

Supplier Selection in the Construction Material Purchasing Function

Don Amila Sajeevan Samarasinghe*, John E Tookey**, James Olabode Bamidele Rotimi***, and Sivadass Thiruchelvam****

Construction materials occupy a significant part of the construction's value contributing nearly 50%. Thus when selecting construction materials, it is very important that painstaking decisions should be made. Past literature and anecdotal evidences show that the main issue with building materials purchasing comes with supplier selection, and depend on careful examination of supplier economics among other criteria. Supplier selection is the purchasing function that forms the foundation for the success or failure of projects. Therefore supplier selection criteria should be well defined. Supplier selection is a multi-criteria decision making problem which includes both qualitative and quantitative considerations. A trade-off between tangible and intangible criteria is important in selecting the best supplier. This paper presents a review of supplier selection processes and decision making methods reported in academic and other literature related to the construction industry. The study is a part of an on-going doctoral research study on construction material purchasing decisions aimed at determining how small to medium scale (SME) construction contractors could secure 'best prices' for their key material inputs in New Zealand construction industry. This is a first step towards a comprehensive empirical study of securing best construction material prices.

JEL Codes: C0, D82 and L74

1. Introduction

According to the definition provided by McConville (as cited in Hadikusumo et al., 2005, pp 48), purchasing is “a fundamental function of material procurement that refers to the acquisition of goods and services and an establishment of mutually acceptable terms and conditions between a seller and a buyer”. Considerable attention has been paid to the purchasing function in past literature mainly due to its contribution to profitability, survival of business organisations and firms' performances (Bayazit et al., 2006, Carr and Pearson, 1999). Gadde and Hakansson (2001) found that purchasing is not seen as a separate function but as an integral part of running a company. As far as the construction industry is concerned, purchasing can occur in all phases of a construction project.

*Don Amila Sajeevan Samarasinghe, School of Engineering, Auckland University of Technology, New Zealand. Email : asamaras@aut.ac.nz

**Associate Professor John E Tookey, School of Engineering, Auckland University of Technology, New Zealand. Email : jtookey@aut.ac.nz

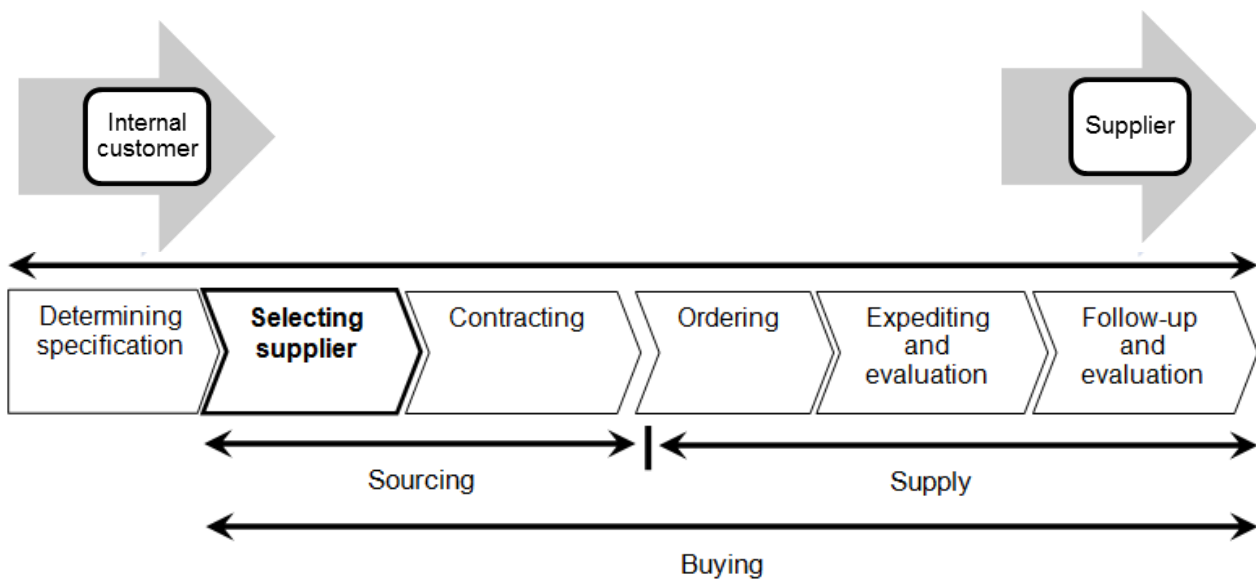
***Dr. James Olabode Bamidele Rotimi, School of Engineering, Auckland University of Technology, New Zealand. Email : jrotimi@aut.ac.nz

****Sivadass Thiruchelvam, School of Engineering, Auckland University of Technology, New Zealand. Email : sthiruch@aut.ac.nz

The purchasing function of a construction firm is central to materials management and especially includes the commitment of project funds for construction materials. Purchasing within an organization typically involves all activities associated with the buying process. According to van Weele (2005), these activities include: determining the need, selecting the supplier, arriving at a proper price, specifying terms and conditions, issuing the contract or order, and ensuring proper delivery. The step involving supplier selection is one of the most significant steps in the building construction process. Past literature and anecdotal evidence suggest that the main issue with materials purchasing is with supplier selection in the building materials industry, which depends on careful examination of supplier economics.

