Analytic Hierarchy Process in Third-Party Logistics Provider Selection Criteria Evaluation: A Case Study in IT Distributor Company

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Abstract—**Selecting a good third party logistics (3PL) service provider is one of the key success factors in a supply chain management. Logistics service provider firms produce a critical service in the chain that helps to meet customer's requests in terms of quantity, quality and on time delivery. The conventional supplier evaluation criteria such as quality, price and delivery are not enough in today's competitive environment. Recent studies have shown that operational performance, service quality, technology and sustainability are some of the important criteria that determine the performance of the supplier. In this study, we consider the 3pl service provider selection process of an IT distributor firm in Turkey. The different selection criteria which are used by the corresponding firm have been observed and the various sub-criteria have been grouped under five main criteria such as cost, operational performance, service quality, technology, sustainability. Analytical hierarchy process (AHP) is proposed to evaluate the importance value of the criteria in the selection process of 3pl service providers for an IT distributor firm.**

Keywords—**Analytic Hierarchy Process, Criteria Evaluation, Third Party Logistics and IT Distributor Firm**

I. INTRODUCTION

A successful supply chain management is a key factor to gain a competitive advantage in today's global environment. The main idea of the supply chain management is generation of good relationships between chain members to serve customers accurately. Indeed, the definitive operation levels between supply chain members determine the quality of final product/service in a supply chain. Therefore, supplier selection process in the supply chain management has a great impact on competitive advantage. From this point of view, selecting a good 3PL provider is one of the key success factors in a supply chain management. 3PL firms produce a critical service in the chain, which helps to meet customer's requests in terms of quantity, quality and on time delivery.

The performance of the logistics service provider has a great impact on operational service levels in the chain. Selecting an accurate 3PL provider is one of the important factors of the sustainable success. Collaboration with reliable strategic partner helps firms to ensure sustainability in their product and service quality with perfect operational skills. Therefore, firms can gain a competitive advantage by maintaining good relationship with its suppliers. However, as the supplier's performance may have both positive and negative impacts on the firm's future operations, it is important to make right decisions in the supplier selection process (Ramanathan, 2007).

In order to achieve sustainable competitive advantage in the market, a firm should not only consider the performance of the supplier but also the number of the suppliers to be at the minimum level. A firm should have long term relationships with a few reliable suppliers to continue its operations in a successful manner. Therefore, while selecting the suppliers in the competitive conditions of the market, the firm should consider various factors to achieve its strategic goals rather than just reviewing the price lists which may seem to be the most important factor at first sight (Ho et al., 2010).

Evaluating the suppliers according to specific criteria and cooperating with them within this framework enables a firm to keep pace with the changing market conditions. The supplier selection problem is to measure the performance of a group of suppliers by using developed methods and models. The aim is to determine the suppliers that will meet the needs of the final customers in the best possible way (Bruno et al., 2012).

There are two critical steps in the supplier selection problem. The first one is to determine the criteria in selecting the suppliers and to reflect the experience of experts to the evaluation process (Deng et al., 2014). While the important factors in supplier selection differ according to each sector, the importance level of these factors varies in line with the firms' strategic goals. In general, traditional criteria such as price, quality, and delivery time are not sufficient for competitive success. In today's competitive landscape, economic success is not enough for a firm to sustain its presence. In order to gain a sustainable competitive advantage, a firm should be responsible to economic, environmental and social landscapes. The firms that achieve success in all three aspects are considered to have the sustainability criterion which gains more importance each and every day in line with the decreasing natural resources. Not only the big firms but also their suppliers should meet the criterion which is important for competitive advantage (Molamohamadi et al., 2013 Therefore, sustainability criterion is now among the criteria that are used to evaluate suppliers in the supplier selection problem.

3PL firms are the most important strategic partners in the supply chain in terms of the service quality. However, the transportation that is main service of the 3PL firms is one of the most significant sources of unsustainability in a supply chain. This activity has some harmful effects on the environment such as fossil fuel use, global warming, noise, congestion and decreased city commute. (Quak and Koster, 2007) Therefore, sustainability criteria need to be considered when selecting an appropriate 3PL provider. Nevertheless, sustainability criteria are barely studied in the 3PL provider selection literature.

