Multimodal transportation via TSR for effective Northern logistics

Perspectives of Korean logistics companies

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Abstract

Purpose – This paper aims to identify the factors that experts consider important for the effective operation of multimodal transport using the Trans-Siberian Railway (TSR) in the Russian Far East and to also establish operational strategies that enable Korean logistics companies to use TSR efficiently for multimodal transportation.

Design/methodology/approach – A total of 65 questionnaires were distributed to predominantly Korean logistics companies/shippers with experience in TSR and 19 replies were received. The majority of the respondents are senior executives with at least 10 years of work experience. To identify the factors and present strategies, this study applied the strengths, weaknesses, threats and opportunities -fuzzy analytic hierarchy process (FAHP) method, which is based on complex multiple-criteria decision-making (MCDM) that facilitates decision-makers in considering an operational strategy by calculating the importance of input factors.

Findings – Results from the FAHP indicate that the Strengths is the main factor affecting TSR multimodal transport decisions, followed by the Threats, Opportunities and Weakness factors. In terms of rank, reduction of transportation distance and time are determined as the most crucial factor from the perspective of Korean logistics companies, followed by the northern logistics development plan, the Russian Government's willingness to the development plan, political instability and possible linkages with the Korean ports.

Originality/value – Through a hybrid MCDM analysis of Korean logistics companies, three operational strategies were proposed: foreign direct and small investments in the Russian Far East, Korean logistics

companies implementing a cold-chain logistics service in the fishery industry and a government-led "Block Train Integration System" to secure the minimum threshold volume of cargo for small and medium-sized companies.

1. Introduction

There has been a recent surge in interest in multimodal transport because of global outsourcing and the diversity of end-consumer needs. International multimodal transportation is defined as cargo transport through two or more different modes of transport (UNECE, 2009). The development of intermodal freight transport is vital in terms of the reduction of transportation costs, distance and time for logistics companies and shippers (Seo *et al.*, 2017a, 2017b). In addition, businesses are deeply invested in determining optimal logistics routes using multimodal transport so as to enhance customer service quality and cost/time (Wang and Yeo, 2018; Kim *et al.*, 2018). Furthermore, with a growing awareness of the environment, the use of efficient intermodal transport routes can reduce CO_2 as well as other pollutants (Regmi and Hanaoka, 2012).

The main existing logistics route between the European Union (EU) and South Korea is dominated by the Suez Canal. Currently, the supply chain of alternative routes through Far East Russia, Northeast China and Commonwealth of Independent States countries are expanding and is known as the Northern Logistics route from the perspective of Korean logistics companies in practice. The Northern Logistics market has been activated by plans from South Korea, China and Russia to develop Eurasian logistics, including "the New Northern Policy", "the One Belt One Road Initiative" and "the New Eastern Policy", respectively. Regional development programs specialized in Far East Asia have been a topic of discussion for the Russian Government since 2012. Furthermore, Russia launched the Eurasian Economic Union in 2015 to encourage regional economic integration. In particular, a multimodal transport system is being promoted for the improved connection of railways and ports in the logistics and transportation sector (Hong *et al.*, 2014). The seamless connection between the Far East Port and the EU via the Trans-Siberian Railway (TSR) can attract more cargo and increase competitiveness over alternative transport routes such as the Suez Canal. In particular, the high cargo volume contributes economies of scale, resulting in the cost competitiveness of rail networks (Woodburn, 2007).

The development plan between the Russian and Korean Governments for Far East Asia has the potential to be highly advantageous for logistics companies and shippers that operate international multimodal transportation using TSR. This is because TSR, connecting Vladivostok to Moscow, is an alternative route that has geographical advantages in connecting Europe and the Pacific Ocean (Huh *et al.*, 2012). Moreover, TSR is approximately 10,000 km shorter with 20 fewer days of lead-time than the Suez Canal (Kim, 2018). TSR saves up to 80 per cent of airfare, assuming transport from Busan to St. Petersburg (Koo, 2018) and provides an alternative route – which had been blocked by North Korea – through its connection with a port of the Russian Far East. Korea's main export commodities to Russia include automobiles and related components, amounting to $3.1bn as of 2018 (Korea Customs Service, 2018). The port handling volume in the Russian Far East region is approximately 80.48 million tons as of 2018. TSR container cargo volume increased from 1,631,000 forty-foot equivalent units (FEU) in 2016 to 1,941,000 FEU in 2017, with Korean logistics companies mainly using the Vladivostok and Vostochny ports for TSR transhipments. Companies such as Hyundai Glovis Co., Samsung Electronics Co., Hyundai

Mobis Co., Pantos Co. and GM Korea Co. are seeking to use their high-value cargo through TSR. For example, in August 2018, Hyundai Glovis launched the TSR regular express logistics project from the Russian Far East to the EU. In addition, BMW conveyed vehicle parts from Germany to Gyeonggi Anseong using TSR in 2017, possibly activating the European bound TSR multimodal transport (Kim *et al.*, 2019).

