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Economic Ripple Effect of the TKR on the Logistics Industry

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Abstract

Purpose: The purpose of this study is to analyze the economic ripple effect(ERE) of logistics industry by construction of Trans-Korea Railway (TKR) and present policy measures to minimize the economic loss of South Korea (SK). **Research design, data and methodology:** As the analysis method, exponential smoothing was used for demand forecasting, Input-Output analysis was used to estimate the economic ripple effect coefficient, and scenario analysis was used to an efficient way to invest in TKR to minimize SK's economic losses. **Results:** 1) the production(logistics fares) of TKR for 10 years after its completion is about 11.42 trillion won in positive relations, and 26.89 billion won in negative relations. 2) the ERE of SK in positive relations is 24.32 trillion won in production inducement effect, 8.1 trillion won in value-added inducement effect, 3.54 trillion won in import inducement effect, and 70,930 persons in employment inducement effect . But the ERE was insufficient in the negative relations. 3) SK's efficient investment method is providing materials and equipment by SK and building the TKR by North Korea in positive inter-Korea relations. **Conclusions:** For the successful operation of TKR, international cooperation, legalization and stable peace settlement on the Korean Peninsula are required.

Keywords: Logistics Industry, TKR, Production Inducement, Value-added Inducement, Import Inducement, Employment Inducement

JEL Classification Code: A14, A19, R11, R15, R41

1. Introduction

Trans-Korea Railway (TKR) refers to a railroad that connects North and South as one by reconnecting railway sections that were cut off due to division of the Korean Peninsula. TKR has a very symbolic meaning of overcoming the division of the Korean peninsula and establishing a peace regime. In addition, new economic value can be created by linking with major lines in the Asian continent.

Accordingly, the government is promoting the TKR project as part of the New Deal policy and the New Economy initiative and is expecting a great economic effect. The economic effect of TKR is expected to be significant when tourism, substitution of North Korea (NK) mineral resources imports, trade expansion, and logistics effects are combined. In addition, if TKR is completed, the east coast of Korea is expected to develop into a logistics hub. In addition, the use of the Eurasian continental railroad, including China and Russia, connected to NK will significantly reduce logistics costs in South Korea(SK).

When the TKR business is realized, it is expected that the Gyeongui Line will handle 150 million tons and the Donghae Line will handle 130 million tons of cargo in 2030, and the transport demand for the entire Korean Peninsula will be more than 100 million tons. (Lee & Chung, 2016).

And when TKR is connected to the Eurasian Railway, the logistics effect of TKR is the TKR effect, the Trans-Siberian Railway (TSR) connection effect, and the Trans China Railway (TCR) connection effect.

However, skeptical opinions have also been raised about the effectiveness of the TKR project. This is a concern over the possibility that SK will unilaterally invest

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the cost of railroad construction in NK and fail to recover it. In the past, the experiences of NK's sudden request for a

Therefore, this study seeks to find a way to avoid loss of SK investment resources in the TKR project. The purpose of this study is to analyze the economic effects of the logistics of the TKR project by analyzing production, value added, import and employment induction coefficients using the SK Input-Output analysis. Based on the results of the analysis, we propose a plan to minimize economic losses in SK by analyzing the investment cost scenario of the TKR project, and present policy implications for the TKR project. And the academic implication of this study is that the railroad industry was exogenized in the estimation of the number of relations related to the railroad industry to offset excessive estimates.

