Evaluation and Selection of Freight Forwarder for Excavator Manufacturer in China with Adjustment on Regional Specification and Situational Analysis Using STEEP-AHP-TOPSIS

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Abstract

The heavy equipment market in China is experiencing a considerable increase. It is supported by competitive product prices and better product quality. The company has set out strategies to increase the heavy equipment market share globally by having several distribution offices in several countries with aggressive sales. This paper aims to provide the best results in selecting the freight forwarder that is most suitable for each destination country and customer. STEEP-AHP-TOPSIS method emphasizes each destination country's regional boundaries and accommodates market preferences in selecting freight forwarders. The case study is applied to a multinational manufacturing company in China. Social, technical, economic, environmental, and political (STEEP) is used to find specific problems that directly and indirectly affect freight forwarder selection. The study also combined the Analytical Hierarchy Process (AHP) to gain weight on the criteria in conducting the assessment of the freight forwarder and Technique for Order of Preference Similarity to Ideal Solution (TOPSIS) to obtain the final value of the evaluation of each freight forwarder. The assessment is also based on the Importance Performance Matrix (IPM) in selecting the freight forwarders. This study's results rank seven freight forwarders of heavy equipment exports into four different quadrants and recommend the most suitable one for each destination country.

Keywords
Freight Forwarder Selection, Analytical Hierarchy Process, Technique for Order of Preference Similarity to Ideal Solution, Importance Performance Matrix

1. Introduction

Freight forwarding services are one of the mainstays of choice for companies that strive to achieve several goals at once, such as customer satisfaction, fast, precise, and accurate product delivery based on conditions, time, and place. Cost savings are also needed to avoid unnecessary activities and costs in handling cargo administration. The increase in the global trade market encourages businesspeople to find partners who are experts in distributing their goods to reach a broader range of customers.

One of the commodities that are generally distributed with a freight forwarder is heavy equipment products. Hydraulic Excavator is a heavy equipment product with the best demand in the machine market and is well known in forestry, agriculture, construction, and mining applications. The growth in commodity prices has an impact on the demand for hydraulic excavator machines. More than 50 excavator manufacturing companies operate worldwide, including ABC Ltd., as China's excavator manufacturers.

Currently, China's heavy equipment market, especially the demand for hydraulic excavators, has experienced a considerable increase. This is supported by competitive product prices and increasingly better product quality. The company has also set a strategy to increase the heavy equipment market share globally by planning to have several distribution offices (subsidiaries) in several countries with aggressive sales. China is not only a significant procurement market (procurement) globally but also for manufacturing, where 76% of products are produced from

China (*PwC* 2012). Therefore, of course, the company must have a logistics, transportation, and distribution system that is robust and strong. The purchasing process is very important for the company, so an increase must be made to meet the increasing demand and remain competitive (Dachyar and Praharani 2016).

However, it should be noted that excavator sales from 25 leading Chinese excavator companies continued to be strong, reaching a total of 19,110 excavators in July 2020. This represents a 54.8% increase year on year (China Construction Machinery Association 2020). In detail, as many as 190,222 excavator units were sold in the domestic market, up 29.7% from 2019, while exports increased by 20.8% with 20,252 units sold. Thus, as a percentage, 85% of excavators are sold in the domestic market, and 15% are the proportion of shipments (overseas customers) (China Construction Machinery Association 2020).

Hydraulic excavator manufacturing company ABC Ltd. in China's southern coastal region, shipping predominantly in the domestic market and making export shipments divided into more than 70 countries. In 2019, ABC Ltd. reportedly made a total of 16,400-unit shipments of excavators, 15% of which were export shipments. If you look at the proportion of shipments abroad, the volume exported is less than domestic but has increased. The company can adequately handle domestic shipments. However, for shipments a proportion of exports, ABC Ltd. just started to expand in the last few decades, so it has not been fully addressed so it must be prepared to produce effects for the company, given that the proportion of shipments of these smaller export units is divided to several countries, which of course are not entirely close to China.

