Integrated ISM-ANP Method for Supplier Selection Criteria Analysis: A Case Study of Construction Company

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Abstract. Supplier is one of the most important parts in supply chain. Supplier ensures the availability of materials for company’s continuity. Supplier selection using several criteria is needed to get a reliable supplier. Therefore, selecting key criteria for supplier selection is essential. This study discussed the relationships between criteria to obtain supplier selection key criteria in a construction company with interpretive structural modeling (ISM) and selecting supplier with analytic network process (ANP). Data used in this study are initial criteria, the relationships between criteria, the grouping of criteria, and pairwise comparison are obtained from interviews and questionnaires. Using ISM method, 19 key criteria are identified, such as availability and integrity. The best supplier based on key criteria is obtained from ANP method. The result of integrated ISM and ANP method shows that the key criterion with the highest weight is availability, and supplier 1 is the best supplier based on key criteria. Availability refers to the availability of materials in supplier, and this key criterion is considered as very important thus having spare suppliers must be considered.

Keywords: Supplier Selection, Interpretive Structural Modeling, Key Criteria, Analytic Network Process, Construction Company

1. Introduction
Raw material supplier is a part of supply chain management that greatly influence the production process [1]. Supplier selection has an essential part in business because the performance and efficiency of the supplier directly affect the success of the company [2]. Supplier selection is a multi-criteria decision-making problem that consider many criteria to deliver a solution [3]. Thus to get a maximum supply chain performance, supplier selection must consider criteria that relevant to company goals [4]. The supplier selection list by [5] is the most common criteria used in supplier selection, [6] then updated the list by comparing supplier selection criteria in the year 1966-1990 and 1990-2001 and some criteria, such as operational control, packaging ability, and training aids, are not used anymore. But there are also new criteria, such as reliability, flexibility, and long term relationship. [7] compares studies in the year 2005 to 2009 and get that traditional criteria which are price, quality, delivery, and service are still in use. However, the study also finds new criteria such as supplier’s profile and availability. Therefore it can be seen that there is a change in supplier selection criteria tren.

Every company uses different supplier selection criteria. [8] conducted a study in an automobile company and used criteria such as cost, quality, and long term relationship to select the supplier. A
study by [4] uses 9 criteria, for example, price, material specification, and quality consistency. [9] conducted supplier selection in a construction company using 8 criteria, such as quality, delivery, location, and warranties and claim policies. The supplier selection criteria in the three studies mentioned above differ between one another. Location and warranties and claim policies are used in the construction project but not taken into consideration in other studies. The difference in criteria is caused by the construction project supply chain that is different from the conventional supply chain.

A large number of parties involved in the construction project supply chain makes the project unique, and the process is temporary. The nature of the construction project causes it has triple constraint that is cost, quality, and construction time; thus, optimization of time and resources must be done [10]. One of the stages in the construction project is selecting suppliers. The supplier selection process can be done much more effective and efficient when focusing on key criteria [11].

Key criteria hold a vital role in supplier selection because of the considerable influence it can cause to the supplier selection criteria model. The interpretive structural modeling (ISM) method can produce key criteria. This method identified the direct and indirect relationships from criteria that define the problem to obtain key criteria. Key criteria is criteria that have high driving power that can affect many criteria in the model [12]. A study by [13] uses ISM to identifies the mutual relationships among supplier selection process enablers and to develop a hierarchical model of the enablers. However, the study is limited to only determining the key enablers and has not implemented them in the supplier selection process.

ISM method can be used as a basis for weighting supplier selection criteria as done by [11] that used ISM with the technique for others preference by similarity to ideal solution (TOPSIS). The study uses ISM to determine the key criteria then followed by supplier selection using TOPSIS with criteria weighting from experts. [14] integrate ISM with ANP to get third-party logistics (3PL). The ISM method produces a model that take into consideration in evaluating the criteria. Then the ANP method is used to get the best third-party logistics providers. The identification of key criteria has not been done in this study as conducted in research by [11] whereas it does not consider the interrelationship between criteria when selecting a supplier. ANP method uses network model that has feedback structures and is not rigid to illustrate the relationships between criteria. Thus the model from ISM can be used as a basis in ANP method.

