3PL Provider selection in oil and gas industry using the analytic hierarchy process: A case study in oil-field services company X

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ABSTRACT

This study aims to: (1) Summarize the criteria for selecting 3PL Provider in supply chain management from literature review and apply these criteria to build the criteria model in choosing 3PL Provider for oilfield services company X for the purpose of expanding their market in the oil and gas industry and (2) Analyze, evaluate two 3PL Providers, along with a new 3PL Provider and suggest the strategy for selecting the suitable 3PL Provider to meet the specific requirements from company X.

By arranging in-depth interviews with ten people with different positions, including Operation Manager, Supply Chain Manager, Logistics Manager, Base Manager and Logistics Specialist, along with AHP approach and expert choice 11.0 software support in collecting, processing and synthesizing data to evaluate and determine the appropriate 3 PL Provider for company X. In this study, three 3PL Providers have been chosen for analyzing and evaluating - 3PL Providers A, B, and C. The final results demonstrate that there are six main criteria and 13 sub-criteria in choosing 3PL Provider for oilfield services company X. The six main criteria are Performance, Price, Services, Quality assurance, IT system and Intangible values. The results and hypothetical situations have also been presented and discussed again with the expert logistics group to get their feedback about the practicability of the built model. The expert logistics group has agreed that the built criteria model and results are appropriate and adequate for evaluating and selecting a suitable 3PL Provider from the company's specific demands. Consequently, this study can also be applied for similar purposes in other companies and shipping agents who need to work with outsourcing logistics services in oil and gas industry by using this built criteria model and synthesis results to find out the right decision for selecting 3PL Provider.

1. Introduction

Nowadays, supply chain management plays an important role in the success of the company's business. Selecting the right 3PL Provider is an arduous task for supply chain management, but it is a vital step to build the foundation of the company. Many companies have implemented logistics outsourcing of their logistics activities in order to be more beneficial and significant in their operation (Baki & Ar, 2009). Hence, the right selection 3PL Provider can avoid problems for the company in the operation and will give the company an advantage over its rivals. 3PL Providers have various strengths as well as weaknesses which are required carefully assessed by the supply chain management before giving ranks to them (Tahriri, Osman, Ali, Yusuff, & Esfandiary, 2008). In the past, the traditional method to select vendors was mainly based on pricing (Asamoah, Annan, & Nyarko, 2012). However, there were more and more companies recognizing that it would not be sufficient if they only base on pricing to select the best 3PL Provider. Therefore, the company has looked at other options to select 3PL Provider based on multi-criteria such as safety, environments, social, political, customer satisfaction, and etc. behind the basic traditional criteria such as cost, quality, delivery performance services (Thiruchelvam & Tookey, 2011). The oilfield services company X provides multi-drilling services to Clients, such as administering pressure and measurement while drilling, directional drilling, installing wireline, testing and completing at the local and international level. In the oil and gas industry, the operating expense for the offshore rig is costly. If the shipment is not delivered to the offshore rig on time or shipment is damaged during the transportation, it will greatly delay the company's drilling schedule, resulting in penalizing a large amount of money from clients for wasting time at the offshore rig. This is the reason why all the approved 3PL Providers of an oilfield services company X are required to strictly follow plans as well as to ensure the equipment and materials arrived at the offshore rig in excellent condition and on time. The oilfield services company X currently has 2 to 3 regular 3PL Providers that can accommodate logistic services for handling normal drilling equipment to the company X. The company X would also like to expand the market in the local country by providing wireline and testing services that are necessary to develop the current existing 3PL Providers or search for another 3PL Provider that can handle more complex or dangerous shipment in and out of the country smoothly with reasonable price. The criteria for choosing 3PL Provider may be changed over time, depending on the purpose and strategy of each company. In this scenario, Multi-criteria Decision Making (MCDM) is used to determine the right 3PL Provider that meets multi-criteria requirements. As a result, the need for oilfield services company X is related to multi-criteria decision-making. To support this process, the AHP method is implemented to select the right 3PL Provider. AHP method can indicate the value of each criterion's relative weighting. These results would then support oilfield services company X in selecting a suitable 3PL Provider.

2. Literature review

Selecting a 3PL Provider in Supply chain management is related to MCDM. From previous studies, MCDM is divided into two groups: Multi-objective decision making (MODM) and Multi-attribute decision making (MADM) (Kumar et al., 2017).

MODM technique, such as mathematical programming problems with multiple objective functions, is used when the decision space is continuous (Kumar et al., 2017).

MADM administers the discrete decision spaces where the decision alternatives are predetermined. Alternatives represent different choices of action available to the decision-maker. The choice of alternatives is often assumed to be limited. Alternatives are studied, analyzed and prioritized with respect to the multiple attributes in which the MADM problems are associated. Most of the MADM methods require that each attribute is given weight or relative importance with respect to their impact on the decision of the problem being solved. MADM consists of Analytic Hierarchy Process (AHP) by Saaty, Technique for Order Preferences by Similarity to Ideal Solutions (TOPSIS) by Hwang and Yoon, ELECTRE by Benayoun, PROMETHEE by Brans and Vincke (Kumar et al., 2017).

Table 1

Summary of MADM Methods

Method	Description	Advantages	Disadvantages
AHP	Using pairwise comparison for comparing both the alternatives with respect to the various criteria and estimating criteria weights	Easy to use Scalable Easily adjust to fit many sized problems with hierarchical structure	Interdependence between criteria and alternatives can lead to inconsistencies between judgment and ranking criteria
Data Envelopment Analysis (DEA)	Measuring the relative efficiencies of alternatives based on the linear programming technique	Capable of handling multiple inputs and outputs, efficiency can be analyzed and quantified	Does not deal with imprecise data, assumes that all input and output are exactly known
ELECTRE	An outranking method. To be used for selecting the best solution along with maximum advantages and less conflict with other function criteria	The more priority ranking is used	Take time to process
PROMETHEE	Family of outranking method	Easy to use, does not require the assumption that criteria are proportioned	Does not provide a clear method by which to assign weights

Method	Description	Advantages	Disadvantages
TOPSIS	To identify an alternative which is closest to the ideal solution and farthest to the negative ideal solution in a multi-dimension computing space	Has a simple process Easy to use and program The number of steps remains the same regardless the number of attributes.	Its implementation of Euclidean Distance does not consider the correlation of attributes. Difficult to weight and keep the judgment's consistency.

