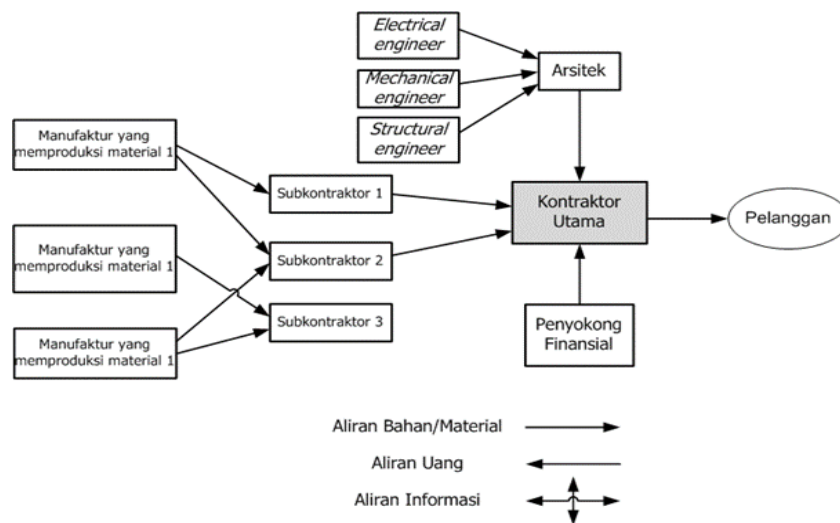
To develop effective techniques for selecting subcontractors, this research set out to determine which factors should take precedence and which alternatives may be useful in terms of BCR, benefits, costs, and risks. Based on the results Project managers, control managers, procurement bureau managers, production managers, finance bureau managers, and employees/staff directly related to procurement activities (i.e., procurement staff) were randomly selected to participate in in-depth interviews and questionnaires to gather data for the study of subcontractor selection criteria in construction services. Analytical Network Process (ANP) using BCR network structure methodology is used to analyze the data in this study. Benefit, Cost, and Risk (BCR) study of the subcontractor selection process yielded the following results: control criteria. As a result, the decision-making process for choosing subcontractors shifts its focus to other technical competency factors, which might provide advantages.

**Keywords:** Subcontractors, Construction Services, Analytic Network Process (ANP), Benefit-Cost Risk (BCR)

## INTRODUCTION

The growth of the construction industry is heavily influenced by the government's focus on accelerating infrastructure development across Indonesia, an initiative started by President Joko Widodo. The National Development Planning Agency (Bappenas) estimates that the number of government and commercial infrastructure projects in 2017 will drive 8.1% growth in the construction industry (BAPPENAS, 2016). Of course, the selection of a prime contractor is necessary for large-scale projects to be implemented. The prime contractor may have to decide whether to assign subcontractors to complete certain work packages or complete the scope of work themselves once appointed.

In their research, Adi Pandarangga, M. Agung Wibowo, and Jati Utomo Dwihatmoko (2013) proposed the Building Supply Chain (BSC) pattern, as reported by Vaidyanathan (2009). Figure 1 illustrates how subcontractors are involved in a development project. The pattern shows the provision of value-added services by several entities, including project managers, architects, engineers, main contractors, subcontractors, and finance (Pandarangga et al., 2015).



**Figure 1.**  
**Vaidyanathan's RPK Pattern (2009)**

Subcontractors are given specific tasks to complete to maximize efficiency, reduce potential hazards on the job, and accelerate the progress of the construction project. In selecting a subcontractor, in addition to the quantity of quotes submitted by the subcontractor, it is important to consider the demands of the main contractor. To find a reliable

subcontractor who can help carry out the project, many factors must be considered. PT Adhi Karya (Persero) Tbk, the main contractor oversees the implementation of the project following the requirements outlined in the contract.

The company has implemented vendor/subcontractor/mandor selection as stated in the Goods and Services Procurement Procedure BP 013 LP P01. This process uses several factors to evaluate and select suppliers, subcontractors, and foremen. These criteria include administrative, legality, qualifications, bid price, quality, financial capability, execution time, and mobilization capacity. The lowest price is usually used to select contract partners at this stage. When selecting subcontractors, the trend towards the lowest price may be a selection factor as it is expected to save costs on the current budget; however, it is also important to consider the risks associated with the choice.

Numerous studies have shown that in addition to the criteria that companies currently use, there is a wide range of assessment criteria that can be used in the vendor selection and evaluation process. Furthermore, each of these criteria is weighted to give priority to the criteria that the company considers more important. Dewayana and Budi (2009) assert that the company's requirements are fulfilled by using the ANP decision-making model, which incorporates connected criteria and sub-criteria. Dewayana and Budi (2009) state that the decision-making model known as ANP is used because it is in line with organizational demands, where criteria and sub-criteria are interrelated. The BCR analysis network is a form of network in ANP. The construction of the Trans Sumatra Highway (TSH) in Sumatra, Indonesia, can help determine the optimal development plan using the BCR Analysis Network (Ascarya & Yumanita, 2005).

Saaty (2013) argues that in any decision-making process, there are multiple factors that must be evaluated and that each criterion must be weighed against the pros and cons of each (Saaty et al., 2013). Those that are considered useful are referred to as benefits, while those that are not considered useful are referred to as costs. With the uncertainty of decision-making comes the possibility of good and bad outcomes, such as opportunities and risks (Turangan et al., 2019).

