Critical Success Factors for Supplier Selection in the Construction Industry: The Case of Public Works Department

M.C. Ngam¹, S. Thiruchelvam¹, K. N. Mustapha², M. E. Rusli³, A. Mohd Hashim⁴, A. Ghazali¹ and H. Hakimie¹

¹Centre for Research in Disaster and Emergency Preparedness (CRDEP) @ TNB
²Chancellery
³Centre for Information and Network Security (COINS), Universiti Tenaga Nasional (UNITEN); Jalan IKRAM-UNITEN 43000 Kajang, Selangor, Malaysia;
⁴Bahagian Kerja Jalan Dan Cearun, Cawanagan Kontrak Dan Ukur Bahan, Ibu Pejabat JKR Malaysia, Aras 16, Menara Tun Ismail Mohammed Ali, No. 25, Jalan Raja Laut, 50250 Kuala Lumpur; ngam@uniten.edu.my

Abstract

This research aims to identify Malaysia construction industry’s procurement system as well as its supplier selection decision making factors. This study also aims to establish a metric importance hierarchy as well as to find the correlation of metrics with major stakeholders of the construction industry. All this is done through a mixed-method approach using survey questionnaire and semi-structured interviews. Target respondents are from Public Works Department headquarters in Malaysia that are directly involved with supplier selection. Findings shows that an established construct of metric hierarchy simplifies supplier selection process as well as the process can be made optimal with less errors. This will anticipate more path of improvement towards the current policies besides creating a more transparent procurement process in supplier selection. Moreover, developing a systematic procedure in supplier selection will enable and ensure better optimization in construction projects. Hence, this will boost organizational effectiveness and profit and further improve the procurement development in Malaysia. The final outcome of this study is to embark in greater supplier selection standards and to raise procurement to the next level.

Keywords: Construction Industry, Metrics, Public Works Department, Supplier Selection

1. Introduction

The definition of supplier selection is basically a mixed method approach that helps simplify multi-criteria decision making problems. As many countries are developing rapidly, supplier selection is a common phenomenon in modern day procurement processes. Additionally, with the advancement of modern day procurement, the practices of procurement have to adapt and coincide to keep up with the ever demanding industry. Besides that, much emphasis is being placed on procurement transparency to bring up the outmost efficiency of an organization. With that said, this paper aims to develop a supplier selection model for optimization.

To aid policy makers of the industry, a construct is proposed in order to refine procedures in supplier selection. Before it could be established, the identification of metrics for supplier selection becomes an
important objective. Factors affecting decision making in supplier selection can become a fundamental framework for an organization in order to become more efficient and improve in managing their supply chain. This framework is not intended to not only improve the over performance of projects but also helps reduce cost, save time and become more transparent in dealing with the processes in supplier selection.

For a viable framework to be constructed, extensive studies have to be carried out with regards to the perspective of stakeholders in the industry. The stakeholder’s evaluation on supplier selection metric can become a strong point in understanding the current need of change in the organization and the industry as a whole. The importance of each metric will then be weighted accordingly by stakeholders to determine its hierarchy.

This study is conducted through the theoretical lens of a positivist perspective. Therefore, this study was conducted purely based on quantitative approach whereby the corresponding method in data collection shall be questionnaire survey. Moreover, the scope of this study was to identify and define the metrics from the perspective of stakeholders in the Malaysia Public Works Department (PWD). PWD plays the role as a main custodian in most government related projects is also believed to have credible influence in the policy making for the construction industry. Lastly, this paper’s output is to bring advancement to the procurement sector in Malaysian construction industry. This study can be further used in other construction organization especially in upgrading their supplier selection process. The value of this study can be seen as a foundation to bring greater transparency into organizational decision making thus boosting the credibility of procurement practices.