For companies to remain competitive, export shipments must be more economical and competitive both in terms of costs and good selling prices that are acceptable to customers. This is based on the fact that excavator companies do not fully have production plants overseas, so machines' delivery is centralized from China. Therefore, shipments abroad must be optimized.

To solve these problems to provide the best results for overseas customers, research is needed to design the best freight forwarder selection strategy to optimize the proportion of export shipments to overseas customers. The method to be used in this research is the AHP method to obtain weight on the best freight forwarders assessment criteria, TOPSIS is also used to get the value of the proximity coefficient which will be used as a basis for assessing—and segmenting freight forwarders in two dimensions in the Importance Performance Matrix (IPM) so that the freight forwarders selection strategy can be determined optimally.

1.1 Objectives

This study aims to design the most suitable freight forwarder selection analytical model for each destination country and target customer for ABC Ltd. in China.

2. Literature Review

2.1 Supply Chain Management

Supply chain management is a network in which there are all parties involved directly or indirectly, including manufacturers, freight forwarders, retailers, buyers and so on, in the process of production and delivery of goods or services to arrive at the last buyer. (Mentzer et al. 2001) through distribution, information flow and finance (Stock and Boyer 2009). SCM is a series of approaches applied to efficiently integrate suppliers, entrepreneurs, warehouses, and other storage places to produce and distribute in the right quantity, location, and time to reduce costs and satisfy customer needs. (Simchi-Levi 2001). A supply chain consists of all entities involved in the process of meeting consumer needs, either directly or indirectly. Supply chain members are not only manufacturers and freight forwarders, but also retailers and even consumers themselves (Chopra and Meindl 2016).

The main objective that the company wants to achieve by implementing SCM is to increase revenue, productivity, and investment in raw materials (Daugherty et al. 2005). Due to the collaboration in the supply chain and reducing costs, another benefit that is felt is a faster turnover of goods that reach consumers. In addition to increasing revenue, productivity, and investment in raw materials, SCM is also useful in reducing the level of inventory stored goods, reducing the carrying costs of inventory, reducing the frequency of inventory run out, shortening the order process cycle, lowering prices, and increasing product availability in the market (Leonard et al., 2009).

2.2 Logistics System

Logistics is a planning orientation and framework that seeks to design the flow of products and information in a business (Christopher 2011). Arvis et al. (2018) define logistics as a service network that supports the physical movement of goods, trade across borders, and commerce within borders. Logistics covers a range of activities outside of transportation, including warehousing, brokerage, express delivery, and critical infrastructure services such as terminals. Logistics systems have evolved because of the relationships shown about managing the flow of products and services from the starting point to the destination point.

2.3 Freight Forwarder

International freight forwarders (IFF) can be defined as international trade specialists who can facilitate shipping across borders (Murphy and Daley 1997). The duties assigned by the IFF company include shipping and distribution services, handling payment arrangements, assistance with documents required for shipments, and arranging local and international shipments; information services; Coverage; customs service; warehousing; and consolidation services (Markides and Holweg 2006). Besides, paying freight charges, tracing, expediting shipments, and making routing recommendations emerged as functions mostly provided by the IFF. (Murphy and Daley 1997). Freight forwarders act as intermediary agents who manage transport and commercial documents, insurance, licensing requirements, visas, customs, sea, air, and surface transportation. Freight forwarders arrange shipments for individuals or companies to get orders in bulk from manufacturers or manufacturers to the final market or distribution point. Freight Forwarders will enter into a contract with the carrier to facilitate the movement of goods.

2.4 Analytical Hierarchy Process

Analytical Hierarchy Process (AHP) is a method used to make a simple approach in making decisions to solve multicriteria decision making (MCDM) problems by building a hierarchy consisting of objectives, criteria, sub-criteria, and alternatives for each decision. AHP is used to find the weight of the criteria that have been obtained previously by doing a pairwise for the opinion of experts (Dachyar and Purnomo 2018). AHP is used to describe complex and unstructured situations. There are multicriteria that must be resolved into several components, and these components will be sorted into a hierarchy.

