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MULTICRITERIA DECISION MAKING ON SUPPLIER SELECTION USING SOCCER MODEL INTEGRATED WITH ANALYTICAL HIERARCHY PROCESS

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ABSTRACT: Supplier evaluation and selection are key components in the supply chain because supplier performance directly affects the supply chain's efficiency. Therefore, companies should think strategically when they need to select their suppliers. Thus, selecting and evaluating new suppliers is essential in shaping the supply chain's smoothness and efficiency. Selecting suppliers is a complex issue as it involves many factors and decisions to be considered and needs to be assessed with an auditing process. However, a supplier audit is an expensive way to evaluate supplier capability. This research aims to propose a supplier selection model for a corrugated carton manufacturing company. The SOCCER model, developed by Steve Rogers, was used as the supplier selection criteria. Analytical Hierarchy Process (AHP) was used in the supplier selection. A face-to-face interview method was used in collecting data. The results show that the cost structure is the ultimate concern on supplier selection which bears 44.2% of the SOCCER model, followed by operational capability (23%), customer approach (13.5%), economic performance (8.3%), strategic direction (6.9%), and lastly research and development (4.1%). The percentages inform the company how much attention they need to pay when evaluating and selecting a new supplier.

ABSTRAK: Penilaian dan pemilihan pembekal adalah kunci utama dalam rantaian bekalan kerana prestasi pembekal secara langsung melibatkan kecekapan rantaian bekalan. Oleh itu, syarikat perlu memikirkan secara strategik apabila ingin memilih pembekal. Dengan demikian, pemilihan dan penilaian pembekal baru adalah penting dalam pembentukan kelancaran rantaian bekalan dan kecekapan. Pemilihan pembekal adalah isu kompleks kerana ianya melibatkan banyak faktor dan keputusan perlu difikirkan dan perlu dinilai bersama proses audit. Namun, audit pembekal adalah mahal bagi menilai kemampuan pembekal. Kajian ini mencadangkan model pemilihan pembekal bagi syarikat pembekal kotak karton. Model SOCCER dicipta oleh Steve Rogers, telah digunakan sebagai kritia pemilihan pembekal. Proses Hirarki Analitikal (AHP) digunakan dalam pemilihan pembekal. Kaedah temuduga bersemuka digunakan dalam pengumpulan data. Dapatan kajian menunjukkan struktur harga adalah kehendak utama dalam pemilihan pembekal iaitu 44.2% daripada model SOCCER, diikuti kemampuan operasi (23%), pendekatan pelanggan (13.5%), prestasi ekonomi (8.3%), misi strategik (6.9 %), dan

akhirnya penyelidikan dan pembangunan (4.1%). Peratusan ini berguna untuk syarikat dalam memberi keutamaan dalam penilaian dan pemilihan pembekal baru.

1. INTRODUCTION

Today, with a rapidly changing world and markets, companies face a vital challenge to stay competitive [1]. Markets nowadays are witnessing major changes due to the global nature of trade and rapid technological development that leads to aggressive competition between manufacturers. This rapid technological advancement changed supply chain work and made it easier to communicate and faster to deliver goods. As a result, manufacturers have realized that suppliers' performance is one of the main and important factors to survive in the market. Capable suppliers are essential to ensure the supply chain runs smoothly and efficiently. Thus, establishing a strong relationship and partnering with suppliers will result in a win-win situation where both parties would gain advantages through this relationship. However, supplier selection is complex as it should consider many factors [2]. Researchers spend most of their time finding and determining the best supplier selection criteria, resulting in many approaches and checklist assessments [3]. Each company may have different selection criteria as they have their own goals, needs, and industry types. Selecting the best supplier is a complex and challenging procedure. Therefore, choosing the best method has become one of the main success factors for manufacturers and thus, multicriteria decision-making methods (MCDM) will be useful and effective.

2. LITERATURE REVIEW

MCDM methodology is a decision-support framework that can consider multiple inconsistent criteria [4]. It is a method in which different criteria are traded off to achieve the best alternative. It includes quantitative and qualitative factors, which are considered complex decision-making tools, making it the most widely used and favorable decision methodology in many fields [5]. Different MCDM techniques employ different approaches. Throughout their analysis research, Velasquez and Hester [6] identified eleven different MCDM. However, supplier selection is a complex critical problem that must trade off various conflicting criteria such as price, quality, and delivery time. These methods have been used and applied by different researchers in supplier selection such as Multi-Attribute Utility Theory [8], Analytic Hierarchy Process (AHP) [7], Fuzzy Set Theory [9], Case-Based Reasoning [10], Data Envelopment Analysis [11], Goal Programming [12], ELECTRE method [13], Simple Additive Weighing [14], and Fuzzy TOPSIS Technique [15]. Other researchers prefer integrating two methods or techniques to have better and more effective decisions as an efficient approach [16-20].

Many researchers [21-22] claim that merging AHP with one of the intelligent methods such as Fuzzy Set Theory is favorable in decision making on the selection of suppliers due to high uncertainty in this decision-making process. However, each multicriteria technique has its advantages and disadvantages. Thus, integrating several techniques is common in multicriteria decision-making to overcome deficiencies [6].