The increasing importance of supply chain management is motivating companies to fit purchasing and sourcing strategies into their supply chain objectives. Figure 1 exemplifies the main activities within the purchasing function. One of the purchasing functions is selecting suppliers capable of procuring the demanded items that meet the required specifications. Thus supplier selection is an essential task of purchasing (Monczka et al., 2005). Purchasing as a whole plays a key role in corporate strategic success through the appropriate selection of suppliers supporting the company's long term strategy and competitive positioning (Ellram and Carr, 1994).

Figure 1: Purchasing process activities
(Source: van Weele, 2005)



Similarly Aretoulis et al. (2009) contend that supplier selection is substantial and forms the foundation for success or failure of construction projects. Ho and Nguyen (2007) discuss the significance of maintaining a strong relationship with suppliers to be competitive in today's construction environment. It is recommended that construction organisations should select their material suppliers based on value-added capabilities rather than competitive process considering today's aggressive sourcing environment (Benton and McHenry, 2010).

Quality and cost of material procurement are two attributes that are directly affected by the material supplier selection process (Yong and Qi, 2012). In order to maintain both of these attributes, material supplier selection should be well defined, in a way that decreases project logistics and supply chain management costs (Wang and Xiaolong, 2004). Benton and McHenry (2010) suggest that construction material supply managers make the following common mistakes:

- lack proficiency at identifying the capabilities of their suppliers
- base materials supplier decisions on convenience
- delay the assessment of the value added by suppliers and service providers
- fail to recognize the impact of economic changers on bulk materials prices

Benton and McHenry (2010) further suggest the following success factors to overcome the mistakes outlined previously.

- Perform a realistic assessment of the capabilities and expertise of each potential supplying firm (e.g. If core competencies exist, what happens if a key supplier goes out of business? Can the supplier be easily replaced?)
- Evaluate alternative strategic supplier arrangements and select appropriate suppliers
- Share information with all strategic suppliers and request their input.

However, construction supply chain management literature show that far too little attention has been paid to scientific approaches to material supplier and quite often selections are based on experience or other means that are not objective (Chen et al., 2011). Inadequate consideration is also being paid to the process of construction materials selection despite the high costs of construction materials (Formoso and Revelo, 1999). Therefore, the overarching aim of this paper is to signify the importance of supplier section in any purchasing function and reviews the basic materials supplier selection methods related to the construction industry. This paper is intended as a preliminary literature review, prior to full research project intended to explore how contractors could secure best prices for key materials on construction projects in New Zealand. It is hoped that the result of the research investigations will be beneficial to project participants and the wider construction industry by understanding the complexities involved in procurement decisions and strategies for securing best prices for construction materials.

2. Research Methods

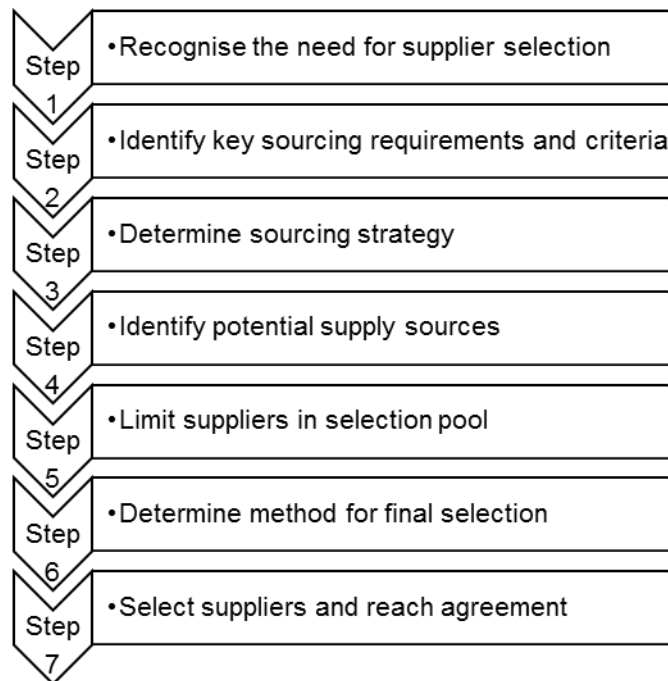
This paper is based on a wider research undertaken for a PhD degree in the field of construction management which finds the best value for construction materials in the New Zealand construction industry. The study is a theoretical research based on a systematic literature review. In other words, it is a proposed future research plan which is based on past literature. The literature sources were accessed through databases which provided numerous academic journals and conference papers. Also, some textbooks found to be useful to the research process were referenced. The aim of the study is to determine the significance of construction material supplier selection in purchasing function. This study will cover the range of literature on supplier selection process, criteria for evaluation, and appropriate supplier selection methods focusing on the construction sector. A comprehensive literature survey was carried out to determine the significance of construction material supplier selection and methods adopted.