The advancement of Northern Logistics may promote the integration of the continent's economic bloc, thereby securing new markets and various import/export routes. Thus, multimodal transport systems that use TSR are highly significant to logistics and shipper enterprises. Several studies have applied the analytic hierarchy process (AHP) and Fuzzy AHP (FAHP) methods to investigate multimodal transportation. Ko (2009) proposed an intermodal transportation network system in Korea using the FAHP and decision support system methods. Qu and Chen (2008) applied a comprehensive multiple-criteria decision-making (MCDM) model to determine the optimal intermodal transport route. Moreover, several studies have adopted the strengths, weaknesses, threats and opportunities (SWOT)-AHP/FAHP methods in fields such as political strategy, energy, productivity, management and investment (Kahraman *et al.*, 2007; Eslamipoor and Sepehriar, 2014; Adar *et al.*, 2016; Gottfried *et al.*, 2018). However, there is a lack of research on multimodal transport TSR in the Russian Far East using SWOT-FAHP. To fill this gap, this study adopted the SWOT-FAHP method to identify the external/internal factors and analyze the importance of the criteria with regards to multimodal transport using TSR in the Russian Far East. Hence, this study proposes operational strategies for multimodal transport of TSR by investigating its SWOT and determining the priorities of these factors. The SWOT-FAHP method is suitable for achieving complex MCDM in considering qualitative and quantitative information about a company's environment and establishing a new tactic that has not been studied (Kurttila *et al.*, 2000). The rest of the paper is set out as follows. Section 2 reviews the literature concerning multimodal transportation and the status of the Russian Far East. Section 3 presents the methods and data collection used for the study. Section 4 reports and describes the results, whereas Section 5 presents the conclusion.

2. Literature review
2.1 Multimodal transport
The diffusion of globalization has increased the demand of differentiated products and customer needs. In response to these demands, global outsourcing is prevailing, and global logistics companies struggle to meet manufacturer/consumer needs while enhancing customer satisfaction. Thus, exporters and shippers, forwarders and third-party logistics are focusing their interest on cutting logistics costs to achieve cost-competitiveness. In particular, the suitable selection of multimodal transport modes or optimal transport routes is able to reduce the cost and transit time and improve end-consumer needs (Banomyong and Beresford, 2001; Seo *et al.*, 2017a, 2017b).

Selecting the optimal multimodal transport route requires complex decision-making. For a precise analysis, both qualitative and quantitative factors should be considered. In the current literature, route selection is mainly classified as a mathematical analysis and MCDM process methods.

The choice of optimal alternative combined transport routes and modes has been applied to the classic economic model by considering cost and time. Empirical studies use multimodal case studies with a cost model (Beresford, 1999; Beresford *et al.*, 2011; Kwak and Seo, 2016; Seo *et al.*, 2017a, 2017b). Such a model provides the best multimodal transport option to users by comparing the cost and time of distance with real data. Beresford *et al.* (2011) investigated the most appropriate multimodal

transport route for transporting iron ore from Australia to China by applying a cost model and case study, considering the characteristics of freight, cost and distance. Other studies included the confidence index felt by decision-makers to the original cost-model (Banomyong and Beresford, 2001; Seo *et al.*, 2017a, 2017b). Eremina and Sohn (2010) investigated the most efficient alternative route regarding the Trans-Korean Railway (TKR) and TSR connections by considering the costs and benefits. Woo *et al.* (2017) proposed the optimal route of transportation of automobile parts from Korea to the USA by applying the inventory-theoretic model.

Additional research comprehensively considered the real data and opinions of experts. For the analysis criteria, both qualitative and quantitative factors were used for ranking competing alternative routes or modes (Tuzkaya and Onut, 2008; Moon *et al.*, 2015; Wang and Yeo, 2016; Wang and Yeo, 2018; Pham and Yeo, 2018). Moon *et al.* (2015) adopted qualitative and quantitative criteria to select the most preferred transport routes from Busan to Berlin using the overall scores of each alternative. Wang and Yeo (2016) presented a method for decision-makers to determine the optimal transport network by combining real data and expert opinions for exporting used-cars. Pham and Yeo (2018) evaluated the determination of competitive transport routes for high value-added commodities from China to Vietnam using the Delphi and Consistent Fuzzy Preference Relations methods. Tuzkaya and Onut (2008) synthetically investigated various criteria for the choice of transport mode freight between Turkey and Germany.