2. Literature Review

2.1. TKR, TSR, TCR

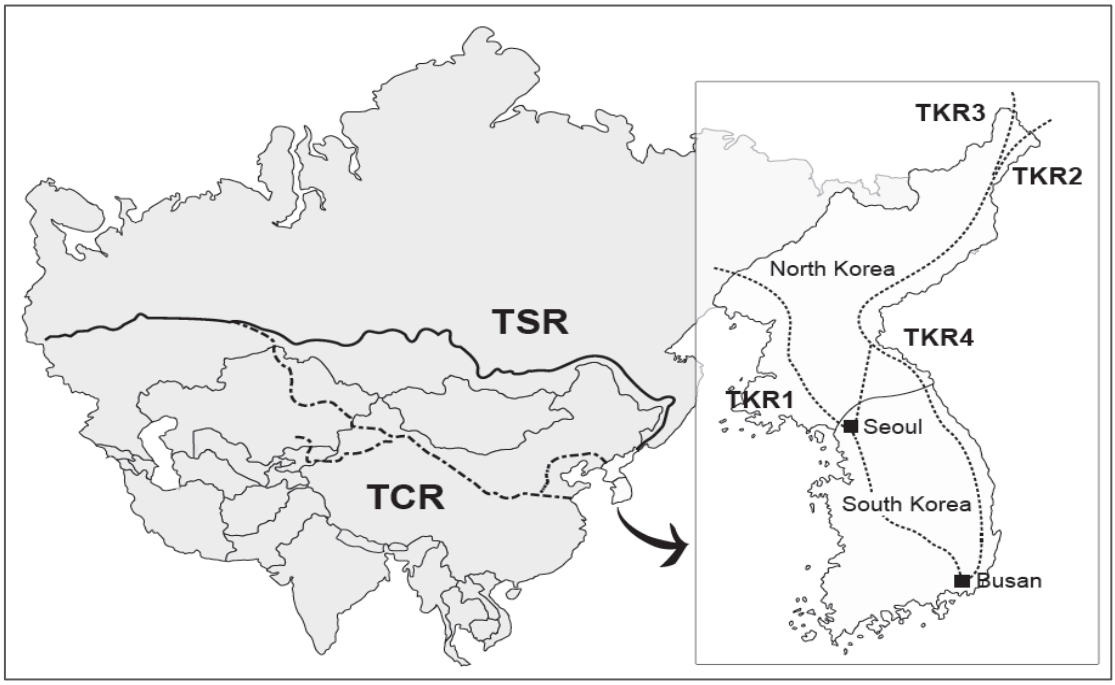
The route of TKR, TCR, TSR is shown in Figure 1 below. According to the Korea National Railway, TKR routes are as follows. The route of TKR1 is Busan,-Seoul-Munsan-Kaeseong-Pyongyang-Shinuiju and is connected by TCR. TKR2's route is Busan-Seoul-Sintanri-Pyeonggang-Cheongjin-Dumangang-TSR. The route TKR3 business suspension in the inter-Korean railroad project are fueling this possibility

is Busan station-Seoul-Sintanri-Pyeonggang-Cheongjin-Hoeryeong-Namyang and is connected by TSR. The route of TKR4 is Busan station-Pohang-Samcheok-Gangneung-Jejin-Wonsan-Najin and is connected by TSR (The Korea National Railway).

TSR's route is Vladivostok-Khabarovsk-Chita-Ulan-Ude-Irksk-Novosibirsk-Omsk-Yekaderinburg-Moscow in Russia (The Korea National Railway).

The route 1 of TCR is Lianyungang-Zhengzhou-Ranzhou-Urmchi- AraSanku in China-Druzba in Kazakhstan-Presgonovka in Kazakhstan, and TSR is connected at the station Zaurali in Russia. The route 2 of TCR is Renyun Port-Arasan in Kazakhstan/Druzhba-Moscow-Berlin-Rotterdam (Zhatkanbaev, Mukhtar, & Suyunchaliyeva, 2015).

Korea is expected to grow as a logistics center in Europe and Asia through TKR's step-by-step strategy and virtuous cycle structure (Lee et al., 2018). TKR's step-by-step strategy is TKR's minimal renovation, reinvestment of logistics business profits, improvement of NK railways, laying the foundation for international logistics expansion, modernization of NK railways, and completion of Eurasian railway lines (Chung, Kim, & Namkung, 2016; Hahn, & Kim, 2016; Jin, & Zhang, 2018; Kim, 2016; Kim, & Song 2019).



Note: Author drawing

Figure 1: Routes of TKR, TCR, TS

However, TKR has low economic efficiency and NK's political problems always exist (Yoo, 2016). Therefore, it is necessary to switch to NK ports and shipping investment that can guarantee profitability, and it is necessary to approach the inter-Korean railroad project through cooperative methods of the international community including the United States, China, and Russia (Chun, & Rhee, 2014; Oh, 2015; Rahman et al., 2020).

Korea is highly likely to develop into a logistics hub in Northeast Asia through the connection of TKR (Roh et al., 2015; Ryu, & Lee, 2011). But it is necessary to find an alternative to overcome the operational difficulties that may arise due to the political risk of NK (Kim, 2018).

2.2. Economic effect of TKR

The current government is promoting the business with strong will, emphasizing the economic effect of TKR. Therefore, research related to this is actively conducted and it is necessary to verify the economic feasibility of TKR, but studies related to the economic effect of TKR are very insufficient, and most of the related studies were before 2010.

Recent studies are as follows.