One of the most specific multicriteria frameworks in supplier selections is the SOCCER model [3]. The acronym represents the six main criteria, S- Strategic Direction, O- Operational Capability, C- Customer Approach, C- Cost Structure, E- Economic Performance and R-Research & Development. Rogers, in his book [3], explained that the supplier assessment is needed to make sure that the supplier can handle the orders.

Therefore, the SOCCER model is simply one of the most effective checklists when auditing suppliers. Ho et al. [23] have reviewed the literature of the MCDM approaches for supplier selection in the international journals from 2000 to 2008. However, in this research, the integration between AHP as one of the effective tools in multicriteria methods with SOCCER model as one of the effective checklists in suppliers' selection auditing was implemented.

2.1 Analytical Hierarchical Process

Thomas Saaty introduced the Analytical Hierarchical Process (AHP) in 1970 [24-25]. AHP is a structured method for dealing with complex decision-making. It aids the decision-maker in setting priorities and making the best decision. It derives relative priorities on absolute scales (invariant under the identity transformation) from discrete and continuous paired comparisons in multilevel hierarchical structures [26].

AHP is a method that merges a decision's subjective and objective characteristics. The AHP considers a group of evaluation criteria and different options, among which the most effective decision will be created. First, the AHP generates a weight for every evaluation criterion according to the decision-makers pairwise comparisons of the factors. The higher Weight, the more essential is the corresponding criterion. Next, the AHP assigns a score to every possibility for a set criterion according to the decision maker's pairwise comparisons of the choices based on that criterion. The higher the score, the better the performance of choice concerning the considered criterion. Finally, the AHP combines the criteria weights and the choices' scores, determining a global score for every option and a consequent ranking. The global score for a given possibility is a weighted total of the scores it obtained concerning all the criteria.

Sipahi and Timor [27] presented a comprehensive review of applications of AHP method and ANP from 2005 to 2009. The paper additionally contains fuzzy AHP and fuzzy ANP applications. Ishizaka and Labib [28] presented a theoretically-view of the AHP articles instead of classifying them by application areas. Their paper mentioned problem modeling, pairwise comparisons, judgment scales, derivation techniques, consistency indices, incomplete matrix, synthesis of the weights, sensitivity analysis, and group decision problems.

Subramanian and Ramanathan [29] reviewed and methodologically analyzed applications of AHP in operations management from 1990 to 2009. They classified 291 application research of AHP into operations strategy, process, and product style, designing and planning resources, project management, and managing the supply chain.

AHP-primarily based techniques for supplier analysis were studied by Bruno et al. [30]. Their study underlined that the weak and strong points are rising from applying the AHP in a greater supply chain.

2.2 SOCCER Model

The SOCCER model was developed by Rogers [3] to focus on the main factors in any supplier selection and what is needed for supplier analysis. The acronym represents the six main criteria, S- Strategic Direction, O- Operational Capability, C- Customer Approach, C-Cost Structure, E- Economic Performance and R-Research & Development. Each of the criteria has five sub-criteria, as shown in Fig. 1.

Finally, after a sweeping review of the current literature in the area, it was identified that various investigators used diverse criteria and different methods. In this research, the integration between the SOCCER model developed by Steve C. Rogers and the Analytical

Hierarchy Process (AHP) will add value to the area of knowledge and will reduce the risk of selecting an inappropriate supplier. AHP aids in developing a relative weighting and prioritizing the different criteria based on the organization's objectives.

This integration considers the advantages of using a powerful qualitative method presented by the AHP method that focuses on the pairwise comparisons for every two main criteria and strengthens it by using a well-established framework that considers six main dimensions: Strategic Direction, Operational Capability, Customer Approach, Cost Structure, Economic Performance, and Research & Development. Each of those dimensions has a sub-criteria that covers all the possible factors.
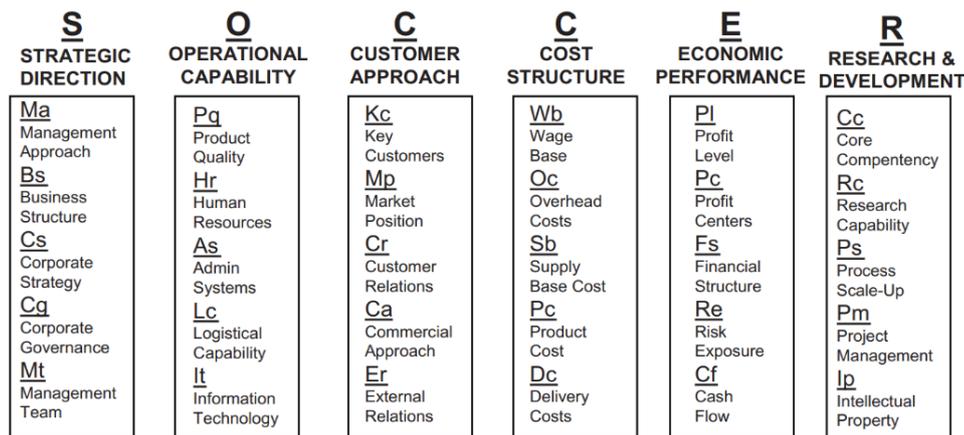
Fig. 1: Supplier analysis factors [3].

