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DECISION MAKING APPROACH OF DIRECT FEEDER SERVICE VIA PORT KLANG IN MALAYSIA

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Abstract: The feeder service plays an important role in the Malaysian shipping service industry to link between the main line service and ports. It appears to be an important mode of transport within intra-Asian countries, regional, and local trades, which allows access to certain ports with ship draught restrictions. The feeder service is efficient in terms of flexibility, travelling time consumed between ports and fast cargo delivery to consignors. The issue now is how can Malaysian feeder operators truly sustain the future via trade and route assessment perspectives. Efficient route selection and strategic trading partners is the key to boosting the Malaysian feeder economy by considering the five main factors of markets, time, miscellaneous, service and cost. The purpose of this research is to discover a benchmark of current assessments of overall direct feeder service of route parameters which connect Port Klang and five potential ports or trade partners as alternatives. The ports selected are Ho Chi Minh City, Laem Chabang, Jakarta, Yangon, and Chittagong due to their consistent previous years of container import and export activities. A combination method, known as the AHP-Fuzzy Link Based and Evidential Reasoning method, is applied in this research. The results show that the Port Klang – Laem Chabang route is the most preferred sailing route that can optimize feeder vessel utilization, reduce environmental pollution, and potentially gain high returns to both feeder operators and ports. This research contributes in terms of providing indicator of routes and a potential port appraisal case study of the feeder service in Malaysia by using a decision making approach.

Keywords: Analytical hierarchy process, evidential reasoning method, containers, short sea shipping, feeder hub, sustainability of feeder service.

Introduction

According to Abdul Rahman *et al.* (2014), the opening of the Northern Sea Route (NSR) had a potential prospect to decrease the number of vessels passing through Malaysian waterways. In 2006, a fluctuation of container demand and supply, by means of 83% import and 80% of export in North America, Europe and Asia, was reported to be influenced by the NSR (Verny & Grigentin, 2009). Accordingly, it is important to find a solution to maintaining the Malaysian maritime economy in the future.

The feeder service sector has played an important role of excellent cargo transportation in Malaysia and has been identified as a future solution that needs to be strengthened. This is largely due to outstanding annual feeder calling and container throughput at Port Klang, which is also known as a Malaysian feeder hub port. Port Klang is ranked first in the list of Malaysian container ports and was positioned 12th in the world between 2012 and 2014 (UNCTAD, 2015). More than 70% of feeder calling in Malaysia originated from Port Klang in 2010 (10,751 ships calling), 2011 (11,273 ships calling), 2012 (10,300 ships calling), 2013 (9,950 ships calling), and 2014 (9,601 ships calling) (ASEAN Ports Association Malaysia, 2015). The container throughput of Port Klang from 2011 to 2014, using the feeder service, is shown in Table 1.

Table 1: Container throughputs of Port Klang using the feeder service (2011 – 2014)

Year	Import (Teus)	Export (Teus)	Transshipment (Teus)
2011	1,330,621	1,673,333	6,022,454
2012	1,873,257	1,821,995	6,305,963
2013	1,915,603	1,860,613	6,574,193
2014	1,962,431	1,942,773	7,040,600

Source: ASEAN Ports Association Malaysia, 2015

Table 1 shows that the container volumes of import, export and transshipment in Port Klang grew from 2011 to 2015. Over five consecutive years, from 2011 to 2015, Port Klang operated regularly as a transshipment port, and 64.9% average of its total container throughputs were derived from transshipment activities. According to UNCTAD (2015), the total container throughputs for Port Klang increased by 3.48% from 2012 to 2013 and 5.76% from 2013 to 2014. Port Klang appears to be outstanding as a Malaysian feeder hub, with consistent annual container throughputs. Further, Port Klang was deemed excellent because it is a feeder hub for transshipment point containers. An estimated 60 to 75% of all container through Port Klang in 2015 and previous years were transshipment containers (Westport, 2016). It attracted a lot of feeder operators to allocate their services and company bases in Selangor; especially in Klang and Shah Alam areas. Moreover, Port Klang is efficient in terms of proficient cargo handling facilities interrelated with rapid container inbound and outbound services provided. The excellent transportation services provided by the feeder operators have helped Port Klang to be one of the most superior and competitive ports worldwide. Therefore, the question is how to maintain this situation in the future.

Feeder service route plays an important role influencing the feeder service sector. There are several types of route design network for feeder shipping service and commonly, there is a mixture of service patterns based on specific route connectivity. However, according to Hsu and Hsieh (2007), the optimal decision of direct service is more preferable than the hub and spoke service. A direct service was indicated to have less transit time, less additional costs, more attractive service, more reliable, increased shelf life, and decreased transportation damage. Less transit time includes the ports of departure and destination with no waiting time at the next port (Polat, 2013). Polat (2013) justified that the direct service is better although somehow it depends on the specific area, whether it has a low or high current demand.

Therefore, the purpose of this paper is to analyse the routes of potential trading partners in order to maintain the Malaysian feeder and container port's economy in the future by considering market, time, cost, service and miscellaneous factors using the Multiple Criteria Decision Making Approach (MCDM).

Methodology

Application of the Multiple Criteria Decision Making Approach

In applying the MCDM approach in this study, the factors considered are market, time, cost, service and miscellaneous factors as they were commonly highlighted in the literatures (Hsu & Hsieh, 2007; Lun, 2013; Polat *et al.,* 2014; Tran *et al.,* 2016; Polat & Gunther, 2016). Market factor includes the daily container supply (pick-up) of port and daily container demand (delivery) of port. Time factor covers on the duration of sailing season/days, maximum allowable voyage duration/hours, vessel set-up duration of ship type in port (pilotage, berthing, cleaning etc.), lay-up duration of ship, and berthing duration of ship at port. Cost factor covers on the chartering cost of ship, operating cost of ship (administration, maintenance, lubricant, insurance etc.), vessel set-up cost of ship at port, auxiliary fuel consumption of ship type at berth, and main fuel consumption of ship. Service factor covers on the available number of container feeder ship, port operation efficiency, and frequency of service in a sailing season. Miscellaneous factor covers on the ship loading capacity, average voyage speed of ship, distance between ports, main fuel oil price, and auxiliary fuel oil price.

Selection of Alternative Ports

Five ports are selected as alternative ports. They are Ho Chi Minh City, Laem Chabang, Jakarta, Chittagong and Yangon ports. The selection is based on the statistical data provided by the Port Klang Authority (2015) concerning the import and export container data via Port Klang from 2010 to 2012. The summarized data is presented in Table 2.