First, there are studies approached from the perspective of traffic including north-south roads and railroads (Cheng, & Jiang, 2018; Nguyen, Hoang, & Nguyen, 2020).

Ahn (2020) analyzed the economic effect by analyzing the traffic demand and cost of roads and railroads in South and North Korea. This study comprehensively reviewed the continuous demand for inter-Korean exchanges and the demand for SK-NK special zones.

Na (2005) studied ways to improve and expand the inter-Korean transport logistics system. The content of the study estimates passenger and cargo demand divided into positive and negative scenarios.

In addition, there are studies that have analyzed the socio-economic ripple effect of inter-Korean transport cooperation projects (Hae, & Kim, 2018). This study analyzed the time-saving effect of freight forwarding by inter-Korean transport cooperation using conditional value measurement methods, input-output analysis, and multinational multi-regional general balance model.

Second, studies analyzing the economic effect of TKR are as follows.

Kim et al. (2016) classified the cargo traffic volume between the two Koreas into the East Sea and Gyeongui Line, and in the study, the researcher arbitrarily determined the share of the East Sea Line and the Gyeongui Line.

Choi et al. (2012) limited the study to estimate the economic effect by comparing the cargo volume of shipping and railroads to the cargo transport effect. The study to analyze the economic ripple effect of TKR was to estimate the economic effect of logistics and analyze the economic ripple effect of NK. However, the study considered both the logistics effect and the economic ripple effect at the same time, but the target of analysis was limited to the connection of Gyeongui-Line and the renovation effect of Gyeongui-Line.

In addition, the use of the NK Input-Output analysis table that was estimated in previous studies only analyzed the economic ripple effect of NK (Tran, Hoang, Nguyen, Truong & Dong, 2020; Wjaya, Ilmi, & Darma, 2020; Yoo, Nam, & Son, 2005).

2.3. Research Differentiation

There were many discussions on the direction of the TKR project in research related to TKR (Chun, & Rhee, 2014; Kim, 2018; Lee et al., 2018).

Also, there are studies on the economic effect of TKR: 1) The economic effect of the Gyeongui Line connection and modernization discussed during the Gyeongui Line connection project period (Kim et al., 2016). 2) In terms of transportation cooperation, there are studies on the economic effects of road and rail traffic related to traffic (Ahn, 2020; Choi et al., 2012; Hae, & Kim, 2018; Na, 2005).

In addition, studies on the economic ripple effect of TKR analyzed the economic ripple effect of the NK region by using the estimated NK Input-Output analysis (Yoo, Nam, & Son, 2005).

Currently, studies that analyze the economic ripple effect of SK through the use of the SK Input-Output analysis table are insufficient. Therefore, this study used the SK Input-Output analysis table to analyze the economic ripple effect of SK in the TKR project. In addition, a scenario analysis was conducted to minimize the loss of investment resources in SK.

Therefore, the differentiation of this study is the study of ways to estimate the economic ripple effect in SK and minimize financial losses in SK by using SK Input-Output analysis table.

3. Data and Research Methods

3.1. Data

The data for forecasting logistics demand were data from the Korea Customs Service and Statistics Korea. The data are 180 time series data from January 2005 to December 2019 (Korea Customs Service and Korea National Statistical Office). The data consisted of logistics demand between the

following countries: 1) SK and NK 2) SK and Russia 3) SK and China.

The trend of inter-Korean logistics changes is also largely changing in relation to political issues (Kim, 2018). Therefore, in this study, the logistics demand of the two Koreas was also predicted by dividing it into positive and negative.

3.2. Research Question

The Korean government expects TKR Construction to grow into a logistics hub in Northeast Asia. To this end, a huge investment of capital is being planned. In this situation, the need to practically analyze the logistics effect of TKR is raised.

The following research questions (RQ) are examined:

RQ1: What is the economic ripple effect of inter-Korean logistics caused by TKR construction?

RQ2: How much is the economic ripple effect of logistics caused by TKR construction between SK and Russia?

RQ3: What is the economic ripple effect of logistics caused by TKR construction between SK and China?

RQ4: What is the total economic ripple effect of logistics caused by TKR construction?

3.3. Analysis Methods

The analysis method was 1) Exponential Smoothing Method, which predicted the logistics demand of SK-NK, SK -Russia, and SK -China railroad. 2) Assuming the completion of the TKR in 2030, the production costs of railroads in SK -NK, SK-Russia, and SK-China from 2031 to 2040 was calculated. 3) Production inducement coefficient, value-added inducement coefficient, import inducement coefficient, and employment inducement coefficient were calculated using the 2018 Input-Output analysis table of the Bank of Korea (Bank of Korea). 4) Using the calculated output and induction coefficients, we analyzed the logistics economic effect of TKR. 5) Scenario analysis presented an efficient investment plan for SK.