2. Current state of Procurement in PWD

A large portion of Malaysia GDP is made up from the construction industry. Because of this, the construction industry can be said to be an important source of wealth which also improves the quality of life of the nation. As Malaysia has its eyes set to recognized as a developed nation by 2020, construction and development could be considered as the building block in realizing this dream. The only way towards this is through an effective project management. However, projects in the construction industry is often clouded by complex issue and lacks project management performance analysis. Numerous research on supplier selection focusing on electricity utility, manufacturing, health and defence industry have been actively emerging since 1960s. However the basis of supplier selection of the construction projects in the terms of constructs are not receiving needed attention.

According to Day and Barksdale, not many published studies looked into the purchasing process of materials and services. Even with numerous publications about suitable metrics in supplier selection, there is a gap where decision making procedure in supplier selection lacks credibility.

On the other hand, Lu and Swaminathan argues that supply chain management (SCM), a serious component in managing project that is highly sorted by many organizations. The evaluation of performance aspect becomes one of the major or most important pillars in SCM. Because of the complex nature of SCM, a define scale for performance needs is required to ensure internal structure control.

With the increasing importance of SCM, it has become an essential for organization to keep their resources in check. More perspectives on processes involving strategic decision making is being incorporated by many organizations in order to gain competitive advantages. This is one of the main driving factors in providing efficient product delivery and maximizing profit for an organization. SCM in modern day scenarios is seen as a way to identify and characterize the deficiencies of supplies and also to improve the coordination and problem solving process between supplier and end user.

As the development in Malaysia continues to quicken its pace, organizations such as PWD have started to consider towards lowering cost while increasing flexibility without compromising quality and time. The way forward for PWD was to concentrate on essential proficiencies and outsourcing secondary activities. The effect directly increase the competitive factor between other organizations as the market continues to expand exponentially. There is a study which says that an precise analysis is needed to be done on important
activities in an organization to determine what can be outsourced.10

Over the years, the environment of project procurement have seen a rise in many ethical issues. The main driver for this is due to the wanting higher profit margins and the high competition in the industry. This causes the increase in illegal activities. A study was states that 17.3% of 417 Malaysian government projects were considered unhealthy mainly because of underperforming contractors.11,12 The number of issues have been predicted to double over the past decade and is now a great concern in the construction industry. Hence, it is important to have true transparency and accountability throughout the procurement process and especially in decision making while awarding suppliers13.

Supplier selection process can be broken down by obtaining a group of suppliers that are chosen for procurement according to a predefined set of criteria. Xu reviewed 78 related articles from 2000 to 2008 regarding popular metrics used in supplier selection. From his findings, quality topped all other metrics. This was backed by findings from another 68 papers where researchers also agreed that quality was a popular metric in supplier selection process. He discover that 64 papers talked about delivery and was the second most popular metric among researchers. Price which was commonly mentioned by the industry and was originally thought as an important criteria follows after the two with 63 papers mentioning about it.

In most developing countries, the awareness in corporate governance has spiked in these recent years and can be directly manifested in the growing concern for a strong economic performance. Dalton addressed corporate governance as a long chain of rules and practices which controls and directs an organization. The function of corporate governance is to form and implement policies that will smoothen out operations. Autio mentioned that corporate governance is an instrument to monitor and advice teams involved in decision-making so that they can be on par with stakeholder’s interests as well as improving the quality of the organization’s strategies in decision-making. Neill believes corporate governance is able to guide decision-makers to be responsible in order to maximize stakeholders’ profits. Therefore, by reviewing the insides of a business processes, PWD could have greater savings as well as having a higher integrity to the community.

3. Proposed Measurement

The ultimate purpose of this study is to construct an advance supplier selection method to achieve better effectiveness in procurement processes as well as to bring an organization to greater profit making. To achieve this, an orthogonal perspective is needed to aid the identifications of metrics in supplier selection. Supplier selection metrics can be obtained through an in-depth investigation from current and past studies on supplier selection practices.