Table 2: Container throughput in deadweight tonnage of trading ports via Port Klang

No.	Port/Country	Year	Container throughput in deadweight tonnage	
			Import	Export
1.	Ho Chi Minh City, Vietnam	2010	666,035	404,780
		2011	596,302	518,449
		2012	233,355	265,963
2.	Laem Chabang, Thailand	2010	1,674,451	1,001,096
		2011	2,535,734	1,200,239
		2012	2,334,485	1,323,414
3.	Jakarta, Indonesia	2010	1,829,204	2,179,393
		2011	1,751,283	2,057,321
		2012	1,801,213	2,063,369
4.	Chittagong, Bangladesh	2010	626,760	1,819,244
		2011	916,184	2,064,749
		2012	745,897	2,311,520
5.	Yangon, Myanmar	2010	868,253	883,198
		2011	1,317,825	1,030,849
		2012	1,273,156	1,231,866

Source: Port Klang Authority (2015)

Table 2 shows the container throughput in deadweight tonnage derived from feeder service connected via West Port and North Port to the five selected ports. For the import of containers from 2010 to 2012, Laem Chabang generated the highest container throughput in deadweight tonnage, followed by Jakarta, Yangon, Chittagong and Ho Chi Minh City. For export containers during the same period, Jakarta ranked first, followed by Laem Chabang, Chittagong, Yangon and Ho Chi Minh City. During this three-year period, supply and demand generated by the customers fluctuated. In fact, supply and demand are intangible and can change depending on certain trade area market conditions.

Data Sources

A qualitative approach was used in this study to get the opinions from the industrial experts regarding the assessment of feeder routes service in Malaysia. Ten experts participated in this study and delivered their opinions on the subject matter. The respondents are described in Table 3.

Table 3: List of respondents participated in the study

No.	Feeder Service Providers	Level of Position	Year of Experience	Routes
1.	Malaysia Trade & Transport (MTT) Shipping	Operation Manager	17 year in shipping operation	Malaysian Peninsular to Sabah and Sarawak
2.	Perkapalan Dai Zhun Lines (PDZ)	Operation Manager	12 years sailing and 10 years in shipping operation	Malaysian Peninsular to Sabah and Sarawak
3.	Regional Container Lines (RCL)	Manager of Operational Support Division	20 years in shipping operation and logistics	East Asia, South East Asia, and Middle East
4.	Evergreen Marine Corp (MALAYSIA) Sdn Bhd	Deputy Manager Operation	16 years in shipping operation	East Asia, South East Asia, Southern Asia
5.	X-Press feeder (Sea Consortium Sdn. Bhd)	Senior Executive Operations	11 years in shipping operation	East Asia, South East Asia, East Asia, Southern Asia and Oceania
6.	Bengal Tiger Line (M) Sdn Bhd	General Manager	16 years in logistics and shipping operation	Southern Asia and South East Asia
7.	Q-Express Line (QEL)	Operation Manager	19 years in shipping operation	South East Asia and Oceania
8.	Harbour-Link Group Berhad	Operation Manager	22 years in shipping operation	South East Asia and East Asia
9.	Port Klang Authority	Planning and Development Officer	12 years	Malaysian waterways and ports
10.	Westport (M) Bhd.	Marketing Manager	15 years in shipping marketing	Domestic and International waters

Table 3 shows that the respondents were from feeder service providers, port authority and port operator. Basically, they were selected because of their broad knowledge and experiences in feeder shipping services. Besides, they are among the decision makers or policy makers in the management and operational level of their organization which involves and have influences in the companies' decisions process to operate their businesses.

Data Analysis

There are three types of data analysis used in this study. The first is Analytical Hierarchy Process (AHP), second is Fuzzy-Link Based Technique and third is Evidential Reasoning (ER). The outcome of the first method is linked to the second method. Then, the result of the second method is used in the analysis using the third method.

Analytical Hierarchy Process (AHP)

According to Abdul Rahman (2012) and Abdul Rahman and Ahmad Najib (2017), the assessment on pairs of criterion A_i and A_j are represented by a *n* x *n* matrix *A* as follows:

$$A=(a_{ij})=\begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \dots & \dots & 1 & \dots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \quad (1)$$

Legends of items as *i,j* = 1, 2, 3,..., *n* and each a_{ij} in respect of attribute A_i to attribute. Then, the weight value of pairwise comparison between attributes can be calculated as below (Abdul Rahman, 2012):

$$w_k=\frac{1}{n}\sum_{j=1}^{n}\left(\frac{a_{kj}}{\sum_{i=1}^{n} a_{ij}}\right) \qquad (k=1, 2, 3,\dots, n) \quad (2)$$

Where, a_{ij} stands for the entry of row *i* and column *j* in a comparison matrix of order *n*. The validity of analysis is checked through Consistency Ratio (CR) obtained from IDS software which must be equal or less than 0.10 (Yang & Xu, 2002).

Application of Fuzzy Link Based Technique

Yang *et al.* (2009), Abdul Rahman (2012) and Abdul Rahman and Ahmad Najib (2017) stated the different criterion, use different grades of assessment, which need to be standardized by using the transformation of belief degree from fuzzy input to fuzzy output. The transformation process is a process to convert parent of Lower Level Criteria (LLC) to the Upper Level Criteria (ULC). Equation 3, 4, and 5 are represented by referring to Figure 1:

$$u^j = \sum_{i=1}^{5} l^i \beta_i^j \quad (3)$$

$$\sum_{i=1}^{5} l^i \leq 1 \quad (4)$$

$$\sum_{j=1}^{5} \beta_1^j = 1, \sum_{j=1}^{5} \beta_2^j = 1, \sum_{j=1}^{5} \beta_3^j = 1, \sum_{j=1}^{5} \beta_4^j = 1, \sum_{j=1}^{5} \beta_5^j = 1 \quad (5)$$

Where, u^j is fuzzy output; l^i = fuzzy input; β_i^j = belief degree assigned by experts, (*j,i*=1, 2, 3, 4 and 5) and sum of $\sum u^j = 1$; $\sum l^i = 1$.