3.3.1. Input-Output Analysis

Input-Output analysis can calculate coefficients by considering the indirect, triggering, and relevance of other industries of individual industries (Lee & Huh, 2020). However, the input-output analysis assumes that the coefficients are invariant and proportional, requires data collection costs, and it is difficult to classify the industries of the collected data. The basic model of the Bank of Korea Input-Output analysis table is shown in Equation (1), and the determinant is shown in Equation (2).

$$\begin{bmatrix} p_{11}p_{12} \cdots \cdots p_{1n} \\ p_{21}p_{22} \cdots \cdots p_{2n} \\ \cdots \cdots \\ \cdots \cdots \\ p_{n1}p_{n2} \cdots \cdots p_{nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ . \\ . \\ X_n \end{bmatrix} + \begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ Y_n \end{bmatrix} - \begin{bmatrix} M_1 \\ M_2 \\ . \\ . \\ M_n \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ . \\ . \\ X_n \end{bmatrix} \quad (1)$$

$$P \cdot X + Y - M = X \quad (2)$$

P: Input coefficient matrix
X: gross product vector
Y: final demand amount vector
M: Income amount vector

This study used a method of exogenizing the railroad industry by input-output analysis of the demand induction model. Through this, the effects of their own sector and those of other sectors were separated.

3.3.2. Production inducing effect

In this study, the production inducement effect means an increase in output of other industries excluding the railroad industry when the production volume (fare income) of the railroad industry increases by 1won. The industry-related analysis model is suitable for analyzing railroad demand because it is possible to correlate the input and output of industry with the intermediate demand and final demand of the railroad industry. Equation (3) is obtained by deriving an exogenous matrix of the railway industry (T), which is the target of analysis, by subscripting 'e'.

$$\Delta X^e = (I - P^e)^{-1}(Z_T^e \Delta X_T) \quad (3)$$

ΔX^e: It is the amount of change in output of other industries excluding the railroad industry. $(I - P^e)^{-1}$: the inverse of Leontief, excluding the railway industry from the input coefficient matrix. Z_T^e is calculated by excluding the column vector of the T part of the input coefficient matrix Q. X_T is the output of sector T. Equation (3) is the production induction effect of the railway industry. The output of the railroad industry includes both direct and indirect effects that affect the output of other industries. Equation (3) can analyze the ripple effect on the total output (total freight income) of the railroad industry (Yoon, 2008; Yoon, 2016).

3.3.3. Value-added inducing effect

The value-added induction effect means that if the production of the railroad industry increases by 1 won, it means the amount of added value increases in other industries excluding the railroad industry. Equation (4) that exogenized the railroad industry in the estimation of the value-added inducing effect coefficient, which is the influence of other industries, is as follows.

$$\Delta V^e = \widehat{P_v^e}(I - P^e)^{-1}(P_T^e \Delta X_T) \quad (4)$$

ΔV^e is value-added of other industries excluding the railway industry. $\widehat{P_v^e}$ is excluding rows and columns of the railroad industry

3.3.4. Import inducing effect

The import inducement (M) effect refers to the increase in imports of industries other than the railroad industry when the output of the railroad industry increases by 1 won. Equation (5) of the import induction effect of exogenizing the railroad industry is as follows.

$$\Delta M^e = \widehat{P_m^e}(I - P^e)^{-1}(P_T^e \Delta X_T) \quad (5)$$

ΔM^e is import effect of other industries excluding the railway industry. $\widehat{P_m^e}$ is excluding rows and columns of the railroad industry

3.3.5. Labor inducing effect

The labor inducing effect of exogenizing the railroad industry is shown in Equation (6).

$$\Delta L^e = \widehat{P_l^e}(I - P^e)^{-1}(P_T^e \Delta X_T) \quad (6)$$

ΔL^e is import effect of other industries excluding the railway industry. $\widehat{P_l^e}$ is excluding rows and columns of the railroad industry.

3.4. Analysis Procedure

The analysis procedure is shown in Fig. 2. The analysis method of this study estimated the economic ripple effect by analyzing the SK Input-Output analysis table.