2.5 Technique for Order of Preference by Similarity to Ideal Solutions

TOPSIS is one of the ranking multi-criteria decisions making (MCDM) method that generates alternative ranking based on the closeness from an ideal solution (Dachyar and Maharani 2019). The concept of TOPSIS is to define a solution based on distance to positive and negative ideal solution.

3. Methods

3.1 Criteria Assessment

In identifying criteria, the authors conducted a literature study on the criteria used in evaluating freight forwarders. Based on the literature study, the research obtained 9 criteria with 75 sub-criteria through various literature studies. The next step is to validate the criteria by distributing questionnaires to the five selected experts. All experts are responsible for selecting and evaluating freight forwarders. The results of the validation of the criteria were the finding of 6 criteria and 30 sub-criteria on the capability dimension, and 4 criteria and 10 sub-criteria on the willingness dimension to be used. The criteria and sub-criteria for the freight forwarder assessment used in this study are shown in Table 1.

Table 1. Criteria and sub-criteria for freight forwarder assessment

Capabilities dimension		Willingness dimension	
Criteria	Sub-criteria	Criteria	Sub-criteria
Organizational Considerations (O)	Industry experiences or expertise (O1)	Information Technology (I)	Readiness with internal system (I1)
	International scope (O2)		Readiness with company data (I2)
	Organization structure (O3)	Regulatory (R)	Quality standards, certifications (R1)
	Market share (O4)		Safety standards, certifications (R2)
	Amount of past business served (o5)	Services and Prices (S)	Value-added service (S1)
Transportation Management (T)	Business contingency plan (T1)		After-office hours support (S2)
	Lashing competency (T2)	Reliability and Conformance (C)	Prevention for damage or loss (C1)
	Loading and unloading (T3)		Building long term relationship (C2)
Information Technology (I)	Pre-alert system (I1)		Responsiveness (C3)
	Track and trace (I2)		Continuous improvement (C4)
	Integration technology (I3)		
Industry Expertise and Performance (E)	Previous experience (E1)		
	KPI reports generation (E2)		
	On-time performance (E3)		
	Coordination of shipments (E4)		
	Global networking (E5)		
	Customs clearance expertise (E6)		
	Storage capability (E7)		
Services and Prices (S)	Flexibility of payment (S1)		
	Cost of shipment (S2)		
	Competitive pricing (S3)		
	Cost savings (S4)		
	Conflict resolution (S5)		
Quality of Service (Q)	Service quality and performance (Q1)		
	Accuracy of fulfilment (Q2)		
	Service reputation (Q3)		
	Total order cycle time (Q4)		
	Transit time (Q5)		
	Risk management (Q6)		
	Completed delivery rate (Q7)		

3.2 Weighting Criteria

The weighting calculation using the AHP method shows the level of importance of each criterion and sub-criteria for each dimension used in this study by designing a pairwise comparison questionnaire that will be filled out by each expert. The weighting assessment by more than one expert requires calculating the combined weight so that the final weight for each criterion and sub-criteria can be obtained. The weighting assessment will also be carried out separately for each dimension, namely capability and the dimension of willingness. The calculation step using the AHP method is to make pairwise comparisons assessed by experts using Equation (1).

$$D_k = \begin{pmatrix} b_{11k} & \cdots & b_{1mk} \\ \vdots & b_{ijk} & \vdots \\ b_{n1k} & \cdots & b_{nmk} \end{pmatrix} \tag{1}$$

Where: $k = 1, \ldots, K$; $i = 1, \ldots, n$; $j = 1, \ldots, n$. D_k is the pairwise comparison matrix for k number of experts, K is the number of experts, k is the expert index, and b_{ijk} is the degree of influence for i-criteria on j-element of the k-expert judgment. Calculation of the geometric mean from the expert's judgments are resulted using Equation (2) and (3).

