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Green Supplier Selection Criteria Using Integrated Delphi-Analytic Network Process in Malaysia Public Procurement

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Abstract

This study explores green supplier selection criteria and sub-criteria using an integrated Delphi–Analytic Network Process methodology. Criteria and sub-criteria were identified from the literature and evaluated through pairwise comparisons. Preliminary findings resulted from the study showed consensus achieved for eight (8) criteria comparisons and 114 sub-criteria comparisons but reveal lack of consensus for two (2) criteria pairwise comparisons and 57 sub-criteria comparisons, warranting further discussion. Initial limitations underlying the non-consensus results were identified, providing insights to the model and method employed. The result of this study could provide insights into the green procurement subject, while shedding clarity to the criteria and sub-criteria relevant to supplier selection in green supplier selection. This study could be beneficial and may contribute to the development of a robust and comprehensive green supplier selection model or any similar studies in the future.

Keywords: Policy Planning, Green Procurement, Supplier Selection, Sustainability, Delphi, Analytic Network Process (ANP)

Introduction

Procurement is considered as one of primary function (Chai & Liu, 2014; Kannan, Govindan & Rajendran, 2015; Mukherjee & Kar, 2013) and perceived as one of vital activity in an organisation. It is part of outsourcing initiatives by organisation, thus it makes the organization dependent on suppliers (Appolloni, Hui, Fu & Li, 2014; Kannan, Govindan, & Rajendran, 2015) to accomplish its objectives and needs. The recognition of procurement as a vital activity in an organisation has highlighted the importance of supplier evaluation and selection. In addition to that, some organisations consider supplier selection decision as one of most significant responsibilities of managers in organisations (Hashemi, Karimi and Tavana, 2015) as it usually leads to a partnership development between organisation and supplier (Mukherjee & Kar, 2013; Blome, Hollos & Paulraj, 2014; Chai & Liu, 2014; Lima Junior, Osiro & Carpinetti, 2014; Wetzstein, Hartmann, Benton & Hohenstein, 2016). The

dependency and relationship between organisation and supplier were noted and mentioned as possible critical factor in successful projects (Wetzstein et al., 2016), hence contributing towards achievement of organisation's objectives.

Background

Supplier selection (SS) is perceived as a vital process in procurement function and is mostly considered as multiple criteria decision-making problem (Dargi, Anjomshoae, Galankashi, Memari, & Tap, 2014; Zak 2015; Chen & Zou, 2016). In most situations, quality, cost and service performance are generally considered for supplier selection decision. As supplier selection takes into consideration organisation's specific requirement, the selection model needs to be flexible to accommodate such needs (Govindan, Rajendran & Sarkis, 2015.). The selection process also could reflect the organisation's strategic policies as well as forming part of organisation's development via association with right suppliers. This is due the current trend of organisation's outsourcing certain function to relevant parties (Wetzstein et al., 2016).

Supplier selection process is usually referred to an activity consist of several tasks (Igarashi, De Boer & Fet, 2013). The whole process is normally regulated, procedural and consists of standards set by organisation. It usually begins with identification of needs and specifications, followed by development of measurement criteria of potential suppliers. Tenders were called to communicate to potential supplier and selection is made after evaluation is conducted based on submitted information by potential suppliers. The evaluation process could involve several rounds of reviews by experts in the organisation. Finally, the selection is usually made among qualified suppliers, derived from the evaluation process.

Emergence of sustainability concept has led to emergence of green economy. The green economy comprises of numerous ecomponents including green procurement. Green supplier selection (GSS) is associated as one of key activities in defining changes towards green procurement. Green supplier selection can be defined as a process of supplier selection by incorporating environmental considerations (Igarashi, Boer & Michelsen, 2015) as well as traditional selection criteria (Govindan, Rajendran & Sarkis, 2015).

While there is ample studies of supplier selection based on traditional criteria, it is discovered that lack of studies which included environmental criteria in the selection process (Hashemi, Karimi & Tavana, 2015). In most current practices of supplier selection, traditional criteria such as quality, cost/price, performance and timeliness are mostly being used (Govindan, Rajendran & Sarkis, 2015). However, neither environmental nor social sustainability criteria had been emphasised in conventional supplier selection studies, thus highlighting the necessity of considering both traditional and environmental criteria in the selection process (Hashemi, Karimi & Tavana, 2015). In addition to that, though existing literature on supplier selection is quite extensive, with numerous studies concentrated on methods and approaches employed to evaluate and select the supplier, and criteria used to select the supplier, this is on contrary with green supplier selection, with only small numbers of studies addressing these elements in green supplier selection (Igarashi, De Boer & Fet, 2013).