Based on past studies by Thiruchelvan, suitable metrics in supplier selection were proposed and divided into two constructs to distinct each other. His research helped the establishment of a decision making framework for the electrical industry in Malaysia. With further research on recent papers, it was found that there are fire other criteria that are as important that can have strong ties with the construction industry. Hence, two new construct consisting of supplier effectiveness and supplier magnetism were proposed to cater for procurement targeting the construction industry. The main attributes an organization wants from a supplier and is relatively similar across every other organization is placed under the construct of supplier effectiveness. On the other hand, attributes that only a few organization place high priority is placed under the construct of supplier magnetism. On the other hand, attributes that only a few organization place high priority is placed under the construct of supplier magnetism. Figure 1 shows the dual construct of supplier selection metrics.

![Figure 1. Supplier selection metric](image-url)
Besides identifying the main factors and grouping them into constructs, arranging each metric based on ranking will be another objective of this study. To achieve this, a weightage system was proposed in order to identify the importance of each metric based on the perception of stakeholders. The results can only be obtained through fieldwork to obtain valuable data from targeted organizations.

In this study, data collected from survey questionnaire is considered to be an important asset as it is a significant resource and the quantity of the data reflects the reliability as well as the effectiveness of the research process. For all these reasons, a quantitative approach was adopted by using questionnaires as a medium to obtain reliable information. The responses will be then assessed using appropriate statistical tools in order to determine the reliability and validity of the data.

4. Data Collection

The PWD supply selection process was investigated through a preliminary study. This preliminary study was to identify the data reliability and to what degree of validity it contributes towards the research findings. Besides that, a small scale study is conducted to evaluate feasibility, time, cost, adverse events, and statistical variability. This was a key step in the study’s methodology in order to predict an appropriate sample size and to perfect the study design prior to the performance of a full scale study. Additionally, the preliminary study was also to look into the research flow and approach needed to analyse the data.

PWD stakeholders that were involved in procurement related issues were the targeted population for preliminary findings. Two PWD offices were selected for data collection namely PWD Tun Ismail and PWD Maju Junction. The two offices consist of relatable population that is suitable and reliable for the objective of the study. A total of 80 individuals were sampled and 53 questionnaire samples were returned making it a 65% response rate. Based on the demographic results as shown in Table 1, Table 2 and Table 3, most respondents were from purchasing branches and had been holding procurement related positions for at least 5 years.

Reliability of the data can be correlated with the years of experiences and position of respondents. This is because the experience respondents in the field of procurement and in supplier selection helps identify factors in decision making that is of higher priority in comparison of policy makers or general public which are not directly involved in the subject matter. Reliability and validity of the data obtained can be further tested using

| Table 1. Respondents from respective PWD branches |
|--------------------------------------------------|
| PWD Branch       | Frequency | Percent (%) |
| Building         | 20        | 37.7        |
| Road             | 4         | 7.5         |
| Water Works      | 1         | 1.9         |
| Military Works   | 2         | 3.8         |
| Contract & Quantity Surveying | 14 | 26.4 |
| Maintenance & Public Facilities | 1 | 1.9 |
| Safety Works     | 3         | 5.7         |
| Architect        | 5         | 9.4         |
| Education        | 3         | 5.7         |
| Total            | 53        | 100         |

| Table 2. Respondent's current position in PWD |
|------------------------------------------------|
| Current Position         | Frequency | Percent (%) |
| Architect                | 9         | 17.0        |
| Civil Engineer           | 4         | 7.5         |
| Mechanical Engineer      | 1         | 1.9         |
| Quantity Surveyor        | 37        | 69.8        |
| Safety Officer           | 1         | 1.9         |
| Project Manager          | 1         | 1.9         |
| Total                    | 53        | 100         |

| Table 3. Number of years of experience in PWD |
|------------------------------------------------|
| Years of Experience | Frequency | Percent (%) |
| 0 to 5 years        | 6         | 11.3        |
| 6 to 10 years       | 27        | 50.9        |
| 11 to 15 years      | 8         | 15.1        |
| 16 to 20 years      | 5         | 9.4         |
| 21 to 25 years      | 3         | 5.7         |
| above 25 years      | 4         | 7.5         |
| Total                | 53        | 100         |
Cronbach’s Coefficient Alpha and Kaiser-Meyer-Olkin (KMO) as shown in Table 4 and Table 5 respectively. A Cronbach alpha value of 0.7 or higher is said to be accepted for reliability check, but 0.8 and above is preferred\textsuperscript{22}. Reliability is often associate with the usefulness of the data collected by the researcher. On the other hand, validity is often tested to identify if the data collected is suitable to be subjected to further analysis. KMO value greater than 0.5 is considered before proceeding with factor analysis\textsuperscript{23}. This test ensure that the data going through the next stage of analysis is valid and will not create errors or complication that might jeopardize the outcome of the study.