3. RESEARCH METHODOLOGY

In this research, the integration between AHP with SOCCER framework was implemented. The advantage of using the AHP method is that it focuses on pairwise comparisons for every two main criteria. To enhance the output of using the AHP method and strengthens it by using a well-established detailed framework that considers six main dimensions: Strategic Direction, Operational Capability, Customer Approach, Cost Structure, Economic Performance, and Research & Development. Each of those dimensions has a sub-criteria that covers all the possible factors. A sequential feedback loop is summarized in Fig. 2. The main steps of the research can be concluded in the following steps:

1. Analyze the suitability of using the SOCCER framework
2. Integrate the framework with the AHP method
3. Select the internal expertise in supplier selection for the company: quality assurance, customer service, and purchasing
4. Design the interview framework: Interview questions were designed to utilize the pairwise matrix.
5. Creating the pairwise matrix based on the interview results.
6. Test the consistency by avoiding bias due to the area of the expertise
7. Develop a conceptual framework

The consistency was determined using the followings steps [9,30]:

1. Calculating the consistency index CI, using Eq, (1), where n is the number of criteria in the comparison.

$$CI = (Max\ Eigenvalue - n)/(n-1) \qquad (1)$$

2. Dividing its value by the random consistency index, which is stated by Saaty depending on the value of n. The results are shown in Table 14.

3. Calculating the Consistency Ratio (CR) value using equation (2) where the value below 10% is considered consistent.

$$CR=CI/RI<0.1\sim10\% \tag{2}$$

where CI is the consistency index, CR is the Consistency Ratio, and RI is the Random Consistency Index
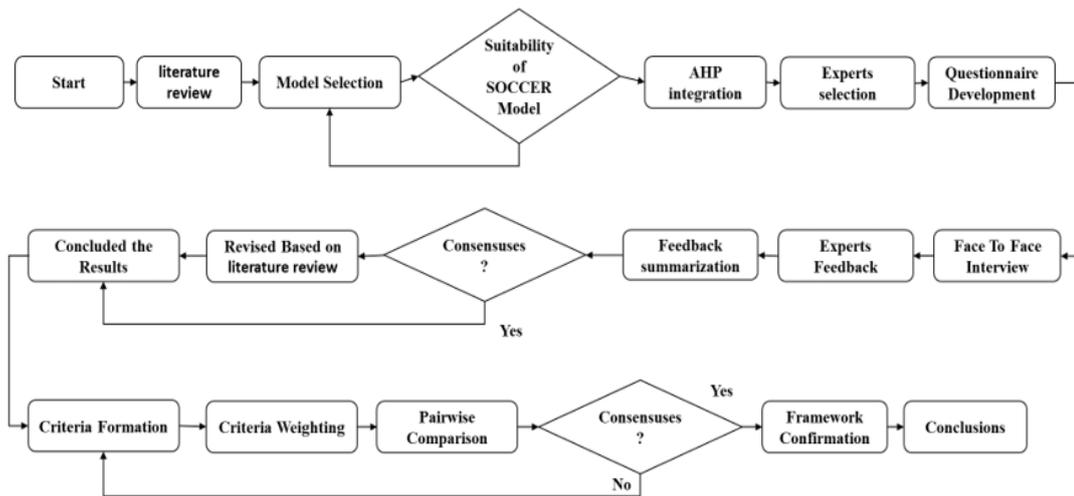
Fig. 2: Research methodology flow chart.

4. RESULTS

Supplier selection is a complex issue involving many factors and decisions due to the difficulties of trading off financial and performance evaluation. The data were gathered through interview sessions using the criteria based on the SOCCER model. The relative "priority" given to each element in the hierarchy is determined by comparing pairwise using the AHP method. The criteria ranking is decided through pairwise comparisons, and the preference scale ranking the hierarchy.

An industrial company was selected to implement SOCCER and AHP. The representatives from three different departments: quality assurance, customer service, and purchasing, were interviewed through a comprehensive individual interview session designed in order to fit for pairwise comparison. The results were concluded based on the SOCCER model. The results were analyzed based on two steps:

STEP 1: Developing a decision matrix of the SOCCER model for the main factors for each interviewee. The results are shown in Tables 1, 2, and 3.

The results show an agreement on the cost structure with the higher priority of 0.45, 0.42, and 0.44 for the quality assurance, customer service, and purchasing departments. Moreover, all the experts show agreement that the second essential criterion is the operational capability with the values of 0.27, 0.27, and 0,23.