$$D = \begin{pmatrix} d_{11} & \cdots & d_{1m} \\ \vdots & \ddots & \vdots \\ d_{n1} & \cdots & d_{nm} \end{pmatrix} \tag{2}$$

$$d_{ij} = \sqrt[k]{\prod_{k=1}^{K} b_{ijk}} = \frac{1}{d_{ji}} \forall\, i, j \tag{3}$$

Where: D is the geometric mean of the expert's opinion. Then proceed with normalizing the pairwise comparison matrix using Equation (4).

$$r_{ij} = \frac{d_{ij}}{\sqrt{\sum_{i=1}^{n} d^2{}_{ij}}} \forall\, i, j \tag{4}$$

Where: r_{ij} is the value of a normalized matrix. Then proceed with calculating the weights for each criterion with Equation (5) as follows.

$$W_i = \frac{\sum_{j=1}^{n} r_{ij}}{\sum_{i=1}^{n} \sum_{j=1}^{n} r_{ij}} \forall\, i \tag{5}$$

Where: *CR* is the inconsistency factor, *CI* is the consistency index, and *RI* is the consistency index of the reciprocal matrix that is randomly determined. All of the calculation steps are being implemented on all criteria and sub-criteria. The final results obtained from the calculation are the local weights and global weights for all criteria.

3.3 Freight Forwarder Evaluation

The freight forwarder assessment calculation will use the TOPSIS method based on the freight forwarder assessment questionnaire filled out by experts and use the value of each sub-criteria's global weight. The freight forwarder assessment will be carried out based on two dimensions: capability and willingness. At the end of the data processing, the results of grouping seven freight forwarders into four quadrants are based on the rating carried out for each freight forwarder. The first step is to create an initial decision matrix with the following Equation (9).

$$A = \left(a_{ij}\right)_{mxn} = \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \tag{9}$$

Where: a_{ij} is the value for *j*-criterion from *i*-alternative; *i* = 1, 2, …, *m* and *j* = 1, 2, …, *n*. Then proceed with making a normalized decision matrix with the following Equation (10).

$$b_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} X_{ij}{}^{2}}} \tag{10}$$

Where: a_{ij} represents the value of *j*-criterion for *i*-alternative; b_{ij} is the normalization value of *j*-criterion for *i*-alternative. Through these calculations, the normalized decision matrix can be produced in Equation (11) as follows.

$$B = \left(b_{ij}\right)_{mxn} = \begin{pmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{m1} & \cdots & b_{mn} \end{pmatrix} \tag{11}$$

Then proceed with making a weighted normalized decision matrix with the following Equation (12).

$$C = \left(c_{ij}\right)_{mxn} = \begin{pmatrix} W_1 x b_{11} & \cdots & W_n x b_{1n} \\ \vdots & \ddots & \vdots \\ W_1 x b_{m1} & \cdots & W_n x b_{mn} \end{pmatrix} \tag{12}$$

Where: c_{ij} is the weighted normalization value of *j*-criterion for *i*-alternative. Then proceed with determining the positive ideal (C^{+}) and the negative ideal solution (C^{-}) using Equation (13).

$$\begin{aligned} C^{+} &= \left(c_j{}^{+}\right) = \left\{\left(\max c_{ij} \middle| j \in J_1\right), \left(\min c_{ij} \middle| j \in J_2\right)\right\} \\ C^{-} &= \left(c_j{}^{-}\right) = \left\{\left(\min c_{ij} \middle| j \in J_1\right), \left(\max c_{ij} \middle| j \in J_2\right)\right\} \end{aligned} \tag{13}$$