In Malaysia public procurement, though there is a guideline issued about green procurement, there is limited definitive criteria and sub-criteria which could be used in the supplier selection process. Moreover, the procuring agencies are given some flexibility to identify and define the green criteria and sub-criteria in selecting supplier. Hence, the need to identify a set of criteria and sub-criteria which could be beneficial in Malaysia public procurement in selecting green supplier.

This study aims to achieve several objectives. There are:

i. to identify green supplier selection main criteria and sub-criteria from current practices and literatures, develop a selection model and validate the model using Analystic Network Process (ANP);
ii. to examine the current supplier selection criteria used in public projects;
iii. to develop and propose a comprehensive model for green supplier selection in public projects; and
iv. to propose a suitable method to evaluate and select the best green supplier, which also analyses the most appropriate alternative supplier.

Methodology

For data collection, a Delphi method is used. Delphi method is a systematic technique to obtain most reliable consensus of judgement/opinion from a panel of experts by intensive questionnaire and controlled feedback. In this study, ten (10) participants comprised of experts and practitioners in public procurement are identified. They have been involved in public procurement ranging from **one (1) to fifteen (15) years**. In addition to that, several of them are qualified public procurement officers with certification by Ministry of Finance and all these participants **work at different agencies and ministries**. Detailed summary of participants involved in this Delphi exercise is as below:

Table 1
Summary of Participants

	Experience in public procurement (years)	**Number of participants**
1	11 to 15	1
2	5 to 10	4
3	1 to 5	5

Based on Analytic Network Process (ANP), a network structure consists of criteria and sub-criteria should be established before pairwise comparisons conducted. For this study, five (5) criteria and nineteen (19) sub-criteria were identified and selected for green supplier have been identified from previous studies. The summary of criteria and sub-criteria are listed Table 2

Table 2
Criteria and Sub-criteria for Green Supplier Selection derived from Literatures

	Criteria	Consists of sub-criteria:		Authors
C1	**Cost/Price** refers to all type of costs that involved in producing the product. This includes product cost, transportation cost, environmental cost or any relevant cost.	C11	Product Cost	Kannan *et al,* (2013); Viwanadham and Samvedi, (2013); Galankashi *et a.l,* (2015); Govindan *et al.,* (2015); Rajesh and Ravi, (2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016); Valipour and Ma, (2017)
		C12	Logistics Cost	Kannan *et al.,* (2013) Galankashi *et al.,*(2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C13	Transportation Cost	Kannan *et al.,*(2013) Zak (2015); Lima-Junior and Carpinetti, (2016)
		C14	Environmental Cost	Kannan *et al.,* (2013); Govindan *et al.,* (2015; Lima-Junior and Carpinetti, (2016); Rezaei *et al.,*(2016); Testa *et al.,* (2016)
C2	**Quality Management** evaluates how organisation perceives and manages quality in its organisation.	C21	Eco-Design	Kannan *et al.,* (2013); Galankashi *et al.,*(2013); Govindan *et al.,* (2015); Hashemi, Karimi and Tavana, (2015); Kannan, Govindan and Rajendran, (2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,*(2016)
		C22	Eco-Labelling and Packaging	Lima Junior, Osiro and Carpinetti, (2014); Govindan *et al.,* (2015); Kannan, Govindan and Rajendran, (2015)
		C23	Eco-Impact of Product/Service	Kannan *et al.,* (2013); Viswanadham and Samvedi, (2013); Lima Junior, Osiro and Carpinetti, (2014); Galankashi *et al*., (2015); Govindan *et al*., (2015); Hashemi, Karimi and Tavana, (2015); Kannan, Govindan and Rajendran, (2015); Rezaei *et al.*,(2016); Testa *et al.*,(2016)
		C24	Product/Service Quality and Conformance to Standards	Kannan *et al.,* (2013); Viswanadham and Samvedi, (2013); Kar, (2014); Lima Junior, Osiro and Carpinetti, (2014); Galankashi *et al.,*(2015) Govindan *et al.,*(2015); Hashemi, Karimi and Tavana, (2015)