There is a relationship between the subcontractor selection criteria and the company's challenges, so this makes sense. The researchers in this study selected their subcontractors

using the ANP method. The ANP approach can ensure that the evaluations of expert decision-makers are consistent. Because it can provide more complicated relationships as well as mutual influence relationships between criteria, the ANP approach is also applied. After that, this research aims to find out which subcontractor selection factors are most important, as well as which alternative criteria are relevant and favorable (Saaty & Vargas, 2006).

## **REVIEW OF LITERATURE**

Yunita A. claims that primary contractors and subcontractors are the two main categories of construction executors/contractors. Rohi D. Raja Sejati and I, Denik S. Krinsnayanti, published in 2012. The agency or institution designated as the 'primary contractor' is the one that executes the project and supervises its implementation in accordance with budgetary constraints, specifications, and applicable laws and regulations. On the other hand, a subcontractor is an independent contractor hired by the general contractor to perform certain types of construction work, such as earthwork, pile foundation, etc (Ervianto, 2023).

A subcontractor is an independent third party hired by a general contractor to assist with specific tasks associated with a construction project. The subcontractor works under the supervision of the general contractor and instructs the subcontractor to perform its duties. Ultimately, the subcontractor is obliged to do so on legal grounds, which include (Fuady, 1998):

1. Impossibility of execution of all works by the contractor due to:
  - a. Limited manpower.
  - b. Limited expertise.
  - c. Limited funds.
  - d. Equipment limitation.
2. Using small or local contractors is sometimes mandated by laws or regulations that contractors must follow when working on certain projects. Subcontractor is the best way to describe their role here.
3. Actually, there are cases when local laws allow certain organizations - for example, government-owned trade groups - to become or join as contractors, even though they

lack the internal resources to carry out such activities. When a contractor does not have the necessary skills, they may often hire subcontractors to help them complete the work.

According to Imam Suharto (2001), It is common practice for large-scale projects to have an increasing number of work packages passed from main contractors to subcontractors to improve efficiency and production (Mahyuddin, Ritnawati, Fatmawaty Rachim et al., 2023). In addition to the above reasons, the following conditions or factors must also be met (Sujoko, 2019):

1. Availability of capable/bonafide subcontractor companies.

Subcontractors should only be considered for the project scope if the company is financially stable and technically competent, and fair pricing is also an important consideration.

2. The type of work is specialized.

For example, rather than a general contractor undertaking dredging for a manufacturing dock, it would be more effective to hire a subcontractor with expertise in that sector.

3. Government policy.

The government prefers using competent local businesses for certain projects. Subcontracting is promoted by this.

Managing the work of a contractor or prime contractor is very similar to managing the work of a subcontractor. It's just that some things need to be emphasized more because of the following things (Sujoko, 2019):

1. The number of workers is rather small.
2. Focuses on a very specific field of work.
3. Set yourself up with full process and control systems.
4. Comparative cost estimation.

The process of selecting subcontractors is much the same as the main contractor/contractor, with emphasis on some details as the nature of the task or area of expertise, and the quantity or extent of the project restricted. Given this, the staff and specialists available must have their skills and expertise thoroughly investigated for technical assessment. The same applies to the condition of the equipment in question. Evaluation of pricing proposals can begin once convinced. When assessing bids, more so than when

selecting a general contractor. Comparative budgets are more important when assessing subcontractor bids than when selecting a main contractor. Proposals and comparative figures differ greatly due to the relatively small scope of work; the reasons for this discrepancy will be discussed during the discussions.

Construction quality, work control, project coordination system, capital, payment method, banking history, experience with claims, frequency of delays in contract fulfillment, and other factors were outlined by Shiau, Yan-Chyuan, et al (2006) as subcontractor selection criteria (Messah et al., 2009). Meanwhile, according to Lavelle, Derek et al. (2007) The following factors are considered when selecting a subcontractor: bid price, performance track record, Occupational Health and Safety record, financial capacity, ongoing projects, company standing, human resources, equipment, technical competence, and company age (Messah et al., 2009).

Research from previous studies, Presidential Regulation No. 54 of 2010 on the procurement of goods/services, and the Minister of Public Works regulation on the guidelines for the qualification of the national tender for construction services (chartering) No. 43/PRT/M/2007, indicate that six categories of factors should be considered in selecting subcontractors: general, financial, technical, managerial, safety, and company reputation (Rio Patria & Patria, 2017).

1. Part One: Overview. This section discusses the administrative data provided by the subcontractor with the aim of obtaining a high-level overview of the legitimacy and legal standing of the subcontractor company.
2. Money Matters. This section is about knowing the financial situation of the subcontractor so that you can gauge the strength of the company's working capital and the value of the subcontractor's bid.
3. Details about the Technology. The purpose of this section is to find out if the subcontractor has the minimum technical knowledge, expertise, and understanding to do the job.
4. In the realm of management. This section is about finding out how well the management system is used to complete the work so that the project objectives can be met.

5. Occupational Safety Considerations. The purpose of this section is to find out how seriously the business takes the possibility of workplace accidents during project execution.

Aspects of the company's reputation. This aspect is related to previous claims or demands as well as the frequency of delays in contract fulfillment.