Where: $c_j{}^{+}$ shows the positive ideal solution from *j*-criteria; $c_j{}^{-}$ shows the negative ideal solution from *j*-criteria; max c_{ij} $\left[max\left(w_j \times b_{ij}\right)\right]$; min c_{ij} $\left[min\left(w_j \times b_{ij}\right)\right]$; *i* = 1, 2, …, *m* ; and *j* = 1, 2, …, *n*. J_1 shows a set of benefit type criteria and J_2 shows a set of cost type criteria. To calculate the distance between each alternative with the positive ideal and the negative ideal solution, the Equation (13) and (14) is used.

$$d_i^{+} = \sqrt{\sum_{j=1}^{n} (c_{ij} - cj^{+})^2} \tag{13}$$

$$d_i^{-} = \sqrt{\sum_{j=1}^{n} (c_{ij} - cj^{-})^2} \tag{14}$$

The d_i^{+} is an equation for the distance of *i*-alternative from the positive ideal solution and d_i^{-} is an equation for the distance of *i*-alternative from the negative ideal solution. The next step is to calculate the closeness coefficient for all alternatives using Equation (15) below.

$$CC_i = \frac{d_i^{-}}{(di^{+} - di^{-})} \tag{15}$$

And the last step is to rank the alternatives based on the value of CC_i. Before ranking the alternatives, the value of CC_i needs to be normalized first to produce the value of CC_{ni}, using Equation (16).

$$CC_{ni} = \frac{CC_i}{Max\ (CC_i)} \tag{16}$$

4. Results and Discussion

The results of calculating local and global weights for each criterion and sub-criteria on the capability dimension are shown in Table 2.

Table 2. Weight of criteria and sub-criteria

Capabilities dimension					Willingness dimension				
Criteria	Weight of the criteria	Sub criteria	Weight of the sub criteria	Global weight	Criteria	Weight of the criteria	Sub criteria	Weight of the sub criteria	Global weight
O	0,0320	O1	0,510	0,016	I	0,0950	I1	0,183	0,017
		O2	0,190	0,006			I2	0,817	0,078
		O3	0,163	0,005	R	0,0514	R1	0,833	0,043
		Q4	0,092	0,003			R2	0,167	0,009
		Q4	0,046	0,001	S	0,4492	S1	0,187	0,084
T	0,0907	T1	0,134	0,012			S2	0,813	0,365
		T2	0,138	0,013			S3	0,128	0,032
		T3	0,728	0,066	C	0,4042	C1	0,023	0,056
I	0,0691	I1	0,083	0,006			C2	0,036	0,089
		I2	0,650	0,045			C3	0,130	0,321
		I3	0,267	0,018			C4	0,216	0,534
E	0,2533	E1	0,068	0,017					
		E2	0,035	0,009					
		E3	0,398	0,101					
		E4	0,148	0,038					
		E5	0,032	0,008					
		E6	0,191	0,048					
		E7	0,128	0,032					
S	0,2802	S1	0,068	0,017					
		S2	0,035	0,009					
		S3	0,398	0,101					
		S4	0,148	0,038					
		S5	0,032	0,008					
Q	0,2747	Q1	0,081	0,022					
		Q2	0,038	0,011					
		Q3	0,219	0,060					
		Q4	0,199	0,055					
		Q5	0,271	0,074					
		Q6	0,167	0,046					
		Q7	0,024	0,007					

Freight forwarder segmentation is carried out to classify freight forwarders assessed through the TOPSIS method into four quadrants based on the dimensions of the Importance Performance Matrix (IPM) segmentation method. The initial stage in segmenting the freight forwarder is normalizing the proximity coefficient's value on each dimension; (see Table 3).