Supplier selection criteria from previous studies, including the one conducted in the construction company, are still determined with a literature study with the approval from the company and key criteria identification for supplier selection has not been done. Therefore, this study uses an integrated ISM and ANP methods to get the best supplier focusing on key criteria. ISM is used to identified key criteria that are used for supplier selection with ANP, which also consider the relationships between criteria. This study is conducted in a construction company in Jakarta and the result of this study helps the construction company to conduct a more effective and efficient supplier selection with key criteria.

2. Methods

The study is divided into two sections, the ISM method to get the key criteria for supplier selection and the ANP method to weigh the criteria and supplier. ISM method consists of 6 steps, namely initial criteria, structural self-interaction matrix (SSIM), reachability matrix, level partition and conical matrix, ISM model, and MICMAC analysis. ANP method consists of 4 steps: key criteria grouping, ANP modeling, pairwise comparison, and ANP data processing.

2.1 Initial Criteria

The criteria used in this study are 38 supplier selection criteria collected from several studies in table 1. The criteria are selected by an expert, a procurement manager from the construction company using a questionnaire. At the initial stage, The company chooses criteria that considered as crucial in supplier selection, the obtained 19 criteria : quality, delivery, price, repair service, reliability, flexibility, attitude, communication system, performance history, consistency, long term relationship, reciprocal
arrangement, quality standard, integrity, professionalism, reputation and position in industry, operational control, amount of past business, and availability.

Table 1. Supplier Selection Criteria

| No. | Criteria                     | Sources       | No. | Criteria                  | Sources       |
|-----|------------------------------|---------------|-----|---------------------------|---------------|
| 1   | Quality                      | [5], [6], [7], [15] | 20  | Process improvement       | [6]           |
| 2   | Delivery                     | [5], [6], [7], [15] | 21  | Product development       | [6], [7], [16]|
| 3   | Price                        | [5], [6], [7], [15], [16] | 22  | Inventory cost            | [6]           |
| 4   | Repair service               | [5], [6], [7] | 23  | JIT                        | [6]           |
| 5   | Technical capability         | [5], [6], [7], [15] | 24  | Quality standard          | [6]           |
| 6   | Production facilities and capacity | [5], [6], [7], [15], [16] | 25  | Integrity                 | [6], [7]       |
| 7   | Financial position           | [5], [6], [7], [15], [16] | 26  | Professionalism           | [6]           |
| 8   | Management and organization  | [5], [6], [7], [15], [16] | 27  | Research                  | [6]           |
| 9   | Reliability                  | [6], [7] | 28  | Cultural                   | [6]           |
| 10  | Flexibility                  | [6], [7] | 29  | Reputation and position in industry | [5], [6], [15] |
| 11  | Attitude                     | [5], [6] | 30  | Labor relations record    | [5]           |
| 12  | Communication system         | [5], [6], [7] | 31  | Operational control       | [5]           |
| 13  | Performance history          | [5], [6], [7], [15] | 32  | Packaging ability         | [5]           |
| 14  | Geographical location        | [5], [6], [7], [15] | 33  | Training aids             | [5]           |
| 15  | Consistency                  | [6] | 34  | Desire for business       | [5]           |
| 16  | Long term relationship       | [6] | 35  | Amount of past business   | [5], [7]       |
| 17  | Procedural compliance        | [5], [6] | 36  | Warranties and claim      | [6]           |
| 18  | Impression                   | [5], [6] | 37  | Supplier’s profile        | [7]           |
| 19  | Reciprocal arrangement       | [5], [6] | 38  | Availability              | [7]           |

2.2 Structural Self-Interaction Matrix (SSIM)
SSIM consists of supplier selection criteria that have been selected in the previous step. The interconnections between criteria determined by the expert’s opinions are shown in this matrix and it used four symbols. V means there is a relation from i to j, A for relation from j to i, X for there are connections from both i and j, and O means there is no connection between i and j. The matrix can be seen in table 2.

