Project logistics company selection from EPC shippers' perspective†

EPC화주의 프로젝트 물류 기업 선정에 관한 연구

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〈Abstract〉

Efficient company selection for project logistics has become a fundamental requirement for sustainable growth and corporate competitiveness in the engineering, procurement, and construction (EPC) industries. Although the prior literature has mostly analyzed how shippers select third-party logistics companies, research regarding project logistics company selection is overlooked so far. To fill this gap, this study examines the EPC companies' selection when outsourcing project logistics using the fuzzy Delphi-AHP approach. In addition, results can present operational implication to the logistics providers. Findings indicate general service criteria, such as reasonable cost and timely delivery/reliability, are the most important factors. Despite

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this study's novelty, it has limitations: 1) the difficulty of obtaining stable data and 2) periodic updates to criteria appropriate to the methodology.

Key words: Project Logistics, EPC, Fuzzy Delphi-AHP, Selection, Priority

Ⅰ. Introduction

The engineering, procurement, and construction (EPC) industries have a large effect on our daily lives and have become major contributors to the national economy because of the growing population and the need to maintain, expand, remodel, and replace buildings. However, logistics management in EPC is an emerging business area that differs substantially from manufacturing logistics management, where the emphasis is on modeling volume production. Moreover, the organization and sourcing of materials are becoming increasingly complex across EPC industries due to both global sourcing of materials and the combination of advances in transport technologies and a shortage of professionals. At the same time, EPC customers are demanding faster, more responsive logistics processes and higher quality services. These demands generally involve both more responsive transportation and closer coordination between EPC and project logistics companies. Accordingly, a sound project logistics company selection can be seen as key to the successful transport of EPC cargo and to ensuring the competitiveness of EPC industries (Peng, 2012).

However, there is a lack of exploration on project logistics and its significance when EPC companies challenge to perform project logistics through project logistics company selection despite the value of project logistics in EPC industries. To fill this gap, this study executes an empirical analysis focusing on the crucial factors used by EPC companies in project logistics company selection. This study seeks to help stakeholders and practitioners by analyzing the salient factors for project logistics company selection in EPC industries and draw relevant implications. The priority of project logistics company selection is analyzed using the fuzzy AHP method, after using the fuzzy Delphi method (FDM) with experts. Questionnaires are distributed to EPC companies' employees. After the selection of preemptive evaluation factors by requesting an expert group to answer a questionnaire, the paper presents directions for project logistics company selection by analyzing the importance of and preference for the various selected factors. The rest of paper is structured as follows. The literature are reviewed in the second section, and the methodology is explained in the third section. The empirical analysis is presented in the fourth section. Finally, the fifth section provides a discussion and presents concluding remarks.

Ⅱ. Literature Review

There is no consensus on the definition of "project logistics." After a comprehensive review of the literature, this paper argues project logistics may generally include heavy and oversized cargo transportation in EPC industries. Project logistics companies supply services to the customers involved in EPC projects, regardless of their role as project owner, contractor, or supplier. In this case, logistics requires complex operations such as special handling, chartering of vessels, and heavy-lift services by sea, air, road, or rail. Therefore, it is based on interdependencies between multi-supplier and multi-product environments to coordinate entire project logistics (Sandhu, 2006). Project logistics is characterized by three elements—converging, temporary, and made-to-order—which differentiate it from the ordinary logistics. All incoming materials are converged at the construction site, where the construction effort is directed toward a single product, that is, the processing facility. Additionally, apart from few exceptions, project logistics is temporary, producing one-off construction projects through repeated reconfiguration of project contractors and suppliers. Further, project logistics requires made-to-order supply chains, with every project logistics process creating a new business opportunity (Steyn and Lourens, 2017).

In terms of project logistics, a significant body of research has explored transport scheduling and efficiency. Most scholars adopt a service perspective focused on timely delivery (e.g. time performance, accuracy of transit/ delivery time) (Garcia et al., 2012) and lower cost (e.g. price, cost reduction) (Jin et al., 2018). They also examine logistics capability by focusing on flexibility (e.g. ability to meet future requirement and capacity to adjust to customers' needs) (Naim et al., 2010) and risk management (e.g. risk prevention during natural disasters, piracy, and terrorism) (Feinberg and Gupta, 2009; Kwak et al., 2018). Further, project logistics companies' experience, such as number of contracts (Kaynak and Avci, 2014) and infrastructure/equipment (Huo et al., 2008), were also analyzed. For example, according to Shi and Blomquist (2012), project scheduling is linked to the issues of resource handling, organizational structure, and behaviors of stakeholders that may affect the information split mechanism among different project partners. On the other hand, Jin et al. (2018) advanced a framework to map the effects of project management elements on project cost, and then tested the relationships between project management element and project cost for manufacturing construction projects.