Further, logistical issues are more than an operational issue, they are considered as a strategic issue in the supply chain management. 3PL selection process requires a detailed examine since a single criteria does not satisfy every situation in an operation. Additionally to this, since different companies have different organizational structure, management strategy, primacy requirements depend on product or service and others, the criteria for supplier selection changes for an individual companies and industries. For this reason, the identification of supplier selection criteria requires experts' assessment and discernment (Deng et al., 2014). Determination of the selection criteria framework can be time-consuming, costly and complicated. However, company special selection criteria framework makes it possible to act fast during an operation.

In addition to this, contracts made with 3pl providers are important since they have big budgets and they include strategic activities. Therefore, while selecting 3PL provider firm for strategic cooperation, determining the evaluation factors is an important decision process. (Mangan, et al., 2008)

For the aforementioned reasons, we aim to develop an AHP method to present an evaluation framework for selecting an appropriate 3PL partner. In this study, the different selection criteria which are used by the corresponding firm have been observed and the various sub-criteria have been grouped under five main criteria such as cost, operational performance, service quality, technology, sustainability. The purpose of the paper is to provide a practical reference for the 3PL selection process and examine the relative importance of sustainability criteria for the selection of a 3PL provider in the business surroundings of Turkey.

The remainder of the paper is organized as follows. In section 2, Third-Party logistics service provider selection is presented. In section 3, the solution procedure is defined. The Application of AHP Methodology is demonstrated in section 4. Finally, the experimental results and conclusion are considered in section 5, followed by the references.

II. THIRD PARTY LOGISTICS SERVICE PROVIDER SELECTION

In today's global economy, firms prefer to collaborate with 3PL service provider firms for logistics, warehousing, distribution activities in order to take advantage of lower operating cost in a foreign country (Anderson et al., 2010). Maloni and Carter (2006) show that firms prefer to outsource logistics services from a 3PL company in order to improve their services, reduce operation costs and focus on their own core non-logistics activities. (Leuschner et al., 2014) 3PL providers improve customer satisfaction by accurate and on-time delivery. Thus, selecting a good 3PL service provider can help firms to gain competitive advantage with meeting customer expectations timely, accurately. 3PL service providers improve the efficiency, effectiveness and flexibility of a company's logistics functions by the integration of some logistics activities professionally such as warehousing, transportation, inventory management etc. Additionally to this, company does not need to make investment to provide these actions. It can better focus on its core businesses

Nowadays, outsourcing services provided by 3PL firms have gone beyond the traditional transportation and distribution services, 3PL firms offers a great variety of services such as inventory management, IT services, such as tracking and tracing, value added activities, such as secondary assembly and installation of products. (Gol and Çatay, 2007) Since, 3PL service provider firms serve a bundle complex service to different firms with different requirements, the key criteria to select a 3PL service provider firm differs from company to company. It is also evident that no single criterion would be self-sufficient, and therefore it becomes more important to identify and classify the key criteria so that the potential 3PL services providers may be identified. Thereby, the 3PL service provider selection problem can be defined as a multi-criteria decision problem in which multiple intangible and tangible criteria need to be considered.

In the literature, the 3PL service provider selection criteria discussed frequently by researchers. Spencer et al. (1994) study with 154 firms listed in the American Public Warehouse Register in order to determine the importance of the selection criteria used by them to select their 3PL service provider. 23 specific criteria are identified in the following order of importance: on-time performance, service quality, good communication, reliability, service speed, flexibility, customer support, easy to work with, management quality, early notification of disruptions, order cycle time, willingness to customize service, reputation, price, location, variety of available services, cost reduction, special expertise, decreased labor problems, technical competence, decreased asset commitment, increased competition, and global capabilities. (Aguezzoul, 2014) Gol and Catay (2007) consider 3PL service provider selection problem for a Turkish automotive company. They address 27 critical criteria under five main criteria such as general company considerations, capabilities, quality, client relationship and labor relations in the logistics service provider selection process. Mangan et al. (2008) listed some critical factors that are considered in 3PL selection process such as cost, service, speed, reliability, information systems, staffing issues, client references, reverse logistics issues, etc. Tsai et al. (2008) introduce the critical success factors for 3PL firms in a high-tech industry. They show that the service performance, cost and added value are the critical success factors for 3PL firms in the high tech industry as well in other industries. Qureshi et al., (2008) suggested an integrated model to determine and classify critical 3PL service provider selection criteria for shippers' logistics necessity. Four classifications are stated namely dependent criteria, independent criteria, autonomous criteria and linkage criteria. According to their results, some criteria such as