### **Analytical Network Process/ANP**

ANP is a mathematical theory that provides a systematic way for decision-makers to address feedback and connected elements. It is a new qualitative technique that extends the AHP methodology (Puspitasari & Yancadianti, 2016). The original author of ANP was Thomas L. 'The Analytical Hierarchy Process' was his first published work (1980). Afterward, in 1996, Thomas L. Saaty republished a book titled 'The Analytical Network Process' which detailed additional developments of this technology (Gurpinar, 2006).

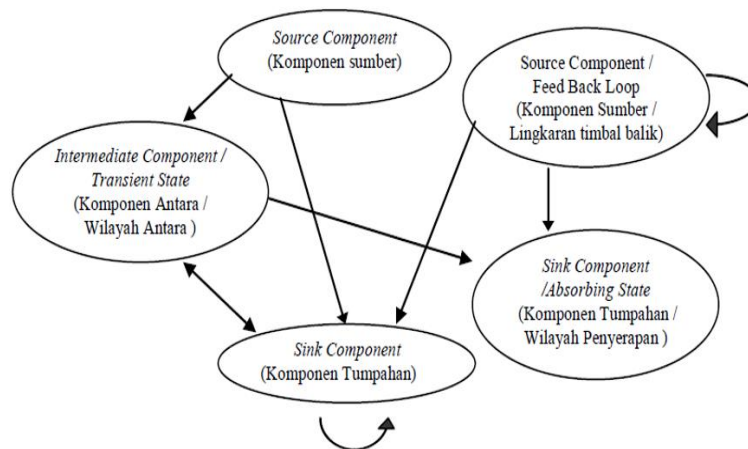
Connected to the decision-making process, MCDM (Multi-Criteria Decision Making) is a way to select the optimal option from many possibilities by comparing them according to predetermined criteria (Nugrohadi et al., 2015). When used for judgment and selection, ANP looks for inter-criteria relationships to assign relative importance to each criterion after their interactions (Zahra et al., 2015). As it progresses, it uses some methods to select options or alternatives, such as (Nugrohadi et al., 2015):

- a. AHP techniques are based on human perception and use a functional hierarchy. The hierarchical system is formed by first breaking down a complex, unstructured problem into smaller groupings.
- b. An improvement on the AHP approach is the ANP method. Using ANP, components both inside and outside the cluster can communicate with each other and provide feedback.

Despite the various approaches, all studies lead to the same result: a decision on which subcontractors to work with. When faced with several possible options, MCDM makes it easy to choose the best one. There are many factors to consider when choosing a subcontractor, and many of those factors are related to (Yoserizal & Singgih, 2012) stated that ANP will assign weights to all supplier selection factors. Particularly for critical raw

materials that are likely to require long-term partnerships, the results of this weighting can inform the supplier selection strategy in the supply chain (Kurniawati et al., 2013).

Saaty (1996) and Saaty (2001), assert that feedback networks are hierarchically inaccessible problem-solving systems (Saaty & Vargas, 2006). Elements at lower levels interact and depend on each other to form a feedback network. The feedback structure is not level-like in that it appears to be a cyclical network within each cluster of elements and can be looped within those clusters; this shape is not linear from top to bottom. The source and drain are both components of feedback. Whereas the source point is always the starting point for the intended path, the fulcrum is always the endpoint and never the starting point for other interests.



**Figure 2.**  
**Structure of the Feedback Network in ANP (Saaty & Vargas, 2006)**

A complete network has an origin (source node), a route (sink node) originating from the source (or intermediate nodes), a cycle point (or both), and a spill point (sink node) as its endpoint. As seen in Figure 2, the ANP structure consists of two parts: inner dependencies, which involve the inner components, and outer dependencies, which involve the outer component elements. Unlike AHP, which focuses on the beginning and continuation of the end, ANP networks may be able to illustrate some difficulties.

Considering and verifying empirical experience is the decision-making process in the use of ANP. This approach can find, categorize, and organize all aspects that have an impact



on the output or subsequent choice due to the network structure used, i.e. BCR (Saaty & Vargas, 2006)

## **RESEARCH METHOD**

The data for this research came from in-depth interviews and questionnaires completed by participants, making it a qualitative case study. The purpose of conducting in-depth interviews was to measure the level of participation of decision-makers concerning the research on subcontractor selection criteria in the building services industry (Qomarudin & Fitriyah, 2023). While filling out the questionnaire was given to the selected respondents (Suryawirawan et al., 2023). Project managers, control managers, procurement bureau managers, production managers, finance bureau managers, and personnel directly involved with procurement activities (procurement staff) were the respondents with decision-making power in this study of subcontractor selection criteria in the construction services industry. Decisions were made based on various aspects of the judgment sampling, which determined responses (Fransisca et al., 2024). BCR is a network structure methodology that the Analytical Network Process (ANP) uses to analyze data. The aim is to find, categorize, and control all the interests and variables that influence the decision outcome. To further aid decision-making, ANP analysis allows feedback and interrelationships among BCR network criteria (Saaty & Peniwati, 2013).