### Table 4. Reliability check using Cronbach’s coefficient alpha

| Variables                  | Mean  | Std. Deviation | Cronbach’s Alpha |
|----------------------------|-------|----------------|------------------|
| Product Quality            | 4.64  | .522           | .907             |
| Price                      | 4.53  | .608           |                  |
| Delivery                   | 4.47  | .639           |                  |
| Support Service            | 4.34  | .706           |                  |
| Production System          | 4.34  | .649           |                  |
| Customer Focus             | 4.30  | .668           |                  |
| Safety Awareness           | 4.70  | .540           |                  |
| Financial Performance      | 4.34  | .678           |                  |
| Environmental Attributes   | 4.28  | .717           |                  |
| Government Policy          | 4.58  | .535           |                  |
| Flexibility                | 4.26  | .711           | .933             |
| Performance History        | 4.32  | .673           |                  |
| Customer Training          | 4.21  | .661           |                  |
| Information and Communication Technology | 4.23 | .697     |                  |
| Product Innovation         | 4.25  | .677           |                  |
| Quality Management System  | 4.26  | .738           |                  |
| Management and Organization| 4.09  | .658           |                  |
| Employee Training and Development | 4.06 | .770     |                  |
| Corporate Social Responsibility | 4.02 | .909     |                  |

Once the data is deemed reliable, questionnaire responses were aim in obtaining respondents inclination towards the proposed supplier selection metrics. Respondents were asked to rate the degree of importance of each metrics based on Likert scale from not important to very important\textsuperscript{24,25}. Furthermore, utilizing Statistical Package for Social Sciences (SPSS), data analysis was conducted with aims for the reduction of data to simplify analysis. Based on mean responses of each metrics, the ranking of 19 metrics in accordance to their importance in supplier selection were summarised in Table 6. The hierarchy of metrics can be used to base the weightage of each factor in supplier selection decision making\textsuperscript{26}. With this result in hand, this will help define the construct of supplier selection
metric as well as to test the hypothesis which was to see if the variables were essential in determining the constructs. Moreover, having a hierarchy of importance helps to free out time for decision makers on supplier evaluation.

Next, factor analysis was conducted to obtain factor values and correlation between variables. Table 7 show the results for factor analysis with factorial value of 0.4 and below removed as it was said to have low significance. As a result, two component were obtain with 9 items in component 1 and 10 items in component 2. Using a well-defined construct, organizations such as PWD will be able to increase overall procurement transparency.

### Table 6. Metrics Ranking for Supplier Selection

| Rank | Metrics                | Mean | t      |
|------|------------------------|------|--------|
| 1    | Safety Awareness       | 4.70 | 16.149 |
| 2    | Product Quality        | 4.64 | 15.909 |
| 3    | Government Policy      | 4.58 | 14.771 |
| 4    | Price                  | 4.53 | 12.318 |
| 5    | Delivery               | 4.47 | 11.077 |
| 6    | Support Service        | 4.34 |  8.663 |
| 7    | Production System      | 4.34 |  9.422 |
| 8    | Financial Performance  | 4.34 |  9.019 |
| 9    | Performance History    | 4.32 |  8.879 |
| 10   | Customer Focus         | 4.30 |  8.746 |
| 11   | Environmental Attributes | 4.28 |  7.947 |
| 12   | Flexibility            | 4.26 |  7.822 |
| 13   | Quality Management System | 4.26 |  7.541 |
| 14   | Product Innovation     | 4.25 |  8.018 |
| 15   | Information and Communication Technology | 4.23 |  7.584 |
| 16   | Customer Training      | 4.21 |  7.793 |
| 17   | Management and Organization | 4.09 |  6.574 |
| 18   | Employee Training and Development | 4.06 |  5.263 |
| 19   | Corporate Social Responsibility | 4.02 |  4.155 |