quality of service, information sharing and trust, delivery performance, financial stability need to study carefully since these are unstable. The decision maker needs to monitor these types of criteria at the each stage of the service providing process. Cakir et al., (2009) demonstrate a fuzzy AHP method to select the best logistics service provider for a fast-moving-consumer goods company. They determine the cost of the service, operational performance, financial performance, reputation and long-term relationships as decisive criteria for logistics provider selection decision of corresponding company. Wolf and Seuring (2009) examine the importance of the environmental criteria on 3PL service buying decisions. They report that even though environmental issues become popular by 3PL service providers, companies still consider traditional criteria such as quality, price and delivery time frequently and ignore sustainability criteria when they are sourcing third party logistics services. Soh (2010) develop a decision model for evaluating third-party logistics service providers. In this study, the critical 3PL provider selection criteria are categorized under five main criteria: finance, service level, relationship, management, and infrastructure. The proposed model shows that information technology capability is the most important criteria in logistics outsourcing decisions. Gupta et al., (2011) indicate on time delivery, management capability and reputation as the three most cited evaluation criteria in choice of a qualified 3PL service provider. Aguezzoul (2014) present a literature review on 3PL selection decision in terms of criteria and methods. They investigate 67 study published within 1994- 2013 and show that the critical selection criteria can change for an individual companies and industries. Additionally to this, while some criteria can determine with strategy specific requirements, the others can be common for all situations. According to their study, cost is the most commonly used selection criteria followed by respectively relationship, services and quality.

III. THE ANALYTIC HIERARCHY PROCESS IN THE SUPPLIER SELECTION PROBLEM

Multi-criteria decision making (MCDM) methods are widely applied to selection problems. The main MCDM methods used to solve 3PL service provider selection problem are: Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Decision-Making Trial and Evaluation Laboratory (DEMATEL), Fuzzy Sets Theory (FTS) etc. (Aguezzoul, 2014)

AHP is one of the popular MCDM methods, which is developed by Saaty (1980). Since then, it used to solve different kind of problems in the literature. It is applicable to complicated real life problems since it incorporates expert comments to the solution. Thanks to this feature of the method, the qualitative or intangible attributes can be evaluated by using pair-wise comparisons along with expert judgments. (Cho et al., 2012; Chai et al., 2013)

In the AHP solution procedure, each alternative is assigned with an efficacy value. (Chai et al., 2013) One could rank and order the alternate 3PL service providers on their final score and choose the best. Since, AHP can handle both qualitative and quantitative data effectively; it is applicable to the 3PL service selection problems in which both tangible and intangible criteria are taken part (Cho et al., 2012).

Usually, the AHP application process can be divided into four steps as below:

Step 1. Designate pair-wise comparison between criteria to indicate the relative importance of alternatives. A numerical rating including nine rank scales is suggested, as shown in Table I.

TABLE I
NUMERICAL RATING IN THE AHP

Scale	Meaning
1	Equal importance
3	Moderate importance
5	Strong importance
7	Demonstrated importance
9	Extreme importance
2,4,6,8	Intermediate importance

Step 2. Calculate the priority weights of alternatives according to the pair-wise comparison matrix.

Step 3. Compute the λ_{max} and the consistency index (CI) to measure the inconsistency within the pair-wise compassion matrix by using the formulation below:

$$CI = \frac{\lambda_{max-n}}{n-1}$$

Step 4. Define the consistency ratio (CR) with using the formulation below and test the acceptance each of the consistency of the judgment matrix.

$$CR = \frac{CI}{RI}$$

IV. THE APPLICATION OF AHP METHODOLOGY

The application of the proposed method is exhibited for an IT distributor company. The corresponding company Armada distributes Cisco, EMC, VMware, Dell, Riverbed, Lenovo, Polycom, Fortinet, HP Network, Symantec, Iomega, Tyco (AMP), HCS, Enterasys, Motorola, Zebra, Intel, Kingston in the Turkish market. With a staff of 155, in Istanbul, Ankara, Izmir and Adana, Armada provides products and solutions to over 5,000 IT companies. The company has a broad product range including personal computer, storage, server and backup services, industrial handheld terminal, barcode printer and computer components

By using AHP, the importance level of 3PL provider selection criteria is defined for the corresponding company. By taking expert opinions, various sub-criteria have been grouped under five main criteria as Cost(C), Operational Performance (O), Service Quality (S), Technology (T) and Sustainability (S).