Source: Revised from Velasquez and Hester (2013); Nguyen, Luong, and Le (2015)

From the advantages and disadvantages of MADM shown in Table 1 as above and the special advantages of AHP, the AHP is an eminently flexible and powerful tool because AHP helps to solve the problem when there are conflicts and differences between the criteria during comparison and evaluation process. A number of studies applied AHP to select 3PL Providers for Aerospace in USA (Bayazit & Karpak, 2013), for firms operating in Istanbul (Gürcan, Yazıcı, Beyca, Arslan, & Eldemir, 2016), for integrated circuit manufacturing in Taiwan (Hwang, Chen, & Lin, 2016) … showing that the selection criteria are diverse, depending on the various business area, current situations and demands of each company. However, studying regarding choosing 3PL Provider in the oil & gas industry is rarely conducted. Therefore, AHP is selected for studying the selection process of 3PL Providers for oilfields services company X. With the approach of AHP, the final ranking is obtained on the basis of the pairwise relative evaluations of both all the criteria and the options provided by the user. The computations made by the AHP are always guided by the decision maker's experience, and it can be considered as a tool that is able to translate the qualitative and quantitative evaluations made by the decision-maker into multi-criteria ranking.

AHP Method

AHP is an effective tool for dealing with complex decision making in which the decision-maker is able to set priorities and make the best decision (Saaty, 1980). Additionally, it is a multi-criteria decision-making methodology. The complex decisions have been reduced by using a series of pairwise comparisons and synthesizing the results (Saaty, 1980). Furthermore, the AHP integrates a useful technique to check the consistency of the decision maker's evaluations, thus reducing the subjectivities in the decision-making process (Saaty, 1980). There are three basic stages in AHP method: *(a)* define the decision hierarchy level, *(b)* make pairwise comparison matrix for each level of the hierarchy and *(c)* synthesize priority weight of each criterion in weight matrix. Based on these basic principles, the analysis steps in AHPs process, including: *(1)* define the problem and specify the desirable solution; *(2)* structure the hierarchy tree from the highest levels (main criteria) through lower levels (sub-criteria); *(3)* collect opinions and ideas from experts regarding priority criteria and sub-criteria; *(4)* construct a pairwise comparison matrix; *(5)* calculate the weight of each level criterion; *(6)* calculate the

consistency index (CI) and check the consistency ratio (CR) using the following equation: CR = CI/RI in which RI is a random index. The consistency ratio CR should be less than or equal to 10%. If this ratio is higher than 10%, then repeat steps 3, 4 and 5; *(7)* perform all steps from 3, 4, 5 and 6 for all levels of the criterion from hierarchical structure; *(8)* calculate overall weight, ranking and comments.

3. Methodology

This study is to answer the demand of selecting 3PL Provider for oilfield services company X: (a) which criteria should be the most important and necessary for selecting 3PL Provider in oil and gas industry and (b) with the current situation of oilfields services company X, it should select 3PL Providers based on its criteria and 3PL Providers' abilities to meet the requirements of company's expanding markets in oil and gas industry. At first stage, the table of semi-structural question and survey form has been sent to ten people with different positions, including Operation Manager, Supply Chain Manager, Logistic Manager, Base Manager and Logistic Specialist in order to define important criteria for selecting 3PL Provider. The feedback results from the above have been synthesized and the second stage is to arrange in-depth interviews with Operation Manager, Supply Chain Manager, Logistic Manager, Base Manager and Logistic Specialist who has great experience working in oil and gas industry from 15 to 20 years. The purpose is to define the most essential main criteria and sub-criteria in selecting 3PL Providers for the oilfield services company X. The data and information after collecting have been analyzed and pairwise compared by applying the AHP method with the support of expert choice software 11.0 to find out the right 3PL Provider as well as to know the strengths and weaknesses of each 3PL Provider. The final calculated results and hypothetical situations have been discussed again with the experts to check the practicability of using this building criteria model for selecting 3PL Provider in oil and gas industry. Finally, the experts have agreed that this built criteria model is appropriate for selecting 3PL Provider in oil and gas industry.

4. Results by criteria and sub-criteria for selecting vendors and 3PL Providers

4.1. Summary of criteria and sub-criteria for selecting vendors and 3PL Providers from previous research

According to Dickson's study in 1966 regarding vendor selection criteria, the 23 vendor selection criteria were discussed. The Dickson's study was based on the questionnaires sent to 273 Purchasing agents and Managers (Dickson, 1966). In 1991, Weber, Current and Benton's study reviewed these 23 criteria from Dickson's study and presented the changes in the importance of each criterion (Weber et al., 1991). In 2011, Thiruchelvam and Tookey developed 36 criteria that also included 23 criteria of Dickson's study in 1966 (Thiruchelvam & Tookey, 2011). Some previous case studies only used 9 criteria (Gürcan et al., 2016), 9 criteria (Bayazit & Karpak, 2013) or 11 criteria (Ecer, 2017) for selecting 3PL Provider. With the high globalization scenario, there are some new criteria that can be used for supporting the selection of suitable 3 PL Provider: safety, problem-solving capacity, customer support services, control cost of value-added services, system reliability and stability, client relationship, ISO compliance… Bang-Ning, Tsai-Ti and James's study in 2016, as cited in

Hwang et al. (2016) has listed 34 selection sub-criteria and group them in six general criteria group (suggested by Vaidyanathan, 2005, as cited in Hwang et al., 2016) for selecting 3PL Provider. In general, criteria to be used for evaluating 3 PL Provider are depended on the situation and business of the company. Criteria such as prices, performance, and services are widely used (Thiruchelvam & Tookey, 2011).