3. Literature Review

3.1 The Overview of Supplier Selection Process

The initiation of supplier selection is the choosing of potential suppliers for each type of material for a specific project. In general, past performance of suppliers is a key criterion in the selection process. Once a pool of potential source is formed, requests for quotations are sent out, negotiations conducted, and specific suppliers are selected. Presently, contractors' trend is to reduce the supplier base and mean time the percentage of purchased materials becomes vast (Benton and McHenry, 2010). Ma and Yang (2010) suggest that it is essential to establish different relationships with different material suppliers which means that the assessment methods are dependent on the type of material purchased. Therefore, in order to select suppliers who continually outperform the competition, suppliers must be carefully analysed and evaluated. Usually the detail process of supplier selection involves 7 major steps (see Figure 2) of recognition of the need for supplier selection, identification of key sourcing requirements and criteria, determination of sourcing strategy, identification of potential supplier sources, limit suppliers in the pool, determination of methods for final selection, and final supplier selection (Mendoza, 2007).

Figure 2: Supplier Selection Process



More information about these key steps is explained by the Table 1 with appropriate examples where applicable.

Table 1: The key information on each step of the supplier selection process

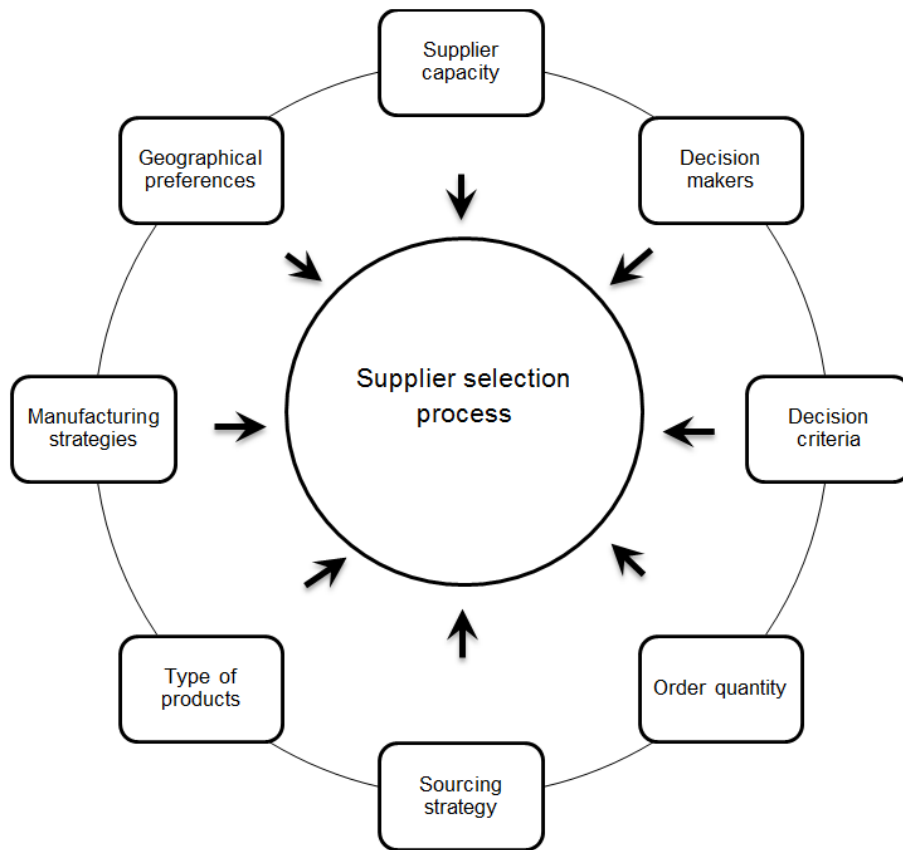
Step	Key information
Identification of the need for a specific product	Different situations may trigger the need for supplier selection. For example, new product development, modifications to a set of existing suppliers due to a bad performance, the end of a contract, expansion to different markets, current suppliers' capacity is not sufficient to satisfy increases in demand.
Identify key sourcing requirements and criteria	Defining the proper criteria becomes critical since the nature of supplier selection involves multi-criteria decision making. The set of criteria to be chosen largely depends on the company's objectives and the type of industry in which the company competes.
Determine Sourcing Strategy	Sourcing requires that companies clearly define the strategy approach to be taken during the supplier selection process. Examples of sourcing strategies are: single versus multiple suppliers, domestic versus international and short term versus long term.
Identify Potential Supply Sources	The importance of the item under consideration influences the resources spent on identifying potential suppliers.
Limit Suppliers in Selection Pool	Given the limited resources of a company, a purchaser needs to pre-screen the potential suppliers to reduce their number before proceeding with a more detailed analysis and evaluation.
Determine Method for Final Selection	There are some multi-criteria techniques which are widely used to evaluate the suppliers (these will be discussed in this paper).
Select Suppliers and Reach Agreement	The final step of the supplier evaluation and selection process is to clearly select those suppliers that best meet the company's sourcing strategy. This decision is often accompanied with determining the order quantity allocation to selected suppliers.

