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Impact Analysis of Economic Linkages of South Korea with North Korea Using a CGE Model

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Impact Analysis of Economic Linkages of South Korea with North Korea Using a CGE Model (draft version)

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ABSTRACT: The purpose of this paper is to estimate impacts of core infrastructure investments in North Korea on South and North Korea. The investment expenditures of core infrastructure projects in North Korea are calibrated as 9.35 billion US\$ including highway, railroad and industrial complex. Since South and North Korea are based on market and planned economies respectively, the Computable General Equilibrium model is applied to the economic analysis of South Korea and an Input-Output Model for that of North Korea. The base year for the analysis is year of 2007 due to the data availability of North Korea. The CGE model for Korean economy accounts for the economic behavior of producers and consumers on the real side economy, following the neoclassical elasticity approach such as market-clearing prices, the maximization of a firm's profit, and a household's utility. This paper finds that the annual total output of North Korea would increase by 20.30 billion US\$ with investments on infrastructure projects. This could result in increases of GDP of Korea by 2.16 billion US\$ as a construction effect and by 0.08 billion US\$ as an operation effect on the annual average.

KEY WORD: CGE Model, Infrastructure, Economic Impact (D58; O18)

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1. Introduction

Economic structure of South Korea is market-oriented, but North Korea has a planned and non-pecuniary incentive system with few contribution of resource allocation under a market system. Each economic principle could affect an economic development pattern and growth consequence: the per capita incomes of South and North Korea in 2012 were 27,830 and 1,370 US\$ respectively. In a sense that this disparity could cause to further increase social costs of socio-economic conflicts¹, it is necessary to formulate an economic cooperation system of two Korea with infrastructure development of North. Two national parts started to discuss the cooperation issue through ‘The Agreement on the Implementation of Trade and Economic Co-operation and the Establishment of the South-North Joint Economic Committee’ in 1985, but there have been great fluctuations in the economic ties over the past 40 years. For example, ‘Sunshine policy’ succeeded to open North Korea’s economy through allowing South Korea’s firms to invest on special economic zones of Geasung industrial complex and Mt. Keumkang resort projects in the early 2000s, but most cooperation projects have been temporarily suspended due to military conflicts in Yellow sea in 2010.

The purpose of this paper is to analyze economic effects of core infrastructure projects of North Korea on both Korean economies. Korea Research Institute for Human Settlements (hereafter KRIHS) in 2013 has proposed the core projects including highway, railroad and industrial complex for the integration of Korean peninsula economy, which were selected with program-based approach (see Figure 1). Their annual investment amounts were calibrated as 9.35 billion US\$, and the economic effects are assessed in terms of construction and operation stages. Since two nations have different economic mechanisms for resource allocation and price adjustment, the analytical tools for the impact analysis of North and South Korea are price-fixed and price-flexible models respectively. The benchmark year for the analysis is set to 2007 which is the latest year for data availability of North Korea economies including Input-Output Table.

¹ Wolf (2006) estimated a range between 50 billion US\$ and 700 billion US\$ as the development costs of North Korea, which tends to rely on the development goal and investment periods.

Figure 1 Core Infrastructure Projects



2. Model

Impact Analysis of North Korea

The infrastructure investment effects can be classified into short term effects during the construction phase and long term effects during the operation phase of the project (Kim and Hewings, 2009). The construction investments affect only final demands, but have impacts on the resource allocation by increasing the production of goods and services in the

operation process. The former effect by the infrastructure investments for North Korea is calibrated with the Input-Output (Hereafter IO) model as shown in Table 1, and the latter is with production function approach. The industrial sectors of North Korea are disaggregated into 11 activities; primary industry, mining, light industry, coal and petroleum, heavy industry, utility, construction, sales, transportation and communication, government service, and other service. As discussed in the introduction section, the price fixed model is applied to the this economic analysis since it is not easy to take into account endogenous changes in the commodity and factor input prices in this national economy through there have been a few cases to apply a market-oriented model to North Korean economy such as Computable General Equilibrium (CGE) Model (Noland *et al.* 1997, 2000; Nolard *et al.* 2000, 2001). In particular, the output level is estimated with the Cobb-Douglas technology of not only the labor and capital stock inputs but also spatial accessibility, because the core investment projects in this paper are expected to affect travel times and volumes. The accessibility is derived from a gravity type of minimum distances and population size by city and county level, measuring the level of services provided by a transport network and ease of access to opportunities across spatial distances.