Project logistics may be related to 3PL. A large body of literature explored 3PL transport efficiency (Hamdan and Rogers, 2008), service quality measuring (Gupta et al., 2017), and service quality improvement (Baligil et al., 2011) such as network optimization, and established the framework for measuring logistics performance. For example, Caron et al. (1998) presented a stochastic model for scheduling the transportation of substances to a construction site for the continuity of the construction process. Percin (2009) argued that establishing a flexible and scalable logistics outsourcing network with 3PL providers is a key element in achieving lower costs, responsiveness to market, and enhanced flexibility. The results identified the model of 3PL provider selection can help stakeholders and practitioners understand the strengths and weaknesses of potential 3PL providers using evaluation criteria and sub-criteria. Specifically, according to Aguezzoul (2014), 3PL selection is empirical in nature and related to a region/country, industrial sector, and the logistics activities outsourced. His paper also reviewed the literature on 3PL selection decision in terms of criteria and methods based on the analysis of 67 studies on 3PL selection published during 1994–2013. This paper adopts numerous factors from prior studies on 3PL because the nature of project logistics' is somewhat akin to that of 3PL.

Notwithstanding the extensive body of literature on project logistics and 3PL, there is a lack of investigation that integrates the various factors to be considered by EPC companies selecting project logistics companies. There were also many previous studies regarding selection of only 3PL (Aguezzoul, 2014; Liu and Wang, 2009; Bottani and Rizzi, 2006). To fill this gap, this study conducts an analysis to determine the priorities of EPC companies in selecting project logistics partners. Therefore, this paper shed lights on theoretical foundation based on empirical analysis of EPC companies as well as to provide practical implications to project logistics service providers.

Ⅲ. Methodology

1. Fuzzy Delphi Method

Decision-making in selection problems is often uncertain or unclear. To deal with this vagueness of human thought, fuzzy set theory focusing on the reasonableness of uncertainty due to imprecision or vagueness. A major contribution of fuzzy set theory is its capability of representing vague data (Cebeci, 2009). Ten experts participated in this research to prioritize criteria for project logistics company selection. Based on the evaluation criteria selected for priority ranking, the fuzzy-AHP method is then used to determine the relative importance of each factor. This paper also used expert interviews and the relevant literature on project logistics (including 3PL and partnership selection). FDM is used to repeatedly obtain expert opinions until there is a comprehensive consensus on selecting projects, predicting problems, and resolving problems (Delbecq et al., 1975).

In the selection of evaluative indicators, the FDM proposed by Hsu et al. (2013) is adopted to denote expert consensus using geometric means. The process is demonstrated as follows.

Step 1: Collect expert opinions using a decision group.

After identifying the relevant factors, n experts (decision makers) are invited to determine the importance of factors through a questionnaire using linguistic variables. This study applies triangular fuzzy numbers (TFNs) for evaluating the factors and a geometric mean model (Ma et al., 2011) to determine the experts' group decision. The TFN $\widetilde{T}_A$ is as follows:

$$\widetilde{T}_A = (L_A, M_A, U_A), \tag{1}$$
$$where, L_A = \min(X_{Ai}), M_A = \sqrt[n]{\Pi_{i=1}^{n} X_{Ai}}, U_A = \max(X_{Ai})$$

where i indicates the ith expert, I = 1, 2, ⋯, n; X_{Ai} the factor's weight of the ith expert for criterion A; L_A the bottom of all the factor's weight for criterion A; M_A the geometric mean of all the factor's weight for criterion A; and U_A the ceiling of all the factor's weight for criterion A.

Step 2: Geometric mean M_A of each factor's weight.

This step denotes the consensus of the expert group on the factor's weight, so that the impact of extreme values could be avoided. For threshold factor r, the 80/20 rule is adopted, with r set as 8. This indicates that, among the factors for selection, "20% of the factors account for an 80% degree of importance of all the factors" (Kuo and Chen, 2008, p. 1934). The selection criteria are:

$$If\, M_A > r = 8, this\, factor\, is\, accepted, \tag{2}$$
$$If\, M_A < r = 8, this\, factor\, is\, rejected.$$

For example, the timely delivery/reliability factor was awarded by each of the 10 experts 10, 9, 10, 10, 10, 10, 10, 10, 10, and 10:

$\widetilde{T}_A$=(9, 9.895, 10), where M_A>8, and this factor was accepted.

The other 22 factors were analyzed in the same way, with 16 factors identified by FDM ranking. The details are as shown in Table 2.