## **RESULTS AND DISCUSSION**

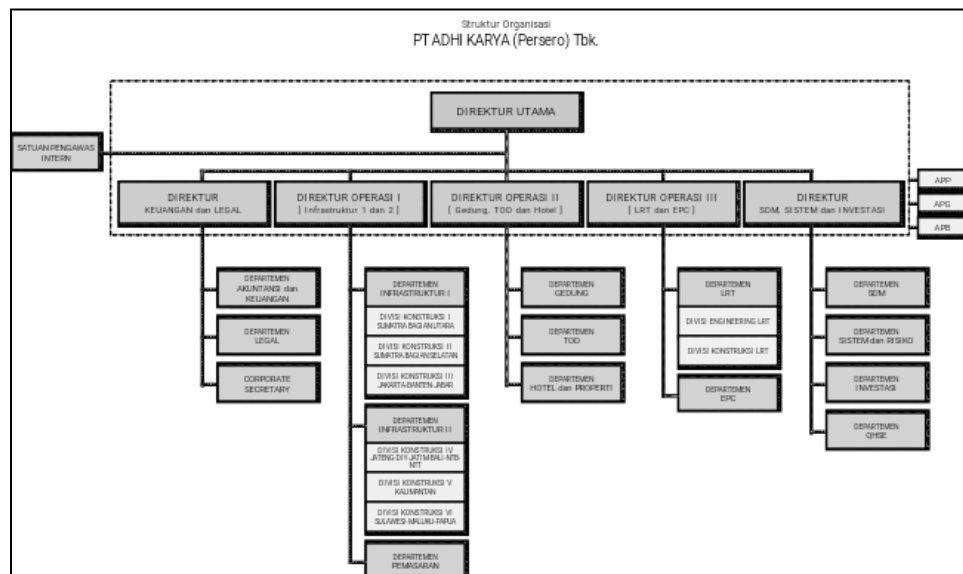
In Arabic vocabulary, sacrifice is better known as al-Udhiyyah, which means slaughtering a sacrificial animal.(Al-Ansori, 2015.). Meanwhile, in the Arabic-Indonesian Dictionary al-Udhhiyah it is defined as a goat that is sacrificed, slaughtered(Yunus, 1990). So it can be concluded that in terminology, sacrifice is slaughtering livestock such as sheep, cows, camels, buffaloes, on a predetermined day (10-13 Dzulhijjah)(Ministry of Education and Culture of the Republic of Indonesia, 1998). with the aim of getting closer to Allah SWT(Al-Khatib, 2009).

### Overview of the Company

Based in Jakarta, Indonesia, PT Adhi Karya (Persero) Tbk. (ADHI) operates as a publicly traded construction company. On 11 March 1960, it was established. The improvement of Indonesia's infrastructure was driven by this nationalization. On 1 June 1974, ADHI became a Limited Liability Company with the blessing of the Minister of Law of the Republic of Indonesia. The first construction business to be listed on the Indonesia Stock Exchange was ADHI until 2004.

To be strong and competitive in the face of intense competition, the company is involved in construction as well as adjacent industries including EPC, property, industrial, and investment businesses. ‘Beyond Construction’ is the company's slogan, and aims to convey the company's drive to expand into related industries.

In addition to its subsidiaries, ADHI relies on seven operational departments spread across Indonesia for its operations (Figure 3). The company aspires to become a leading construction company in Southeast Asia by learning and growing, embracing corporate values, acting professionally across five business lines, practicing good governance, supporting corporate growth, and building a simple yet grounded and applied corporate culture. The company's involvement in PKBL and CSR will increase along with its development.



**Figure 3.**  
**ADHI's Organisation Structure**

### Infrastructure Department 1

Figure 4 shows that ADHI's construction industry is supported by Infrastructure Department 1, an operational department. This department mainly handles infrastructure projects in the provinces of DKI Jakarta, West Java, and Sumatra. The following functional sectors assist the three operational divisions of Infrastructure Department 1 in carrying out its operational activities:

Construction Division 1, Northern Sumatera operating area

Construction Division 2, South Sumatera operation area

Construction Division 3, DKI Jakarta and West Java operation area

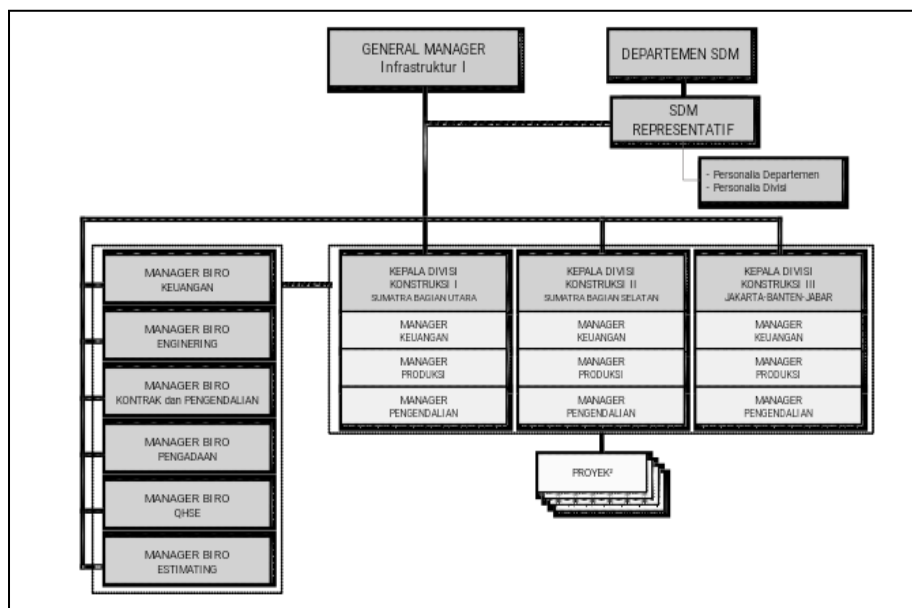


Figure 4.