Table 1 Calibrated Input-Output Table for North Korea in 2007

2007	1	2	3	4	5	6	7	8	9	10	11	Sum	Consumption	Investment	Export	Output	Import	Supply
Primary industry	1.46	0.19	1.17	0.00	0.08	0.00	0.04	0.00	0.00	0.06	0.00	2.99	5.55	0.26	0.28	8.76	0.31	9.08
Mining	0.07	0.02	0.02	0.15	1.36	0.28	0.19	0.00	0.00	0.68	0.00	2.77	0.09	1.01	0.26	3.94	0.20	4.14
Light industry	0.90	0.14	2.18	0.00	0.48	0.04	0.46	0.00	0.06	0.43	0.06	4.75	1.45	0.00	0.13	5.95	0.38	6.33
Coal and petroleum	0.03	0.07	0.01	0.01	0.04	0.09	0.01	0.00	0.16	0.01	0.01	0.44	0.00	0.00	0.00	0.24	0.21	0.45
Heavy industry	0.82	0.35	0.63	0.00	4.17	0.16	1.74	0.00	0.09	1.43	0.01	9.42	0.17	0.98	0.29	10.08	0.77	10.86
Utility	0.01	0.18	0.15	0.00	0.54	0.22	0.01	0.00	0.01	0.28	0.01	1.42	0.63	0.00	0.00	2.05	0.00	2.05
Construction	0.08	0.01	0.01	0.00	0.04	0.04	0.00	0.00	0.00	2.06	0.18	2.42	0.00	2.45	0.00	4.87	0.00	4.87
Sales	0.00	0.05	0.02	0.00	0.00	0.02	0.01	0.00	0.03	0.00	0.00	0.13	0.00	0.00	0.00	0.14	0.00	0.14
Transportation	0.06	0.04	0.07	0.01	0.08	0.02	0.15	0.00	0.07	0.11	0.03	0.64	0.37	0.18	0.00	1.19	0.00	1.19
Government service	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.08	0.00	0.00	11.08	0.00	11.08
Other service	0.09	0.09	0.07	0.00	0.12	0.04	0.06	0.00	0.02	0.08	0.06	0.63	1.01	0.33	0.00	1.96	0.00	1.96
Sum	3.51	1.13	4.34	0.18	6.91	0.92	2.68	0.01	0.43	5.15	0.35	25.62	20.35	5.21	0.96	50.27	1.88	52.14
Labor	0.91	1.85	0.54	0.01	1.18	0.29	1.42	0.02	0.29	5.83	0.38	12.73						
Capital	4.34	0.96	1.07	0.05	1.99	0.84	0.77	0.10	0.46	0.11	1.23	11.92						
Value added	5.25	2.81	1.61	0.06	3.17	1.13	2.19	0.13	0.76	5.94	1.61	24.65						
Total input	8.76	3.94	5.95	0.24	10.08	2.05	4.87	0.14	1.19	11.08	1.96	50.27						

Source: KRIHS (2013)

Figure 2 Transportation Network of North Korea



Source: KRIHS (2013)

