A Decision Support Model to Select Suppliers In Apparel industry

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Abstract

Within the competitive supplier base environment, firms are more conscious about selecting the right supplier at the right time by considering a wide range of qualitative and quantitative criteria. This present research work devises a mathematical model for selecting suppliers and develop the decision support model framework for apparel industry in Sri Lanka with the incorporation of Pareto analysis and Analytic Hierarchy Process (AHP). The developed model allows procurement professionals in apparel industry in Sri Lanka to make sound decisions with respect to supplier selection. The study seeks to address the supplier selection modeling that have not well explored in previous Sri Lankan literature.

Keywords

Decision support model, supplier selection, apparel industry in Sri Lanka, Pareto analysis, Analytical Hierarchy Process

1. Introduction

Today, many companies crave to constantly intensify its competitiveness through reliable and efficient supply networks based on supplier relations to increase profits and promote the customer value while minimizing the total supply chain cost. Which is one of the most important aspects of supplier selection. Within a competitive environment, firms are paying more attention for procurement of raw materials and components for their products with the intention of selecting the right suppliers.

In the context of procurement, supplier selection is one of the highly researched problems due to the high degree of complexity and criticality of the domain (Kar, 2015).The current scenario of the supplier selection process is how to cope up with dynamic situations. Major issue for dynamic situation is unpredictable markets (Pearson, 2012) where there are changes in customer demand (order quantity) with the changing taste, consciousness of quality, price and the delivery time. Along with the supplier selection, the topic of decision support has been extensively explored. And also it is still one of the important areas which require regular revisiting. (Kar, 2015). Generally, procurement professionals use their experience and intuition when selecting suppliers. But it is important to have a more generalized method to select suppliers that minimize the time that taken to decision making while optimizing the resources and selecting the best option available.

According to Purchasing Insight, supplier selection has been included as a major step in the procurement process. When considering about supplier selection, it is important to identify the right supplier. According to Charted Institute of Procurement & Supply, supplier is one term used to describe external organizations that deliver services or goods to a buyer (CIPS, n.d.). The choice of supplier/partner is one of the key factors for the operational success of many companies, but also a time and resource-consuming complex process (Ávila, et al., 2012).

In order to select the best suppliers, it is vital to consider the both qualitative and quantitative factors. (Hwang, Moon, Chuang, & Goan, 2005). Vendor selection is an important decision since it directly affects various costs involved, including those associated with delivery lead times, quality of goods and general goodwill (Denise & Selwyn, 2004). Several conflicting criteria which should give competitive priorities make the supplier selection problem a complex one. Compromising among the conflicting criteria is desirable (Singh, Multi-period demand allocation among supplier in a supply chain, 2015). Determining selection criteria and selection techniques are the most important phases of supplier selection process (Ali & Zeynep, 2008).

Today, Sri Lanka has become a hub of apparel manufacturing where there is a severe competitive supplier base within the industry. And also with the dynamic environment, it is essential to select the most suitable supplier with the situational change. Large and medium apparel industry in Sri Lanka was focused as the population.

2. Related work

A number of studies have been found in the literature related to modeling supplier selection process.As the supplier selection models that were developed so far, Weber & Ellram have developed a multi objective programming model to a firm which practices Just in Time manufacturing philosophy. A model is developed for supplier selection in developing countries as a tool in guiding a firm in purchasing internationally with the objective of reducing the uncertainty of quality (Motwani, Youssef, Kathawala, & Futch, 1999).In 2005, there was a proposed first analysis model using AHP, which is a three-step decision analysis model which converts the qualitative factors into quantitative measures and integration model integrates the results of multi-analysis and selects the best supplier (Hwang, Moon, Chuang, & Goan, 2005). Shyur & Hshih, 2006 have developed a hybrid model for supporting the vendor selection process in new task situations which evaluate problem using multi criteria decision making approach, five step hybrid model which incorporate techniques of ANP and TOPSIS to rank competing products in terms of their overall performances. A three phase methodology which was developed using AHP and goal programming techniques* reduces the base of potential suppliers to a manageable number and optimize allocation of orders in a situation like risky and consist a variety of qualitative and quantitative criteria such as flexibility, price, quality, service and delivery (Mendooza, Santiago, & Ravindran, 2008).