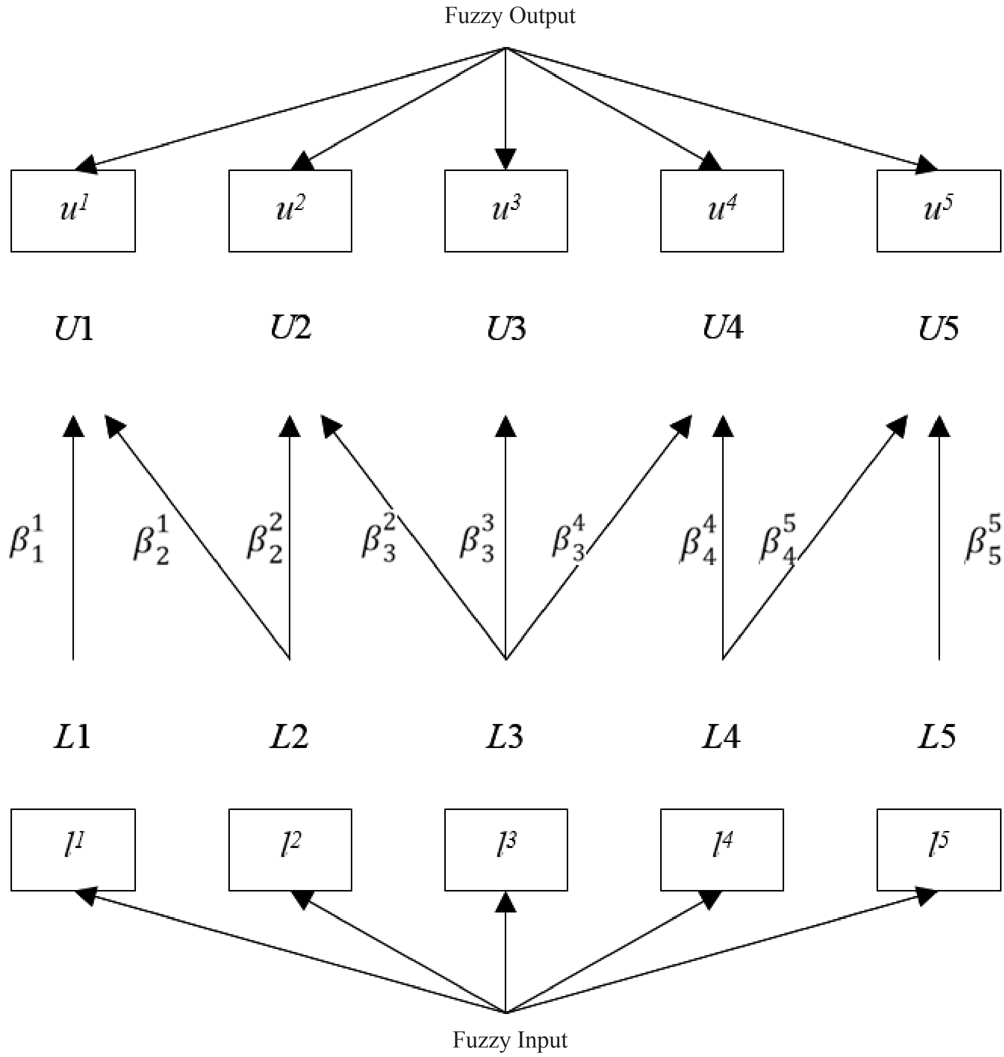

Figure 1: Transformation of fuzzy input to fuzzy output values (Abdul Rahman, 2012; Abdul Rahman & Ahmad Najib, 2017)

Evidential Reasoning (ER)

Referring to Zhou *et al.* (2013), ER is used to solve problem dealing with aggregate of Multiple Attribute Decision Analysis (MADA). There are top level and lower level attributes which are known as main criteria and sub criteria with L basic criterion $e_i(i = 1, 2,...,L)$ linked with a general criterion y (Yang & Xu, 2002; Abdul Rahman, 2012). The weight values of criterion or attributes denoted as. $w_i(i = 1,2,...,L)$ Where, w_i is the relative weight of the ith basic attribute e_i with $0 \leq w_i \leq 1$. The AHP's algorithms is used to obtain the weight value of criterion. The assessment of attribute $e_i(i = 1,2,...,L)$ is denoted in Equation 6 (Yang & Xu, 2002; Abdul Rahman, 2012; Zhou *et al.,* 2013).

$$S(e_i) = \{(H_n, \beta_{n,i}), n = 1, 2,...,N\}, i = 1, 2,...,L, \quad (6)$$

Where, H_n is the nth is assumed to be collectively comprehensive of evaluation grade. $\beta_{n,i}$ is denoted by a degree of belief satisfying $\beta_{n,i} \geq 0$ and $\Sigma_{n=1}^{N} \beta_{n,i} \leq 1$ (Abdul Rahman, 2012). Then, an assessment of $S(e_i)$ is completed if $\Sigma_{n=1}^{N} \beta_{n,i} = 1$ (respectively, $\Sigma_{n=1}^{N} \beta_{n,i} \leq 1$) or otherwise it is considered incomplete (Zhou *et al.,* 2013). According to Abdul Rahman (2012), $m_{n,i}$ be a basic probability mass which indicates the degree to which the ith basic criterion e_i support the hypothesis that the criterion y is assessed to the nh grade. H_n $m_{n,i}$ is calculated following Yang and Xu (2002) and Abdul Rahman (2012):

$$m_{n,i} = w_i \beta_{n,i};\ n = 1,2, \dots, N;\ i = 1, 2, \dots, L \tag{7}$$

Then, w_i is required to be normalized. $m_{H,i}$ is denoted as (Abdul Rahman, 2012):

$$m_{H,i} = 1 - \sum_{n=1}^{N} \mathrm{m}_{\mathrm{n,i}} \qquad i = 1, 2, \dots, L \tag{8}$$

Then, the residual of probability mass $m_{H,i}$ is divided into two parts, $\bar{m}_{H,i}$ and $\tilde{m}_{H,i}$ and the calculation process is conducted by referring to Equation 9 and Equation 10 (Yang & Xu, 2002; Abdul Rahman, 2012; Zhou *et al.,* 2013).

$$\bar{m}_{H,i} = 1 - w_i \qquad i = 1,2,\dots,L \tag{9}$$

$$\tilde{m}_{H,i} = w_i \left(1 - \sum_{n=1}^{N} \beta_{n,i} \right) \qquad i = 1,2,\dots,L \tag{10}$$

$m_{H,i} = \bar{m}_{H,i} + \tilde{m}_{H,i}$. $\bar{m}_{H,i}$ is a fundamental probability mass representing the belief degree of the basic attributes e_i, while $\tilde{m}_{H,i}$ is the residual of the belief degree assessment. The recursive evidential reasoning algorithm can be summarised as Equation 11, 12, and 13 (Yang & Xu, 2002; Abdul Rahman, 2012; Zhou *et al.,* 2013; Zhou *et al.,* 2016):

$$\mathrm{K} = \left[1 - \sum_{t=1}^{N} \sum_{\substack{j=1 \\ j \neq t}}^{N} m_{t,i} m_{j,i+1} \right]^{-1} \qquad i = 1, 2, \dots, L-1 \tag{11}$$

$$m_n = K\left[m_{n,i} m_{n+1,i} + m_{n,i} m_{H,i+1} + m_{H,i} m_{n+1,i} \right] \quad n = 1,2,\dots,N \tag{12}$$

$$\tilde{m}_H = K\left[\tilde{m}_{H,i} \tilde{m}_{H,i+1} + \bar{m}_{H,i} \tilde{m}_{H,i+1} + \tilde{m}_{H,i} \bar{m}_{H,i+1} \right] \tag{13}$$