	Criteria	Consists of sub-criteria:		Authors
				Zak, (2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C25	Assurance and Certification	Kannan *et al.,* (2013); Rajesh and Ravi, (2014); Govindan *et al.,* (2015; Kannan, Govindan and Rajendran, (2015); Lima-Junior and Carpinetti ,(2016); Rezaei *et al.,*(2016); Hamdan and Cheaitou, (2017)
C3	**Financial and Market Outlook** acknowledges supplier's status in the finance and its status in green industry based on its current financial position, financial asset owned and its market share in green industry.	C31	Financial position	Kar, (2014); Lima Junior, Osiro and Carpinetti, (2014); Govindan *et al.,* (2015); Zak, (2015); Lima-Junior and Carpinetti,(2016)
		C32	Financial Asset	Kar,(2014)
		C33	Green Market Share	Govindan *et al.,* (2015); Hashemi, Karimi and Tavana, (2015); Kannan, Govindan and Rajendran, (2015); Hamdan and Cheaitou, (2017)
C4	**Technical Capabilities** addresses whether a supplier has an ability to perform its duty based on previous record and history, its readiness to perform and its green innovation which reflect the organisation's capability to a greener and sustainable operations.	C41	Experience and Past Performance	Rezaei *et al.,*(2016)
		C42	Facilities and Technology Level	Kannan *et al.,* (2013); Kar, (2014); Rajesh and Ravi, (2014); Govindan *et al.,*(2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C43	Green Innovation	Govindan *et al.,* (2015); Kannan, Govindan and Rajendran, (2015); Rezaei *et al.,* (2016); Hamdan and Cheaitou, (2017)
C5	**Management Practices** explains organisational characteristics of supplier.	C51	Compliance to rules, regulation and policies	Viswanadham and Samvedi, (2013); Rajesh and Ravi, (2014); Govindan *et al.,* (2015); Kannan, Govindan and Rajendran,(2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C52	Relationship and communication	Lima Junior, Osiro and Carpinetti, (2014); Rajesh and Ravi, (2014); Govindan *et al.,* (2015); Hashemi, Karimi and Tavana, (2015); ; Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C53	Culture	Lima Junior, Osiro and Carpinetti, (2014); Rajesh and Ravi, (2014); Govindan *et al*., (2015); Hashemi,

	Criteria	Consists of sub-criteria:		Authors
				Karimi and Tavana, (2015); Kannan, Govindan and Rajendran, (2015); Lima-Junior and Carpinetti, (2016); Rezaei *et al.,* (2016)
		C54	Resource Management and Competency	Galankashi *et al.,* (2015); Govindan *et al.,* (2015); Kannan, Govindan and Rajendran, (2015); Rezaei *et al.,* (2016);Valipour and Ma, (2017)

The selected criteria and sub-criteria for this study have been organised and illustrated in Figure 1.