Table 1: Decision matrix of SOCCER model by Quality Assurance

	Strategic Direction	Operational Capability	Customer Approach	Cost Structure	Economic Performance	R&D	Priority Vector
Strategic Direction	1	1/7	1/4	1/8	3	3	0.060
Operational Capability	7	1	3	1/3	6	7	0.270
Customer Approach	4	1/3	1	1/5	5	6	0.150
Cost Structure	**8**	**3**	**5**	**1**	**9**	**6**	**0.450**
Economic Performance	1/3	1/6	1/5	1/9	1	1/3	0.030
R & D	1/3	1/7	1/6	1/6	3	1	0.040

CI = 0.1116, RI = 1.24, CR = 0.09 < 0.1 OK

Table 2: Decision matrix of SOCCER model by Customer Services

	Strategic Direction	Operational Capability	Customer Approach	Cost Structure	Economic Performance	R&D	Priority Vector
Strategic Direction	1	1/6	1/5	1/8	½	2	0.050
Operational Capability	6	1	3	1/2	4	5	0.270
Customer Approach	5	1/3	1	1/4	2	4	0.140
Cost Structure	**8**	**2**	**4**	**1**	**5**	**8**	**0.420**
Economic Performance	2	1/4	1/2	1/5	1	2	0.080
R & D	½	1/5	1/4	1/8	1/2	1	0.040

CI = 0.0372, RI = 1.24, CR = 0.03 < 0.1 OK

Table 3: Decision matrix of SOCCER model by Purchasing

	Strategic Direction	Operational Capability	Customer Approach	Cost Structure	Economic Performance	R&D	Priority Vector
Strategic Direction	1	1/5	1/3	1/6	1	3	0.070
Operational Capability	5	1	3	1/4	2	5	0.230
Customer Approach	3	1/3	1	1/3	2	3	0.140
Cost Structure	**6**	**4**	**3**	**1**	**4**	**7**	**0.440**
Economic Performance	1	1/2	1/2	1/4	1	2	0.090
R & D	1/3	1/5	1/3	1/7	1/2	1	0.040

CI = 0.0868, RI = 1.24, CR = 0.07 < 0.1 OK

STEP 2: Developing a decision matrix of the SOCCER model for each interviewee for each sub criterion. Tables 4, 5, 6, 7, 8, and 9 show the decision matrix for quality assurance.

Table 4: Decision matrix of Strategic Direction by Quality Assurance

Strategic Direction	Management Approach	Business Structure	Corporate strategy	Corporate Governance	Management team	Priority Vector
Management Approach	1	1/5	1/3	5	1/6	0.070
Business Structure	5	1	4	7	1	0.360
Corporate strategy	3	1/4	1	6	1/6	0.130
Corporate Governance	1/5	1/7	1/6	1	1/8	0.030
Management team	**6**	**1**	**6**	**8**	**1**	**0.410**

CI = 0.0784, RI = 1.12, CR = 0.07 < 0.1 OK

Table 5: Decision matrix of Operational Capability by Quality Assurance

Operational Capability	Product Quality	Human Resource	Admin Systems	Logistical Capability	Information Technology	Priority Vector
Product Quality	1	1/5	1/3	5	1/6	0.070
Human Resources	5	1	4	7	1	0.360
Admin Systems	3	1/4	1	6	1/6	0.130
Logistical Capability	1/5	1/7	1/6	1	1/8	0.030
Information Technology	**6**	**1**	**6**	**8**	**1**	**0.410**

CI = 0.1008, RI = 1.12, CR = 0.09 < 0.1 OK

Table 6: Decision matrix of Customer Approach by Quality Assurance.

Customer Approach	Key Customers	Market Position	Customer Relations	Customer Approach	External Relations	Priority Vector
Key customers	1	9	1/2	2	6	0.330
Market Position	1/9	1	1/6	1/4	1/3	0.040
Customer Relation	**2**	**6**	**1**	**1**	**5**	**0.340**
Customer Approach	1/2	4	1	1	4	0.220
External Relation	1/6	3	1/5	1/4	1	0.070

CI = 0.0784, RI = 1.12, CR = 0.07 < 0.1 OK.

Table 7: Decision matrix of Cost Structure by Quality Assurance

Cost Structure	Wage Base	Overhead Costs	Supply Base Cost	Product Cost	Delivery Cost	Priority Vector
Wage Base	1	1/3	1/2	1/8	1/7	0.040
Overhead Costs	3	1	3	1/5	1/4	0.110
Supply Base Cost	2	1/3	1	1/7	1/6	0.060
Product Cost	**8**	**5**	**7**	**1**	**4**	**0.520**
Delivery Cost	7	4	6	1/4	1	0.270

CI = 0.1008, RI = 1.12, CR = 0.09 < 0.1 OK

Table 8: Decision matrix of Economic Performance by Quality Assurance

Economic Performance	Profit Level	Profit Centers	Financial Structure	Risk Exposure	Cash Flow	Priority Vector
Profit Level	1	1/2	1/6	1/3	1/4	0.050
Profit Centers	2	1	1/7	1/2	1/5	0.070
Financial Structure	**6**	**7**	**1**	**4**	**3**	**0.500**
Risk Exposure	3	2	1/4	1	1/2	0.140
Cash Flow	4	5	1/3	2	1	0.240

CI = 0.0336 RI = 1.12, CR = 0.03 < 0.1 OK.