Where, K is a normalising factor. The normalisation of the probability $\bar{m}_H$ can be computed by using Equation 14:

$$\bar{m}_H = K\left[\bar{m}_{H,i} \bar{m}_{H,i+1} \right] \tag{14}$$

The degree of belief β_n for specific of grade is stated in Equation 15 (Yang & Xu, 2002; Abdul Rahman, 2012):

$$\beta_n = \frac{m_n}{1 - \bar{m}_H} \quad n = 1,2, \dots, N \tag{15}$$

Steps in the Assessment of Direct Feeder Service via Port Klang in Malaysia

Step 1: Set up a goal

The main purpose of this study is to find the benchmark of current assessments of direct feeder service by using route parameters (refer Step 2). The assessment parameters are summarized in a route assessment model of feeder service, which are separated to goal, main criteria, sub criteria, and alternatives (Figure 2).

Step 2: Identification of main criteria and sub criteria

The selection of route assessment factors is conducted through a comprehensive discussion and brainstorming by the experts to ensure the factors obtained from the literature were relevant and acceptable. While some of these factors can be measured numerically, others are less tangible and must be assessed on a qualitative basis. Then, a model has been developed to evaluate the alternative ports via direct service by using route assessment. The main criteria act as parents to sub criteria as shown in Figure 2.

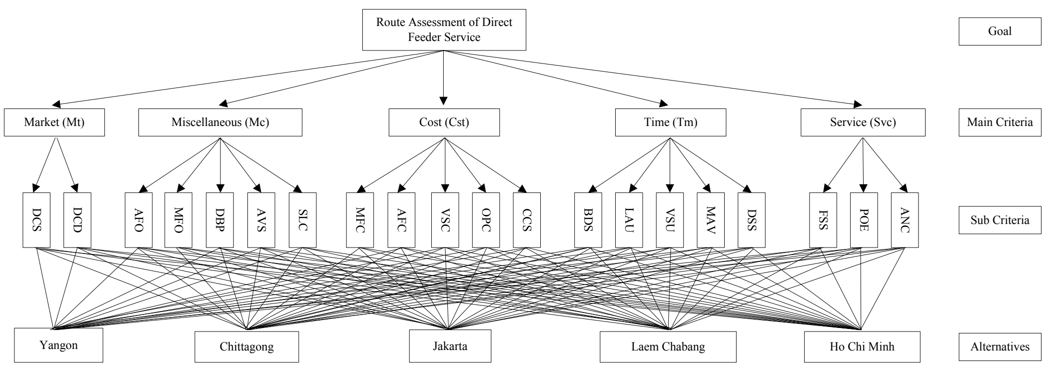

Figure 2: The proposed model for route assessment of direct feeder service

According to Hsu and Hsieh (2007), Maras *et al.* (2012), Lun (2013), Polat *et al.* (2014), Tran *et al.* (2016), Polat and Gunther (2016) and validated by industrial experts, the route assessment criterion include five factors which have been discussed above (in the section 'Application of the Multiple Criteria Decision Making Approach'). They are summarized as follows: (Market's sub criteria: Daily container supply (pick-up) of port (DCS); Daily container demand (delivery) of port (DCD)); (Miscellaneous sub criteria: Ship loading capacity (SLC); Average voyage speed of ship (AVS); Distance between ports (DBP); Main fuel oil price (MFO); Auxiliary fuel oil price (AFO)); (Cost's sub criteria: Chartering cost of ship (CCS); Operating cost of ship (administration, maintenance, lubricant, insurance etc.) (OPC); Vessel set-up cost of ship at port (VSC); Auxiliary fuel consumption of ship type at berth (AFC); Main fuel consumption of ship (MFC)); (Time's sub criteria: Duration of sailing season, days (DSS); Maximum allowable voyage duration, hours (MAV); Vessel set-up duration of ship type in port (pilotage, berthing, cleaning etc.) (VSU); Lay-up duration of ship (LAU); Berthing duration of ship at port (BDS)); (Service's sub criteria: Available number of container feeder ship (ANC); Port operation efficiency (POE); Frequency of service in a sailing season (FSS)).

Step 3: Identification of potential trading partners via route assessments

There are five trading partners which have been discussed above (in the section 'Selection of Alternative Ports'). The first route is between Port Klang – Ho Chi Minh City, second route is Port Klang – Laem Chabang, third route is Port Klang – Jakarta, fourth route is Port Klang – Chittagong, and fifth route is Port Klang – Yangon. All five routes are assessed from the perspective of route assessment parameters as shown in Figure 2.

Step 4: Data collection process

A comprehensive data set is obtained from eight feeder operators and three port authorities in Port Klang, who have been detailed above (in the section 'Data Sources'). The qualitative data set is extracted from the questionnaire's answers conducted along with interview session. They also need to justify their answers related to the parameters used. Table 4 shows the route assessment using pairwise comparison which was extracted from primary data.

Table 4: Route Assessment using Pairwise Comparison

	Main Criteria	SVC	TM	CST	MT	MC
A(SvcTmCstMtMc)=	SVC	1.0000	4.4000	5.1250	0.8181	4.4000
	TM	0.2273	1.0000	2.8333	0.2759	2.0000
	CST	0.1951	0.3529	1.0000	0.2273	2.0000
	MT	1.2222	3.6250	4.4000	1.0000	2.2500
	MC	0.2273	0.5000	0.5000	0.4444	1.0000
	SUM	2.8719	9.8779	13.8583	2.7657	11.6500

Note: SVC=Service; TM=Time; CST=Cost; MT=Market; MC=Miscellaneous

Step 5: Establishment of weight value for each criterion using AHP approach

The weight value or normalised principal eigenvector of the main criteria in Step 4 is computed by using Equation 2. The weight values of A(SvcTmCstMtMc) are calculated in Table 5 and summarised in Table 6.

Table 5: Values of Normalised Principal Eigenvector of each main criterion

Main Criteria	SVC	TM	CST	MT	MC
SVC	1.0000 ÷ 2.8719 = 0.3482	4.4000 ÷ 9.8779 = 0.4454	5.1250 ÷ 13.8583 = 0.3698	0.818 ÷ 2.765 = 0.2958	4.4000 ÷ 11.6500 = 0.3777
TM	0.2273	1.0000	2.8333	0.2759	2.0000
CST	0.1951	0.3529	1.0000	0.2273	2.0000
MT	1.2222	3.6250	4.4000	1.0000	2.2500
MC	0.2273	0.5000	0.5000	0.4444	1.0000
SUM	2.8719	9.8779	13.8583	2.7657	11.6500

Note: SVC=Service; TM=Time; CST=Cost; MT=Market; MC=Miscellaneous

An example, the weight value of main criteria "SVC" is shown as follows:

$$WSVC = (0.3482+0.4454+0.3698+0.2958+0.3777) / 5 = 0.3674$$

The weight value of the main criteria "SVC" is 0.3674. By using the similar technique in Step 4 and Step 5, the calculation algorithms are applied to all main criteria.