2. Fuzzy Set and Fuzzy AHP

Relative criteria weights at the same level can be obtained using pairwise comparisons. A number of selected experts are approached to respond to questions such as “which criterion should be emphasized more in selecting a project logistics company, and how much more?.” The AHP procedure consists of the following steps (Kim and Seo, 2019; Kim et al., 2019; Roh et al., 2018; Ha et al., 2018; Saaty, 1980).

Step 1: Define the pairwise comparison matrix.
Step 2: Establish a pairwise comparison of decision.
Step 3: Define the fuzzy geometric mean and fuzzy weights.

Let r_{ij} be the relative importance judgement on the pair of criteria Ci and Cj (i, j=1, 2, ..., n) by the lth expert. Then, the aggregated weight comparison between Ci and Cj by m experts $(l \in m)$ can be obtained by

$$r_{ij} = \frac{1}{m}(r_{ij}^1 + \cdots + r_{ij}^l + \cdots r_{ij}^m) \quad (3)$$

Next, the synthesized ith criterion weight comparison between Ci and Cj by m experts can be calculated using

$$w_i = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{r_{ij}}{\sum_{i=1}^{n} r_{ij}}\right),\ where \sum_{i=1}^{n} w_i = 1 \tag{4}$$

Step 4: Calculate consistency.

The relative weights, which would also present the eigenvalues of criteria are calculated as

$$A_w = \lambda_{\max^w},\ where\ \lambda_{\max} = \frac{\sum_{j=1}^{n}\frac{\sum_{i=1}^{n} r_{ij} w_i}{w_j}}{n} \tag{5}$$

Another critical characteristic of AHP is the consistency of pairwise judgements by calculating the consistency ratio (CR) in Eq. (6). When the value of CR is greater than 0.1, an inconsistency in pairwise judgements appears and the experts need to revise their pairwise judgements. Therefore, the judgements should have an acceptable CR level of 0.10 or less.

$$CI = \frac{\lambda_{\max} - n}{n-1},\ CR = \frac{CI}{RI} \tag{6}$$

where CI is the consistency index, $\lambda_{\max}$ the principal eigenvalue of the comparison matrix, RI the average random index, and n the number of criteria.

Table-1. Random Consistency Index

size (n)	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40

Step 5: Perform defuzzyfication and rank criteria.

The study determines the best crisp or non-fuzzy values in accordance with the center of area (COA) or center index (CI). The calculation method of the BNP value for each weight (l, m, u) is as follows:

$$BNP\,value = \frac{[(u-l)+(m-l)]}{3}+l \tag{7}$$

Finally, the criteria are ranked using BNP values. The criterion with a larger BNP value is considered to have a stronger effect compared to other criteria.

3. Data collection and Preparation

Extant studies pertaining to project logistics were circulated among experts to obtain better insights into the problem. Due to the absence of a single directory for the respondents' list, we crosschecked multiple directories, such as Korea Customs Logistics Association and Korea International Freight Forwarders Association. Additionally, 10 experts from logistics companies, consisting of CEOs, general managers, and operations managers with professional experience, were selected. From October 15 to January 26, 2018, we interviewed 10 experts using the 23 factors obtained from the literature review. Based on the 80/20 rule, 16 detailed sub-criteria under the four main criteria (general service, logistics capability, organization characteristics, and organization resource) were identified.

Table-2. Key Factors before and after Delphi Analysis

No	Key factors (before:23)	Geometric value	Key factors (after:16))
1	Corporate reputation	6.28	Corporate scale
2	Corporate scale	8.10	CRM
3	Corporate social responsibility	6.15	Engineering technology
4	Customer relationship management (CRM)	8.06	Experience
5	Engineering technology	8.88	Financial stability
6	Experience	9.49	Network/partnership
7	Financial stability	8.25	PLE
8	ISO compliance	6.08	PLV
9	Know-how	7.35	Problem solving flexibility
10	Location	5.24	Reasonable cost
11	Loyalty	6.31	Risk management
12	Network/partnership	8.17	Skilled manpower
13	Project logistics related loading/unloading equipment (PLE)	8.46	The provision of information technology
14	Project logistics related transport vehicle (PLV)	8.65	Timely delivery/reliability
15	Problem solving flexibility	9.69	Transport route planner
16	Professionalism	7.74	Worldwide office
17	Reasonable cost	9.18	
18	Risk management	8.07	
19	Skilled manpower	8.31	
20	The provision of information technology	8.02	
21	Timely delivery/reliability	9.90	
22	Transport route planner	8.14	
23	Worldwide office	8.16	