Table 3. Freight forwarder segmentation

Freight forwarder	Ability Dimension		Willingness Dimension		Segmentation
	CCn_i	Classification	CCn_i	Classification	
FF1	0,5143	High	0,7494	High	Quadrant 4
FF2	0,8421	High	0,9733	High	Quadrant 4
FF3	0,1868	Low	0,7861	High	Quadrant 2
FF4	0,3086	Low	0,7892	High	Quadrant 2
FF5	1,0000	High	1,0000	High	Quadrant 4
FF6	0,4533	Low	0,7425	High	Quadrant 2
FF7	0,4235	Low	0,7425	High	Quadrant 2

After getting the normalized proximity coefficient value, the next step is to classify the normalized proximity coefficient value for each dimension's freight forwarder. Classification provisions are if the normalized proximity coefficient value lies in the range 0 - 0.5, then it is classified as "low," but if it is in the range of 0.5 - 1.0, it is classified as "high." The results of the freight forwarder segmentation can be seen in Table 3 above. The results of the freight forwarder segmentation mapping can be seen in Figure 1.

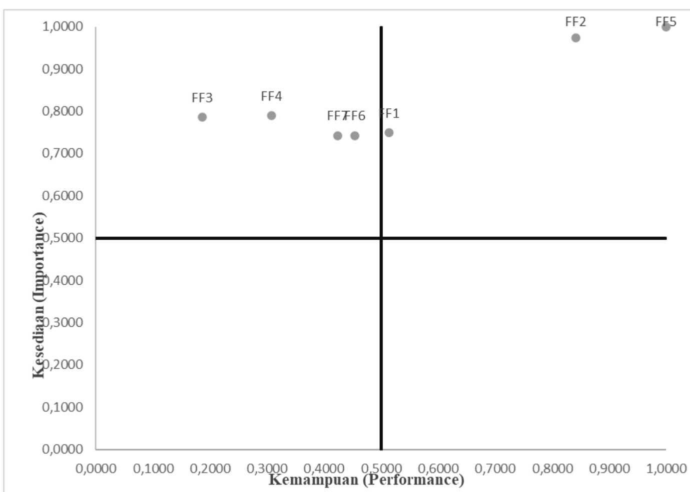

Figure 1. Freight forwarder segmentation

The freight forwarder segmentation results can be grouped into four quadrants, as shown in Table 4.

Table 4. Results of freight forwarder segmentation

Segment	Total freight forwarders	Freight *forwarder*
Quadrant 2	4	FF3, FF4, FF6, FF7
Quadrant 4	3	FF1, FF2, FF5

Freight forwarders in Quadrant 4 are the best freight forwarders because they have a high level of capability and will Freight forwarders segmented in Quadrant 2 are freight forwarders who have low capabilities, but their willingness to establish relationships with companies is high. Freight forwarders included in Quadrant 2 are Freight forwarder 3 (FF3), Freight forwarder 4 (FF4), Freight forwarder 6 (FF6), and Freight forwarder 7 (FF7).

Companies can take to increase freight forwarders' availability in Quadrant 2 to demonstrate company loyalty and collaboration by making long-term commitments. Then, the company can carry out a communication strategy to increase freight forwarders' availability, mainly focusing on communication with top management personnel of the freight forwarder.

There are 3 freight forwarders included in Quadrant 4, namely Freight forwarder 1 (FF1), Freight forwarder 2 (FF2), and Freight forwarder 5 (FF5). Companies can benefit from working with freight forwarders in Quadrant 4. Companies should maintain relationships with these freight forwarders by developing inter-organizational information and realizing long-term involvements with the freight forwarder.

6. Conclusion

Based on the research that has been done regarding the evaluation and selection of freight forwarders for excavator manufacturers ABC Ltd. in China with adjustments to the situation analysis and regional specifications using the AHP method and the TOPSIS method, using the Analytical Hierarchy Process (AHP) in this research obtains 9 criteria and 40 sub-criteria for selecting freight forwarders. The criterion for evaluating the freight forwarder with the highest weight on the capability dimension is the cost of shipment. In contrast, the criterion that has the highest weight for the willingness dimension is after-office hours support. The freight forwarder in Quadrant 4 is the best because this freight forwarder has a high level of capability and willingness. There are 3 freight forwarders included in Quadrant 4, namely FF1, FF2, and FF5.

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