2.3 Reachability Matrix
Reachability matrix is developed from SSIM by changing the VAXO notation into biner with the following rules:
- V – the entries in the reachability matrix are 1 for (i, j) and 0 for (j, i).
- A – the entries in the reachability matrix are 0 for (i, j) and 1 for (j, i).
- X – the entry for both directions is 1.
- O – the entry for both directions is 0.

Then the transitivity or the indirect relationships in the matrix are checked. The transitivity follows these rules; if criteria i can affect criteria j, and criteria j can affect criteria k, then criteria i can affect criteria k indirectly. The cell that undergoes transitivity is highlighted. The reachability matrix after transitivity can be seen in table 3.

2.4 Level Partition and Conical Matrix and Model ISM
The reachability matrix after transitivity is divided into several levels by eliminating criteria that have the same reachability set and intersection. The reachability set is a set of criteria it can affect. On the contrary, the antecedent set is a set of criteria that can affect the criteria. While the intersection is the criteria listed in both reachability and antecedent set. The level partition can be seen in table 4. Then a conical matrix is made by sorting the reachability matrix by level partition to help the making of the ISM model. Next, The structural model or digraph is made from level partitioning and the relationships...
between criteria in the reachability matrix. Next, the digraph is transferred into ISM model by changing the element node with criteria. The ISM model can be seen in Figure 1.

Table 2. SSIM

| Criteria | Criteria j (Column) |
|----------|---------------------|
| 1 Quality| O O O V A V O A A V V A V V O O X X O |
| 2 Delivery| A O V V A V A A O O X V O O O O O |
| 3 Price | A O X V A V A A O O X V O O O O O |
| 4 Repair service | O O V V O O O O O X X O X O X |
| 5 Reliability | A V X V A X A O O X V A V X A X |
| 6 Flexibility| O O X V O A A X X X O V V A |
| 7 Attitude | O O X V V V X X X X O V X |
| 8 Communication system | O O V V O X O O X V O |
| 9 Performance history | A O O V O O X A A X A |
| 10 Consistency | O V V V X X A V V V |
| 11 Long term relationship | A O O X O A A A A X |
| 12 Reciprocal arrangement | O O V V O O X A A |
| 13 Quality standard| O O V V X V O A |
| 14 Integrity | O O V V O V X |
| 15 Professionalism | O O V V V V |
| 16 Reputation and position in industry | O O O V V |
| 17 Operational control | O O V V |
| 18 Desire for business | O O A A |
| 19 Amount of past business | A O |
| 20 Warranties and claim policies | O |
| 21 Availability |

Table 3. Reachability matrix after transitivity

| CRITERIA | Criteria j (Column) | Driving Power |
|----------|---------------------|---------------|
| Criteria i (row) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 9 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 11 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 12 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 13 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 14 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 17 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 18 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 19 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

2.5 MICMAC Analysis
The value of driving power and dependence that are obtained from the reachability matrix after transitivity in table 1. These values are inputted to driving power-dependence diagram for MICMAC analysis. The chart is divided into four categories after drawing lines at half of the maximum values from driving power and dependence. The four categories are:

- **Autonomous factors.** Because of the low driving power and dependence in this factor, the criteria in this category can be separated from the system. No criterion is in this category
- **Linkage factors.** The criteria in this factor are high in both driving power and dependence, making it unstable. Because it has high driving power, criteria in this category are considered as key criteria.
The criteria in this category are quality, delivery, price, repair service, reliability, flexibility, attitude, communication system, performance history, consistency, long term relationship, reciprocal arrangement, quality standard, integrity, professionalism, reputation and position in industry, operational control, and amount of past business.

- **Dependent factors.** This factor has low driving power and high dependence power that makes it vulnerable to change. The criteria in this category are business need, business processes, and business activities.
- **Independent factors.** This factor has high driving power, but low dependence; thus, it can be the key criteria. The criteria in this category is availability (criteria 21).