3.2 Criteria for Supplier Evaluation

Process-based evaluations and performance based evaluations are known as the main categories of supplier evaluations. In the process based evaluation, supplier's production or services process is evaluated. Numerous factors are considered for the evaluation procedure of supplier selection. Figure 3 demonstrates the key factors which affects the supplier selection process.

Figure 3: Factors affecting supplier selection

(Source: Khaled et al., 2011)



Supplier evaluation is carried out by the construction organisation as an inspection at the supplier's site to measure the capability level of the operating system. As a result, non-value-added activities can be eliminated to enhance the business efficiency. In performance-based evaluation, supplier's actual performance is evaluated based on different criteria (delivery reliability, cost, quality defect rate etc.). This evaluation measures daily performance of the supplier and hence it is known as after-the-fact-evaluation. In general, performance based evaluation is more common and practical than process based evaluation. This could be due to the ready availability and easy measurement of objective data.

In the selection of supplier, the cost of the material is not the only criteria but quality and service of the supplier and the previous history should be taken in to account. However, an appropriate number of criteria should be included in the supplier selection process and these criteria based on which, the project manager would be able to define the rightest supplier for the job under consideration (Aretoulis et al., 2009). Benton & McHenry (2010) explain that the most critical criteria for supplier selection in the construction industry are material quality, delivery dependability and price although the degree of importance varies in line with the nature of individual firms (Ho and Nguyen, 2007).

Generally, high-quality materials are expected from every potential supplier and it is assumed that the suppliers' quality performance is continuing as shown in the past. It is hard to find any formal measures taken to ensure the quality of materials delivered on the site other than by visual inspection. The specifications that should be complied with the supplier make quality as an issue which does not cause problems. However, it is a significant aspect to the buying firm although it does not play a large role in selection supplier over another.

Delivery dependability: Today's fast-track construction environment boosts the importance of delivery dependability as construction begun before completing the architect's final design. Loss of delivery deadlines could cause costly results (loss of time and additional labour cost) for both owner and contractor as time is considered as money in the construction industry. The faster delivery company will get the chance of being selected as the supplier. Therefore, delivery consideration is the key criterion used in selecting suppliers for the construction industry.

Price: Price has a significant effect on the process of supplier selection while it is not given the chance to overshadow other criteria by the nature of the supplier selection practice. A balanced should be maintained between price and the other criteria to engage the best supplier for a given material. Subsequently, negotiation permits to reach the price agreement that satisfy both contractor and supplier.

Studies conducted in the USA, Taiwan, and Vietnam construction industry recognised some supplier evaluation and selection criteria as the most important ones (Ho and Nguyen, 2007, Kannan and Tan, 2002). These are presented in Table 2.

Table 2: Comparison of five most important supplier selection criteria

Rank	(Kannan and Tan, 2002)	(Ho and Nguyen, 2007)	
	USA	Taiwan	Vietnam
1	Ability to meet delivery due dates	Commitment to quality	Commitment to quality
2	Commitment to quality	Ability to meet delivery due dates	Prices of materials, parts and services
3	Technical expertise	Prices of materials, parts and services	Ability to meet delivery due dates
4	Prices of materials, parts and services	Reputation of supplier	Technical expertise
5	Honest and frequent communications	Supplier's process capability	Industry knowledge

Further, Aretoulis et al (2009) suggests other pertinent criteria to include: discount, progress payments/cost of money, special chargers, freight chargers, total evaluated cost to destination, terms of payment, escalation, acceptance of project terms and conditions, promised delivery date based on award, shipping weight, and expiration date of bidder's quotation. However, it is apparent that specific criteria and their relative importance are highly dependent on the type of purchase being made.