Table 9: Decision matrix of Research & Development by Quality Assurance

Research & Development	Core Competency	Research Competency	Process Scale-Up	Project Management	Intellectual Property	Priority Vector
Core Competency	1	4	7	1/4	1/2	0.180
Research Competency	1/4	1	3	1/9	1/5	0.060
Process Scale-Up	1/7	1/3	1	1/6	1/3	0.040
Project Management	**4**	**9**	**6**	**1**	**2**	**0.470**
Intellectual Property	2	5	3	1/2	1	0.240

CI = 0.0784, RI = 1.12, CR = 0.07 < 0.1 OK

The results are concluded in Table 10. The priority vector of Strategic Direction, Operational Capability, Customer Approach, Cost Structure, Economic Performance, and R & D were management team, product quality, customer relation, Product Cost, financial structure, and project management were 0.41,0.41, 0.43, 0.52, 0.50, and 0.74, respectively. The SOCCER model overall Weight by the Quality Assurance is concluded in Table 10. The Quality Assurance preferred Cost structure (45%), followed by Operational Capability (27%), Customer Approach (15%), Strategic direction (6%), Research & Development (4%), and Economic performance (3%).

Table 10: Results of SOCCER model (Quality Assurance)

Factor	Item	Priority Vector (%)	Sub-Criteria Weight According to Main-Criteria Weight (%)
Strategic Direction (6%)	Management Approach	7.00	0.42
	Business Structure	36.00	2.16
	Corporate strategy	13.00	0.78
	Corporate Governance	3.00	0.18
	Management team	**41.00**	**2.46**
Operational Capability (27%)	**Product Quality**	**38.00**	**10.26**
	Human Resources	5.00	1.35
	Admin Systems	25.00	6.75
	Logistical Capability	26.00	7.02
	Information Technology	6.00	1.62
Customer Approach (15%)	Key customers	33.00	4.95
	Market Position	4.00	0.60
	Customer Relations	**34.00**	**5.10**
	Customer Approach	22.00	3.30
	External Relations	7.00	1.05
Cost Structure (45%)	Wage Base	4.00	1.80
	Overhead Costs	11.00	4.95
	Supply Base Cost	6.00	2.70
	Product Cost	**52.00**	**23.40**
	Delivery Cost	27.00	12.15
Economic Performance (3%)	Profit Level	5.00	0.15
	Profit Centres	7.00	0.21
	Financial Structure	**50.00**	**1.50**
	Risk Exposure	14.00	0.42
	Cash Flow	24.00	0.72
Research & Development (4%)	Core Competency	18.00	0.72
	Research Competency	6.00	0.24
	Process Scale-Up	4.00	0.16
	Project Management	**47.00**	**1.88**
	Intellectual Property	24.00	0.96

The decision matrices for each main criteria for the customer service are shown in Tables 11,12, 13, 14, 15, and 16.

Table 11: Decision matrix of Strategic Direction by Customer Service

Strategic Direction	Management Approach	Business Structure	Corporate Strategy	Corporate Governance	Management Team	Priority Vector
Management Approach	1	2	3	4	1/2	0.250
Business Structure	1/2	1	2	3	1/4	0.140
Corporate strategy	1/3	1/2	1	2	1/5	0.090
Corporate Governance	1/4	1/3	1/2	1	1/6	0.060
Management team	**2**	**4**	**5**	**6**	**1**	**0.460**

CI = 0.0112, RI = 1.12, CR = 0.01 < 0.1 OK

Table 12: Decision matrix of Operational Capability by Customer Service

Operational Capability	Product Quality	Human Resource	Admin Systems	Logistical Capability	Information Technology	Priority Vector
Product Quality	**1**	**8**	**6**	**4**	**3**	**0.500**
Human Resources	1/8	1	1	1/5	1/4	0.050
Admin Systems	1/6	1	1	1/5	1/3	0.060
Logistical Capability	1/4	5	5	1	3	0.250
Information Technology	1/3	4	3	1/3	1	0.150

CI = 0.0896, RI = 1.12, CR = 0.08 < 0.1 OK

Table 13: Decision matrix of Customer Approach by Customer Service

Customer Approach	Key customers	Market Position	Customer Relations	Customer Approach	External Relations	Priority Vector
Key customers	1	4	1/3	1/5	4	0.140
Market Position	1/4	1	1/6	1/8	1/2	0.040
Customer Relation	3	6	1	1/3	4	0.250
Customer Approach	**5**	**8**	**3**	**1**	**7**	**0.510**
External Relation	1/4	2	1/4	1/7	1	0.060

CI = 0.056, RI = 1.12, CR = 0.05 < 0.1 OK

Table 14: Decision matrix of Cost Structure by Customer Service

Cost Structure	Wage Base	Overhead Costs	Supply Base Cost	Product Cost	Delivery Cost	Priority Vector
Wage Base	1	1/5	1/2	1/9	1/8	0.030
Overhead Costs	5	1	3	1/6	1/5	0.110
Supply Base Cost	2	1/3	1	1/8	1/5	0.050
Product Cost	**9**	**6**	**8**	**1**	**3**	**0.520**
Delivery Cost	8	5	5	1/3	1	0.290