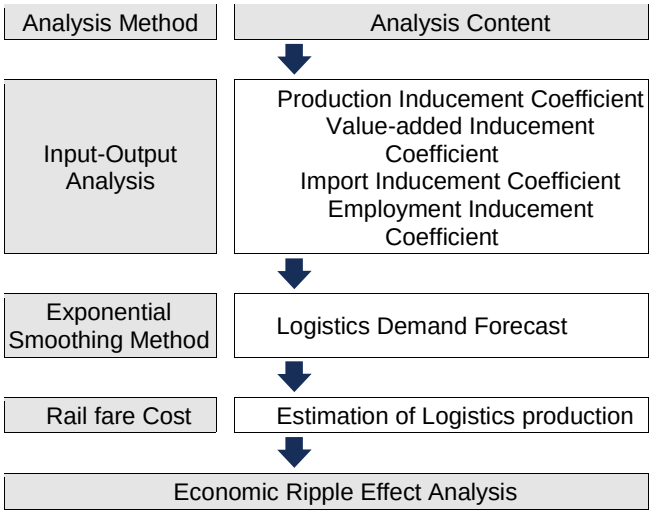


Figure 2: Analysis Method and Procedure

4. Results and Discussion

4.1. Logistics demand forecast

The trend of inter-Korean logistics changes is largely related to inter-Korean relations (Table 1).

Table 1: Inter-Korean Logistics Status

Year	Vehicle (1,000Ton)	Ship (1,000Ton)	Railway (1,000Ton)
2005	659	6,800	-
2006	612	16,310	-
2007	904	25,110	0.2
2008	442	15,060	0.1
2009	230	1,910	0
2010	293	1,068	0
2011	209	2	0
2012	245	1	0
2013	133	1	0
2014	259	41	0
2015	278	255	0
2016	30	0	0
2017	0	0	0
2018	9	0	0
2019	0	1	0

It is difficult to find a certain trend in the volume of inter-Korean trade. The change is great according to the situation of the times.

The data for estimating the logistics demand in North and SK are 180 time series data from January 2005 to December 2019 from the South Korea Customs Service(Korea Customs Service). In addition, data on the volume of goods in Korea-Russia and Korea-China were also used by the Korea Customs Service. The demand for railroad logistics between SK-Russia and SK-China cannot occur if the inter-Korean railroad cannot be used due to political problems between the two countries.

In this study, the logistics demand of the two Koreas was divided into positive and negative to predict. Logistics demand from 2031 to 2040 was predicted by dividing into positive and negative cases. A positive case is the demand when TKR is connected to the Eurasian Railway, and the forecast of logistics demand between SK-NK, SK- Russia, and SK-China. The negative case is the case that the long-term railroad on the Korean Peninsula was stopped due to deteriorating inter-Korean relations.

This study used a method of exogenizing the railroad industry by input-output analysis of the demand induction model. Through this, the effects of their own sector and those of other sectors were separated.

The results of TKR's logistics demand divided into positive and negative inter-Korean relations are shown in Table 2 below.

In NK, about 90% of cargo transportation was used by rail, in Russia about 80% of cargo transportation was handled by railroads, and in China, railroads accounted for 48% of cargo transportation (Yun, 2008; Jung, 2018). This study applied this ratio to the TKR demand forecast.

Table 2: Forecasting the logistics Demand OF TKR

Year	Positive(1,000Ton)			Negative (1,000Ton)
	SK-NK	SK-R	SK-C	
2031	7,851	90,970	79,662	46
2032	13,180	93,900	80,771	47
2033	21,619	96,830	81,880	46
2034	28,983	99,759	82,989	82
2035	34,312	102,689	84,099	82
2036	42,751	105,618	85,208	81
2037	50,115	108,548	86,317	117
2038	57,159	111,477	87,426	118
2039	62,488	114,407	88,536	117
2040	70,927	117,336	89,645	153

4.2. TKR Logistics production forecast

TKR's logistics output was predicted based on the logistics demand forecast. The production volume of the railroad was calculated by the freight rate of the logistics. Logistics freight was calculated using the following equation.

Table 3: Estimation of the Production(fares) of TKR

Year	Positive (100 Millionwon)	Negative (100 Millionwon)
2031	9,782	2.01
2032	10,115	1.46
2033	10,511	1.31
2034	10,887	2.61
2035	11,217	2.81
2036	11,612	2.25
2037	11,983	2.88
2038	12,352	3.42
2039	12,684	3.6
2040	13,078	4.53
Total	114,222	26.89

It was calculated by applying distance (km) × weight (ton) × wage rate (45.9 won). It is the standard for general freight and freight rates of Korea Railroad Corporation(Korea Railroad Corporation). The result of TKR's output (logistics freight) forecast is about 11.57 trillion won for 10 years from 2031 to 2040 when inter-Korean relations are positive. On the other hand, in the negative case, the difference was quite large at 2.73 billion won.