TABLE II
CRITERIA OF 3PL PROVIDER SELECTION

Main Criteria	Sub-criteria
Cost **(C)**	**C1:** Service cost **C2 :**Distribution cost **C3:** Warehousing cost
Operational Performance **(O)**	**O1 :**Operational speed **O2:** Delivery performance **O3:** Defective delivery **O4:** Flexibility
Service Quality **(SQ)**	**SQ1 :**Customer satisfaction **SQ2 :**Tangibles **SQ3 :**Reliability **SQ4 :**Information sharing and trust **SQ5:** Responsiveness **SQ6 :**Empathy **SQ7:** After-sale service
Technology **(T)**	**T1:** IT capability **T2:** Transportation systems **T3 :**Storage systems
Sustainability **(S)**	**S1 :**Economic **S2:**Social responsibility **S3:**Environmental responsibility

Decision makers from the company are asked to make the pair-wise comparison of criteria and sub-criteria. Table III presents the compassion of main criteria used for 3PL selection process in the company.

TABLE III
PAIR-WISE COMPARISON MATRIX OF THE MAIN CRITERIA

Goal	C	O	SQ	T	S
C	1,00	0,20	0,20	0,50	5,00
O	5,00	1,00	1,00	5,00	5,00
SQ	5,00	1,00	1,00	3,00	5,00
T	2,00	0,20	0,33	1,00	5,00
S	0,20	0,20	0,20	0,20	1,00

The proposed AHP method is applied to derive a normalized value of the each criterion. Table IV shows the normalized matrix of criteria. The last column of the Table IV shows the computed relative eigenvalue vector.

TABLE IV
NORMALIZED MATRIX OF CRITERIA

	C	O	SQ	T	S	Priority
C	0,0758	0,0769	0,0732	0,0515	0,2381	0,1031
O	0,3788	0,3846	0,3659	0,5155	0,2381	0,3766
SQ	0,3788	0,3846	0,3659	0,3093	0,2381	0,3353
T	0,1515	0,0769	0,1220	0,1031	0,2381	0,1383
S	0,0152	0,0769	0,0732	0,0206	0,0476	0,0467

TABLE V
PAIR-WISE COMPARISON JUDGMENT MATRICES OF 3PL SUB-CRITERIA

Cost	**C1**	**C2**	**C3**					**Priority**
C1	1	3	0.2					0.193
C2	0.33	1	0.14					0.083
C3	5	7	1					0.724
								CR=0.057
Operational Performance	**O1**	**O2**	**O3**	**O4**				**Priority**
O1	1	3	0.5	0.25				0.139
O2	0.33	1	0.2	0.11				0.0523
O3	2	5	1	0.33				0.239
O4	4	9	3	1				0.568
								CR=0.078
Service Quality	**SQ1**	**SQ2**	**SQ3**	**SQ4**	**SQ 5**	**SQ 6**	**SQ7**	**Priority**
SQ1	1	7	0.33	0.33	9	7	5	0.184
SQ2	0.14	1	0.11	0.11	5	5	0.33	0.061
SQ3	3	9	1	1	9	9	7	0.321
SQ4	3	9	1	1	9	9	7	0.321
SQ5	0.11	0.2	0.11	0.11	1	1	0.33	0.024
SQ6	0.14	0.2	0.11	0.11	1	1	0.33	0.025
SQ7	0.2	3	0.14	0.14	3	3	1	0.063
								CR=0.096
Technology	**T1**	**T2**	**T3**					**Priority**
T1	1	0.33	0.2					0.106
T2	3	1	0.33					0.26
T3	5	3	1					0.633
								CR=0.033
Sustainability	**S1**	**S2**	**S3**					**Priority**
S1	1	3	5					0.633
S2	0.33	1	3					0.26
S3	0,2	0.33	1					0.106
								CR=0.33

The consistency index (CI) is calculated to measure the inconsistency within the pair-wise compassion matrix with using the formulation below. (λ_{max} =5.399857)

The CI is defined as 0,099964359 when n value is 5 and random index (RI) is 1.12.