4.2. Construct main criteria and sub-criteria for selecting 3 PL Providers for oilfields services company X

The results after conducting an in-depth interview with ten people with different positions, including Operation Manager, Supply Chain Manager, Base Manager, Logistic Manager and Logistic Specialist in oil and gas industry, by using outline interview details, there are 6 main criteria with 13 sub-criteria that are the most important and essential for selecting 3 PL Provider. The definitions of criteria are shown in Table 2.

Table 2

The 6 main criteria and 13 sub-criteria for selecting 3PL Providers of company X

Main criteria	Sub-criteria	Definition
Performance	On-time delivery	Deliver the goods on time. The total amount of time from departure to arrival. This also requires the preparation and accurate document in advance, fast respond to customer's request and avoidance of the shipment errors, ensuring that it will be delivered on time.
	Transportation safety	To evaluate the equipment/materials and labor safety during the handling and transporting process to ensure shipment can be used immediately when arriving at the predetermined location.
Cost	Price	Competitive price including service charges, freight and transportation charges, packaging and labels…
	Cost control of value added services	To look for the optimum cost performance of value added services offered by 3PL Providers, inform company all the estimated cost of value added services before processing shipment such as warehouse fees, inspection certificates, license import & export, COO fees…

Main criteria	Sub-criteria	Definition
Services	Customer support services	The ability of customer support query from pick-up location to destined location
	Problem-solving capability	The capability and flexibility of 3PL Provider to handle unforeseen problems or unexpected events for the company.
	Services scope	Refer a 3PL Provider can provide a multi-range of services such as local transport, freight forwarding, bounded warehouse, customer clearance and formalities, payment on a company's behalf so the company can reduce vendor involvement in the tasks and make the tasks more convenient and faster.
Quality Assurance	ISO Compliance	Local and International standard compliance, ISO required
	Key performance indicator tracking	To evaluate the performance of 3PL Provider at the regular time
IT system	Function coverage	To refer IT system scope, such as supply chain planning and routing freight, tracking shipment status…
	System stability	To refer IT system operating smoothly and normally
Intangible	Experience	To measure how experienced a 3PL Provider in the Oil and Gas industry by looking at the list of top clients that they have provided services as well as the duration they have worked in oil and gas industry
	Financial stability	Refer to finance strength for long term stability, processing payment for import taxes and warehouse fees on behalf of the company, regularly upgrading of the equipment and services used in logistics operation as well as credit term provided to the company

Source: The researcher's data analysis

4.3. AHP approach for selecting 3PL Providers for oilfield services company X

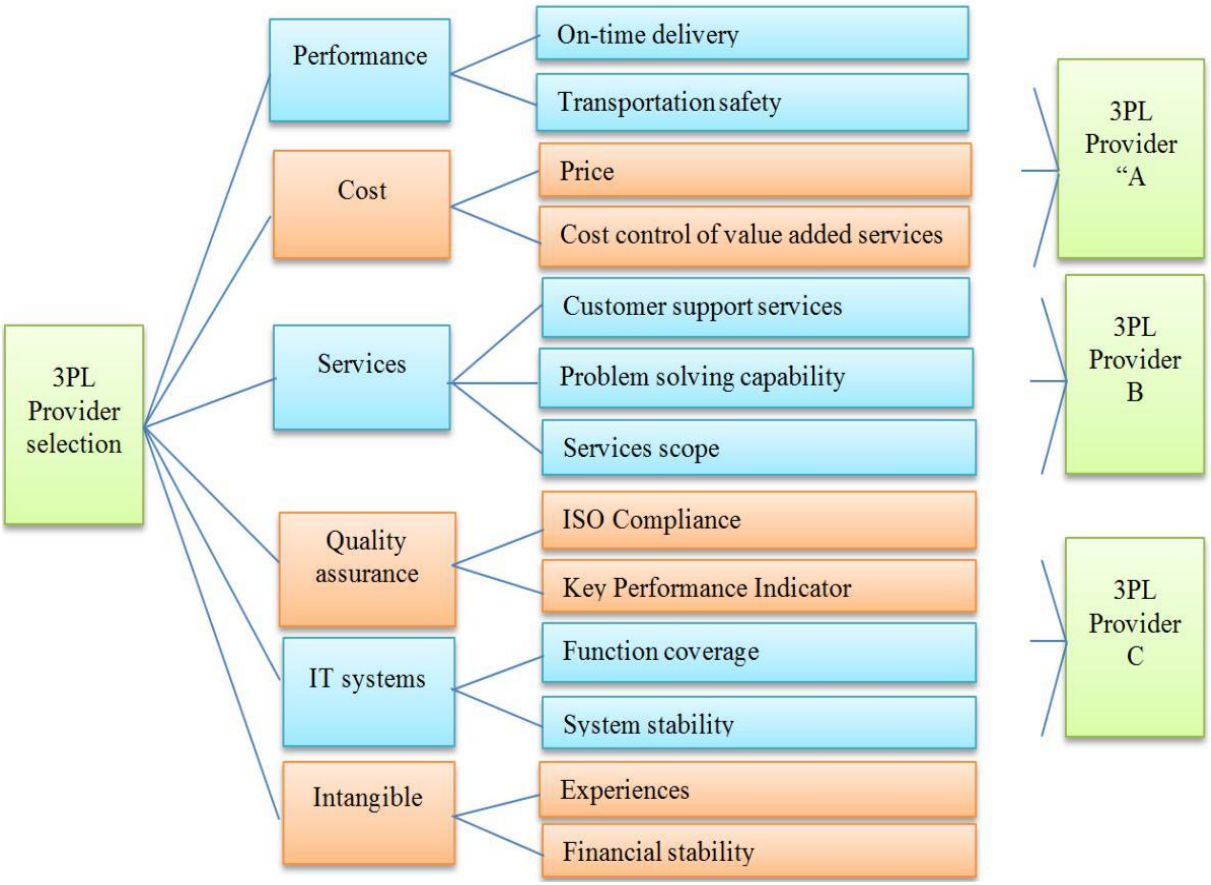

Figure 1. The hierarchical model structure

Company X currently has 2 to 3 regular 3PL Providers that they can provide logistic services for handling a normal shipment for company X. Company X considers evaluating and searching for an alternative 3PL Provider for expanding the market by providing more technical drilling services such as wireline logging and testing services in the local country. The process for selecting 3PL Provider consists of two phases: primary phase and AHP phase. At primary phase, based on information from websites, observations in the oilfields services industry, and from expert's opinions, there are some others 3PL Providers can handle the normal shipment in oil and gas industry, but 3PL Provider C used to handle the types of dangerous good shipment for influential clients over a long time. It meets most of the company's demands; therefore, they have been selected for analyzing and evaluating the selection process. The evaluation and selection of 3PL Provider are suggested for the company as Figure 1 above.