3.3 Supplier Selection Methods

Literature show that there are number of studies have been devoted to examining performance based supplier selection methods. However, there has not been any general set of standards for supplier selection and evaluation. Basically, the characteristics of the firms, their goals and many other reasons actually decide the criteria for supplier selection and these are very subjective (Ho and Nguyen, 2007). Multi-criteria decision making (MCDM) process is common to supplier selection in previous studies (Boer et al., 2001; Ghodsypour and O'Brien, 1998; Karpak et al., 2001). A set of objectives need to achieve for a given project should be addressed as multi-objectives in the supplier selection process. Categorical method, the cost ratio method, and the linear averaging method are the three general types of supplier evaluation systems used today (Benton and McHenry, 2010). Implementation and overall reliability are the guided factors of the system basically determine the best fitted method.

3.3.1 Categorical Method

Categorical methods are qualitative models that help decision makers to evaluate their suppliers' performance on a set of criteria using historical data and buyers' experience. Timmerman (1986) discussed this method thoroughly. This is a traditional method and basically, it is a procedure whereby the buyer relies on a historical record of supplier performance and ability of the individual buyer. Thiruchelvam and Tookey (2010) have discussed that it is a simple, economical, and fast technique for supplier evaluation. In detail, a list of attributes (performance factors) should be maintained by the buyer for the track keeping purpose of each area by assigning a grade in simple terms such as "good", "neutral" and "unsatisfactory" (Benton and McHenry, 2010). Thereafter, supplier's performance could be evaluated and informed through regular contractor-supplier meetings. Evaluation lists are often provided to other sections of the construction team involved. Khaled, Paul, Chakraborty, and Ayuby (2011) identify the main advantage of the categorical method as its contribution to structure strong and efficient supplier selection practices. In addition, fast execution and economical nature of the system benefits the supplier selection process. However, on the other hand it is a simple and informal which details performance achievement or deficiencies are not evaluated. Another drawback of this method is that its dependence on the judgements of its users with no concrete supporting data (Ordoobadi, 2009). In the categorical method both subjective and objective factors are evaluated, converted to consistencies, dimensionless indices and then combined with the critical measure to yield the performance measure of a supplier. The 8-steps procedure was given by (Khaled et al., 2011) based on evaluation of critical factors (CF), objective factors (OF), and subjective factors (SF).