### Table 7. Factor analysis for main variables

| Variables                                      | Component 1 | Component 2 |
|------------------------------------------------|-------------|-------------|
| Corporate Social Responsibility (CSR)          | .921        |             |
| Management and Organization                    | .913        |             |
| Information and Communication Technology (ICT) | .883        |             |
| Quality Management System (QMS)                | .806        |             |
| Employee Training and Development              | .769        |             |
| Flexibility                                    | .758        |             |
| Product Innovation                             | .688        |             |
| Customer Training                              | .501        |             |
| Performance History                            | .501        |             |
| Delivery                                       | .880        |             |
| Price                                          | .784        |             |
| Customer Focus                                 | .769        |             |
| Product Quality                                | .680        |             |
| Production System                              | .554        |             |
| Environmental Attributes                       | .530        |             |
| Safety Awareness                               | .506        |             |
| Financial Performance                          | .499        |             |
| Support Service                                | .489        |             |
| Government Policy                              | .451        |             |

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
Rotation converged in 11 iterations.

From preliminary findings, it shows that stakeholders in PWD place great importance on safety awareness as the most important factor in supplier selection. Product quality follows as the second most important factor in supplier selection. Government policy takes third place from the perspective of stakeholders in PWD as an important criteria. However, similar with past research on other organization, the factor of price falls at fourth place. This clearly indicates that price may be an important factor in supplier selection but there are other more highly ranked factors that have to be examined first. Hence, the current policy and procedure that places highest importance on price as a main measure in decision making for purchasing is not entirely the most effective and optimal practice. To fill these gaps, new policies and procedures needs to be...
revised and revised in order to increase organizational procurement effectiveness and transparency. The outcome of this study can become evidence for policy makers to adapt to the growing market and to deliver more effective procurement system in the country. However, a more extensive study has to be undertaken to ascertain the validity of the preliminary findings. This study will be tested with similar research instrument but with a wider sample size and the findings will we shared using similar media.

5. Conclusion

From past studies, there were many issues with the procurement system as it was filled with predicaments. In order to level up construction procurement, PWD needs to bring advances in pursuit of ethical decision making and refining the current system as the demand in construction projects increases. The attribute of price was found to be less important while other attributes were more dominating factors in supplier selection. Other attributes also shows weightage that cannot be neglected in an overall supplier decision making process. Stakeholder’s views on important factors within supplier selection is taken into consideration. With this investigation into supplier selection decision making practices, the results will create greater awareness and to further describe important metric in supplier selection. The outcome will see significant increase in effectiveness as well as a more transparent procurement in organizations. Lastly, this study will bring great improvement in the for many construction organization towards the area of procurement as they begin to adapt to new optimized supplier selection methods.