Then, the weight values of main criterion are summarized in Table 6. In addition, the weight values of sub criteria are calculated by using the Intelligent Decision Software (IDS). The weight values of sub criteria are obtained as follow: 0.5455 (DCD), 0.4545 (DCS), 0.5189 (DSS), 0.2892 (MAV), 0.0867 (VSU), 0.0536 (LAU), 0.0517 (BDS), 0.3641 (SLC), 0.2240 (AVS), 0.0909 (DBP), 0.2636 (MFO), 0.0574 (AFO), 0.1356 (ANC), 0.4731 (POE), 0.3913 (FSS), 0.2707 (CCS), 0.3434 (OPC), 0.1098 (VSC), 0.0688 (AFC), and 0.2073 (MFC).

Table 6: Weight values of evaluation criteria

Main Criteria	SVC	TM	CST	MT	MC	Weight Values
SVC	0.3482	0.4454	0.3698	0.2958	0.3777	0.3674
TM	0.0791	0.1012	0.2044	0.0998	0.1717	0.1310
CST	0.0680	0.0358	0.0722	0.0821	0.1717	0.0861
MT	0.4256	0.3670	0.3175	0.3616	0.1931	0.3330
MC	0.0791	0.0506	0.0361	0.1607	0.0858	0.0825
SUM	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Step 6: Using Fuzzy-link based theory to convert lower level criteria (LLC) to upper level criteria (ULC)

Then, a set of assessment grades of ULC and LLC is established. It is determined by a brainstorming process conducted via industrial experts and academicians. The example of assessment grades used in this study can be referred to in Table 7.

Table 7: Assessment Grades of Main Criteria (ULC)

Main Criteria /Upper Level Criteria	Assessment Grades				
SVC	Excellent	Good	Average	Poor	Worst
TM	Short	Reasonably Short	Average	Reasonably Long	Long
CST	Low	Reasonably Low	Average	Reasonably High	High
MT	High	Reasonably High	Average	Reasonably Low	Low
MC	Excellent	Good	Average	Poor	Worst

An example of fuzzy input data for "Market" towards "Ho Chi Minh City", referring to the assessment grade in Table 7 is shown as follows: Fuzzy input for sub criteria *"DCD" under "MT": (High = 0.4; Reasonably High = 0.4; Average = 0.2; Reasonably Low = 0.0;Low = 0.0)*. β_1^1 =1.0; β_2^1 = 0.2; β_2^2 = 0.8; β_3^2 = 0.2; β_3^3 = 0.6; β_3^4 = 0.2; β_4^4 = 0.8; β_4^5 = 0.2; β_5^5 = 1.0

Then, the fuzzy input is converted to fuzzy output using Equation 3, 4, 5 and Figure 1. The example of calculation as follows:

High	= (0.4 x 1.0) + (0.4 x 0.2)	= 0.4800
Reasonably High	= (0.4 x 0.8) + (0.2 x 0.2)	= 0.3600
Average	= (0.2 x0.6)	= 0.1200
Reasonably Low	= (0.2 x 0.2) + (0.0 x 0.0)	= 0.0400
Low	= (0.0 x 0.0) + (0.0 x 0.0)	= 0.0000

Step 7: Application of Evidential Reasoning (ER) Algorithm and Intelligent Decision System (IDS) software

The aggregated assessment values of criterion can be computed using Intelligent Decision Making (IDS) software, which is similar to manual calculations using the algorithms shown in Step 5. In Step 7, the weight values and belief degree assessments of all main criteria and sub-criteria were completed using a fuzzy link based on manual calculation and computed using the IDS software. The IDS software compares between AHP and ER to analyze the constructed model. Example of the calculation is shown in Table 8.

Table 8: The Belief Degree Values of the Main Criteria "Market" towards "Ho Chi Minh City"

Belief Degree (β)		Assessment Grades				
		High	Reasonably High	Average	Reasonably Low	Low
Market	DCD	0.4800	0.3600	0.1200	0.0400	0.0000
	DCS	0.0600	0.3600	0.3600	0.2000	0.0200

The belief degree values of DCD and DCS are arranged using Equation 6:

S (DCD) = {(High, 0.4800), (Reasonably High, 0.3600), (Average, 0.1200), (Reasonably Low, 0.0400), (Low, 0.0000)}.

S (DCS) = {(High, 0.0600), (Reasonably High, 0.3600), (Average, 0.3600), (Reasonably Low, 0.2000), (Low, 0.0200)}.

The weight value of "DCD" is 0.5455 and "DCS'" is 0.4545. Both of weight values also known as normalized principal eigenvector have been obtained by applying same step in Step 6. By using the information given in Table 6 and the weight values, the basic probability masses $m_{n,i}$ are calculated using Equation 7:

$m_{n,i}$ of DCD = [$m_{1,1}$ = 0.5455 × 0.4800 = 0.26184, $m_{1,2}$ = 0.5455 × 0.3600 = 0.19638, $m_{1,3}$ = 0.06546, $m_{1,4}$ = 0.02182, $m_{1,5}$ = 0.0000]

$m_{n,i}$ of DCS = [$m_{2,1}$ = 0.4545 × 0.0600 = 0.02727, $m_{2,2}$ = 0.4545 × 0.3600 = 0.16362, $m_{2,3}$ = 0.4545 × 0.3600 = 0.16362, $m_{2,4}$ = 0.09090, $m_{2,5}$ = 0.00909]

Then, the values for $m_{H,i}$ refer to $m_{H,1}$ and $m_{H,2}$ are calculated using Equation 8. $\bar{m}_{H,i}$ can be computed using Equation 9, while $\tilde{m}_{H,i}$ can be calculated using Equation 10.