### Table 4. Level partition

| Criteria | Reachability Set | Antecedent Set | Intersection | Level |
|----------|-----------------|----------------|--------------|-------|
| 1        | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 | 1,2,3,4,5,6,7,8,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,10,11,12,13,14,15 | II |
| 2        | 5,16,17,18,19 | 1,6,17,19,21 | 1,6,17,19,21 | III |
| 3        | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 4        | 5,16,17,18,19 | 5,16,17,19,21 | 5,16,17,19,21 | II |
| 5        | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,10,11,12,13,14,15 | II |
| 6        | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | II |
| 7        | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 8        | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | II |
| 9        | 3,4,5,6,7,8,9,10,11,12,13,14,15,16 | 3,4,5,6,7,8,9,10,11,12,13,14,15,16 | 3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19 | I |
| 10       | 5,16,17,18,19,20 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | I |
| 11       | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 12       | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | II |
| 13       | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 14       | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | II |
| 15       | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 16       | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | II |
| 17       | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | 1,2,3,4,5,6,7,8,9,10,11,12,13,14,15 | II |
| 18       | 3,4,5,6,7,8,9,10,11,12,13,14 | 3,4,5,6,7,8,9,10,11,12,13,14 | 3,4,5,6,7,8,9,10,11,12,13,14 | I |
| 19       | 5,16,17,18,19 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | I |
| 20       | 2,3,4,5,6,7,8,9,10,11,12,13,14,15,16 | 2,3,4,5,7,10,12,14,15,16,17,20 | 2,3,4,5,7,10,12,14,15,16,17,20 | I |
| 21       | 5,16,17,18,19,20 | 5,16,17,18,19,21 | 5,16,17,18,19,21 | IV |

### 2.6 Key Criteria Grouping as part ANP Model

The key criteria from ISM method as an output from ISM method is grouped in this step as an input for ANP method. This is the integration step between the two methods and it is done by brainstorming with an expert from company. The grouping is based on the similarity of key criteria. The key criteria is 19 from...
ISM method are grouped into 4 clusters, namely: relationship, performance, service, and product. The relationship cluster is a set of key criteria that has the same characteristic that is the relationship between the supplier and company up until now. The key criteria in this cluster are long term relationship, reciprocal arrangement, amount of past business, and performance history. Performance cluster is a set of key criteria that denote the supplier success rate that can be assessed by the company itself or from outside of the company. The key criteria in this cluster are reputation and position in industry, delivery, operational control, and reliability. Service cluster is a set of key criteria that is related to the supplier’s attitude in serving customers and the easiness of service given by the supplier. Repair service, flexibility, attitude, communication system, integrity, and professionalism are in this cluster. The product cluster is a set of key criteria that are related to the materials. The criteria in this cluster are quality, price, consistency, quality standard, and availability.

![ISM Model](image.png)

**Figure 1. ISM Model**

**Table 5. Criteria Weights**

| Cluster   | Cluster Weight | Criteria                              | Local Weight | Global Weight |
|-----------|----------------|---------------------------------------|--------------|---------------|
| Relationship | 0.088953       | Long term relationship                | 0.11910      | 0.015288      |
|           |                | Amount of past business               | 0.20052      | 0.02574       |
|           |                | Performance history                   | 0.31801      | 0.040821      |
|           |                | Reciprocal arrangement               | 0.36237      | 0.046516      |
| Performance | 0.215626       | Reputation and position in industry   | 0.18105      | 0.030364      |
|           |                | Delivery                              | 0.21780      | 0.036527      |
|           |                | Operational control                   | 0.25126      | 0.042139      |
|           |                | Reliability                           | 0.34988      | 0.058678      |
| Service   | 0.135443       | Communication system                  | 0.04251      | 0.008315      |
|           |                | Repair service                        | 0.04832      | 0.009453      |
|           |                | Flexibility                           | 0.12375      | 0.024208      |
|           |                | Attitude                              | 0.18175      | 0.035555      |
|           |                | Professionalism                       | 0.22300      | 0.043623      |
|           |                | Integrity                             | 0.38068      | 0.074469      |
| Product   | 0.559979       | Quality                               | 0.10021      | 0.026361      |
|           |                | Quality standard                      | 0.10442      | 0.027468      |
|           |                | Consistency                           | 0.23023      | 0.060566      |
|           |                | Price                                 | 0.25025      | 0.06583       |
|           |                | Availability                          | 0.31490      | 0.082837      |

3. Result and Discussion

3.1 ISM Results Discussion

This study uses 19 key criteria by ISM. The key criteria are quality, delivery, price, repair service, reliability, flexibility, attitude, communication system, performance history, consistency, long term...
relationship, reciprocal arrangement, quality standard, integrity, professionalism, reputation and position in industry, operational control, amount of past business, and availability.