Much of the literature has investigated factors that can enhance the efficiency of multimodal transport. Particularly, the improvement of regulatory measures (Regmi and Hanaoka, 2012), customs services and transport infrastructure (Huh *et al.*, 2012; Bulis and Skapars, 2013), government investment and cooperation with related industries (Woodburn, 2007), delivery costs, complicated paperwork (Huh *et al.*, 2012) and speed/punctuality (Tsuji, 2002) were identified as important. Regmi and Hanaoka (2012) demonstrated that speed and technology improvements can significantly increase the efficiency of multimodal transportation, as well as improve regulatory measures. Bulis and Skapars (2013) indicated that personal education/training should be improved to create international freight transit in Latvia through SWOT methods. Woodburn (2007) discussed that efforts to attract even smaller cargo could create a viable freight. Huh *et al.* (2012) identified customs as the main barrier in operating the TSR and Trans-Chinese Railway (TCR), followed by delivery cost and routing transportation. Tsuji (2002) showed that lower cost competitiveness, speed, punctuality, infrastructure and corporate reliability were key factors in activating TSR. The hierarchical structure of the research presented in this paper was created by taking into account the factors that can potentially increase the efficiency of multimodal transport identified in prior studies.

In terms of the identification of impeding factors perceived by users to suggest strategic options, research has been mainly conducted on the selection of intermodal transport routes in the Eurasian region (Ko, 2009; Moon *et al.*, 2015; Seo *et al.*, 2017a, 2017b; Wang and Yeo, 2018). However, specific research on multimodal transport using TSR in the Russian Far East is rather insufficient. In particular, the advancement of logistics companies in Korea into the combined transit route in the Russian Far East region has not captured researchers' interests. To establish a more specific and systematic strategy, this study attempts to present new insights into the Northern logistics using the SWOT-FAHP method. The results may provide more systematic tactics for companies entering the Russian Far East by quantifying the abovementioned qualitative factors and eliciting priorities.

2.2 An overview of the far East Russia
The TSR extends from Vladivostok to Moscow, measuring at approximately 9,228 km, and has a transportation capacity of approximately 100 to 110 million tons a year (Figure 1). A cargo train bound for Vladivostok-Moscow can normally operate 70 wagons on one freight train and is expected to carry close to 2,800 tons of cargo per freight train. Because Japan first started trading with Switzerland using TSR in the 1960s, the use of TSR had gradually decreased because of complicated custom clearance and lead time uncertainties (Tsuji, 2002). However, Korean logistics companies are becoming active in using TSR to secure additional supply chains, whereas Russia is also attempting to develop Far East regions with the use of TSR. According to Hyundai Glovis at the 2018 Policy Discussion Conference, TSR multimodal transport is able to travel 16,000 km from Busan to St. Petersburg, taking 22 days. In comparison, sea transport using the Suez Canal over 22,000 km takes 43 days (KITA, 2018).

Despite the shorter transportation distance and time spent associated with TSR compared with conventional sea transport, there exist several obstacles that prevent the full advancement of TSR and Northern logistics market (Tsuji, 2002; Yun and Kwon, 2004; Song and Na, 2012; Kim *et al.*, 2019).

2.2.1 Inefficiency of customs clearance. The greatest limitation of TSR is the inefficiency of customs clearance procedures, including complicated customs procedures, excessive customs costs and time, and different customs clearance regulations when transferring transport modes in Russia (Choi *et al.*, 2012; Wang and Yeo, 2016). In general, eight to ten documents are required for the clearance of customs, and all documents must be written in Russian only. In addition, customs clearance inspection rates are high compared with other countries. In particular, for the USA, Germany and Britain, the inspection rate is generally less than 3 per cent, whereas that of Russia is approximately 44 per cent. These high customs clearance costs and the burdensome paperwork result in the inefficiency of multimodal transport (Kim *et al.*, 2019).

2.2.2 Difference of railway gauge. During the Soviet era, a wide gauge (1,520 mm) was used instead of a standard gauge (1,435 mm) to prevent invasion from outside. The transhipment between different gauges inevitably increases the number of days of transport (Seo *et al.*, 2017a, 2017b). Also, damage to the item may occur when the gauge is changed by the Eurasian nations (Kim *et al.*, 2019). During the TSR test run in 2016, the Hyundai Glovis cargo was damaged, with an observed scratching between products.

Figure 1.
Trans-Siberian Railway

2.2.3 Frequent change of freight charge. Korean logistics companies that use TSR are not satisfied with the frequent changes in freight fares, failure to notify fares in advance, and the non-publication of tariffs (Huh *et al.*, 2012; Seo *et al.*, 2017a, 2017b). According to Hyundai Glovis at the 2018 Policy Discussion Conference, freight rate volatility exists because shipping contracts are concluded on a yearly basis for sea transport, whereas TSR contracts on a three months basis. As a result, the fare rate of TSR can vary every three months (Kim *et al.*, 2019).

2.2.4 Low transit time reliability. Although the TSR route can reduce transportation distance and time compared with the Suez Canal, the TSR has a poor punctuality rate. This is attributed to the prioritization by Russia of their domestic cargo rather than foreign cargo, as well as delays in customs clearance procedures, and delays due to gauge transhipment (Huh *et al.*, 2012). The reliability of transit time is key for the continued partnership among network stake-holders and the quality of the transport service (Wang and Yeo, 2016).