CI = 0.0784, RI = 1.12, CR = 0.07 < 0.1 OK

Table 15: Decision matrix of Economic Performance by Customer Service

Economic Performance	Profit Level	Profit Centers	Financial Structure	Risk Exposure	Cash Flow	Priority Vector
Profit Level	1	1/2	1/7	1/4	1/5	0.040
Profit Centers	2	1	1/6	1/3	1/4	0.070
Financial Structure	**7**	**6**	**1**	**5**	**4**	**0.520**
Risk Exposure	4	3	1/5	1	1/3	0.130
Cash Flow	5	4	1/4	3	1	0.230

CI = 0.0784 RI = 1.12, CR = 0.07 < 0.1 OK

Table 16: Decision matrix of Research & Development by Customer Service

Research & Development	Core Competency	Research Competency	Process Scale-Up	Project Management	Intellectual Property	Priority Vector
Core Competency	1	2	4	1/6	1/5	0.100
Research Competency	1/2	1	2	1/7	1/4	0.070
Process Scale-Up	1/4	1/2	1	1/8	1/5	0.040
Project Management	**6**	**7**	**8**	**1**	**3**	**0.520**
Intellectual Property	5	4	5	1/3	1	0.270

CI = 0.0672, RI = 1.12, CR = 0.06 < 0.1 OK.

The results are concluded in Table 17. The priority vector of Strategic Direction, Operational Capability, Customer Approach, Cost Structure, Economic Performance, and R & D were management team, product quality, customer relation, product cost, financial structure, and project management were 0.46, 0.50, 0.51, 0.52, 0.52, and 0.52, respectively. The Quality Assurance Preferred Cost structure (42%), followed by Operational Capability (27%), Customer Approach (14%), Economic performance (8%), Strategic direction (6%), and Research & Development (4%).

Table 17: Results of R1 based on SOCCER model (Customer Service)

Factor	Item	Priority Vector (%)	Sub-Criteria Weight According to Main-Criteria Weight (%)
Strategic Direction (5%)	Management Approach	25.00	1.25
	Business Structure	14.00	0.70
	Corporate strategy	9.00	0.45
	Corporate Governance	6.00	0.30
	Management team	**46.00**	**2.30**
Operational Capability (27%)	**Product Quality**	**50.00**	**13.50**
	Human Resources	5.00	1.35
	Admin Systems	6.00	1.62
	Logistical Capability	25.00	6.75
	Information Technology	15.00	4.05
Customer Approach (14%)	Key customers	14.00	1.96
	Market Position	4.00	0.56
	Customer Relations	25.00	3.50
	Customer Approach	**51.00**	**7.14**
	External Relations	6.00	0.84
Cost Structure (42%)	Wage Base	3.00	1.26
	Overhead Costs	11.00	4.62
	Supply Base Cost	5.00	2.10
	Product Cost	**52.00**	**24.84**
	Delivery Cost	29.00	12.18
Economic Performance (8%)	Profit Level	4.00	0.32
	Profit Centers	7.00	0.56
	Financial Structure	**52.00**	**4.16**
	Risk Exposure	13.00	1.04
	Cash Flow	23.00	1.84
Research & Development (4%)	Core Competency	10.00	0.4
	Research Competency	7.00	0.28
	Process Scale-Up	4.00	0.16
	Project Management	**52.00**	**2.08**
	Intellectual Property	27.00	1.08

The results are concluded in Table 24. The priority vector of Strategic Direction, Operational Capability, Customer Approach, Cost Structure, Economic Performance, and R&D were management team, product quality, customer relation, product cost, financial structure, and project management with 0.46, 0.51, 0.50, 0.52, 0.51, and 0.51, respectively. However, the unexpected outcome was that Logistical Capability ranked first with the priority vector of 0.517. The quality assurance preferred cost structure (44%), followed by operational Capability (23%), customer approach (14%), economic performance (9%), strategic direction (7%), and research & development (4%).

5. SUPPLIER SELECTION CRITERIA FRAMEWORK

The overall priority vector of the interviewees is concluded in Table 25, which shows that the cost structure has the highest number by 0.442, which makes it 44.2% from the SOCCER model. The second highest was an operational capability with 23%, however, other factors of customer approach, economic performance, strategic direction, and R&D, had the remaining weightage of 13.5%, 8.3%, 6.9%, and 4.1, respectively.

The decision matrix for each main criteria for the purchasing department represener are shown in tables 18, 19, 20, 21, 22, and 23.

Table 18: Decision matrix of Strategic Direction by Purchasing

Strategic Direction	Management Approach	Business Structure	Corporate strategy	Corporate Governance	Management team	Priority Vector
Management Approach	1	3	4	5	1/2	0.290
Business Structure	1/3	1	2	3	1/4	0.130
Corporate strategy	1/4	1/2	1	1	1/6	0.070
Corporate Governance	1/5	1/3	1	1	1/6	0.060
Management team	**2**	**4**	**6**	**6**	**1**	**0.460**

CI = 0.0224, RI = 1.12, CR = 0.02 < 0.1 OK

Table 19: Decision matrix of Operational Capability by Purchasing

Operational Capability	Product Quality	Human Resource	Admin Systems	Logistical Capability	Information Technology	Priority Vector
Product Quality	1	7	5	1/4	3	0.260
Human Resources	1/7	1	1/2	1/8	1/4	0.040
Admin Systems	1/5	2	1	1/6	1/3	0.060
Logistical Capability	**4**	**8**	**6**	**1**	**4**	**0.510**
Information Technology	1/3	4	3	1/4	1	0.130