The consistency ratio (CR) is defined as 0,089253892. Since CR<0.10, the comparison matrix A is considered as having an acceptable consistency and eigenvector w is used as the weighting vector after normalization.

Priority vector and CR value for each sub-criterion are computed as shown in Table 4. CR values are computed for each sub-criterion to show the acceptance of consistency. All sub-criteria CR < 0.10, therefore each of the consistency of the judgment matrix is acceptable**.** Priorities of all sub-criteria are derived by using main criteria priorities and presented in Table VI. A set of global weights is determined for each of the sub-criterion by multiplying local weights of the sub-criteria with weights of all the main criteria above it.

The weights at the criteria level and attributes level are integrated to obtain the weights and ranking of attributes with respect to the overall objective as shown in the right side of Table V. As seen in Table VII, operational flexibility (O4) is the most important attribute with % 21.4 global weights while environmental responsibility (S3) is the less important attribute with % 0.4 global weight.

TABLE VI
GLOBAL PRIORITIES OF CRITERIA AND ATTRIBUTES

Strategic issues	**Local Weights**		**Local Weights**	**Global Weights**
Cost	0.103	**C1:** Service cost	0.193	0.02
		C2 : Distribution cost	0.083	0.009
		C3: Warehousing cost	0.723	0.075
Operational Performance	0.376	**O1 :**Operational speed	0.139	0.052
		O2: Delivery performance	0.052	0.019
		O3: Defective delivery	0.239	0.09
		O4: Flexibility	0.568	0.214
Service Quality	0.335	**SQ1 :**Customer satisfaction	0.184	0.061
		SQ2 : Tangibles	0.06	0.02
		SQ3 : Reliability	0.32	0.107
		SQ4 : Information sharing and trust	0.32	0.107
		SQ5: Responsiveness	0.024	0.008
		SQ6 : Empathy	0.025	0.008
		SQ7: After-sale services	0.063	0.021
Technology	0.138	**T1:** IT capability	0.106	0.014
		T2: Transportation systems	0.26	0.036
		T3 : Storage systems	0.633	0.087
Sustainability	0.046	**S1 :**Economic	0.633	0.029
		S2: Social responsibility	0.26	0.012
		S3: Environmental responsibility	0.106	0.004

TABLE VII
RANKING OF CRITICAL SUCCESS FACTORS

Rank	**Critical success factors**	**Global Weights**
1	Flexibility	0.214
2	Reliability	0.107
3	Information sharing and trust	0.107
4	Defective delivery	0.09
5	Storage systems	0.087
6	Warehousing cost	0.075
7	Customer satisfaction	0.061
8	Operational speed	0.052
9	Transportation systems	0.036
10	Economic	0.029
11	After-sale services	0.021
12	Service cost	0.02
13	Tangibles	0.02
14	Delivery performance	0.019
15	IT capability	0.014
16	Social responsibility	0.012
17	Distribution cost	0.009
18	Responsiveness	0.008
19	Empathy	0.008
20	Environmental responsibility	0.004

V. EXPERIMENTAL RESULTS AND CONCLUSION

The success of the supply chain depends on the integration of a network of facilities that procure raw materials, transform them into finished products, and deliver the products to the customers through a distribution system to meet customer demand. In a supply chain management process, a manager needs to make strategic decisions regarding raw material procurement, production planning, inventory management, and distribution routing in order to reduce overall supply chain costs.

Indeed, the definitive operation levels between supply chain members determine the quality of final product/service in a supply chain. Therefore, supplier selection process in the supply chain management has a great impact on competitive advantage.

The study used AHP in determining the 3PL supplier selection criteria of the IT distributor firm and the priority values of the criteria are calculated.

According to application results, the most important criteria in the company's 3PL provider selection process is operational flexibility followed by respectively reliability and information sharing and trust. In this study, we consider sustainability criteria in 3PL selection process additionally to the traditional selection criteria studied in literature. In line

with the results, it has been found out that the firm did not attach much importance to the Sustainability Criterion, especially the Environmental Sustainability Criterion (0.004). The study can be used as a reference in logistics supplier selection for the firms who operate in the same industry.

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