2.2.5 Lack of logistics infrastructure facilities. Transportation infrastructure in the Russian Far East is still at the early stage. In particular, there is a lack of both a link system between the port and land transport and transport facilities for storage and distribution (Lee, 2018a, 2018b). The imbalance between East-West imports and exports leads to a shortage of container wagons resulting from a lack of import volume compared with export volume. The shortage of freight wagons and the capacity of the TSR lines negatively affects efficient TSR operations (Hong *et al.*, 2014). Furthermore, Far East ports have the low container-handling capability, despite having suitable natural conditions such as a deep-water level. Therefore, the Russian Far East must improve logistics infrastructure and services for the advancement of international trade (Regmi and Hanaoka, 2012). In addition, the ratio of foreign investment to the Russian Far East is low, adversely affecting infrastructure facilities (Kim *et al.*, 2019).

3. Methodology

3.1 Strengths, weaknesses, threats and opportunities analysis

SWOT analysis is a well-known tool used for the analysis of the internal and external environments of a company. It identifies the strengths and weaknesses of internal factors, and the opportunities and threats of external factors (Figure 2), to establish a business strategy and systematic decision approach (Hill and Westbrook, 1997). The SWOT method is used in various areas for comprehensive decision-making that maximizes strengths and opportunities and minimizes weaknesses and threats (Kahraman *et al.*, 2007).

However, the limitation of SWOT analysis is that important quantitative measurements in decision factors cannot be measured. It is not possible to measure priorities for each group and sub-factor, and the decision-maker cannot determine the ranking of the factors (Eslamipoor and Sepehriar, 2014). The typical SWOT is based on qualitative analysis for the

Figure 2.
The hierarchy presentation of SWOT analysis

judgment of practitioners (Kurttila *et al.*, 2000). This makes it difficult to measure the factors that affect the systematic strategic assessment (Ozcan and Osman, 2009). To overcome this limitation, SWOT analysis can be combined with the FAHP methodology. The AHP method uses a hierarchical classification of multiple attributes to identify the importance of each factor and to derive quantitative priorities through pair-wise comparisons (Kurttila *et al.*, 2000).

3.2 Analytic hierarchy process and fuzzy analytic hierarchy process analysis
3.2.1 Overview of analytic hierarchy process/fuzzy analytic hierarchy process. The AHP is a popular methodology for complex multi-criteria decision-making processes. First introduced by Saaty (1977), a number of factors are classified hierarchically, the importance of each factor is obtained by pair-wise comparisons and the relative weights are then analyzed to derive priorities. AHP is based on mathematical methods for the analysis of complex decisions with multiple criteria. It has the advantage of the ability to handle quantitative and qualitative factors. However, traditional AHP methods are associated with high uncertainty levels and the ambiguity of human thinking. The crisp value obtained through pair-wise comparisons between alternatives cannot fully reflect the decision maker's accurate judgment. Fuzzy set theory, introduced by Zadeh (1965), can be used to overcome these problems. Fuzzy sets are used to represent vague objects that show a degree of proximity to one side "0 or 1", unlike certain expressions "0" or "1". Fuzzy set theory can accurately handle judgments of human value that imply uncertainty and vagueness (Zadeh, 1965). Based on this, Van Laarhoven and Pedrycz (1983) proposed the FAHP method in 1983 using the triangular fuzzy number (TFN) (Figure 3). By combining SWOT analysis with AHP, the limitations of SWOT can be overcome (Kurttila *et al.*, 2000). Research using both Fuzzy AHP with SWOT has been performed in several fields (Lee and Lin, 2008; Lumaksono, 2014).

The use of TSR as multimodal for transportation Korean logistics companies may be an MCDM problem pertaining to the widespread uncertainty in relevant fields. Thus, for this study, the FAHP analysis is applied to examine the decisive factors when logistics companies using TSR with regards to multimodal transportation for alternative supply chains.

3.2.2 Implementing strengths, weaknesses, threats and opportunities-fuzzy analytic hierarchy process analysis. By using FAHP methods with SWOT can compensate for the weaknesses of conventional SWOT analysis (Lumaksono, 2014). To deal with ambiguity about human value, linguistic judgment can be converted with the TFN. $\widetilde{A}$, the fuzzy set, has a factor x within X, where the membership function $\mu_{\widetilde{A}}(x)$ indicates a value between 0
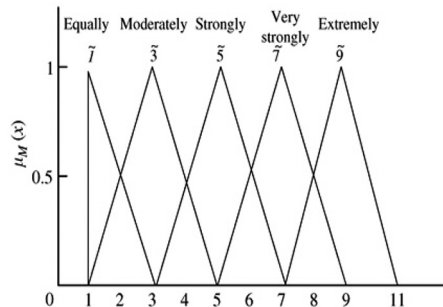