The calculation process to obtain the values for $\bar{m}_{H,i}$, $\tilde{m}_{H,i}$, $m_{H,i}$, $\bar{m}_{H,2}$, $\tilde{m}_{H,2}$, and $m_{H,2}$ are shown as follow:

$\bar{m}_{H,i} = 1 - 0.5455 = 0.4545$

$\tilde{m}_{H,i} = 0.5454\ (1 - (0.4 + 0.4 + 0.2)) = 0.0000$

$m_{H,i} = 1 - (0.2182 + 0.2182 + 0.1091) = 0.4545$

$\bar{m}_{H,2} = 1 - 0.4545 = 0.5455$

$\tilde{m}_{H,2} = 0.4545\ (1 - (1 - (0.3 + 0.6 + 0.1)) = 0.0000$

$m_{H,2} = 1 - (0.1364 + 0.2727 + 0.0454) = 0.5455$

By applying Equation 11, K value is expressed in mathematical form:

$$K = \left\{ 1 - \left(\begin{array}{c} 0.04284 + 0.04284 + 0.02380 + 0.00238 \\ + 0.00536 + 0.03213 + 0.01785 + 0.00179 \\ + 0.00179 + 0.01071 + 0.00595 + 0.00060 \\ + 0.00060 + 0.00357 + 0.00357 + 0.00020 \\ + 0.00000 + 0 + 0.00000 + 0.00000 \end{array} \right) \right\}^{-1}$$

$$K = \{1 - 0.19598\}^{-1} = 1.24375$$

Then, the normalised factor *(K)* is used to obtain probability mass *(m)* values by applying Equation 12:

$m_1 = K (m_{1,1} m_{2,1} + m_{1,1} m_{H,2} + m_{H,1} m_{2,1}) = 1.24375 (0.00714 + 0.14284 + 0.01239) = 0.20195$
$m_2 = K (m_{1,2} m_{2,2} + m_{1,2} m_{H,2} + m_{H,1} m_{2,2}) = 1.24375 (0.03213 + 0.10713 + 0.07437) = 0.26570$
$m_3 = K (m_{1,3} m_{2,3} + m_{1,3} m_{H,2} + m_{H,1} m_{2,3}) = 1.24375 (0.01071 + 0.03571 + 0.07437) = 0.15023$
$m_3 = K (m_{1,4} m_{2,4} + m_{1,4} m_{H,2} + m_{H,1} m_{2,4}) = 1.24375 (0.00198 + 0.01190 + 0.04131) = 0.06864$

The normalization of the probability $\tilde{m}_H$ is computed using Equation 13:

$$\tilde{m}_H = K(\tilde{m}_{H,1}\tilde{m}_{H,2} + \bar{m}_{H,1}\tilde{m}_{H,2} + \tilde{m}_{H,1}\bar{m}_{H,2}) = 1.24375(0 + 0 + 0) = 0.00000$$

Next, using of Equation 14 to obtain the normalization of the probability $\bar{m}_H$:

$$\bar{m}_H = K(\bar{m}_{H,1}\bar{m}_{H,2}) = 1.24375(0.2479) = 0.30833$$

Afterward, Equation 15 is applied to obtain the belief degree values of "Market" with respect to the alternative "Ho Chi Minh City:

$$(High)\beta_1 = \frac{m_1}{1 - \bar{m}_H} = \frac{0.20195}{1 - 0.30833} = 0.29197 \approx 0.2920 \text{ x } 100 = 29.20\%$$

$$(Reasonably\ High)\beta_2 = \frac{m_2}{1 - \bar{m}_H} = \frac{0.26570}{1 - 0.30833} = 0.38414 \approx 0.3841 \text{ x } 100 = 38.41\%$$

$$(Average)\beta_3 = \frac{m_3}{1 - \bar{m}_H} = \frac{0.15023}{1\text{-}0.30833} = 0.21720 \approx 0.2172 \text{ x } 100 = 21.72\%$$

$$(Reasonably\ Low)\beta_4 = \frac{m_4}{1 - \bar{m}_H} = \frac{0.06864}{1 - 0.30833} = 0.09925 \approx 0.0993 \text{ x } 100 = 9.93\%$$

$$(Low)\beta_5 = \frac{m_5}{1 - \bar{m}_H} = \frac{0.00514}{1\text{-}0.30833} = 0.00743 \approx 0.0074 \text{ x } 100 = 0.74\%$$

Therefore, the aggregated assessment of "Market" with respect to the alternative "Ho Chi Minh City" is summarized as:

$S(Market) = S(DCD \oplus DCS)$

{(High, 29.20%), (Reasonably High, 38.41%), (Average, 21.72%), (Reasonably Low, 9.93%), (Low, 0.74%)}

Results and Discussions

According to discussions with industrial experts, the five alternative ports have the potential to be strong and sustainable future trading partners for the import and export containers of Malaysia and Port Klang. The different commodities are derived from demand and supply from all five ports (personal communication with Dev Prasad, Marketing Manager of Westport, Malaysia). However, not all container commodities exported from Port Klang originate, in terms of being manufactured or assembled, in Malaysia.

Further, based on interview session, out of ten respondents, nine of them (90%) agreed that the direct service is better than the multi-port calling service. Hsu and Hsieh (2007) stated that the optimal decision of direct service is more preferable than the hub and spoke service. In fact, there are several types of route design network; and commonly, there is a mixture of service patterns based on specific route connectivity. The 90% of respondents that agreed that multi-port calling was disadvantageous in terms of vessel delays could affect the fix window at ports and links to other ports to serve. A delayed sailing schedule totally influences the schedules of loading and discharging containers at all ports as a whole. It is complicated because it involves multiple ports and the feeder operators need to verify estimated times of arrival (ETA) at the port, consider waiting times and queues at anchorage areas, waiting times of vessel's turn to berth, and discharging or loading containers. Readjustment of schedules adversely affects the efficiency and frequency of service, customer reliability, operational cost, fuel cost, chartering cost, etc. However, a direct service has advantages of less transit time, less additional costs, more attractive service, more reliable, increased shelf life, and decreased transportation damage (Polat, 2013). Less transit time is involved because it specifically involves the ports of departure and destination with no waiting time at the next port (Polat, 2013). Three out of ten (30%) respondents justified that the direct service is better; somehow it depends on the specific area, whether it has a low or high current demand. Multiple port of calling is suitable for certain circumstances, such as the diversion of trade areas or depending on the demand created by the shipper, cargo owner, consignor and consignee. Ships can be fully utilized if the feeder operators are able to cater for the demand using several ports. In fact, the flexibility of route choices depends on the feeder operators themselves empowering their strategy and maintaining the sustainability of a company in the market.

The results of the data analyses are presented in the following bar charts. The assessment grade of belief degree in percentage is shown in Figure 3.