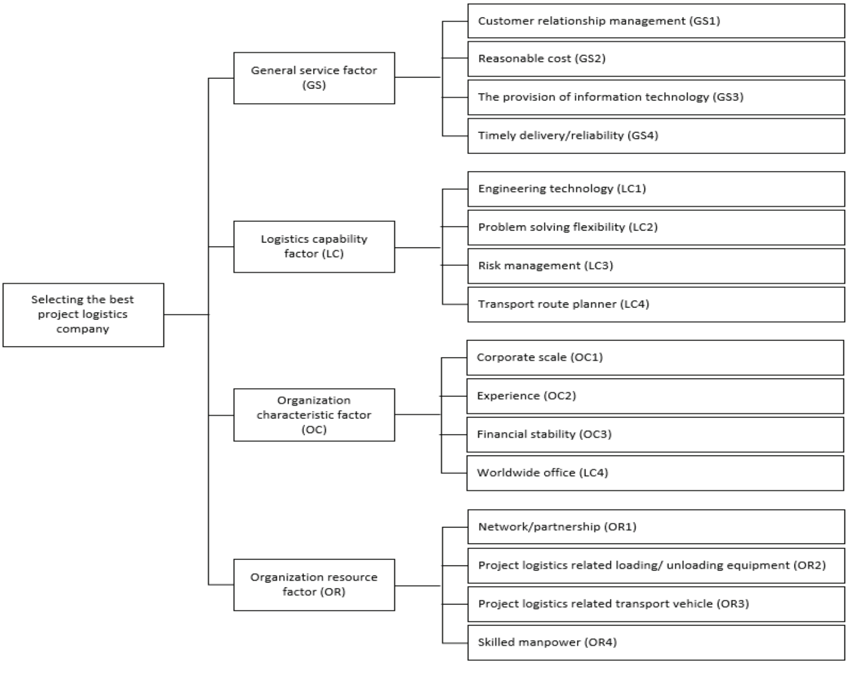
The questionnaire was distributed to EPC companies that had project logistics company selection experience. From February 5 to March 9, 2018, 200 questionnaires were distributed; of these, 51 were returned. The response rate was approximately 26% and 47 valid questionnaires were used for analysis. The respondents ranged from CEOs to managers in business and logistics units. Therefore, a comprehensive and balanced view was ensured.

Table-3. Respondents' Profiles

Position	No	Number of employment year	No	Department	No
Manager	7	5 - 10	14	Purchase procurement	11
Deputy general manager	11	10 - 15	26	Logistics team	17
Department manager	18	Over 15	7	Project team	10
Managing director	8			Site management	6
CEO	3			Etc	3

The overall objective of the decision process for project logistics company selection is at the first level of the hierarchy, the main criteria on the second level, and the sub-criteria on the third level.

Figure-1. Hierarchical Structure of Analysis



Ⅳ. Analysis and Findings

The weighted evaluation matrix is constructed using Eqs. (3)–(7) from the calculated criteria weight. The results are shown in Tables 4 and 5. The results of the general service criteria (M1) indicate timely delivery/reliability (GS4) is the most important factor, followed by reasonable cost (GS2), provision of information technology (GS3), and customer relationship management (GS1). In other words, decision making for project logistics company selection is made based on economic and timely accuracy when EPC companies make decisions. The results of the logistics capability criteria (M2) suggest problem solving flexibility (LC2) is the most important factor, followed by engineering technology (LC1), transport route planner (LC4), and risk management (LC3). It might be argued that factors such as the flexibility of problem solving for timely delivery and essential engineering technology are taken into consideration when EPC companies select project logistics companies in terms of logistics capability. The results of the organization characteristics criteria (M3) show experience (OC2) is the most important factor, followed by worldwide office (OC4), financial stability (OC3), and corporate scale (OC1). Project logistics company selection by EPC companies is sensitive to corporate experience for reliability of the project logistics company. Results of the organization resource criteria (M4) identify project logistics related loading/unloading equipment (OR2) is the most important factors, followed by skilled manpower and transport vehicle (OR3 and OR4) and network/partnership (OR1). Finally, ranking of the sub-criteria for project logistics company selection (Table 5) are as follows. Table 5 shows timely delivery/reliability (GS4) is the most important factor, followed by problem solving flexibility (LC2), experience (OC2), and reasonable cost (GS2).