### Organisational Structure of the Infrastructure Department 1

#### Procurement Process

All procurement of goods and services within ADHI is governed by the procurement policy of PT Adhi Karya (Persero) Tbk which was improved in 2017 following the decision of the Board of Directors 014-6/2017/223:

1. Efficient
2. Effective
3. Competitive
4. Transparent

5. Fair and reasonable

6. Accountable

Guidelines for the implementation of the procurement process of products and services as outlined in procedure 2016 BP013 LP P01, along with its explanation:

- A. By requesting or receiving introductions from potential vendors, subcontractors, or foremen, we can verify their ability to provide the materials, tools, or services required by the company. If they are not already on the approved list, an authorized officer (such as a project manager, division head, or general manager) will make the selection decision.
1. The VAL, SAL, and MAL databases include the names of suppliers, subcontractors, and foremen who have passed the selection process at the Department, Division, or project level.
  2. All divisions and projects within a department can use prospective suppliers, subcontractors, and foremen registered at the VAL/SAL/MAL level; the division or project in question does not need to retrieve them.
  3. Suppliers, subcontractors, and foremen registered at the Val, SAL, or MAL division level apply to all projects within that level, and there is no need for the project to select them again.
- B. Priority will be given to soliciting quotes from suppliers, subcontractors, and foremen who assist in the tender process, provided that a letter of guarantee (MoU or letter of support) is provided at the time of tender:
- a. Generally, when you need to purchase goods or services, you should submit a request for quotation to at least three different vendors or subcontractors. However, if the goods or services are truly unique if there are not many vendors or subcontractors, or if it is truly an emergency, by rule, or due to other factors, then you can hire one vendor or hold a beauty contest. Limited or open auctions can be used to acquire products and services if they are deemed important and will provide better returns.

- b. To negotiate and clarify with potential subcontractors to purchase products and services as efficiently, effectively, and optimally as possible. Negotiation and clarification based on standards:
  1. Costs and payment methods...
  2. When the purchase and execution will take place.
  3. Ability to implement and finance the project.
  4. References from previous employers who have held comparable positions.
- c. Conduct Comparative Analysis:
  1. Meet standard requirements.
  2. Delivery and/or implementation schedule met.
  3. Price per unit.
  4. Procedure/work plan (for acquiring manufactured goods/services).
  5. Fifth, insurance.
  6. After-sales service and warranty.
  7. Payment method.
  8. Conditions of Carriage / Product Delivery Location.
- d. The project manager in charge of cost management ensures that costs, volumes, and available work items are all included in the final price after the execution budget plan (RAP) is clarified and negotiated. The Project Manager will seek permission from the Competent Authority (Division Head, General Manager, or Operations Director) to amend the RAP if there is a price/volume difference between the RAP and the subcontractor's proposal.

The authors of this study will focus on the issue in Point b. 4 above, where subcontractors often submit bids that deviate from the implementation budget plan in terms of cost, volume, and availability of work items.

With consideration of some previous research (Ulubeyli, Azaz, & Arslan, 2017) where the financial aspect (K1) weights 15.48%, the bid price (K2) with a weight of 25.00%, the technical aspect (K4) with a weight of 20.54% prioritizes the criteria for selecting subcontractors, then at point b.2 the criteria that are considered for selection decisions in the Focused Group Discussion (FGD) discussion are grouped into alternative criteria: Price

Criteria, Technical Capability Criteria (procurement time, implementation time, procurement capability, implementation capability, and similar work references), and Financial Capability Criteria (financial capability, payment method). Meanwhile, in point b.3, the comparison analysis or comparison of criteria in the FGD is grouped into Benefit Cost Risk control criteria.

### **Data Description**

Based on what was discussed in the FGDs, the following factors are considered when companies select subcontractors:

#### **A. Benefits**

Decisions should consider benefits, and benefits are the criteria for that. The criteria that improved the FGD results include:

- a. Choosing subcontractors wisely will help you get the job done quickly, efficiently, and with little waste of money.
- b. Subcontractor selection can help with the project's measurable cash flow management, which in turn helps with the company's cash flow management.
- c. Productivity refers to assigning subcontractors to projects in a way that maintains or increases their production capacity according to the plan.
- d. Quality is to ensure that subcontractors are selected with the ability to ensure and maintain quality in accordance with specified requirements.

#### **B. Cost**

Cost is a criterion that, when converted into an expenditure or sacrifice, may have an adverse impact. In terms of FGD outcomes, adverse characteristics are:

- a. The total amount of money spent by the business on contracts with subcontractors is known as the contract cost.
- b. Bank charges are costs that the business has to pay as a result of the contract in accordance with its policies and procedures.
- c. Procurement process length is the time taken from the start of the process to the appointment of the subcontractor, i.e. the signing of the contract.