5. Data analysis and results of 3PL provider selection

5.1. Analyzing the qualitative data by using the AHP pairwise comparison method

Data collection for evaluating the priorities of criteria group

The pairwise comparison is carried out by using AHP's nine-point scale, from 1 to 9. The results of the comparison matrix representing the importance level between main criteria are shown in Table 3 and weight matrix between the main criteria in Table 4.

Table 3

The matrix of the importance level between main criteria

Main criteria	Performance	Cost	Service	Quality Assurance	IT system	Intangible
Performance	1	1	5	3	7	5
Cost	1	1	5	5	7	7
Service	1/5	1/5	1	3	3	3
Quality assurance	1/3	1/5	1/3	1	3	1/3
IT system	1/7	1/7	1/3	1/3	1	1/3
Intangible	1/5	1/7	1/3	3	3	1
Summary	2,876	2.686	12	15.333	24.000	16.667

Source: The researcher's data analysis

Table 4

The weight matrix between main criteria

Main criteria	Performance	Cost	Services	Quality assurance	IT system	Intangible	Average row	Sum row	Consis-tency Vector
Performance	0.348	0.372	0.417	0.196	0.292	0.300	**0.321**	2.196	6.849
Cost	0.348	0.372	0.417	0.326	0.292	0.420	**0.362**	2.516	6.943
Service	0.070	0.074	0.083	0.196	0.125	0.180	**0.121**	0.845	6.962
Quality assurance	0.116	0.074	0.028	0.065	0.125	0.020	**0.071**	0.428	5.991
IT system	0.050	0.053	0.028	0.022	0.042	0.020	**0.036**	0.227	6.363
Intangible	0.070	0.053	0.028	0.196	0.125	0.060	**0.089**	0.566	6.394
Summary	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**6.778**	**39.503**

Source: The researcher's data analysis

Table 5

Value of Random index (RI)

n	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

Source: The researcher's data analysis

In order to analyse the consistency of the weight matrix, the consistency ratio to be calculated by the following formula CR=CI/RI in which Consistency Index (CI):

$$CI = (\lambda max - n)/(n-1). \quad (1)$$

(Largest eigenvalue) λmax = the average of consistency vector = 39.503/6

$CI = [(39.503/6)-6] / (6-1) = 0.1168$

With n =6; RI = 1.24 (Table 5)

$CR = CI/RI = 0.1168/1.24 = 0.0942 < 0.1$

Because the above results show CR < 10%, the weight matrix between the main criteria meets the consistency. This data can be used for comparison by using the AHP method.

Data collection for evaluating the priorities of sub-criteria

The results of comparison matrices about the importance level between sub-criteria are presented in Table 6.

Table 6

The matrices of the importance level between sub-criteria

Performance	On time delivery	Transportation Safety
On time delivery	1	1
Transportation Safety	1	1
Cost	Price	Cost control of value-added services
Price	1	7
Control cost of value added services	1/7	1

Quality Assurance	ISO Compliance	KPI
ISO Compliance	1	7
KPI	1/7	1
IT system	Function coverage	System stability
Function coverage	1	3
System stability	1/3	1

Services	Customer support Services	Problem solving capacity	Services scope
Customer support Services	1	1/5	1/9
Problem solving capacity	5	1	1
Services scope	9	1	1

Intangible	Experience	Financial stability
Experience	1	7
Financial stability	1/7	1

Source: The researcher's data analysis

Table 7

The matrices of the importance level between 3PL Providers on each sub-criteria

On time delivery	Provider A	Provider B	Provider C
Provider A	1	1	1
Provider B	1	1	1
Provider C	1	1	1

Price	Provider A	Provider B	Provider C
Provider A	1	3	5
Provider B	1/3	1	3
Provider C	1/5	1/3	1

Tranporta -tion safety	Provider A	Provider B	Provider C
Provider A	1	1	1
Provider B	1	1	1
Provider C	1	1	1

KPI Tracking	Provider A	Provider B	Provider C
Provider A	1	1/3	1
Provider B	3	1	3
Provider C	1	1/3	1

Customer support services	Provider A	Provider B	Provider C
Provider A	1	3	1
Provider B	1/3	1	1/3
Provider C	1	3	1

ISO Compliance	Provider A	Provider B	Provider C
Provider A	1	1	1
Provider B	1	1	1
Provider C	1	1	1

Problem solving capability	Provider A	Provider B	Provider C
Provider A	1	3	1/5
Provider B	1/3	1	1/5
Provider C	5	5	1

Function coverage	Provider A	Provider B	Provider C
Provider A	1	1/3	1
Provider B	3	1	3
Provider C	1	1/3	1

Services scope	Provider A	Provider B	Provider C
Provider A	1	1/3	1/3
Provider B	3	1	1
Provider C	3	1	1

System stability	Provider A	Provider B	Provider C
Provider A	1	1	1
Provider B	1	1	1
Provider C	1	1	1

Control cost of value added services	Provider A	Provider B	Provider C
Provider A	1	3	1
Provider B	1/3	1	1/3
Provider C	1	3	1

Experience	Provider A	Provider B	Provider C
Provider A	1	3	1/3
Provider B	1/3	1	1/5
Provider C	3	5	1

Financial stability	Provider A	Provider B	Provider C
Provider A	1	1	1
Provider B	1	1	1
Provider C	1	1	1

Source: The researcher's data analysis

5.2. Results of 3PL Provider selection

The calculating process is done according to the AHP method with the supports from expert choice software 11.0. By inputting matrix data from Table 3, Table 6 and Table 7 to expert choice software 11.0, the results from expert choice software 11.0 are presented in Figure 2 and Figure 3. The local weight (LW) and global weight (GW) data shown in Table 8 are collected from Figure 2.