❙ Table-4. Ranking of Main Criteria ❙

Major criterion	Consistency	Major criterion weight	BNP	Ranking
General service	0.092	(0.251, 0.298, 0.349)	0.299	1
Logistics capability		(0.216, 0.254, 0.298)	0.256	2
Org. characteristics		(0.110, 0.130, 0.156)	0.132	4
Org. resource		(0.145, 0.169, 0.197)	0.170	3

❙ Table-5. Ranking of Sub-criteria ❙

Sub-criterion	Consistency	Sub-criterion weight	BNP	Ranking	Total ranking
GS1	0.010	(0.081, 0.092, 0.105)	0.093	4	16
GS2		(0.251, 0.289, 0.330)	0.290	2	4
GS3		(0.137, 0.156, 0.181)	0.158	3	11
GS4		(0.289, 0.336, 0.384)	0.336	1	1
LC1	0.020	(0.233, 0.279, 0.330)	0.281	2	5
LC2		(0.265, 0.313, 0.362)	0.313	1	2
LC3		(0.090, 0.105, 0.124)	0.106	4	15
LC4		(0.127, 0.151, 0.184)	0.154	3	12
OC1	0.020	(0.128, 0.147, 0.172)	0.149	4	14
OC2		(0.256, 0.304, 0.356)	0.305	1	3
OC3		(0.151, 0.176, 0.205)	0.177	3	10
OC4		(0.194, 0.227, 0.267)	0.229	2	9
OR1	0.010	(0.127, 0.150, 0.179)	0.152	4	13
OR2		(0.201, 0.235, 0.277)	0.238	1	6
OR3		(0.196, 0.230, 0.271)	0.232	2	7
OR4		(0.192, 0.230, 0.273)	0.232	3	8

V. Concluding Remarks

Although the prior literature has mostly analyzed how shippers select third-party logistics companies, research regarding project logistics company selection is overlooked so far. This study contributes to filling this gap by exploring the priority factors when EPC companies select project logistics companies via fuzzy Delphi-AHP. To the best of our knowledge, this study is the first to uncover the project logistics company selection of the EPC companies. This is the most powerful motivation to consider this issue. As such, this study may enhance the better grasp of the importance of project logistics company selection of EPC companies and provide the stakeholders and practitioners with meritorious insights. This paper may also provide a clear understanding of the EPC companies' needs regarding project logistics company selection. Additionally, by benchmarking the results, project logistics managers can determine how to provide efficient services and make prompt adjustments to meet their customers' needs. For example, this paper indicates that decision makers of EPC companies may need to contemplate specific factors such as timely delivery/reliability (GS4), problem solving flexibility (LC2), and experience (OC2) when selecting project logistics companies. Hence, project logistics companies can prepare and provide services to meet EPC companies' requirements. This study supports existing academic studies that focused on a general service (M1) of variety selection problems (e.g. logistics supplier, logistics outsourcing, 3PL, logistics partner selection), such as timely delivery (Bottani and Rizzi, 2006; McGinnis et al., 1995; Spencer et al., 1994;), reliability (Briggs et al., 2010; Mortensen and Lemoine, 2008; Tate, 1996), and reasonable cost (Andersson and Norrman, 2002; Colson and Dorigo, 2004).

Because the problem with project logistics is in managing the time factor, which represents a set of constraints for logistics (Sandhu, 2006), the most important factor is timely delivery and reliability (GS4). For example, regular practice in projects is to ship standard elements in the early phases and more complicated ones in the later stages of the project. Remarkably, although the literature did not focus on project logistics related loading/unloading equipment (OR2) and transport vehicle (OR3), this study found these factors have high priority. The results suggest project logistics selection is slightly different from 3PL selection and other service providers. Because it needs to acquire specialized equipment (e.g. module transporter) and transport vehicles (dedicated vessels, multi-module trailers, barges for heavy cargo) for the transportation of EPC cargo, it is an important factor. Thus, this paper might provide valuable insights for strategies, service capability, and sustainable growth as to meet customers' needs in EPC companies through selecting suitable project logistics companies.

This study has some limitations despite the superiority of it over previous ones. It has been refractory for decision makers involved in project logistics company selection to acquire sound and stable data on their decision making and judgments. Hence, it will be required to find more precise results through more in-depth interviews and surveys. Also, this study might ignore some salient variables such as sound relationship between EPC shipper and project logistics company and the number of accumulated transaction between them, so future research may need to include above variables. When we extract, create, and select variables, we did not calculate the exact percentage of construct or content validity by some techniques such as Q-Sorting test. Therefore, future study may need to employ such test so as to improve content validity. This research has exposed that decision making to select a project logistics company by EPC companies is predisposed not only by general service criteria but also logistics capability ones. However, there may be a methodological critique of whether the criteria is appropriately derived for the fuzzy Delphi-AHP. Therefore, rather than asserting that the fuzzy Delphi-AHP of this study fully reflects all factors in the project logistics company selection, it could continually update the factors that need to be considered.

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