Ali & Zeynep, 2008 have developed an integrated analytical hierarchy process and mathematical programs for supplier selection with quantity discount by using price and quality as the prominent criterion. A green supplier selection model focusing high-tech industry with considering environmental issues has been developed using the Delphi method to differentiate the criteria for evaluating traditional suppliers and green suppliers. Fuzzy extended AHP was used to evaluate the importance of the selected criteria and the performance of green suppliers (Lee, Kang, Hsu, & Hung, 2009).During 2010, a concurrent engineering approach integrating AHP with quality function deployment in combination with cost factor measure has been delineated to rank and subsequently select candidate-suppliers under multiple, conflicting-in-nature criteria environment within a value-chain framework. (Bhattacharya, Geraghty, & Young, 2010). A simple supplier selection model using AHP with the intention of application study for Turkey was developed by considering criteria price, service quality, production capability and general & organizational structure. (Özkan, Başlıgil, & Şahin, 2011).

A composite model using structural equation modeling and AHP identifies strengths and weakness of each supplier by considering management and organization, quality, technical capability, production facilities, capacities, financial position, delivery, relationship, safety, environment concern and cost to select the appropriate suppliers (Punniyamoorty, Mathiyalagan, & Lakshmi, 2012). A model has proposed which comprises two parts; identifies suitable criteria for evaluating international express supplier by researching studies from 1989 to 2009, after which the fuzzy analytic hierarchy process (AHP) is applied to determine the relative weights of the criteria and adopts grey relational analysis to extract priority managing strategies (Feng-Chung, Tzong-Ru, & Szu-Wei, 2015).

By considering two decades of studies, following top most criteria were identified.

Table 1: Mostly used supplier selection criteria

Criteria	Consideration percentage out of 30 literature reviews
Supplier's quality	80.00
Price	53.33
On time delivery	53.33
Service level	43.33
Financial position/ Budget	26.67
Purchasing cost/ per unit cost	23.33
Delivery lead time	16.67
Responsiveness	16.67
Buyer supplier relationship	16.67
Organization	16.67
Environment	13.33
Technical capacity	13.33
Technology	13.33

Mostly used supplier selection method in previous studies is Analytical Hierarchy Process (AHP). Temesgen & Shimels, 2014, Shin-Chan & Danny, 2013, Hwang, Moon, Chuang, & Goan, 2005. Feng-Chung, Tzong-Ru, & Szu-Wei, 2015, Ali & Zeynep, 2009 have used AHP. According to the literature review, it is clear that the topic has been attractive in the global context, but still a requirement for a proper analysis of the Sri Lankan context is missing. Therefore, it is important to do an appropriate research in developing supplier selection model for apparel industry in Sri Lanka.

3. Study scope

The apparel industry in Sri Lanka which has competitive supplier base and epic growth during the last four decades is the study scope. This mainly focuses on large and medium scale companies which are registered under the Export Development Board, Sri Lanka.

3.1. Problem Formulation

Problem formulation defines the problem that addressed throughout the study with the intention of achieving objectives.

The research problem is as follows;

"**How to select supplier at the dynamic situation of demand uncertainty while minimizing the cost and giving the optimum value?**" to achieve objectives "**to identify the prominent criteria for selecting a supplier for apparel industry in Sri Lanka" and "to model the supplier selection process at dynamic situation".**

3.2. Planning for data collection

For the first questionnaire form, all the companies in population were considered and 30 responses were selected as the sample. At the first stage, online questionnaire form was developed and sent to the whole population. For the pairwise comparison, five professionals were selected as the easiness while considering the time constraint for the pairwise comparison of prominent criteria.

3.3. Data collection

In order to identify the supplier selection criteria, 30 literature reviews were used. Then 30 valid responses were selected from the entire responses which were gathered from all most all the companies in the population. 30 valid responses were selected with the base of having a supplier pool. 85.7% of the respondents have a pool of suppliers. Hence their responses are selected for the proceeding of the study. Actual data were collected and analyzed using descriptive analytics techniques, Pareto analysis and AHP.
The main output of the research is the model development. Finally, it is important to compare the proposed model with the existing method in order to ensure the applicability of the model in real world scenarios and identify further research opportunities.

4. DESCRIPTIVE ANALYSIS

The results show that the supplier selection process is crucial for their company. It is 100% certain that there should be a proper and organized way for this process. 73.3% of the sample stated they have a distinct department for procurement process and 26.6% remaining have a responsible person such as merchandisers (37.5%) and supply chain advisors (25%) to handle the process.