The corresponding main criterion and sub-criterion weights are multiplied to give a global weight for each sub-criterion. For example, in Table 8, the main criterion of cost has a weight of 0.372 when compared with other main criteria (performance, services, quality assurance, IT system and intangible). Within the main criterion of cost, the first sub-criterion of price has a local weight of 0.875. Therefore, the global weight for the first sub-criterion of price is 0.372 x 0.875 = 0.325. This weight given to the first sub-criterion of price has relative to all the sub-criteria and across all the main criteria; the sum of all such global sub-criterion weights are equal to 1. The first sub-criterion price of 3PL Provider A has a local weight 0.637, thus the global weight for the first sub-criterion price of 3PL Provider A is 0.325 x 0.637 = 0.207. The first sub-criterion price of 3PL Provider B has a local weight 0.258, thus the global weight for the first sub-criterion price of 3PL Provider B is 0.325 x 0.258 = 0.084. The first sub-criterion price of 3PL Provider C has a local weight 0.105, thus the global weight for the first sub-criterion price of 3PL Provider C is 0.325 x 0.105 = 0.034. The global weight results for the rest of all sub-criteria in Table 8 can be calculated similarly.

The sum of all the global weights of all sub-criteria related to each 3PL Provider in Table 8 gives the overall weight of each 3PL Provider. Therefore, the overall weight of 3PL Provider A is 0.409, the overall weight of 3PL Provider B is 0.285 and the overall weight of 3PL Provider C is 0.306 accordingly. Figure 3 demonstrates these overall weights of Provider A, Provider B and Provider C.