Table 3 shows the results of estimating TKR production (fare) by dividing into positive and negative inter-Korean relations.

4.3. Input-Output analysis Coefficient

In this study, data from the Bank of Korea's 2018 input-output analysis table was used to estimate the railway industry coefficient. The calculated induction coefficients (production, added value, income, employment) are shown in Table 4.

In this study, the railway industry was exogenized to estimate the coefficients of the railway industry. The total coefficients of railway industry were calculated by summing coefficients of industries related to the railway industry and coefficients of the railway industry itself.

The economic ripple effect of the railroad industry has the effect of inducing production of 2.080 won when the railroad industry produces 1 won, and the added value of 0.680 won when the railroad industry produces 1 won. And when the railroad industry produces 1 won, there is an import induction effect of 0.320 won, and there is an effect of inducing employment of 6.45 people per 10 billion won.

Table 4: Coefficient in railway-related industries

Industry	PIC (won)	VIC (won)	IIC (won)	EIC (persons)
A, F1, F2	0.0035	0.0031	0.0015	0.0462
Business	0.021	0.0131	0.0093	0.1957
Chemical	0.0584	0.0136	0.0096	0.0504
Coal	0.0647	0.0049	0.0035	0.003
Construction	0.0034	0.0015	0.0011	0.0166
Culture	0.028	0.0072	0.0037	0.0853
Education	0.0014	0.0003	0.0002	0.0033
Electrical	0.0561	0.0146	0.0104	0.0473
Finance	0.0392	0.0246	0.0174	0.1249
Food	0.0072	0.0032	0.0008	0.0116
Health	0.0091	0.0054	0.0024	0.0479
Information	0.0216	0.0106	0.0075	0.0662
Machinery	0.0394	0.0233	0.0094	0.0825
Metal	0.1013	0.0362	0.0257	0.1521
Mining	0.008	0.0054	0.0038	0.0153
Non-metallic	0.0816	0.0259	0.0184	0.1292
Other	0.0192	0.0097	0.0069	0.0205
Power, gas	0.0693	0.0219	0.0155	0.0299
Precision	0.0059	0.0019	0.0014	0.0124

Professional	0.0545	0.0299	0.0212	0.2759
Admin.	0.0021	0.0018	0.0013	0.0112
Real estate	0.0165	0.0228	0.0091	0.0254
Restaurant	0.0129	0.0058	0.0041	0.1246
2nd Metal	0.2162	0.0338	0.024	0.1184
Textile	0.013	0.0036	0.0025	0.0402
transit	0.0894	0.0364	0.0258	0.587
Trans. Equip.	0.0085	0.0022	0.0016	0.0115
Water, Waste	0.0095	0.0052	0.0037	0.0269
Retail	0.0585	0.0349	0.0247	0.4943
Wood, Paper	0.0139	0.0043	0.0031	0.0406
Railway	1	0.31	0.05	3.35
Total	2.13	0.72	0.32	6.25

Note: PIC: production induction coefficient, VIC: value-added induction coefficient, IIC: import induction coefficient, EIC: employment induction coefficient, A, F1, F2: Agriculture, forestry, & fishing, Other: Other manufacturing business, Professional: Professional, Scientific, & Service, Admin.: Public administration and defense, Trans.: Transportation, Trans. Equip: Transportation equipment manufacturing business.

4.4. The economic ripple effect of the logistics industry caused by TKR construction

If TKR is completed, SK is predicted to have significant economic effects. In this study, the economic ripple effects of TKR were analyzed from 2031 to 2040 by categorizing them into production, added value, import, and employment inducing effects. The analysis results are shown in Table 5.

In the case of positive inter-Korean relations, for 10 years from 2031, the production induction effect was 24.64 trillion won, the value-added induction effect was 8.2 trillion won, the import induction effect was 3.6 trillion won, and the employment inducement effect was analyzed as 71,828 people. On the other hand, when inter-Korean relations deteriorated, the production induction effect was 25.7 billion won, the value-added induction effect was 1.9 billion won, the import induction effect was 800 million won, and the employment inducement effect was analyzed as 17.