C. Risk.

Decisions are negatively affected by risk, which is a measure of the uncertainty that may occur. Risk criteria include:

- a. The subcontractor may abandon the project or breach the contract if it cannot complete the work as agreed in the contract.
- b. Potential claims include complaints from subcontractors about unprepared job sites that cause delays, additional costs due to late equipment, costs that were not part of the original contract, and so on.
- c. Possible penalties: In the event that the subcontractor's performance causes the project to run behind schedule or fail in terms of quality, leading to product defects and the need for additional work, the owner or employer may decide to penalize the prime contractor.

D. Decisions are always based on alternative criteria, which is the standard for strategic considerations. Other similar standards include:

- a. subcontractors' bids for the value they can provide for a project are based on the scope of work defined by the prime contractor, and this provides the basis for pricing.
- b. A subcontractor is considered technically capable if it can effectively manage the scope of work from start to finish. This includes tasks related to technical work, such as work execution procedures, organizing execution, ensuring the availability of resources, creating execution schedules and quality plans, and so on.
- c. A subcontractor is considered financially capable if they have a strong financial footing, bank backing, and business guarantees related to the project at hand.

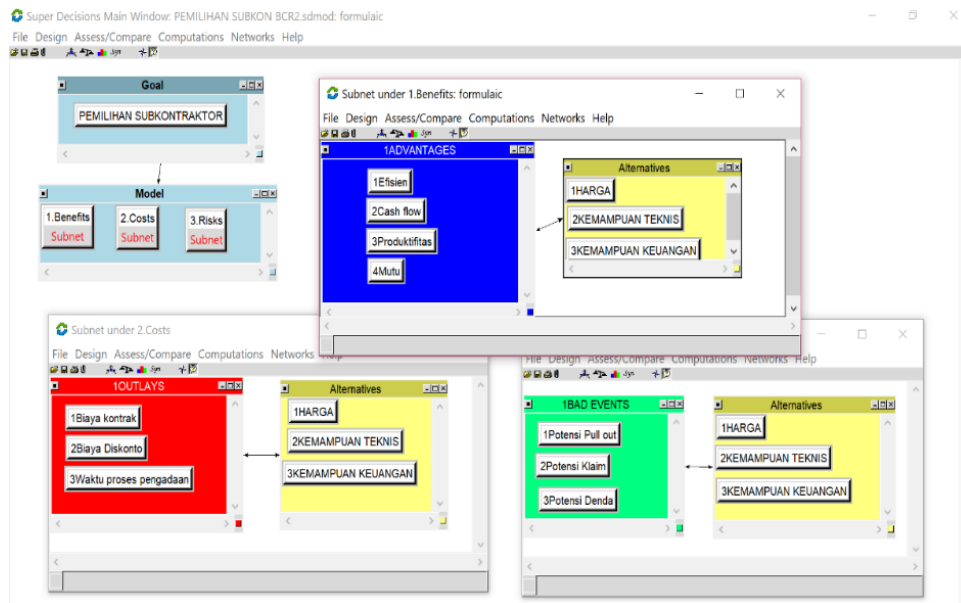
Table 1 is the grouping plan of criteria and sub-criteria from the FGD with the BCR network.

**Table 1.**  
**Plan of Criteria and Subcriteria for the BCR Model**

| Alternatif   | Kriteria Kontrol | Subkriteria            |
|--|------------------|------------------------|
| 1. Harga<br>2. Kemampuan Teknis<br>3. Kemampuan Keuangan | Benefits         | Efisien                |
|  |                  | Cash Flow              |
|  |                  | Produktifitas          |
|  |                  | Mutu                   |
|  | Costs            | Biaya Kontrak          |
|  |                  | Biaya Bank             |
|  |                  | Waktu proses pengadaan |
|  | Risks            | Potensi Pull-out       |
|  |                  | Potensi Klaim          |
|  |                  | Potensi Denda          |

Source: Authors' Compilation of FGD Results

The BCR model 2-level network, shown in Table 1, includes a top-level control network and three subnetworks, as well as a BCR network that uses super decisions. Each of the three control criteria, Cost, and Risk-has its subnetwork, and the top-level network itself is hierarchical. There must be a cluster with all possible possibilities in each subnet.



**Figure 6.**

**Dependency Relationship between Criteria and Subcriteria of the BCR Network**

Source: Data Processing through Super Decision



**Data Analysis and Discussion**

After surveying seven people (including project managers/project managers, control managers, procurement bureau managers, and procurement staff), we can use the results to calculate the relative importance of each sub-network criteria (Benefits, Costs, Risks) and display them in a table format. The scale used for pairwise comparisons ranges from 1 to 9. Using Microsoft Excel, we calculate the average geometric mean of the respondents' evaluations to obtain the relative significance value, which is then processed using super decision.