CI = 0.0896, RI = 1.12, CR = 0.08 < 0.1 OK

Table 20: Decision matrix of Customer Approach by Purchasing

Customer Approach	Key customers	Market Position	Customer Relations	Customer Approach	External Relations	Priority Vector
Key customers	1	5	1/3	2	4	0.240
Market Position	1/5	1	1/8	1/5	1/2	0.040
Customer Relation	**3**	**8**	**1**	**4**	**6**	**0.500**
Customer Approach	1/2	5	1/4	1	2	0.150
External Relation	1/4	2	1/6	1/2	1	0.070

CI = 0.0336, RI = 1.12, CR = 0.03 < 0.1 OK

Table 21: Decision matrix of Cost Structure by Purchasing

Cost Structure	Wage Base	Overhead Costs	Supply Base Cost	Product Cost	Delivery Cost	Priority Vector
Wage Base	1	1/5	1/3	1/9	1/8	0.030
Overhead Costs	5	1	3	1/7	1/5	0.100
Supply Base Cost	3	1/3	1	1/7	1/5	0.060
Product Cost	**9**	**7**	**7**	**1**	**3**	**0.520**
Delivery Cost	8	5	5	1/3	1	0.290

CI = 0.0896, RI = 1.12, CR = 0.08 < 0.1 OK

Table 22: Decision matrix of Economic Performance by Purchasing

Economic Performance	Profit Level	Profit Centers	Financial Structure	Risk Exposure	Cash Flow	Priority Vector
Profit Level	1	1/2	1/9	1/6	1/7	0.030
Profit Centers	2	1	1/7	1/5	1/6	0.050
Financial Structure	**9**	**7**	**1**	**6**	**3**	**0.510**
Risk Exposure	6	5	1/6	1	1/3	0.140
Cash Flow	7	6	1/3	3	1	0.270

CI = 0.0896RI = 1.12, CR = 0.08 < 0.1 OK.

Table 23: Decision matrix of Research & Development by Purchasing

Research & Development	Core Competency	Research Competency	Process Scale-Up	Project Management	Intellectual Property	Priority Vector
Core Competency	1	3	5	1/5	1/3	0.130
Research Competency	1/3	1	2	1/7	1/4	0.060
Process Scale-Up	1/5	1/2	1	1/8	1/7	0.040
Project Management	**5**	**7**	**8**	**1**	**3**	**0.510**
Intellectual Property	3	4	7	1/3	1	0.260

CI = 0.056, RI = 1.12, CR = 0.05 < 0.1 OK.

Table 24: Results of R1 based on SOCCER model

Factor	Item	Priority Vector (%)	Sub-Criteria Weight According to Main-Criteria Weight (%)
Strategic Direction (7%)	Management Approach	29.00	2.03
	Business Structure	13.00	0.91
	Corporate strategy	7.00	0.49
	Corporate Governance	6.00	0.42
	Management team	**46.00**	**3.22**
Operational Capability (23%)	Product Quality	26.00	5.98
	Human Resources	4.00	0.92
	Admin Systems	6.00	1.38

	Logistical Capability	**51.00**	**11.73**
	Information Technology	13.00	2.99
Customer Approach (14%)	Key customers	24.00	3.36
	Market Position	4.00	0.56
	Customer Relations	**50.00**	**7.00**
	Customer Approach	15.00	2.10
	External Relations	7.00	0.98
Cost Structure (44%)	Wage Base	3.00	1.32
	Overhead Costs	10.00	4.40
	Supply Base Cost	6.00	2.64
	Product Cost	**52.00**	**22.88**
	Delivery Cost	29.00	12.76
Economic Performance (9%)	Profit Level	3.00	0.27
	Profit Centers	5.00	0.45
	Financial Structure	**51.00**	**4.59**
	Risk Exposure	14.00	1.26
	Cash Flow	27.00	2.43
Research & Development (4%)	Core Competency	13.00	0.52
	Research Competency	6.00	0.24
	Process Scale-Up	4.00	0.16
	Project Management	**51.00**	**2.04**
	Intellectual Property	26.00	1.04

Table 25: Results of R1 based on SOCCER model

Factor	Item	Priority Vector (%)	Sub-Criteria Weight According to Main-Criteria Weight (%)
Strategic Direction (6.9%)	Management Approach	29.00	2.00
	Business Structure	12.90	0.89
	Corporate strategy	6.70	0.46
	Corporate Governance	6.00	0.41
	Management team	45.50	3.14
Operational Capability (23%)	Product Quality	25.50	5.87
	Human Resources	3.80	0.87
	Admin Systems	6.00	1.38
	Logistical Capability	**51.70**	**11.89**
	Information Technology	12.90	2.97
Customer Approach (13.5%)	Key customers	23.50	3.17
	Market Position	4.30	0.58
	Customer Relations	**50.30**	**6.79**