6. References

1. Ghanbaripour, A.N., Ghoddousi P, Yousefi A, A Framework for Evaluating Project Managers’ Performance-Identification and Analysis of KPIs in Subway Construction Projects in Tehran. Indian Journal of Science and Technology. 2015 December;8(35): 2015.
2. Day E, Barksdale H.C. Organizational Purchasing of Professional Services: The Process of Selecting Providers. Journal of Business & Industrial Marketing. 1994;9(3):44–51.
3. Mohammaditabar, D, Ghodsypour S.H. A supplier-selection model with classification and joint replenishment of inventory items. International Journal of Systems Science. 2016;47(8):1745–754.
4. Safa, M., et al., Supplier selection process in an integrated construction materials management model. Automation in Construction. 2014;48: p. 64–73.
5. Lu L.X, Swaminathan J.M. Supply Chain Management, International Encyclopedia of the Social & Behavioral Sciences. Elsevier. 2015. p. 709–713.
6. Rostamy-Malkhalifeh, M., Mollaeian E, Mamizadeh-Chatghayeh S. A New Non-radial Network DEA Model for Evaluating Performance Supply Chain. Indian Journal of Science and Technology. 2013 March; 6(3): 2013.
7. Miranda M.G, Ramachandran S. A Detailed Study on the Milk Supply Chain Process. Indian Journal of Science and Technology. 2014 March; 7(3): 2014.
8. Forslund H, Jonsson P. Selection, implementation and use of ERP systems for supply chain performance management. Industrial Management & Data Systems. 2010;110(8):1159–175.
9. Segerstedt, A. and T. Olofsson, Supply chains in the construction industry. Supply Chain Management: An International Journal. 2010;15(5): 347–53.
10. Ancarani, A. and G. Capaldo, Supporting decision-making process in facilities management services procurement: A methodological approach. Journal of Purchasing and Supply Management.2005;11(5-6):232–41.
11. Hui WS, et al. Procurement issues in Malaysia. International Journal of Public Sector Management. 2011; 24(6):567–93.
12. Mironov, M. and E. Zhuravskaya, Corruption in procurement: Evidence from financial transactions data. Unpublished working paper. Social Science Research Network. 2014.
13. Aliza, A.H., K. Stephen, and T. Bambang, The Importance of Project Governance Framework in Project Procurement Planning. Procedia Engineering, 2011. 14. p. 1929–37.
14. Ho, W., X. Xu, and P.K. Dey, Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. European Journal of Operational Research. 2010. 202(1): p. 16–24.
15. Zarbini-Sydani, A., A. Karbasi, and E. Atef-Yekta, Evaluating and Selecting Supplier in Textile Industry Using Hierarchical Fuzzy Topsis. Indian Journal of Science and Technology Volume 4, Issue 10, October 2011, 2011.
16. Daily C.M, Dalton D.R. Corporate governance in the small firm: Prescriptions for CEOs and directors. Journal of Small Business Strategy. 2015; 5(1):57–68.
17. Mustakallio, M., Autio E, Zahra S.A. Relational and Contractual Governance in Family Firms: Effects on Strategic Decision Making. Family Business Review, 2002;15(3):205–22.
18. Stovall O.S, Neill J.D, Perkin D. Corporate Governance, Internal Decision Making, and the Invisible Hand. Journal of Business Ethics. 2004;51(2):221–27.
19. Thiruchelvam, S., Strategic Sourcing Supplier Selection for Capital Equipment, in Construction Management, School of Engineering. 2012, Auckland University of Technology: Auckland, New Zealand.
20. Hassany Shariat Panahy, P. et al. A Framework to Construct Data Quality Dimensions Relationships. Indian Journal of Science and Technology. 2013 May; 6(5): 2013.
21. Davis J, Shipley M.F, Stading G. A fuzzy supplier selection application using large survey datasets of delivery performance. Adv. Fuzzy Sys. 2015. p. 3-3.
22. Pallant J. SPSS Survival Manual: A step by step guide to data analysis using IBM SPSS. 2013: Allen & Unwin.
23. Lancaster, G.A. Pilot and feasibility studies come of age! Pilot and Feasibility Studies, 2015;1(1):1–4.
24. Gliem, R.R, Gliem J.A. Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales. 2003. Midwest Research-to-Practice Conference in Adult, Continuing, and Community Education.
25. Matell, M.S, Jacoby J. Is There an Optimal Number of Alternatives for Likert Scale Items? Study. Educational and psychological measurement, 1971.31.p. 657–74.
26. Das T.K. Intelligent Techniques in Decision Making: A Survey. Indian Journal of Science and Technology. 2016 March; 9(12):2016.
27. Brown T.A.Confirmatory Factor Analysis for Applied Research, Second Edition. 2015: Guilford Press.
28. Field A. Discovering Statistics using SPSS for Windows Sage Publications. London, 2000.2. p. 44–322.