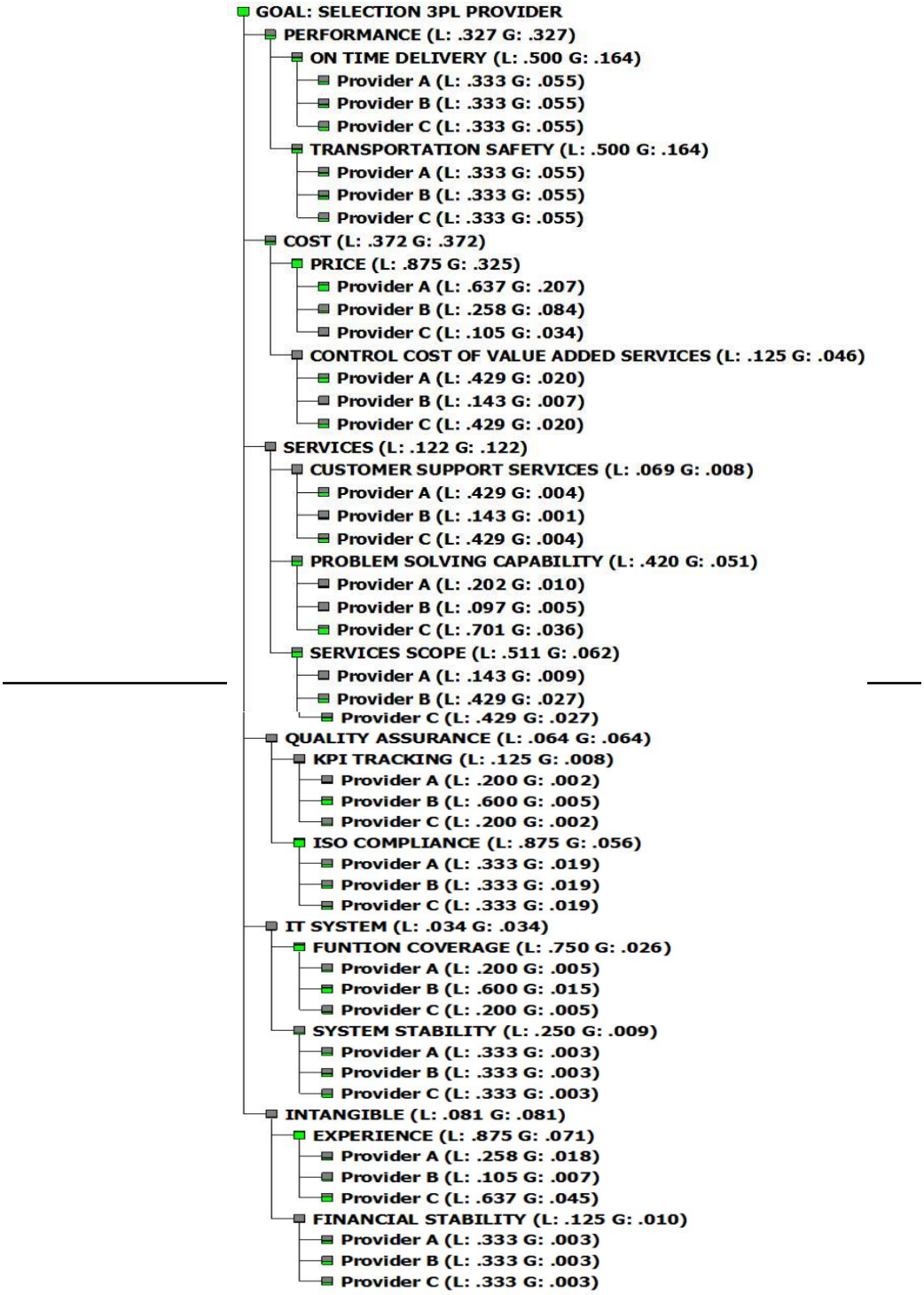

Figure 2. The tree view in expert choice 11.0

Table 8
Process data and results

					3PL Provider A		3PL Provider B		3PL Provider C	
Main criteria	**LW**	**Sub-criteria**	LW	GW	LW	GW	LW	GW	LW	GW
Performance	0.327	On time delivery	0.500	0.164	0.333	0.055	0.333	0.055	0.333	0.055
		Transportation Safety	0.500	0.164	0.333	0.055	0.333	0.055	0.333	0.055
Cost	0.372	Price	0.875	0.325	0.637	0.207	0.258	0.084	0.105	0.034
		Control cost value added services	0.125	0.046	0.429	0.020	0.143	0.007	0.429	0.020
		Customer Support Services	0.069	0.008	0.429	0.003	0.143	0.001	0.429	0.003
Services	0.122	Problem-solving capacity	0.420	0.051	0.202	0.010	0.097	0.005	0.701	0.036
		Services Scope	0.511	0.062	0.143	0.009	0.429	0.027	0.429	0.027
Quality Assurance	0.064	ISO compliance	0.875	0.056	0.333	0.019	0.333	0.019	0.333	0.019
		KPI	0.125	0.008	0.200	0.002	0.600	0.005	0.200	0.002
IT system	0.034	Function coverage	0.750	0.026	0.200	0.005	0.600	0.016	0.200	0.005
		System stability	0.250	0.009	0.333	0.003	0.333	0.003	0.333	0.003
Intangible	0.081	Experience	0.875	0.071	0.258	0.018	0.105	0.007	0.637	0.045
		Financial stability	0.125	0.010	0.333	0.003	0.333	0.003	0.333	0.003
				1.000		0.409		0.285		0.306

Source: Data analysis result of the research

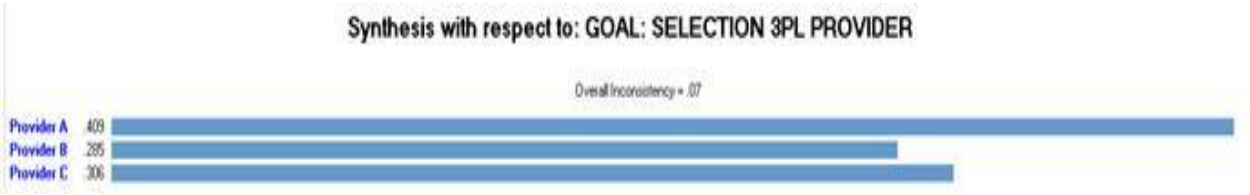

Figure 3. Synthesis with respect to Goal

In Table 9, within the main criterion of cost has the weight of (0.372), the ratio weight for the main criterion of cost of 3PL Provider A compared with 3PL Provider B and 3PL Provider C will be given by the ratio between the sum of global weight for sub-criterion of price (0.207 shown in Table 8) and global weight for sub-criterion of control cost value-added services (0.020 shown in Table 8) of 3PL Provider A at over the weight of the main criterion of cost (0.372 shown in Table 8). Therefore, the ratio weight for the main criterion of cost of 3PL Provider A is (0.207 + 0.020)/ 0.372 = 0.610. By doing a similar calculation, the ratio weights for other main criteria of each 3PL Provider A, 3PL Provider B and 3PL Provider C are shown in Table 9. The overall weight of each 3PL Provider also can be calculated as follows:

The overall weight for Provider A = (0.334 x 0.327) + (0.610 x 0.372) + (0.185 x 0.122) + (0.316 x 0.064) + (0.241 x 0.034) + (0.267 x 0.081) = 0.409

The overall weight for Provider B = (0.334 x 0.327) + (0.243 x 0.372) + (0.268 x 0.122) + (0.366 x 0.064) + (0.547 x 0.034) + (0.133 x 0.081) = 0.285

The overall weight for Provider C = (0.334 x 0.327) + (0.145 x 0.372) + (0.539 x 0.122) + (0.316 x 0.064) + (0.241 x 0.034) + (0.599 x 0.081) = 0.306

Table 9

Summary the overall weighted score for each 3PL Provider

	Performance W=0.327	**Cost W=0.372**	**Services W=0.122**	**Quality Assurance W=0.064**	**IT system W=0.034**	**Intangible W=0.081**	**Overall weight**	**Ranking**
3PL Provider A	0.334	0.610	0.185	0.316	0.241	0.267	0.409	1.000
3PL Provider B	0.334	0.243	0.268	0.366	0.547	0.133	0.285	3.000
3PL Provider C	0.334	0.145	0.539	0.316	0.241	0.599	0.306	2.000