It is a well-known fact that procurement cost is accounts for about 60% of average total cost. It is identified that the procurement cost percentage of apparel industry in Sri Lanka in almost all the companies in the population exceeded the 40% limit with the 93.3% agreement where average procurement cost as the share of total cost lies between 40%-60%. It is an important indication to a logistician. Even though firms have a separate department for the procurement process, there is high procurement cost due to complexity. Companies have a separate department for the procurement, it is identified that there is no reduction of the procurement cost because it lies between 40%-80% of the total cost. The current scenario of the apparel industry in terms of supplier selection process is using past experience (23.3%) whereas 43.3% of respondents have not definite method for the process.

In the context of a dynamic situation, the supplier selection process becomes decisive which leads to the increment of average procurement cost. It is proven that demand uncertainty is a major dynamic situation which makes the supplier selection process more costly and time consuming with the consent of 45.5% of the respondents. Other dynamic situations are changing in the bargaining power of supplier (17.1%), time fluctuations to switch suppliers (5.7%) and not having a proper method to select suppliers (20%).

By considering all the demographic factors, it is proven that there is an opportunity for the research "Developing Decision Support Model for Supplier selection of the Apparel industry in Sri Lanka at the dynamic situation of order changing"

5. Model development

5.1. Phase 1: Identification of supplier selection criteria

With the use of 30 literature reviews, supplier selection criteria were identified. The total number of criteria was 54. Among them, mostly used 14 criteria were selected for the proceeding of the model development.

5.2. Phase 2: Prominent criteria Identification- Pareto Analysis

Table 2 Statistics for Pareto Analysis

Criteria	Score	Cumulative score	Cumulative %	Rank	%rank
Quality	421	421	11.70	1	5.26
Cost	368	789	21.92	2	10.53
Delivery Lead Time	355	1144	31.79	3	15.79
Service Level	352	1496	41.57	4	21.05
Price	328	1824	50.68	5	26.32
On Time Delivery	288	2112	58.68	6	31.58

Financial Position	274	2386	66.30	7	36.84
Responsiveness	257	2643	73.44	8	42.11
Supplier Relationship	223	2866	79.63	9	47.37
Organization	173	3039	84.44	10	52.63
Environment	150	3189	88.61	11	57.89
Green Initiative	137	3326	92.41	12	63.16
Technical Capability	129	3455	96.00	13	68.42
Technology	114	3569	99.17	14	73.68
Other	26	3595	99.89	15	78.95
Flexibility	1	3596	99.92	16	84.21
Supplier capacity	1	3597	99.94	17	89.47
Trust	1	3598	99.97	18	94.74
R&D Capability	1	3599	100.00	19	100.00
		3599			

Apart from 14 criteria identified using 30 literature reviews, 5 criteria were included in table 2 which were identified from questionnaire responses for the Pareto analysis. According to Pareto analysis, 80% of impact is caused by 20% of the criteria. As the most important criteria, the first 4 criteria were selected because they account for 21.05% of the criteria which give impact for about 41% level. In that scenario; quality, cost, lead time and service level were spotlighted as prominent supplier selection criteria.

5.2.1. Prominent Criteria Notation

The following notation is used throughout the study.

C1: Supplier's Quality
C2: Per unit Cost
C3: Delivery Lead time
C4: Supplier's Service level

5.3. Phase 3: Weight calculation using the AHP method

After conducting the pairwise comparison, the relative weights for respective prominent criteria were calculated. The consistency ratio for the pairwise comparison was 16.11% where it is accepted in local context. Hence, the relative weights for Supplier's quality (C1), per unit cost (C2), delivery lead time (C3) and service level (C4) respectively are 0.2510, 0.3298, 0.2285 and 0.1908.

5.4. Phase 4: Identification of the relationship between prominent criteria and supplier Score

The results show that there is a positive relationship between "C1" and supplier's score as well as "C4" and supplier's score. Along with, the results show that there is negative relationship between "C2" and Supplier's score as well as "C3" and supplier's score.