Figure 3.
Triangular fuzzy number (membership function)

and 1. If $\mu_{\widetilde{A}}(x) = 0$, x belongs entirely to A and if $\mu_{\widetilde{A}}(x) = 1$, x does not belong to A. For $0 < \mu_{\widetilde{A}}(x) < 1$, x belongs in part to A. The range of TFN is denoted as (l,m,u) and can be defined as follows:

$$\mu_{\widetilde{A}}(x) = \begin{cases} \dfrac{(x-l)}{(m-l)}, & l \leq x \leq m \\ \dfrac{(x-u)}{(m-u)}, & m \leq x \leq u \\ 0, & x > u; x \end{cases}.$$

In this paper, Buckley's method (Buckley, 1985) is applied to obtain the relative importance weights as follows:

Step 1. Derives the sub-factors of SWOT.

Based on the literature, the sub-factors of each median classification (strengths, weaknesses, opportunities and threats) are identified. For analysis, the number of these sub-factors should not be greater than 10 (Saaty, 1977) (Table 1).

Step 2. Implement a pair-wise comparison between each element within a group.

The relative weight among sub-factors can be determined through pair-wise comparisons using the following matrix $\widetilde{A}$:

$$\widetilde{A} = \begin{bmatrix} 1 & \widetilde{a}_{12} & \cdots & \widetilde{a}_{1n} \\ \widetilde{a}_{21} & 1 & & \widetilde{a}_{2n} \\ \vdots & & \ddots & \vdots \\ \widetilde{a}_{n1} & \widetilde{a}_{n2} & \cdots & 1 \end{bmatrix},$$

where $i = j$, $\widetilde{a}_{ij} = (1,1,1)$, $l_{ij} = \frac{1}{l_{ji}}$, $m_{ij} = \frac{1}{m_{ji}}$, and $u_{ij} = \frac{1}{u_{ji}}$.

Strengths	Opportunities
(S1) Reduction of transportation distance and time	(O1) Active training of logistics professionals in the Russian Far East
(S2) The Northern Logistics development plan	(O2) Increasing cargo volume by government-led efforts
(S3) Possible linkages between Korean ports and Far East Russian ports	(O3) Russian Government's willingness for the development of the Russian Far East
(S4) Possible use of block trains	(O4) The improvement of railway transport system and technology
Weakness	**Threats**
(W1) Complicated and time-consuming customs procedure	(T1) The possibility of trade disputes
(W2) Uncertain punctuality	(T2) Lack of support from the South Korean Government when using multimodal transportation via TSR
(W3) Low cargo safety compared with sea transport	(T3) Political instability with neighboring countries
(W4) Outdated logistics infrastructure facilities	(T4) Frequent freight rate fluctuations

Table 1.
SWOT matrix of Trans-Siberian railway in the Russian far east

Step 3. Determining the value $\widetilde{r}_i$ of the fuzzy geometric mean.
To obtain $\widetilde{r}_i$ can be used as follows:

$$\widetilde{r}_i = \left(\prod_{j=1}^{n} \widetilde{a}_{ij}\right)^{1/n},$$

where $\widetilde{r}_i$ denotes the triangular values.
Step 4. Determining the value of fuzzy weight.
The fuzzy weight $\widetilde{w}_i$ is defined as follows:

$$\begin{aligned} \widetilde{w}_i &= \widetilde{r}_i \otimes (\widetilde{r}_1 \oplus \widetilde{r}_2 \oplus \cdots \oplus \widetilde{r}_n)^{-1} \\ &= (lw_i, \; mw_i, \; uw_i) \end{aligned}.$$

Step 5. De-fuzzify the fuzzy triangular number values and normalize the decision matrix.
As the triangular numbers $\widetilde{w}_i$ are still fuzzy, they need to be de-fuzzification using the best non-fuzzy performance value (BNP) by applying equation:

$$w_i = l_i + \frac{(m_i - l_i) + (u_i - l_i)}{3}.$$

$$i = 1, 2, \cdots, n$$

This is followed by the normalization of the matrix, leading to the normalized matrix $\widetilde{R}$.
The priority of the factors can be obtained according to the BNP values. The larger the BNP value, the higher the priority compared with the other factors (Kim and Seo, 2019).
Step 6. Pair-wise comparison between the SWOT matrix median classifications.
The four SWOT groups (strengths, weaknesses, opportunities and threats) are compared and their relative importance is calculated as in Steps 2-5. These values are subsequently multiplied by the results obtained in Step 6 to determine the overall priorities.
Step 7. Consistency test for logical consistency.
The more consistent the comparison matrix, the closer the maximum eigenvalue λ_{max} is to n (Saaty, 1987). The consistency rate (CR) is denoted as follows:

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

where CI is the consistency value and RI is the random index (Table 2).
A CR equal to or below 0.1 implies that the consistency index of the comparison table is reasonable. If the CR exceeds 0.1, the researcher needs to take appropriate action, such as changing the matrix structure.
Step 8. Alternative tactic determination based on overall SWOT priorities.
The activation plans of TSR multimodal transport are established and a review process is performed. The overall priorities derived through the pair-wise comparisons can be used to allocate efficient resources to the strategic developments of logistic companies. They can also help enterprises in decision-making protocols.