Based on MICMAC Analysis has obtained, availability criteria becomes the most important criterion for selecting a supplier in this study because this factor has high driving power, but low dependence; thus, it can be the key criteria. Constantly changed schedule caused by the number of parties involved in projects makes a change in material requirements. Thus the company may need to do urgent orders, and the suppliers are expected to have high availability in time of urgent orders.

3.2 ANP Results Discussion
The processing for the ANP method is done with Super Decision software. The result from the software, global and local weights for each criterion, is shown in table 5. The highest global weight is availability criteria. This criteria also has an vital position in the ISM model, which is the lowest level, making it the base for the model. Both results support that availability is the most important criteria for selecting a supplier in this study. Construction project needs high availability of materials in supplier because the constantly changing schedule. High availability caused a need for supplier flexibility in order change.

Table 6. Supplier Weights

| No. | Alternatives | Value   |
|-----|--------------|---------|
| 1   | Supplier 1   | 0.372335|
| 2   | Supplier 2   | 0.131659|
| 3   | Supplier 3   | 0.260464|
| 4   | Supplier 4   | 0.128839|
| 5   | Supplier 5   | 0.106683|

From table 6, supplier 1 has the highest weight, 0.372335 followed by supplier 3, supplier 2, supplier 4, and supplier 5. Supplier 1 is significantly higher than the others because it has the best performance in all criteria. Supplier 3 has the same weight in reputation and position in industry with supplier 1, the attitude and professionalism performance of this supplier is also high. On the other hand, supplier 2, supplier 4, and supplier 5 have similar values. Supplier 4 excels in reputation and position in industry, but the availability performance is the lowest. While supplier 2 has a better performance in availability between the three, so the overall weight is better. A construction project needs a high availability of materials in the supplier, so the company can consider having spare suppliers.

3.3 Managerial Implications
ISM model depicts interconnections between supplier selection criteria in hierarchic structure, thus giving the order of importance of criteria. Criteria in the lower level can affect the criteria above them; thus the effect of performance change can be estimated. For example, price fluctuations can affect the customer’s desire to establish a long term relationship with the supplier. Focusing on key criteria can simplify the supplier selection process. Before identifying the key criteria, the company considers the desire for business and claim and warranties policies criteria. These two criteria are eliminated because they do not give significant impact on supplier selection decision. The supplier selection process can be simplified by omitting these criteria.

From ANP results, availability criteria has the highest weights. Availability refers to the availability of materials in suppliers for urgent orders. Because one supplier may not be able to provide the materials in all urgent orders, having a spare supplier must be considered.

4. Conclusion
The supplier selection problem is one of the most essential parts in supply chain operation. The contribution of this study is on the implementation of ISM method to identify key criteria for supplier selection and integrates with ANP method to get the best supplier focusing on key criteria. The key criteria are identified to help the decision-maker to focus on criteria that has a more significant influence.
on the supplier selection model. From this study 19 key criteria are identified with criteria availability has the most influence on the overall ISM model and has the highest weight from ANP, thus making it the most critical criterion. This is caused by the ever-changing construction project schedule. A construction project needs a high availability of materials in the supplier, therefore it is suggested that the company can consider having spare suppliers.

However, this study has limitation that still focused on one specific construction company. Thus a further study using judgment from several experts can be done. Expert’s opinions can differ between one another, making a change in the criteria. This change can trigger an increase or decrease of transitivity in the ISM method that affects the final solution. Moreover, a pairwise comparison questionnaire for ANP is considered wearying by the expert filling the questionnaire because a large number of assessments has to be done. Thus an error in filling the questionnaire could occur. Therefore, TOPSIS can be used to reduce the pairwise comparison assessment to just interconnections between the criteria.

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