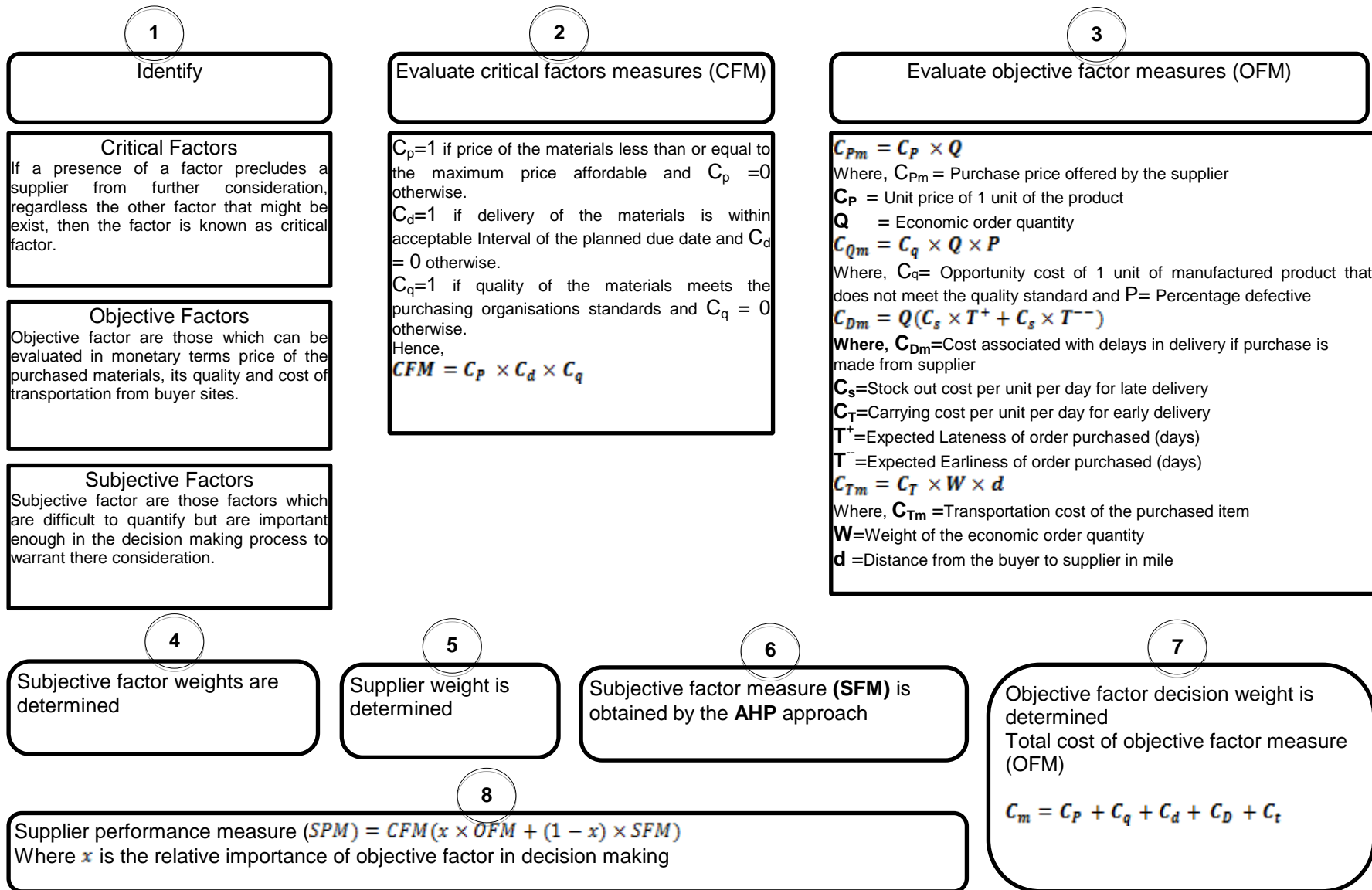


Figure 4: Categorical method - The 8-steps procedure

3.3.2 Cost-Ratio Methods

Timmerman (1986) proposed a method named “cost-ratio” which collects all costs related to quality, service, and delivery, and express them as a percentage of the total unit price (Pi and Low, 2005). The cost-ratio method evaluates supplier performance using standard cost analysis (Willis and Huston, 1989) and relates all identifiable purchasing costs to the value of the shipments received from the respective suppliers. The cost categories used depend on the products involved. The total price is calculated by accounting selling price and buying organisation’s internal operating costs associated with quality, delivery and service (Thiruchelvam and Tookey, 2010). The calculation procedure consists of four key stages: (1) Determining the internal cost associated with quality, delivery, and service; (2) Conversion of each element to a cost ratio; (3) Obtaining the overall cost ratio by summing the individual cost ratios; and (4) Allocation of overall cost ratio to the supplied quoted unit price to obtain the net adjusted cost figures. As the basis of comparison of supplier’s performances, the net adjusted cost figure is used. In this evaluation, all the costs associated with conducting business with suppliers should be gauged as penalty. The best supplier is selected as one with lowest net adjusted cost. The cost oriented nature of the results provides the major advantage of this technique. Therefore, it is essential to recognise all the associated costs. This method is more expensive when compared to the categorical method. Further, this is a complex methodology, necessitating a wide-ranging of cost accounting system to create accurate cost data (Dobler et al., 1990, Timmerman, 1986). Moreover, as another drawback, this method does not take in to account other aspects of supplier performance and it is assumed that all the required data are readily available (Willis and Huston, 1989).

3.3.3 Linear Averaging

Linear average method is also known as weighted point method (Humphreys et al., 1998) and it is possibly the most frequently used supplier assessment method (Willis and Huston, 1990). In this method, the subjective nature of the categorical approach is improved by providing numerical weights to the evaluation criteria and individual supplier’s performance. Then a composite performance index is calculated to determine “the winner”. Further, specific performance factors used are basically quantitative including quality, service (delivery), and price. A weighting system is considered for those factors depending on the nature of the project. As an example, a builder may consider quality as the most imperative for complex bridge projects while price might be given equal or greater weight in an evaluation system used by the highly competitive residential housing project. However, purchase price is a one of the key attributes which is given a higher priority and all the other attributes are considered as non-price attributes (Ittner et al., 1999). Firstly, it is necessary to assign appropriate weights to each performance factors in such a way that the summation of all weightings keep as 100. The allocation of weights is decision making process taken by the contractor’s top management. Secondly, the suppliers are rated on each performance factor according to a numerical scale. Finally each performance factor is multiplied by its respective weight as a percentage and a numerical rating system is created for each supplier. The supplier with the highest score is then selected. However, in this method, the issue of assigning weight is subjective and varied based on the decision maker (Ordoobadi, 2009).