Source: The researcher's data analysis

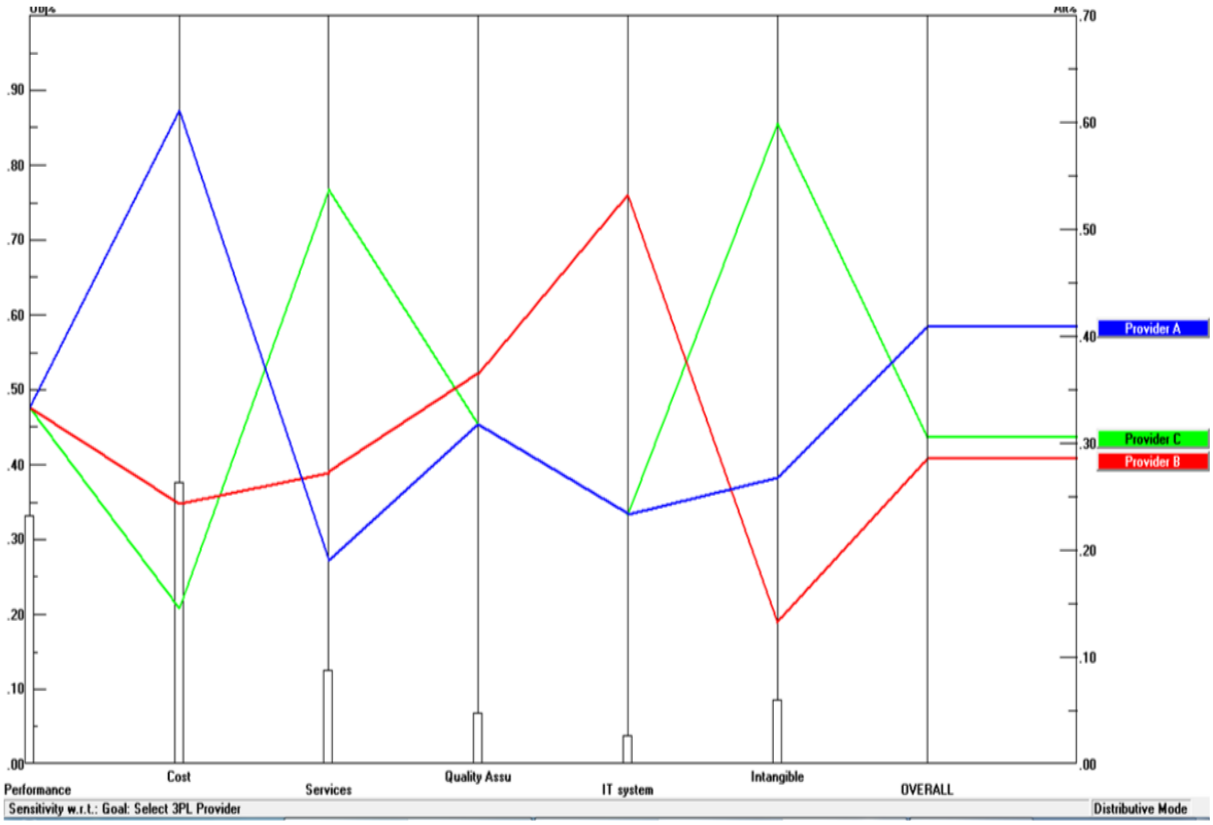

Figure 4. Sensitivity analysis chart

From the results of calculating the weight of each main criterion such as Cost, Performance, Services, Intangible, Quality Assurance and IT are 0.372; 0.327; 0.122; 0.081; 0.064 and 0.034. As a result, the select 3PL Providers for the company in order of priorities are Cost> Performance> Services> Intangible> Quality Assurance> IT systems.

Additionally, from the final results of calculating the weight of each main criterion-related between pairwise comparison 3PL Provider A, 3PL Provider B and 3PL Provider C is shown in Table 9 and in overall results, 3PL Provider A with overall weight (0.409) has prevailed more than 3 PL Provider C (0.306) and 3PL Provider B (0.285). This result suggests that 3PL Provider A is the main 3PL Provider for company X.

The above chart of results and sensitivity analysis also shows that 3PL Provider A is relatively competitive and advantageous in term of cost, while 3PL Provider B is more prevailing in terms of quality assurance and IT system, and 3PL Provider C is more prevailing in terms of services and intangible.

6. Results of logistics group discussion

The final results of this study with prioritized main criteria are Cost> Performance> Services> Intangible> Quality Assurance> IT systems. It has been presented in expert focus group discussion along with some hypothetical situations that may be considered in selecting a suitable 3PL Provider.

6.1. Hypothetical situation #1

If the company focuses more on cost, then 3PL Provider A is the best choice (Figure 5). This is suitable for handling normal shipment or standard size shipment that does not require urgent shipping or more strictly on a document such as a license, related certificates, inspection, declaration dangerous goods, and etc.

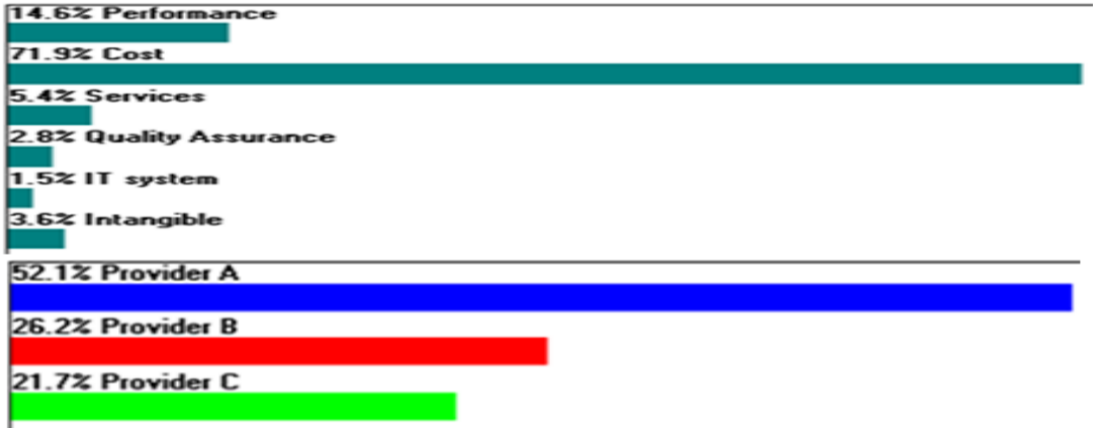

Figure 5. If the company focuses more on cost criterion

6.2. Hypothetical situation #2

If the company focuses more on quality assurance and IT system, then 3PL Provider B is the best selection (Figure 6 and Figure 7). This is suitable for shipping many small shipments that need to strictly follow the compliance and closely track the status of each shipment from everywhere and every time in the world.