3.3 Data collection
The survey respondents were chosen from Korean logistics/shipping companies with experience in multimodal transport using TSR. In particular, correspondents ranged from the president of the company to operations managers with sufficient knowledge on multimodal transport via TSR. A total of 65 questionnaires were delivered to experts from April to May 2019. In all, 22 of the distributed surveys were retrieved. In accordance with the consistency index, 19 questionnaires fulfilling the conditions (CR less than 0.1) were obtained and three cases were excluded. Accordingly, the total return rate was 29.2 per cent (19/65). Most subjects were the board of directors with at least 10 years' experience within the logistics and shipping industries.

4. Results

4.1 Strengths, weaknesses, threats and opportunities-fuzzy analytic hierarchy process analysis
According to FAHP results, the influence factor and importance weights of each criterion are reported in Table 3. Accordingly, we performed the consistency test. All CR values were less than 0.1. Results indicate that the strengths factor (0.363) is the major factor affecting the decision to use TSR multimodal transport, followed by the threats (0.246), opportunities (0.228) and weakness (0.198) factor. The strengths factor is approximately 1.8 times more important than the weaknesses factor. With regards to the sub-criteria referred to in Table 1, the reduction of transportation distance and time

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

Source: Kim and Seo (2019)

Table 2.
The random consistency index (RI)

Main criteria	CR	BNP	Rank	Sub-criteria	CR	Local BNP	Global BNP	Total rank
S	0.045	0.363	1	S1	0.043	0.409	0.148	*1*
				S2		0.285	0.103	*2*
				S3		0.194	0.070	5
				S4		0.146	0.053	12
W		0.198	4	W1	0.069	0.340	0.067	6
				W2		0.314	0.062	9
				W3		0.161	0.032	16
				W4		0.228	0.045	15
O		0.228	3	O1	0.081	0.246	0.056	11
				O2		0.246	0.056	10
				O3		0.330	0.075	*3*
				O4		0.208	0.048	14
T		0.246	2	T1	0.036	0.259	0.064	8
				T2		0.213	0.052	13
				T3		0.289	0.071	*4*
				T4		0.272	0.067	7

Note: The criteria italic data are having a larger influence than the other criteria

Table 3.
Aggregated evaluation of main criteria

(S1; 0.409), the complicated and time-consuming customs procedure (W1; 0.340), the Russian Government's willingness to push for the economic development of the Russian Far East (O3; 0.330) and political instability (T3, 0.289) were considered as the most definitive sub-criteria in terms of the strengths, weaknesses, opportunities and threats factors, respectively. In terms of rank, shortening the distance and time (S1; 0.148) are reviewed as the most crucial factors from the perspective of Korean logistics companies, followed by the development plan of Korea-Russia (S2; 0.103), Russia's willingness to develop the Russian Far East (O3; 0.075), political instability (T3; 0.071) and connection with Korean ports (S3; 0.070) (Appendix).

From the strengths category, the reduction of transportation distance and time (S1) is rated as the most important factor used to select the optimal multimodal transport route. The Northern logistics development plan (S2) and possible linkages with the Korean port (S3) are following in the ranking of important factors for experts. With respect to the weaknesses group, the complicated and time-consuming customs procedure (W1) is the highest-rated factor by a narrow margin of 0.005 with uncertain punctuality (W2). This was followed by outdated logistics infrastructure facilities (W4), with low cargo safety (W3) having the lowest priority in this group. With regards to opportunities, the Russian Government's willingness to advance the economic development of Far East Russia (O3) was selected as the most significant factor. This was followed by the active training of logistics professionals (O1) and increasing the volume of cargo by government-led efforts (O2), which exhibited the same factor weight. In terms of threats, political instability with neighboring countries (T3) was regarded as the most significant factor. The frequent freight rate fluctuation (T4) and the possibility of trade dispute (T1) were then ranked as the next important factors by experts.

5. Discussion
As interest in the Northern Logistics market grows, Far East countries, including Russia, Korea and China, are pushing for economic and logistic development projects. The Far East Russia region is the starting and arrival point for northern Eurasia. Therefore, Korean logistics companies are seeking to diversify their logistics routes by securing additional supply chains through this region. This study combined SWOT-FAHP methods to assess expert perceptions and present tactics in logistics operations. Based on the results, this study presents plans to activate Northern Logistics for Korea's logistics companies. Also, this multimodal transport route might be used for Japanese logistics companies, being that Japan is an island country, whereas South Korea is similar to an island country due to the presence of North Korea.