3.3.4 Value engineering (VE)

Value engineering originated from Myers of United States electrical engineers in 1947 (Yong and Qi, 2012). The basic idea of VE is that to improve the value of the product and it is known as a scientific analysis in management. Further, this method evaluates the product necessary functions with the lowest cost. Therefore, value (V), function (F), and cost (C) are considered as the core elements in the value of the project as shown below (Yong and Qi, 2012)

$$V = \frac{F}{C}$$

Where,

V = Object's value

F = Object's function

C = Cost of an object

Firstly, an evaluation index system should be implemented for the material considered and this should reflect the various functions of the materials (e.g. quality, price, freight, supply capacity, credibility, etc.). Quantitative marking can be conducted according to the importance of factors considered by seasoned front-line experts, including project manager, project engineer, technical engineer, procurement engineers, etc.). Secondly, function evaluation coefficient should be calculated (C_F). Front-line experts can be used to evaluate the suppliers for each factors considered. Let K_i denotes the importance of each factor, and K_{ij} denotes the each factor importance of each supplier. Following formula can be used to test how the supplier's capabilities meet the total score and functional coefficient.

$$F_j = K_i \times K_{ij}$$

$$C_F = F_j / F_T$$

Where,

F_j = The total value of each supplier' evaluation

F_T = The total value of all suppliers' function

Thirdly, Cost evaluation coefficient (C_C) should be calculated. Phase quantity of materials should be determined by project's actual demand. The total cost of its purchase would be calculated with product, the transport distance and the shipping price.

$$C_c = C_j / C_T$$

Where,

C_j = The total cost of each supplier

C_T = The total cost of all manufactures

Fourthly, comprehensive evaluation coefficient (C_v) should be calculated. Finally, there should be a comparison of evaluation coefficient of comprehensive value of each supplier and the supplier with the highest comprehensive coefficient is selected.

4. Summary and Conclusions

Excellent performance of material suppliers is most crucial for the smooth procurement of materials. Supplier evaluation and selection is a usual MCDM issue. Interestingly, the multi-criteria signify both qualitative and quantitative characteristics. Construction contractor should be able to select the appropriate decision making tool which is easy, reliable and affordable. It is essential to have an applicable structured decision making system in today's complex construction industry. This particularly helps quality decisions and consistency and transparency under complex multi-criteria (tangible and intangible) conditions. Mainly, past literature focused on the manufacturing industries and therefore a room exists for development of pertinent supplier selection models in the construction industry as it a unique sector by itself since all decision methods used by manufacturing industry might not be relevant to the construction sector.

This preliminary review of literature is the initial component of an on-going PhD study. The rationale for this research being predicated on the need model the construction material supply behaviour to optimise the material purchasing decisions. The overarching aim of this paper was to signify the process of material supplier selection in the construction purchasing function. In practice, supplier selection is based on perceived importance of selection criteria. However, in reality, several other characteristics may domineer the criterion perceived to be important on a case by case basis. The nature of the MCDM method influences on each criterion (e.g. quality, delivery dependability, price, etc.). Therefore, there a room for examination of the effect of interdependencies among the criteria towards the decision making process of supplier selection in the construction industry.

The next anticipated phase will be the development of a conceptual framework to identify the best practice in the construction material supply chain. This framework will form the basis of a research survey tool that will be developed and validated through a research process anticipated to start in the middle of 2012. An appropriate set of metrics need to be formulated with the intention of managers have a consistent and reliable measurement to evaluate the form's relationship with its suppliers. In order to accomplish this, collaboration among theoretical researchers and practitioners are necessary at this stage. As a result, any new ideas and discoveries can be applied and examined in reality at the right time. This will help the construction industry to propagate and theories to be proved in a short span of time. Further research is needed for a detailed exploration of the supplier selection problem addressed in this study.

References

- Aretoulis, GN, Kalfakakou, GP & Striagka, FZ 2009, 'Construction material supplier selection under multiple criteria', *Operational Research*, vol. 10, no. 2, pp. 209-230.
- Bayazit, O, karpak, B & Yagci, A 2006, 'A purchasing decision: Selecting a supplier for a construction company', *Journal of Systems Science and Systems Engineering*, vol. 15, no. 2, pp. 217-231.
- Benton, WC & Mchenry, LF 2010, *Construction purchasing and supply chain management*, McGraw-Hill , Mexico City.