**Control Criteria Priority Weights**

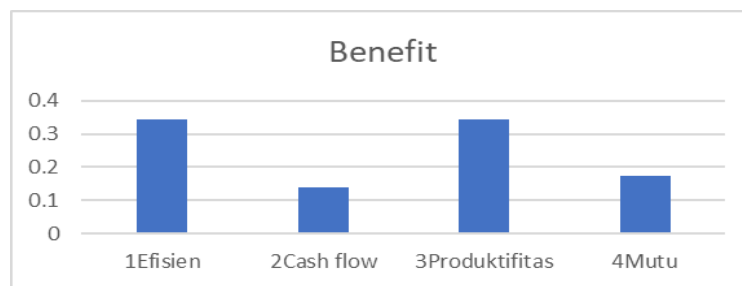
**Benefit**

The results of the benefit sub-network priority weights are shown in Table.2 below:

**Table 2.**  
**Benefit Sub-Network Criteria Weights**

| <i>Name</i>    | <i>Normalized By Cluster</i> | <i>Limiting</i> |
|----------------|------------------------------|-----------------|
| 1Efisien       | 0,34325                      | 0,171626        |
| 2Cash flow     | 0,14059                      | 0,070297        |
| 3Produktifitas | 0,34325                      | 0,171626        |
| 4Mutu          | 0,1729                       | 0,086452        |

Source: Super Decision



**Figure 7.**  
**Benefit-Cluster Prioritization Chart**

With a combined weight of 34.325 percent, the efficient sub-criterion and the productivity criterion rank first in this benefit control criterion; the quality criterion ranks at 17.29%. It has a weight of 14.05% in the cash flow sub-criterion. When selecting subcontractors, the most important factors are efficiency and production.

**Cost**

The results of the cost sub-network priority weights are shown in Table 3 below:

**Table 3.**  
**Sub-Network Cost Criteria Weights**

| <i>Name</i>             | <i>Normalized By Cluster</i> | <i>Limiting</i> |
|-------------------------|------------------------------|-----------------|
| 1Biaya kontrak          | 0,41761                      | 0,208804        |
| 2Biaya Bank             | 0,39114                      | 0,195568        |
| 3Waktu proses pengadaan | 0,19126                      | 0,095628        |

Source: Super Decision



**Figure 8.**  
**Cluster-Cost Prioritization Chart**

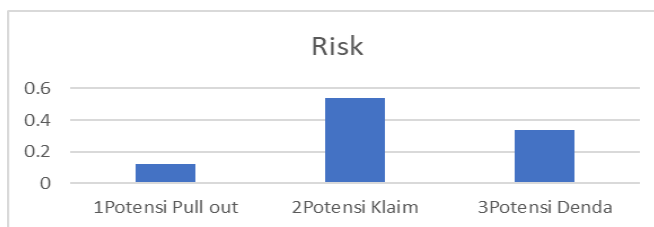
The subcontract cost criterion has a significant impact on the cost control criterion, which is the sacrifice criterion that must be provided when selecting a subcontractor. This can be seen from the super choice in Table 3 and Figure 8 shown above. With a weight of 41.76%, contract cost is the most important criterion, followed by bank charges at 39.114%, and procurement processing time sub-criterion at 19.126%.

**Risk**

The results of the risk sub-network priority weights are shown in Table 4 below:

**Table 4**  
**Risk Sub-Network Criteria Weights**

| <i>Name</i>        | <i>Normalized By Cluster</i> | <i>Limiting</i> |
|--------------------|------------------------------|-----------------|
| 1 Potensi Pull out | 0,12261                      | 0,061303        |
| 2 Potensi Klaim    | 0,53832                      | 0,269159        |
| 3Potensi Denda     | 0,33908                      | 0,169538        |



**Figure 9.**  
**Risk Cluster Prioritization Chart**

The sub-criterion for prospective claims has a significant impact on the risk control criteria, as seen in Table 4 and Figure 9 above. The assessment weight for prospective claims is 53.832%, higher than the weight for potential penalties (33.908%) and withdrawal sub-criteria (12.261%). As they are most likely to occur during subcontractor selection, potential claims have a significant impact.

**Criteria Synthesis**

The findings of the BCR evaluation of each option are shown in Table 5 below. It shows the relative importance of the various options based on their evaluation results against each control criterion. Technical capability is weighted at 54.01% on the benefit control criteria, financial capability at 27.03%, and pricing at 18.96%. In terms of cost control criteria, technical capability accounted for 24.34% of the total, financial capability for 32.63%, and a strong influence on pricing choices for 43.10%. The number one priority in controlling risk criteria is the financial capacity (48.48 percent), followed by technical ability (35.42%), and finally pricing criteria (16.09%).

**Table 5.**  
**Prioritization of Alternatives in Each Sub-Network**

|                | Name                | Ideals | Normal | Raw    |
|----------------|---------------------|--------|--------|--------|
|                |                     |        | s      |        |
| <b>BENEFIT</b> | 1HARGA              | 0,3511 | 0,1896 | 0,0948 |
|                | 2KEMAMPUAN TEKNIS   | 1,0000 | 0,5401 | 0,2700 |
|                | 3KEMAMPUAN KEUANGAN | 0,5006 | 0,2703 | 0,1352 |
| <b>COST</b>    | 1HARGA              | 1,0000 | 0,4302 | 0,2151 |
|                | 2KEMAMPUAN TEKNIS   | 0,5658 | 0,2434 | 0,1217 |
|                | 3KEMAMPUAN KEUANGAN | 0,7585 | 0,3263 | 0,1632 |
| <b>RISK</b>    | 1HARGA              | 0,3319 | 0,1609 | 0,0805 |
|                | 2KEMAMPUAN TEKNIS   | 0,7306 | 0,3542 | 0,1771 |
|                | 3KEMAMPUAN KEUANGAN | 1,0000 | 0,4848 | 0,2424 |

In addition, as shown in Table 6, the results of conditional calculations using the multiplication and additive formulas are used in the synthesis of the primary network, which aims at the selection of subcontractors.