Table 5: The Economic Ripple Effects of the TKR Project

Year	Positive				Negative			
	PIE	VIE	IIE	EIE	PIE	VIE	IIE	EIE
	(100 Million won)			(Persons)	(100 Million won)			(Persons)
2031	20,836	6,945	3,033	6,075	4.26	1.42	0.62	1
2032	21,546	7,182	3,136	6,281	3.10	1.04	0.45	1
2033	22,389	7,463	3,258	6,527	2.79	0.93	0.40	1
2034	23,189	7,730	3,375	6,760	5.55	1.85	0.81	2
2035	23,892	7,964	3,477	6,966	5.99	1.99	0.87	2
2036	24,733	8,244	3,600	7,211	4.79	1.60	0.70	1
2037	25,525	8,508	3,715	7,442	6.13	2.04	0.89	2
2038	26,308	8,769	3,829	7,670	7.28	2.43	1.06	2
2039	27,017	9,006	3,932	7,876	7.68	2.56	1.12	2
2040	27,856	9,285	4,054	8,121	9.66	3.22	1.40	3
Total	243,291	81,097	35,409	70,930	57	19	8	17

PIE: production induction effect, VIE: value-added induction effect, IIE: import induction effect, EIE: employment induction effect

Depending on the situation of inter-Korean relations, the economic ripple effect of TKR showed a big difference. This is a result that shows the need for a device to lead the political problems of inter-Korean relations in the progress of the TKR project. Measures to contain NK's unilateral political attitude should be considered from the beginning of the TKR project.

If NK unilaterally disconnects the railroad and fails to take any action, SK will have no way of recovering the cost of the TKR project. If TKR is not available for railroad logistics demand between Korea-Russia and Korea-China, railroad logistics demand between these countries cannot occur.

In this regard, it is necessary to prepare as much as possible a way for Russia and China to participate in TKR construction as a single entity by emphasizing the active foreign policy and economic advantages of Russia and China in the TKR project. In addition, prior to the TKR project, an international agreement to ensure stable and normal operation of TKR must be drawn, and the process of

legalizing it must proceed. With the support of the International Railroad Association and the United Nations, specific responsibilities and sanctions should be prepared when international agreements on inter-Korean railroad operations are not implemented. In addition to such various international participation and support, a plan to establish a lasting peace on the Korean Peninsula is sought together, and constant and active efforts of the two Koreas are required.

4.5 Scenario analysis

The cost of the TKR project required to discuss SK's efficient investment plan in the TKR project depends greatly on the estimation method, such as the design speed and construction method. The costs of the NK railway project discussed so far are as follows: The Korea Institute of Land, Infrastructure and Transport estimated 4 to 37 trillion won. In 2008, the Ministry of Unification estimated 8.6 trillion won for the improvement and maintenance of the Kaesong-Sinuiju road and railway. In addition, in 2014, the Financial Services Commission estimated 85 trillion won for the North Korean railway modernization project. In this study, cost data of Korea Railroad Corporation was used.

The cost of TKR is single track railroad (22.7 trillion won), double track railroad (34 trillion won), and electric double track railroad (40 trillion won) when SK invests all the costs.

On the other hand, if SK supplies materials and equipment, and NK constructs the NK part of TKR, it costs about 1/10 of that of SK investing all the costs. Specifically, the cost is single track railroad (2.6 trillion won), double track railroad (3.94 trillion won), and electric double track train (4.5 trillion won).

Therefore, 6 scenarios for the investment plan of the TKR project were composed. All scenarios assumed that inter-Korean relations were positive. Scenario 1: Construction of a single-track railway in which SK invests all costs, Scenario 2: Construction of a double-track railway in which SK invests all costs, Scenario 3: Double-track train in which SK invests all costs, Scenario 4: SK invests in materials and equipment Construction of a single-track railroad provided and constructed in NK, Scenario 5: Construction of a double track railroad built in NK while SK provides materials and equipment, Scenario 6: Construction of a double track railroad built in NK while SK provides materials and equipment .

The period for recovering SK's investment costs by scenario was analyzed (Table 7). When all expenses are invested in South Korea, the payback period is as follows. Single-track railways are expected to be 6 years, double-track railways 10 years, and double-track railways 11 years. If South Korea provides materials and equipment and constructs in North Korea, the payback period is as follows. Single track is 1-year, double track is 1 year, and double track is 1 year. On the other hand, in negative inter-Korean relations, it was analyzed that it took a considerable period of time to recover South Korea's investment in all scenarios. This is a result that shows that if inter-Korean relations deteriorate, it is impossible for South Korea to recover the expenses invested in the inter-Korean railway project.