- Boer, LD, Labro, E & Morlacchi, P 2001, 'A review of methods supporting supplier selection', *European Journal of Purchasing & Supply Management*, vol. 7, no. 2, pp. 75-89.
- Carr, AS & Pearson, JN 1999, 'Strategically managed buyer-supplier relationships and performance outcomes', *Journal of Operations Management*, vol. 17, no.5, pp. 497-519.
- Chen, X, Zhou, XF & Zhang, Y 2011, 'Research on building engineering materials supplier selection based on ANP method', *Key Engineering Materials*, pp. 474-476.
- Dobler, DW, Burt, DN & Lee, L 1990, *Purchasing and materials management*, McGraw-Hill, New York.
- Ellram, LM & Carr, AS 1994, 'Strategic purchasing: A history and review of the literature', *International Journal of Purchasing and Materials Management*, vol. 30, no. 2, pp. 10-18.
- Formoso, CT & Revelo, VH 1999, 'Improving the materials supply system in small-sized building firms', *Automation in Construction*, vol. 8, no. 6, pp. 663-670.
- Gadde, L & Hakansson, H 2001, *Supply network strategies*, Wiley, Chichester.
- Ghodsypour, SH & O'brien, C 1998, 'A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming', *International Journal of Production Economics*, vol. 56-57, pp. 199-212.
- Hadikusumo, BHW, Petchpong, S & Charoengam, C 2005 'Construction material procurement using Internet-based agent system', *Automation in Construction*, vol. 14, no. 6, pp. 736-749.
- Ho, C & Nguyen, P 2007 'Supplier evaluation and selection criteria in the construction industry of Taiwan and Vietnam', *International journal of information and management sciences*, vol. 18, pp. 403-426.
- Humphreys, P, Mak, KL & Mcivor, R 1998 'Procurement', *Logistics Information Management*, vol. 11, no. 1, pp. 28-37.
- Iltner, CD, Larcker, DF, Nagar, V & Rajan, MV 1999, 'Supplier selection, monitoring practices, and firm performance', *Journal of Accounting and Public Policy*, vol.18, no. 3, pp. 253-281.
- Kannan, VR & Tan, KC 2002 'Supplier selection and assessment: Their impact on business performance', *The Journal of Supply Chain Management: A Global Review of Purchasing and Supply*, pp. 11-21.
- Karpak, B, Kumcu, E & Kasuganti, RR 2001 'Purchasing materials in the supply chain: managing a multi-objective task', *European Journal of Purchasing & Supply Management*, vol. 7, no. 3, pp. 209-216.
- Khaled, AA, Paul, SK, Chakraborty, RK & Ayuby, MS 2011 'Selection of suppliers through different multi-criteria decision making techniques', *Global Journal of Management and Business Research*, vol. 11, no. 4.

- Ma, L & Yang, G 2010, 'The selection of construction material suppliers in supplier relationship management (SRM)', *Proceedings of the International conference of information science and management engineering*, IEEE, Xi'an, China.
- Mendoza, A 2007, 'Effective methodologies for supplier selection and order quantity allocation' . PhD thesis, The Pennsylvania State University, Pennsylvania.
- Monczka, R, Trent, R & Handfield, R 2005, *Purchasing & supply Chain management*, Thomson, Ohio.
- Ordoobadi, SM 2009 'Development of a supplier selection model using fuzzy logic', *Supply Chain Management: An International Journal*, vol. 14, no. 4, pp. 314-327.
- Pi, W & Low, C 2005 'Supplier evaluation and selection using Taguchi loss functions', *The International Journal of Advanced Manufacturing Technology*, vol. 26, no. 1-2, pp. 155-160.
- Thiruchelvam, S & Tookey, JE 2010, '*Review of supplier selection methods: Suitability for Malaysian electricity supply industry*', Proceedings of the international conference on industrial engineering and business management (ICIEBM), Yogyakarta, Indonesia.
- Timmerman, E 1986 'An approach to vendor performance evaluation', *Journal of Purchasing and Materials Management*, vol. 22, no. 4, pp. 2-8.
- Wang, Y & Xiaolong, X 2004 'The application of supply chain management in construction industry', *China Civil Engineering Journal*, vol. 37, pp. 86-91.
- Weele, AV 2005, *Purchasing and supply chain management: Analysis, strategy, planning and practice*, Thomson Rennie, London.
- Willis, TH & Huston, CR 1990 'Vendor requirements and evaluation in a just-in-time environment', *International Journal of Operations and Product Management*, vol. 10, no. 4, pp. 41-50.
- Yong, L & Qi, W 2012 'Case study of optimal material supplier selection by the Value Engineering Theory', *Key Engineering Materials*, pp. 887-891.