This study derives the importance of suggested factors by SWOT group using FAHP analysis. The relative importance among SWOT groups indicates that strength (0.363) has the highest influence followed by threat (0.246), opportunity (0.228) and weakness (0.198). The reduction of transportation distance and time (0.409) in the strength group, the complicated and time-consuming customs procedure (0.340) in the weakness group, the Russian Government's willingness to develop Far East Russia (0.330) in the opportunity group and political instability with neighboring countries (0.289) in the threat group are the highest-weight attributes. This study suggests the following operational strategies by using factors and reference groups.

Several influential factors recognized by Korean logistics companies belong to the strength group. "Reduction of transportation distance and time (S1)," "the Northern Logistics development plan (S2)" and "Possible linkage between the Korean ports and Far East Russian ports (S3)" were among the top five factors. Through a hybrid MCDM

analysis, the results indicate a greater focus on the internal strength of TSR. Furthermore, the results indicated that respondents recognized the strengths criteria (0.363) as the most significant when making decisions. Thus, the strengths group could be used to overcome the threats criteria, which was observed as the second most important factor (0.246). The northern logistics development plan (S2), which is second on the overall global weight ranking list, can be used to establish a suitable strategy. First, foreign direct and small investments need to be made in the Russian Far East, such as Hyundai Glovis' acquisition of the foreign company Adam Paul. China and the Russian Far Eastern regions of Usurisk have experience in creating an industrial complex. Russia's case of establishing an industrial complex with a foreign country has played a positive role in relieving political instability with neighboring countries (Lee, 2018a, 2018b). Therefore, it is vital to establish a partnership with the Russian Government or Russian companies by activating direct and small investments. For example, CJ Korea Express signed an MOU with Russian logistics company Far East Superintendence Co. Ltd. for the strategic cooperation and development of joint projects in 2018 to vitalize the Northern logistics market. Such investments can reduce instability (T3) among countries and secure the reduction of time/distance (S1), recognized as the greatest advantage of multimodal transport using TSR.

The third most influential factor was "Russian Government's willingness for the development of the Russian Far East (O3)." Korean companies viewed the political and financial support of the Russian Government as salient in promoting multimodal transportation via TSR. This is further maximized when combined with the Northern Logistics development plan (S2) in the strengths factor. The strategy of the Korean Government and companies to enter the Russian Far East may prove to be easier if the Russian Government's development projects (O3) are applied. The Russian Government announced a master plan to create a "fishing cluster" in the Far East regions. Thus, Korean logistics companies can tactically implement a cold chain logistics service in the fishery industry. Korea's cold chain features a stable infrastructure and a systematic system (Choi, 2018). CJ Korea Express and Lotte Global Logistics are expanding their business by acquiring logistics companies in China to enter the cold chain market. Based on this business strategy, Korean logistics companies can operate alternative logistical strategies by joint investments with Far East Russia's fishery-related companies and by building strategic cooperation in the cold chain. Moreover, the aforementioned business strategies can be implemented with local companies as a tactic to overcome the uncertain punctuality (W2) from the weaknesses factor. Various logistics strategies, such as cold chains, are important for the creation of customer values and can allow for the differentiation from competitive means of transportation.

The findings demonstrate that the weakness group has the lowest influence. Nevertheless, "complicated customs procedures (W1)" and "uncertain punctuality (W2)" ranked sixth and ninth in the overall weighting. Complicated customs procedures (W1) and uncertain punctuality (W2) also act as important obstacles for logistics companies. Currently, only large companies are able to organize block train freight wagons. Thus, the Korean Government needs to help collect cargo from each small and medium-sized company. Therefore, a government-led "Block Train Integration System" is required to secure the minimum threshold volume of cargo for small and medium-sized companies. An alternative strategy is to form a block train through a long-term contract with a large Russian logistics company. For example, a Korean logistics company or shipper can sign long-term cooperation deals with Russian logistics firms such as Major Logistics Group, DVTG Group and STS Logistics. Contracts with large logistics enterprises are a significant

means of securing regular freight (Woodburn, 2007) and can improve uncertain punctuality (W2). Meanwhile, Ecovis has also attempted to solve the problem of customs clearance by partnering with a local company that has a custom clearance license. A similar partnership with Russia's enterprises can help improve Russia's complicated customs process (W1). However, the Russian Government might implement reforms for a fundamental solution to complex customs clearance differences (Lee *et al.*, 2015). The demand for many documents, the use of just Russian and bribery by customs officials are obstacles compared with other competing routes such as TCR. Therefore, a flexible operation may enhance the TSR's competitiveness. The Russian administration can benefit from a business mindset to encourage the creation of national wealth and economic advances.