Table 6: The Economic Ripple Effects of TKR Project

Scenario Type				Payback Period (Years)	
Development Type	**Scenario**	**Line**	**Cost (Trillion won)**	**Positie**	**Negative**
SK(All cost)	Scenario 1	Single track	22.65	6.2	635.21
	Scenario 2	Double track	34.05	10.1	824.72
	Scenario 3	Electric Double track	39.85	11.2	901.31
SK(materials, equipment) NK(Constructing)	Scenario 4	Single track	2.61	1.01	65.71
	Scenario 5	Double track	3.91	1.02	85.42
	Scenario 6	Electric Double track	4.47	1.01	92.31

4.6 Efficient Investment Plan for TKR

SK's efficient investment plan for TKR is that SK provides materials and equipment and builds it in NK (Scenarios 3, 4, 5). With this method of investment, once the inter-Korean railway is completed and rail transport to Russia and mainland China becomes possible, it is possible to recover the cost invested in the inter-Korean railway in a short period of time. The worst-case scenario is that after SK invests all costs, including materials and equipment, in the inter-Korean railroad project, if NK declares a unilateral severance, as in the past experience of inter-Korean economic cooperation, SK's economic loss will be enormous. Considering this situation, it is necessary to prepare a commercialization plan as a way to minimize the damage to SK in the construction of TKR.

5. Conclusions

If TKR is completed and connected to the Eurasian Railway, its economic value is expected to be significant. Through this, Korea is expected to have great economic growth and potential for development as a logistics hub in East Asia. However, it is true that there are pessimistic views on the inter-Korean railway project. The NK attitude of declaring a unilateral severance due to political issues in the past inter-Korean economic cooperation projects makes it impossible to rule out these concerns. NK's sudden attitude should reflect on the economic losses that SK had to bear.

Therefore, this study seeks to find a way to avoid loss of SK investment resources in the inter-Korean railway project. In the meantime, in the analysis of the economic effect of the inter-Korean railroad project, there has been no study that analyzed the economic ripple effect of SK using the SK Input-Output analysis table. Therefore, this study used SK's Input-Output analysis table to analyze the economic ripple effect of SK in the inter-Korean railway project. In addition, a scenario analysis was conducted to minimize the loss of investment resources in SK.

The analysis results are as follows. 1) The economic ripple effect generated by SK through TKR is that from 2031 to 2040, when inter-Korean relations are positive, the production induction effect is 24.64 trillion won, the added value induction effect is 8.2 trillion won, the import inducement effect is 3.6 trillion won, and the employment inducement effect is It was analyzed as 71,828 people. 2) When inter-Korean relations deteriorate and Russia and China cease to operate and inter-Korean exchanges are insufficient, production inducement effect is 25.7 billion won, added value induction effect is 1.9 billion won, and import inducement effect is 800 million won. And the employment inducement effect was analyzed as 17 persons. 3) In the case of positive inter-Korean relations, when SK invests all the expenses, the payback period for SK's investment costs is 6 years for single track railroad, 10 years for double track railroad, and 11 years for double track railroad. And if SK provides materials and equipment, and construction is conducted in NK, the payback period for SK's investment costs is one year for single-track trains, one year for double-track trains, and one year for double-track trains. On the other hand, in negative inter-Korean relations, it was analyzed that it took a considerable period of time to recover SK's investment in all scenarios.

Based on the above analysis results, the policy implications of the inter-Korean railway project are as follows. 1) When conducting the TKR project, it is necessary to actively seek ways for Russia and China to participate in the inter-Korean railway project by emphasizing the foreign policy and economic advantages of Russia and China. 2) Prior to the implementation of the TKR project, an international agreement to ensure stable and normal operation of the inter-Korean railways must be drawn and legalized. 3) With the support of the International Railroad Association and the United Nations, specific responsibilities and sanctions should be prepared when international agreements on inter-Korean railroad operations are not implemented. Together with such diverse international participation and support, a plan to establish a lasting peace on the Korean Peninsula must be sought together, and constant and active efforts of the two Koreas must be preempted.

This study analyzed the economic effect considering the connection between TKR and TSR, and TKR and TCR. Limitations and future research directions of this study is to analyze the economic effects of TKR and TMGR (Trans-Mongolian Railway), and TKR and TMR(Trans-Manchurian Railway).

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