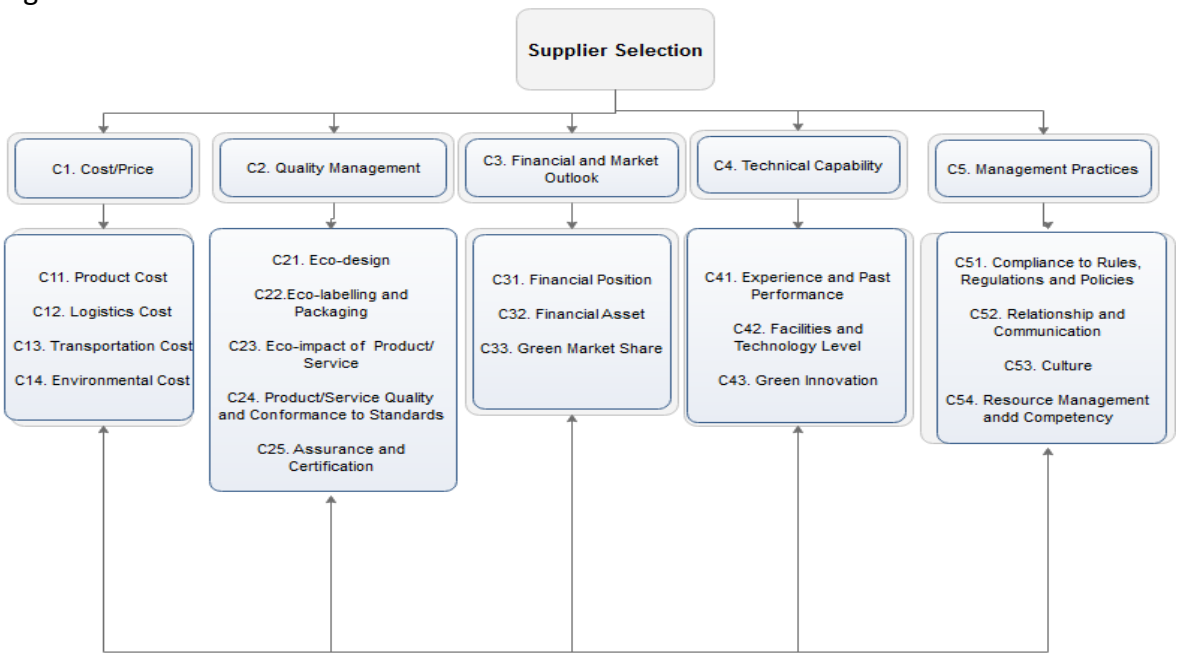

Figure 1 Conceptual Model of Green Supplier Selection

A set of questionnaires comprising pairwise comparison of 5 criteria and 19 sub-criteria have been prepared and distributed to the experts. The experts would need to conduct pairwise comparison between criteria and sub-criteria. For the comparison, the participants are to rate importance level for each pairwise comparison of criteria and sub-criteria using Saaty's scale (Saaty, 2008) described as below:

Table 3
Pairwise Comparison Scale

Preference Level	Equally Important	Moderately Important	Strongly Important	Very Strongly Important	Extremely Important
Numeric Value	1	3	5	7	9

The feedback from the questionnaire were compiled and the pairwise comparison was conducted in three (3) rounds to elicit feedback from the participants. The decision of

consensus is considered achieved once the feedback achieve a majority or exceed half the numbers of feedback received for each pairwise comparison.

Findings

Based on the survey conducted for criteria, it is discovered that eight (8) out of ten (10) pairwise comparisons conducted achieved consensus, while two (2) comparison conducted is unable to achieve consensus.

As for pairwise comparisons related to sub-criteria, 57 out of 171 comparisons (33.0 %) was unable to achieve consensus, while the remaining successfully achieved consensus among the participants. The result is summarised below:

Table 4
Summary of Pairwise Comparison

Details	Criteria	Sub-criteria
Pairwise Comparison conducted	10 comparisons	171 comparisons
With consensus (percentage)	8 (80.0%)	114 (66.7%)
Without consensus (percentage)	2 (20.0%)	57 (33.3%)

Discussion

For pairwise comparisons with consensus, while the weightage might vary based on criteria and sub-criteria, it can be concluded that the participants evaluating the criteria and sub-criteria have similar and clear perspective towards each criteria and sub-criteria involved in the comparison despite working in different background and agencies. However, the main concerns are for those comparisons which unable to achieve consensus. While there could be numerous reasons of why they happened, several key reasons identified are:

(i) The participants may have varied understandings of the criteria and sub-criteria definitions provided in the questionnaire. This variation could originate from the clarity and context of the definitions offered. While participants might grasp the essence of the criteria and sub-criteria, their interpretations are likely influenced by the operational contexts of their respective agencies and unique procurement scenarios.

(ii) The participants rate and assign importance of the criteria and sub-criteria based on the knowledge and experience of the procurement carried out by their agencies. Differing type of procurement conducted by participant at their respected agencies could lead to the participant having bias judgement towards certain criteria and sub-criteria.

(iii) While the participants could be involved in the procurement process in their agencies, the categories of the procurement conducted were limited to the agencies' function. Hence the green procurement frequencies conducted are usually proportionate to numbers and procurement values. Therefore, there might be a possibility of limited knowledge among the participants about green procurement due to less exposure and knowledge of all criteria and sub-criteria provided in the questionnaire.

Summary and Recommendation

Based on this result, it is recommended that comprehensive studies on green supplier selection criteria and sub-criteria should be carried out to investigate further especially for the non-consensus pairwise comparisons. While it might be due to the supplier selection process which could differ for each organisation depending on the procurement categories, knowledge and experience of procuring officers, various criteria or sub-criteria set by the stakeholders and different priorities and methodologies employed in the evaluation process. Regardless, it could be perceived that the selection process is very subjective and could evolve depending on the organisation. However, it is believed that the result of this study could provide insights into the subject, while shedding clarity to the criteria and sub-criteria relevant to supplier selection in green public procurement. On the other hand, the method employed in this study could be reviewed based on the output, so it could be beneficial in any similar studies in the future.

This study aims to establish a model and how to evaluate suppliers in green supplier selection especially for public projects in Malaysia. By providing a comprehensive model, it could play a role in assisting public procurement practitioners in the decision making. In addition to that, this study could pave way to provide a basis for future study in relevant fields, by establishing and detailing criteria, sub-criteria, methods and relevant arguments in the selection process. It is also aimed to raise an awareness of green supplier selection and green procurement importance and their contribution towards sustainable supply chain, by catalysing suppliers' development. In a hindsight, a more inclusive, systematic and objective supplier selection model incorporating traditional and green criteria could be established, and this would benefit the organisation in the long term.

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