Figure 6. If the company focuses more on IT system criterion

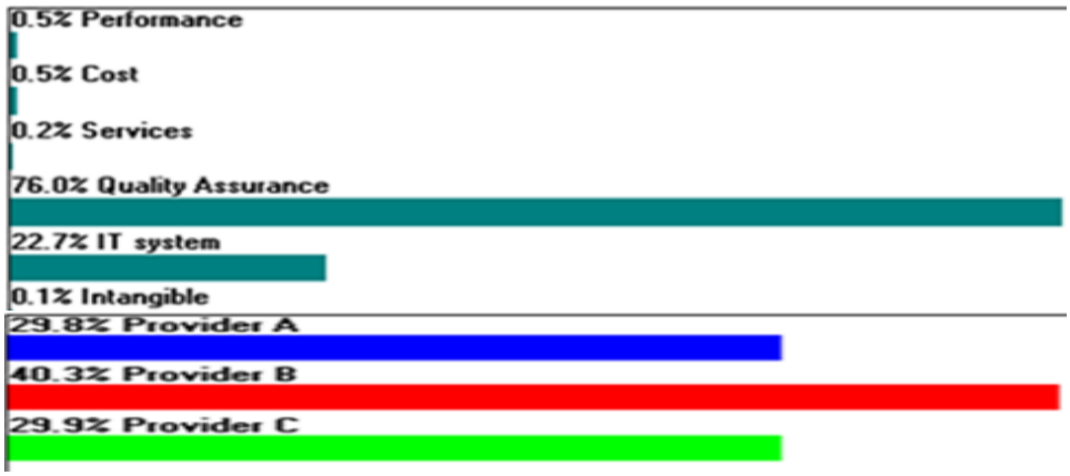

Figure 7. If the company focuses more on quality assurance criterion

6.3. Hypothetical situation #3

If the company needs to ship the complex shipment, specialized or urgent shipment then 3PL Provider needs to have good knowledge and show a deep understanding of the requirements needed to handle the shipment smoothly. They can foresee the issues may issues may occur and prepare the essential document/certificates needed for shipment in advance. With this hypothetical situation, the company may focus more on services and intangible and 3PL Provider C is capable of meeting those criteria, better than other 3PL Providers (Figure 8 and Figure 9).

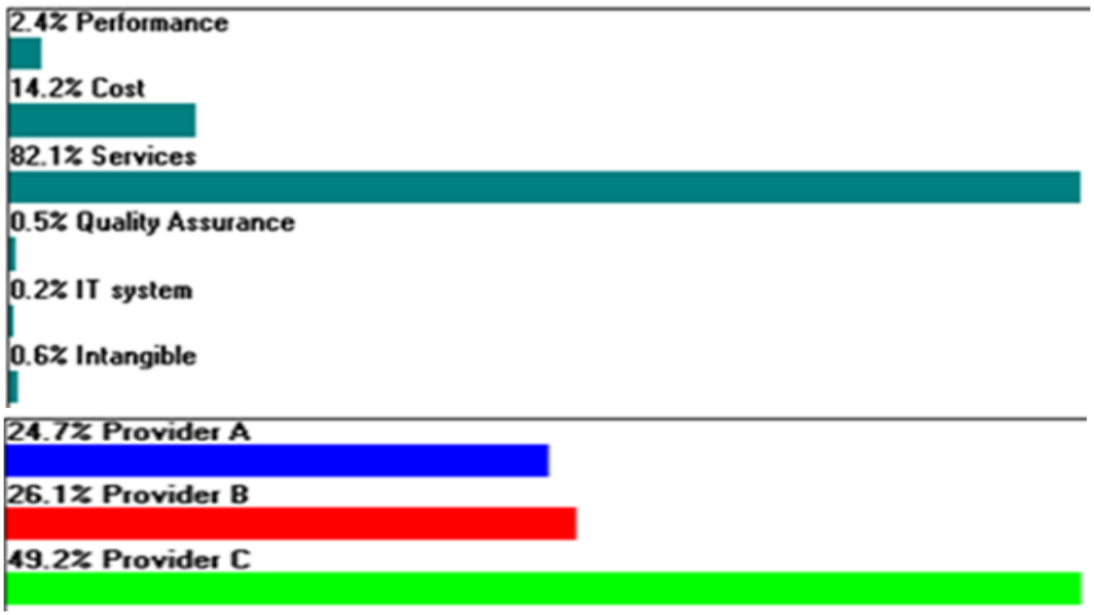

Figure 8. If the company focuses more on services criterion

Figure 9. If the company focuses more on intangible criterion

After discussing synthesized results and hypothetical situations with a logistics focus group, along with the reference of a few previous studies in selecting 3PL Provider in a various business area, the results have shown that: *(a)* the built criteria model is practical in selecting 3PL Provider for oilfields services company X. These criteria model are different from criteria models of previous studies in a various business area *(b)* the strategy for selecting the suitable 3PL Provider to meet the specific requirements from company X based on the analysis sensitivity results and hypothetical situations can inform the company clearly the strengths and weaknesses of each 3PL Provider.

In oil and gas industry, the equipment and materials are diverse, besides the normal equipment; there are other equipment and materials such as processing data equipment, electrical equipment, chemicals, radioactive sources, dangerous goods, oversized and/or overweight shipments. In order to handle the complex and specialized shipment smoothly, 3PL Provider needs to have the best knowledge and understand the requirements for handling these equipment and materials. Depending on the type and specialty of the shipment, the company may shift the focus to another criterion in order to select the suitable 3PL Provider. These findings can help the company X saving the time in evaluating and selecting a suitable 3PL Provider: *(a)* for normal and standard size shipment that does not require more strictly on document such as license, related certificates, inspection, declaration dangerous good and does not need urgent care then the company would consider selecting 3PL Provider with good prices, *(b)* for many small shipments that would need to track and trace on the tracking system, then 3PL Provider with strong in IT systems and KPI is more referable, *(c)* for complex, specialized or urgent shipment that would need 3PL Provider has the best knowledge and understand the requirements, foresee the issues may arise and prepare the essential paperwork needed in advance, then 3PL Provider with the strong in services and intangible is more referable.

7. Conclusion

This study presents the suitable reasoning by using AHP method to handle complex decision making with details such as *(a)* from the results of doing hierarchy analysis and synthesizing the important criteria in literature review basic to build the criteria model for selecting 3PL Provider for oilfield services company X, *(b)* the analysis results were found by applying the AHP method can support company X's in strategy evaluations and selecting the suitable 3PL Provider that can meet company's specific requirements.

The AHP method in this study is applied for the purpose of selecting a suitable 3PL Provider to handle multiple types of equipment and materials in oil and gas industry from normal and standard shipment to complex, specialize, dangerous good, overweight and/or oversize shipment. This study can also be applied for similar purposes in other companies and shipping agents who need to work with outsourcing logistics services in oil and gas industry by using this built criteria model and synthesis results to find out the right decision for selecting 3PL Provider.

In conclusion, this study opens another direction for further research in the future by combining AHP with other methods such as FUZZY or TOPSIS method to have better results.

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