In another theory of Saaty (2001), there are two types of calculations produced by BOCR:

1. Negative additive formula, a common tool for setting future priorities.  $bB + oO - cC - rR$ .
2. The multiplication formula is a short-term prioritization tool that is functionally similar to marginal cost-benefit analysis.  $BO/CR$ .

**Table 6.**  
**Combination of Alternative Priorities on Subcontractor Selection**

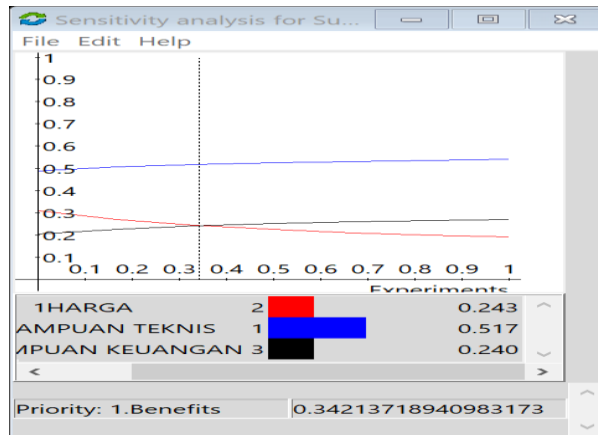
|                    | <b>B</b><br><i>Benefit</i> | <b>C</b><br><i>Cost</i> | <b>R</b><br><i>Risk</i> | <b>B/(C*R)</b><br><i>multiplicative formula</i> | <b>B+1/C+</b><br><i>1/R additive formula</i> |        |        |
|--------------------|----------------------------|-------------------------|-------------------------|---|--|--------|--------|
| Harga              | 0,0948                     | 51                      | 0,21                    | 4   | 0,080  | 0,2557 | 0,2207 |
| Kemampuan Teknis   | 0,2700                     | 17                      | 0,12                    | 1   | 0,177  | 0,5848 | 0,5266 |
| Kemampuan Keuangan | 0,1352                     | 32                      | 0,16                    | 4   | 0,242  | 0,1595 | 0,2527 |

The alternative cost metrics of technical competence and financial capability are less important than pricing criteria in determining total costs. That is, despite having the least risk compared to the other criteria, the pricing criterion still offers fewer positive benefits.

Although the risk associated with technical competence is greater than the pricing criterion but lower than the financial capability criterion, it offers the most profit at the least cost. The prime contractor benefits from the subcontractor's technical capability in the form of management skills in terms of managing the scope of work, task execution methods, execution schedule, resource availability, thorough organization, and efficiency. In addition, due to the high level of technical expertise of the subcontractor, the prime contractor has less risk if the subcontractor cannot complete the work, and the possibility of claims and fines is small.

### Sensitivity Analysis

Sensitivity analysis is a way to find out what will happen if certain variables are changed. This study compares the sensitivity of one set of criteria to another, this time with benefit parameters, and uses Super Decision to conclude. The priority parameter sensitivity graph displays the results of the sensitivity study. The benefits are shown in Figure 10.



**Figure 10**  
**Sensitivity Graph for Benefits**

Figure 10 shows that adjustments to pricing criteria have a greater impact on choice-making than financial capacity with a priority of just under 34.2%. The benefit control criteria for subcontractor selection, however, will always be based on decisions made using the technical competence criteria.

### CONCLUSION

Several things can be deduced from the data collected. To begin with, subcontractor selection is governed by control criteria in the form of Benefits, Costs, and Risks using BCR network analysis. There are four sub-criteria for each control criterion related to benefits, three to costs, and three to risks. Pricing, technological capability, and financial capability criteria are all interdependent sub-criteria. With a combined weight of 34.325%, efficiency and productivity criteria, quality of 17.290%, and cash flow of 14.059%, these sub-criteria rank highest among the benefit control criteria. The following sub-criteria rank in importance under the cost control criteria: contract costs (weight 41.761%), bank charges (39.114%), and procurement process time (19.126%). In contrast, the sub-criteria of risk control criteria are ranked as follows: possible claims (weight 53.832%), potential fines (weight 33.908%),

and potential withdrawals (weight 12.261%). The second change is the emphasis on non-traditional technical competency standards that can improve the subcontractor selection process. Technical competency criteria have an additive formula weight of 52.660 percent, meeting pricing standards of 22.070 percent and financial competency of 25.270 percent. The third conclusion of the sensitivity analysis is that, although technical capacity remains constant in the parameters of the benefit control criterion, a change in the priority parameter below 34.2% of the price criterion has a greater impact than a change in the financial capability criterion. In making decisions about which subcontractors to hire, the technical competence factor may take precedence. The implications of this finding include but are not limited to, the fact that establishing priority criteria for subcontractor selection may assist in the improvement and more thorough organization of the current method. Furthermore, additional selection procedures could use priorities as weighted references, leading to more objective and accurate evaluations and, ultimately, better judgments that affect long-term strategies. In addition, there are some weaknesses in this study: (1) The primary BCR criteria and sub-criteria often encountered in subcontractor selection dilemmas are the only ones taken into account in this study. Considering the possibilities presented by the current external circumstances would change the way potentials are evaluated. two, the study was conducted within the scope of one department, with an operational focus on infrastructure projects. It may be different if the study is conducted in a department/division whose operational activities are ECP projects.

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