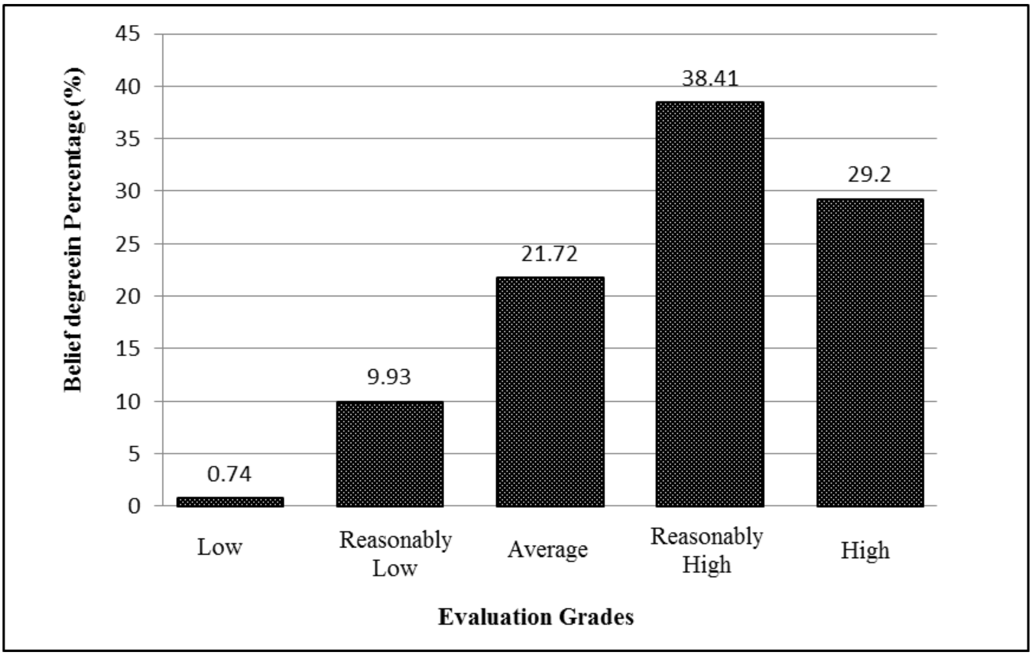

Figure 3: The evaluation of belief degree assessment grade of "market" towards alternative trade between Port Klang and Ho Chi Minh City

The highest evaluation grade, referring to Ho Chi Minh City on "Market" is "Reasonably High" at 38.41%. Second was "High" at 29.20%, third "Average" at 21.72%, fourth "Reasonably Low" at 9.93% and finally, "Low" at 0.74%.

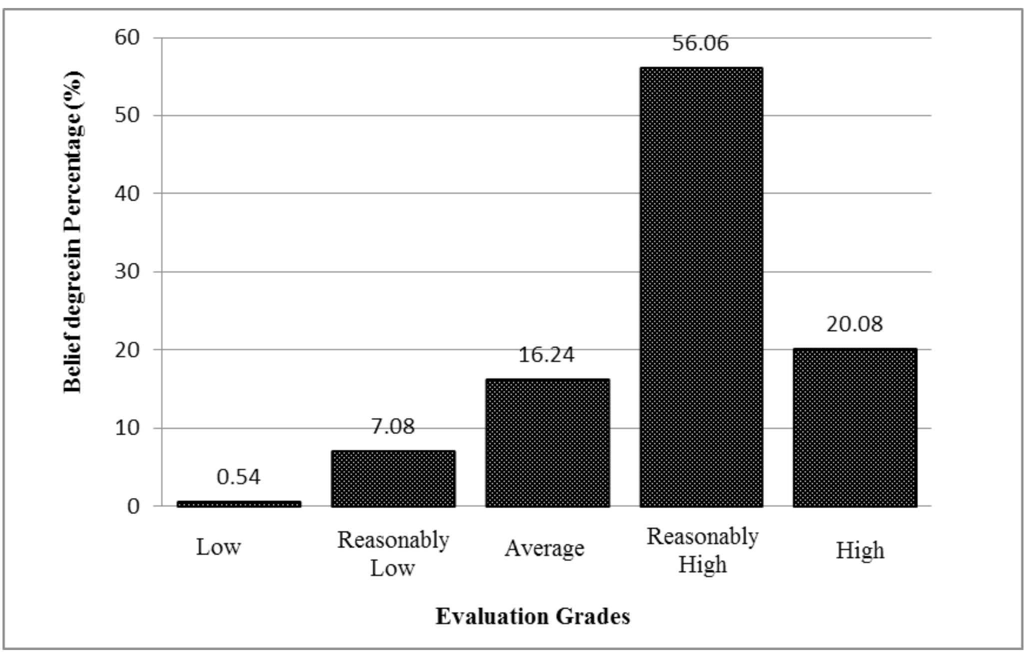

Figure 4: Route assessment of "Port Klang - Ho Chi Minh City"

Figure 4 shows that the highest evaluation grade referring to Ho Chi Minh City on "Route Assessment" was "Reasonably Beneficial" at 56.06%. Second was "Most Beneficial" at 20.08%, third "Moderate" at 16.24%, fourth "Reasonably Less Beneficial" at 7.08% and finally, "Less Beneficial" at 0.54%. All percentage values of evaluation grades on belief degree were used to calculate the ranking of alternatives as overall assessments. The calculation for alternative "Ho Chi Minh City" is shown as follows:

Most Beneficial	: 20.08% ÷100 x 1.00 = 0.2008
Reasonably Beneficial	: 56.06% ÷ 100 x 0.75 = 0.4205
Moderate	: 16.24% ÷ 100 x 0.50 = 0.0812
Reasonably Less Beneficial	: 7.08% ÷ 100 x 0.25 = 0.0177
Less Beneficial	: 0.54% ÷ 100x 0.00 = 0.0000

The average score for Ho Chi Minh City is linked between Figure 3 and 4. The calculation can be shown in mathematical form as: 0.2008 + 0.4205 + 0.0812 + 0.0177 = 0.7202