5.5. Phase 5: Model development

Equation 1: Supplier Selection Mathematical Model

$$Y_i = \frac{(0.2510 * C1_i) + (0.1908 * C4_i)}{(0.3298 * C2_i) + (0.2285 * C3_i)} \quad (1)$$

Subject to:

$$Q_M \geq Q_R \quad (2)$$

$$LT_S \leq LT_R \quad (3)$$

Where ;

Y_i : Score of supplier i
$C1_i$: Quality level of Supplier i
$C2_i$: Per unit cost for supplier i
$C3_i$: Delivery lead time of supplier i
$C4_i$: Service level of supplier i
Q_{Mi} : i[th] supplier's maximum quantity
Q_R : Required raw material quantity
LT_S : i[th] supplier's delivery lead time
LT_R : Required lead time for raw material

Equation (1) provides the final score for supplier by considering prominent criteria. This mathematical model has several limitations and they are given as the constraints in the model. Constraint (2) limits the supplier pool by ensuring a single supplier can supply whole the required quantity. Constraint (3) ensures that the supplier can deliver required raw material at the right time.

5.6. Phase 6: Decision Support Model Framework

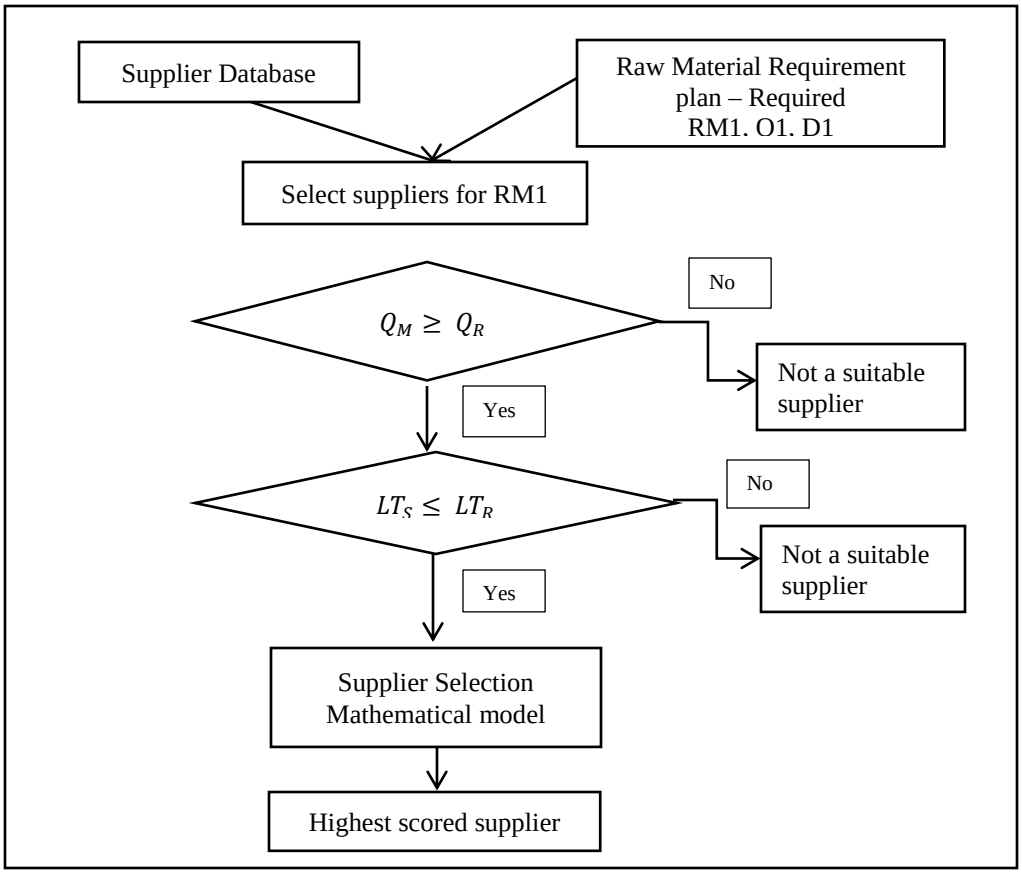

Figure 1: Decision Support Model Framework

The figure 1 shows the decision support model framework for selecting suppliers in a dynamic situation in order changing. When comparing the proposed framework with the typical supplier selection process, when the requirement plan received, the need for supplier selection will be recognized by procurement professionals in the company. The prominent criteria in model; quality, delivery lead time, per unit cost and service level are the key sourcing requirements according to this research. The single source is the sourcing strategy for the proposed model. Select relevant suppliers for RM1 from the supplier database maintained by the company. Using constraints which are

identified in the model, it is possible to limit suppliers in supplier pool. To select the most suitable supplier from the remaining suppliers, the developed model equation can be used. The most scored supplier will be the most suitable one for the sourcing purpose and selecting suppliers.