In terms of academic significance, TSR is approximately 10,000 km shorter with 20 fewer days of lead-time than the Suez Canal (Kim, 2018). TSR saves up to 80 per cent of airfare, assuming transport from Busan to St. Petersburg (Koo, 2018) and provides an alternative route – which had been blocked by North Korea – through its connection with a port of the Russian Far East. Logistics companies and shippers should search for alternative routes that enhance the competitiveness of supply chains (Aguezzoul, 2014). TSR is an alternative to the Suez Canal route, but no practical related research has been conducted. This study has been able to determine which factors influence (and by how much) the multimodal transport using the Russian Far East TSR of Korean logistics enterprises. By compiling perspectives and surveys from experts, comprehensive strategies were put forward using both external and internal factors. This study provides academic value by synthesizing the opinions of Korea's logistics practitioners who use TSR. However, freight subject characteristics were not specified. Therefore, future research should aim to include detailed strategies that identify whether the carrier is bulk or container cargo.

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Appendix

Perspectives of
korean
logistics
companies

307

The results of entire fuzzy pair-wise matrix	P1	P2	P3	P4
P1	(1, 1, 1)	(2.590, 3.130, 3.637)	(0.904, 1.158, 1.414)	(1.047, 1.368, 1.682)
P2	(0.275, 0.319, 0.386)	(1, 1, 1)	(0.707, 0.904, 1.257)	(1.225, 1.414, 1.607)
P3	(0.707, 0.863, 1.107)	(0.764, 1.003, 1.317)	(1, 1, 1)	(0.622, 0.760, 0.955)
P4	(0.795, 1.107, 1.414)	(0.622, 0.708, 0.816)	(1.047, 1.316, 1.607)	(1, 1, 1)

Table AI.
Fuzzy pair-wise matrix of the primary criteria

The results of entire fuzzy pair-wise matrix	S1	S2	S3	S4
S1	(1, 1, 1)	(0.692, 1.189, 1.414)	(2.115, 2.711, 3.253)	(3.440, 3.936, 4.409)
S2	(0.707, 0.841, 1.039)	(1, 1, 1)	(0.760, 1.002, 1.495)	(2.590, 3.130, 3.637)
S3	(0.307, 0.369, 0.473)	(0.669, 1.003, 1.316)	(1, 1, 1)	(1.377, 1.627, 1.911)
S4	(0.669, 1.010, 1.316)	(0.275, 0.319, 0.386)	(0.523, 0.615, 0.726)	(1, 1, 1)

Table AII.
Fuzzy pair-wise matrix of the strengths criteria

The results of entire fuzzy pair-wise matrix	O1	O2	O3	O4
O1	(1, 1, 1)	(0.615, 0.760, 1.104)	(2.449, 3.027, 3.557)	(1.189, 1.861, 2.449)
O2	(1.011, 1.316, 1.627)	(1, 1, 1)	(0.639, 0.795, 1.057)	(2.340, 2.913, 3.440)
O3	(0.281, 0.330, 0.408)	(0.946, 1.257, 1.565)	(1, 1, 1)	(0.398, 0.517, 0.639)
O4	(0.946, 1.257, 1.565)	(0.291, 0.343, 0.427)	(1.565, 1.934, 2.515)	(1, 1, 1)

Table AIII.
Fuzzy pair-wise matrix of the weaknesses criteria

The results of entire fuzzy pair-wise matrix	W1	W2	W3	W4
W1	(1, 1, 1)	(0.991, 1.245, 1.495)	(0.489, 0.595, 0.719)	(1.047, 1.368, 1.682)
W2	(0.669, 0.803, 1.007)	(1, 1, 1)	(0.669, 0.841, 1.136)	(1.225, 1.414, 1.607)
W3	(1.392, 1.682, 2.045)	(0.880, 1.189, 1.495)	(1, 1, 1)	(1.367, 1.614, 1.896)
W4	(0.880, 1.189, 1.495)	(0.622, 0.707, 0.816)	(0.523, 0.615, 0.726)	(1, 1, 1)

Table AIV.
Fuzzy pair-wise matrix of the opportunities criteria

The results of entire fuzzy pair-wise matrix	T1	T2	T3	T4
T1	(1, 1, 1)	(2.449, 2.991, 3.500)	(0.251, 0.289, 0.346)	(1.075, 1.456, 2.000)
T2	(0.286, 0.334, 0.408)	(1, 1, 1)	(0.537, 0.669, 0.841)	(2.000, 2.590, 3.130)
T3	(2.893, 3.464, 3.984)	(1.176, 1.479, 1.848)	(1, 1, 1)	(0.316, 0.380, 0.485)
T4	(1.189, 1.495, 1.861)	(0.319, 0.386, 0.500)	(2.060, 2.632, 3.162)	(1, 1, 1)

Table AV.
Fuzzy pair-wise matrix of the threats criteria

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