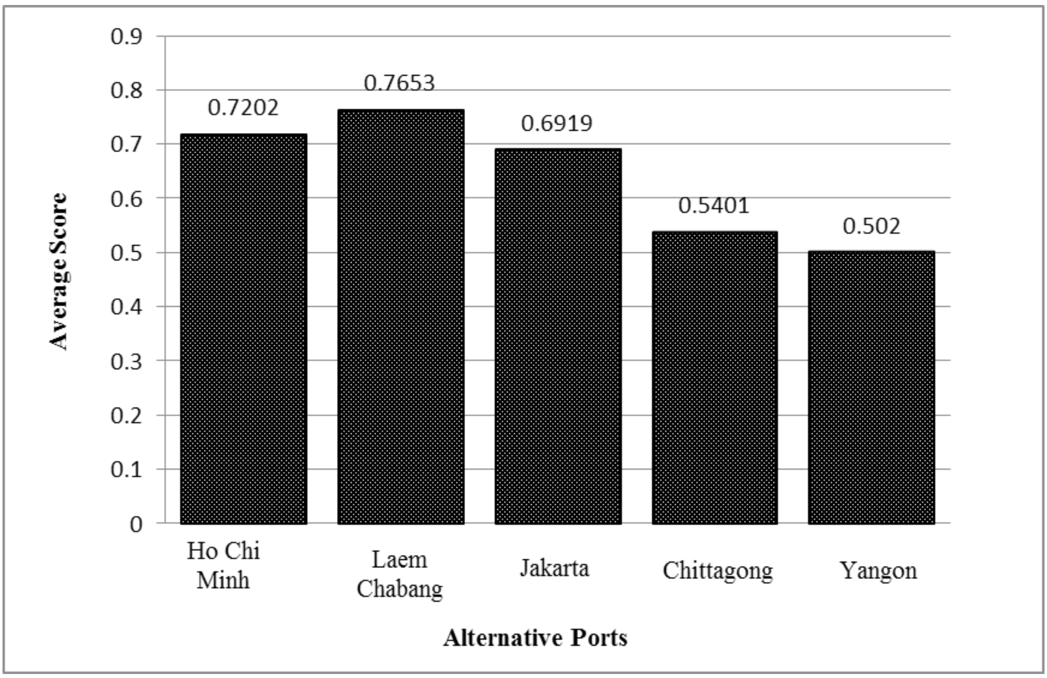

Figure 5: Average score for Port Klang via five alternative ports towards route assessment of the feeder service

Table 9: The summary of results of direct feeder service via Port Klang in Malaysia

Main Criteria	Summary of Results					
Ranking of trading partners via Port Klang, Malaysia	Ports of service	Ho Chi Minh	Laem Chabang	Jakarta	Chittagong	Yangon
	Score	0.7202	0.7653	0.6919	0.5401	0.5020
	Ranking	2	1	3	4	5
Ranking of criterion for feeder route assessment	Main criterion	Service (SVC)	Time (TM)	Cost (CST)	Market (MT)	Miscellaneous (MC)
	Score	0.3674	0.1310	0.0861	0.3330	0.0825
	Ranking	1	3	4	2	5

The results shown in Figure 5 and Table 9 show the average score for Port Klang via five alternative ports towards route assessment of the feeder service. It can be seen that the average score for Laem Chabang is 0.7653, followed by Ho Chi Minh City in second place with 0.7202. Next, Jakarta is in third place at 0.6919, fourth is Chittagong (at 0.5401), and Yangon (at 0.5020) in fifth place. Based on Table 9, the ranking of main criterion in assessment of feeder routes and potential trading partners are "Service" in the first place (0.3674), followed by "Market" (0.3330), "Time" (0.1310), "Cost" (0.0861) and "Miscellaneous" (0.0825). These results are consistent with a Critical Ratio, CR: 0.0766 less than 0.10. SVC, or "Service", is the most important factor of all main criteria. An efficient service, provided by port and shipping companies, results in efficient vessel use via increased service frequency, time and cost saving at the port, retained customer reliability, and catering to rapid market demand. In reality, shipping and port competition is very high (Westport, 2016). Shippers choose the best shipping services to deliver their cargos in time. Competition between commodity manufacturers also needs to fulfil current "Market" demand. "Service" is a key strength of feeder operators to remaining competitive in the "Market". The high-quality "Service" of a port and feeder player also increases "Time" efficiency in both; thus reducing the "Costs" incurred by the shipping company. "Miscellaneous" factors, such as ship's carrying capacity, main and auxiliary fuel prices, average voyage speed, distance between ports of service, are also important to be considered.

Laem Chabang port was identified as the most potential trading partner between the five selected ports. The current view of feeder operators and Port Klang authorities show Laem Chabang as a great prospect to be the port of choice in maintaining the economy of feeder operators and Port Klang in the future. Therefore, it is a great opportunity for feeder operators to create future trading plans in effectively making Laem Chabang a pick-up and delivery point for cargo. Laem Chabang port is more efficient, in terms of cargo handling, than Ho Chi Minh City, Jakarta, Chittagong, and Yangon thus, reduce waiting time by a ship at port. Ship operators always expect the least waiting time for their container ships at port (Kiani *et al.,* 2006). A long waiting time in berth increases the port's profitability. This accounts for port charges, but incurs higher costs for the shipping operators (Malchow & Kanafani, 2001). Shipping liners also bear higher operating costs due to increasing fuel consumption. This results from increased ship speeds, in terms of following fixed sailing schedules (Notteboom, 2006). High fuel consumption produces high emissions of greenhouse gases (mainly Nitrogen Oxide and Sulphur Oxide) from shipping activities (Martinez & Sin, 2011). In Malaysian waterways, merchant ships are required to comply with International Conventions for the Prevention of Pollution from Ships (MARPOL - Annex VI Regulations for the Prevention of Air Pollution from Ships beginning from September 27, 2010 (Marine Department Malaysia, 2011). Therefore, efficient cargo shipments using the route Port Klang – Laem Chabang could potentially reduce air pollution and influence the sustainability of the environment between the ports of service.

Conclusion

In summary, the combined methods of AHP-Fuzzy Link Based Technique and ER are able to assess feeder route parameters. This results in a hierarchal route arrangement of potential trade partners. The managerial contributions of this study can be summarised as the feeder operators in Port Klang needing to strengthen their services, optimise their sailing schedules and trade relationship with Laem Chabang as the first port of call choice, followed by Ho Chi Minh City, Jakarta, Chittagong and finally Yangon. This is considered a strategy that will maintain feeder operators, Port Klang, and Malaysia's maritime economy in the long-term. However, the competition between feeder operators usually high to fulfil market demand due to the limited service windows available at ports. Therefore, to be a competitive shipping operator, the feeder operator must take the initiative and deploy an efficient shipping service with suitable carrying capacities. In addition, they should discover ports that offer a low bunker price. According to Stopford (1998), the bunker is the largest variable cost in shipping operations. An optimised consumption of ship fuel or bunker has also resulted in lower emissions of air pollutants (Martinez & Sin, 2011). Furthermore, a viable freight rate could be offered; and thus, generate the chance to penetrate the potential market.

The theoretical contribution of this paper is that the researchers have proposed a feeder route assessment model using a Multi Criteria Decision Making (MCDM) approach. Experts have been able to assess the tangible factors that result in the arrangement of feeder routes and potential trading partners. The methods and model applied in this research are flexible enough to deal with the uncertain conditions of future or potential prospects that cannot be determined using numerical or quantitative measurements. This assessment can also help feeder companies, terminal operators, and port authorities to enhance their capabilities and service marketability which influences maritime stakeholder's profitability as a whole. Moreover, the constructed model can be used by maritime stakeholders and academicians based on their own test cases.

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