6. Simulation and Results

The considered case study is one large scale company in the apparel industry in Sri Lanka was selected. Let's denote product that is produced by the selected company as P1 to ensure the confidentiality of further data. In the manufacturing of product P1, RM1 raw material is required. For RM1, there are 11 suppliers in the company database. The company measures service levels in terms of on time delivery, order fulfillment and Meeting quality standards. There are five service levels in their selection process scored as 5 to 1 respect to the best service level to low service level. As cost components, the price of the raw material, transportation cost, capacity, product range, financial stability (to pay for failures), flexibility and innovation are identified. According to decision support model framework (Fig. 1), table 3 shows supplier data for the RM1 and table 4 shows the material requirement.

Table 3: Supplier data for RM1

	Quality	Delivery Lead time in days	Unit cost $ per yard	Service level	Maximum quantity in yards
Supplier 1	2	60	4.20	4	29000
Supplier 2	2	60	4.10	5	27000
Supplier 3	1	71	5.50	3	25000
Supplier 4	4	45	3.59	5	15000
Supplier 5	3	60	4.75	3	25000
Supplier 6	1	56	3.45	5	23000
Supplier 7	4	60	5.75	2	30000
Supplier 8	3	90	4.20	4	35000
Supplier 9	2	58	3.82	3	20000
Supplier 10	1	47.5	2.95	2	23000
Supplier 11	4	64	3.02	3	21000

Table 4: Material requirement for received order

Material	Required date	Quantity
RM1	Within 65 days	25000

This is the dynamic situation that company will face where they required 25000 of product P1 within 65 days. 25000 is the required quantity and 65 days is the required lead time for RM1. By using those constraints, supplier pool will be limited.

$$Q_M \geq 25000$$
$$LT_S \leq 65$$

As a result of the constraints, supplier pool will be limited to, supplier 1, 2, 4, 10 and 11. The score for supplier will be calculated with the use of the developed mathematical model. The table 5 shows the calculated scores for the suppliers.

Table 5 : Score calculation

Supplier	Model	Supplier's score
Supplier 1	$Y1 = \frac{(0.2510 * 2) + (0.1908 * 4)}{(0.3298 * 4.20) + (0.2285 * 60)}$	0.08381
Supplier 2	$Y2 = \frac{(0.2510 * 2) + (0.1908 * 5)}{(0.3298 * 4.10) + (0.2285 * 60)}$	0.09667
Supplier 4	$Y4 = \frac{(0.2510 * 4) + (0.1908 * 5)}{(0.3298 * 3.59) + (0.2285 * 45)}$	0.17076
Supplier 10	$Y10 = \frac{(0.2510 * 1) + (0.1908 * 2)}{(0.3298 * 2.95) + (0.2285 * 47.5)}$	0.05349
Supplier 11	$Y11 = \frac{(0.2510 * 4) + (0.1908 * 3)}{(0.3298 * 3.02) + (0.2285 * 64)}$	0.10092

Supplier 4 which has a quality level of 4, 45 days delivery lead time, $3.59 per unit cost (yard), service level of 5 and 15000 unit maximum quantity is judged to be overall best.

7. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

The proposed decision support framework makes ease the decision making process when selecting the supplier at the situation in order changing. After finding possible supplier sources, the model will limit the supplier pool into a manageable number. Then through the mathematical model which was developed with the incorporation of Pareto analysis and AHP technique, relevant score for suppliers will be calculated. When considering about research limitations, the research was carried out using the primary data of Sri Lankan context and secondary data in global context due to there are no local researches were found in supplier selection. In order to overcome the limitation, research design was completely developed with suitable to the Sri Lankan context. This framework enables procurement professionals to make decisions by considering both qualitative and quantitative factors. In order to make the fullest use from proposed method, it is recommended for companies to define score scale with respect to their unique supplier quality level measurements and for the supplier's service level. Furthermore the supplier database should be properly and accurately updated with real time information. And the model should be developed if there are unique constraints of the company. And the model also needs to be upgraded according to the discussed data analysis steps.

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