Cost Structure (44.2%)	Customer Approach	14.60	1.97
	External Relations	7.30	0.99
	Wage Base	3.10	1.37
	Overhead Costs	10.60	4.69
	Supply Base Cost	5.90	2.61
	Product Cost	52.10	23.03
Economic Performance (8.3%)	Delivery Cost	28.40	12.55
	Profit Level	3.30	0.27
	Profit Centres	4.90	0.41
	Financial Structure	**52.00**	**4.32**
	Risk Exposure	14.10	1.17
Research & Development (4.1%)	Cash Flow	25.80	2.14
	Core Competency	13.30	0.55
	Research Competency	6.10	0.25
	Process Scale-Up	3.70	0.15
	Project Management	51.30	2.10
	Intellectual Property	25.60	1.05

Finally, the overall weight supplier selection criteria were calculated. Figure 3 shows the percentages of the SOCCER model supplier selection criteria.

The results show that cost structures are the first criteria in supplier selection, with 44.2% of the total weight. However, out of this weight, 23% focused on product cost. These results are understandable, especially when analyzing the importance of criteria in small and medium companies. Operational Capability came next, with about 23% of the total weightage. However, it is unexpected that Logistical Capability ranked first with a priority vector of 0.517 with 11.89%. Next in the Ranks is the Customer Approach, with 13.5% of the overall weight. Customer Relations was the most focused on Customer Approach in supplier selection criteria, priority vector of 0.503. Following this were the Key Customers (0.235), Customer Approach (0.146), External Relation (0.073), and 55, and lastly Market Position (0.043). The Market Position showed a low percentage of 0.58% of overall weights due to filtering. Thus, considering market position was the last thing they would consider. The Economic Performance stood in the second last place with 8.3% of overall weight. Altogether, the interviewees agreed that Financial Structures (0.520) was the foremost factor to be considered. Financial structure is the long-term and short-term company sources of capital composition. The suppliers manage their liabilities and equity to finance their operations. Financial Structures are significant if the company wants to have a long-term relationship with the suppliers to predict the supplier's performance in the future. A well-planned financial structure means stability and will build trust in the company in the long run. Finally, the overall weight showed that cost structure, operational capability, and customer approach with a total of 80.7% were the factors that contribute the most to supplier selection.
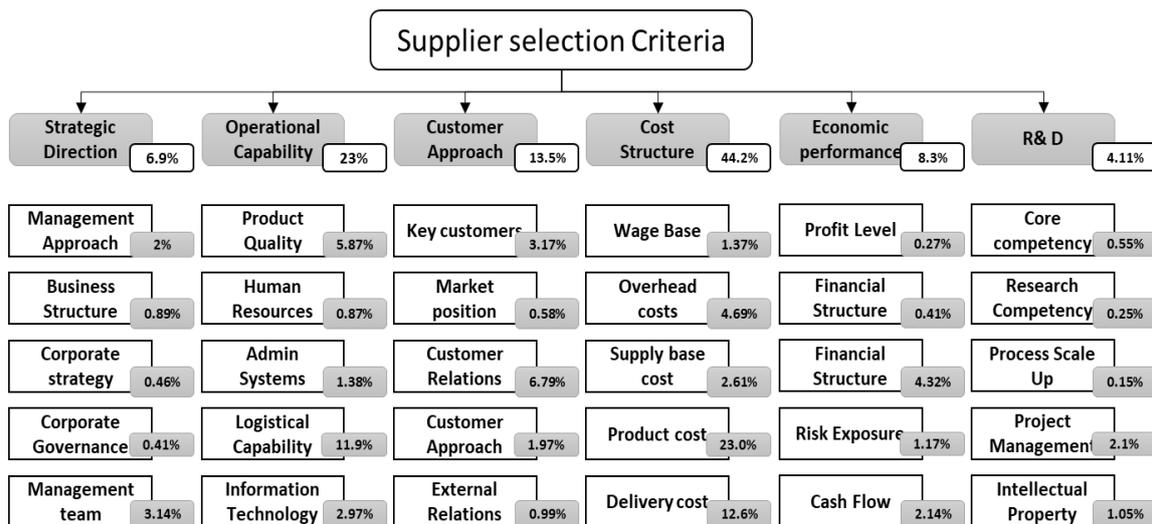
Fig. 3: Overall weight supplier selection criteria**.**

6. CONCLUSIONS

This paper has illustrated a case study for the supplier selection in manufacturing corrugated cartons company in Malaysia. The Research outputs can be concluded as the followings:

1. The SOCCER model is one of the most comprehensive models covering most essential supplier selection criteria.
2. Integrating the AHP method and the SOCCER model gave a practical and valid framework.
3. Consulting the company's internal expertise will make the framework better understood.
4. Success in data gathering needs to recognize the bias due to specialty.
5. The results show that the Consistency Ratio (CR) is 10% or below to ensure data consistency. However, if the Consistency Ratio was more than 10%, the rating gathered during the In-depth interview would be revised using the recording as the reference.
6. The results show that the cost structure is the ultimate concern on supplier selection which bears 44.2% of the SOCCER model. Followed by operational capability (23%), customer approach (13.5%), economic performance (8.3%), strategic direction (6.9%), and lastly research & development (4.1%).

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