Impact Analysis of South Korea

The CGE model is applied to the impact analysis of the infrastructure investment of North Korea on the economic growth of South Korea. The model specifies the behaviors of 11 producers, one representative household, one government, and the rest of the world. The model follows the neoclassical elasticity approach of Robinson (1989) to reflect simultaneous determination of prices and quantities with limitations on the range of degree of substitution in sectoral supply and demand. The model is composed of sub-blocks such as production, consumption, savings and investment, government revenue and expenditure, foreign and interregional trade, and capital mobility in the real side economy. The industrial classification is the same as the North Korean case for an analytical consistency. In the commodity market, each production sector is assumed to produce a single representative commodity and chooses an optimal set of factor inputs to maximize profits. Production consists of two-tiers: at the top, the gross output by sector is

determined as a two-level production function of value-added and composite intermediate inputs. The producer chooses quantities of intermediate demands and values-added using a fixed proportion of gross output, following Leontief production technology. The producer also requires an optimal set of labor and capital inputs in order to produce a given level of value-added and the intermediate inputs are derived from IO coefficients. Each labor input is assumed to be homogeneous and mobile among the sectors, and the labor demand is derived from the first order conditions of the producers' value-added maximization problems. Under the neoclassical closure rule for the labor market, the average wage level is derived from total labor demand and total labor supply, which depends on the population size.

For international trade, the cross hauling is taken into account due to heterogeneity of commodities and the aggregation problem. The consumption of each good is divided into demands for domestic and foreign goods according to the good's origin, and the supplies of products are divided according to the products' final destinations into domestic supplies and foreign exports. The Armington approach is used to distinguish the commodity by industry and place of origin under a small open economy assumption in order to specify imperfect substitutability between the commodities. The solution to the cost minimization problem with the Armington approach yields an optimal level of the ratio of foreign imports to domestic sales. Ultimately, the demand for foreign imports relies on three variables: domestic sales, the price of domestic products relative to the domestic price of foreign imports, and the two key parameters of the share and the elasticity of substitution. In addition, profit maximization with a two-level Constant Elasticity of Transformation (CET) function determines the optimal allocation of the gross output between domestic supplies and foreign exports. The ratio of foreign export to gross output depends on the relative ratio of the price of domestic product to the domestic price of foreign export, the share parameter, and the elasticity of transformation.

The total demand for goods and services by industry consists of intermediate demands, consumption expenditures of households and governments, and private and government investments. Total household income consists of wage, capital income, and exogenous subsidy from the government, and total consumption expenditures are linear function of the total household income, the direct tax rate, and the marginal propensity to save. The household allocates total consumption expenditures to each commodity in order to maximize a Cobb-Douglas type utility function. Household savings are linearly dependent on the household disposable income with a fixed marginal propensity to save. The government expenditures are composed of consumption expenditures, subsidies to producers and households, and savings,

while the common revenue source for the governments is taxation in the form of household income and value-added taxes. In terms of the macroeconomic closure rule for the capital market, aggregate investments are determined by total savings including household savings, corporate savings of production sectors, private borrowings from abroad, and government savings. Overall consistency requires total domestic investment to be equal to net national savings plus net capital inflows, and the average cost pricing rule is applied to determine the price level that clears any excess demand in labor, capital and commodity markets

The development of the CGE model requires a benchmark data set that is internally consistent with overall economic activity and a Social Accounting Matrix (hereafter SAM) is used to track the purchases and expenditures of services and commodities. It consists of six accounts (production, value-added, current and capital accounts of institution, and investment), and is treated as an initial equilibrium for the CGE model.

Table 2 Schematic Structure of SAM of South Korea (unit: billion US\$)

	Production	Value-added	Current account of institution	Capital account of institution	Investment	Total income
Production	1,436.18		1,091.09		287.09	2,814.36
Value-added	964.96					964.96
Current account of institution	413.22	836.06	164.96	14.73		1,428.96
Capital account of institution		128.90	172.91			301.81
Investment				287.09		287.09
Total expenditure	2,814.36	964.96	1,428.96	301.81	287.09	

There are two kinds of parameters: structural coefficients and behavior parameters. The structural coefficients are point estimates or non-elasticity parameters derived from the SAM, and the cross-sectional survey data, which includes various tax rates and consumption propensities. The behavior parameters are derived from the historical data or long-term structural behavior of the economic agents; these data include the elasticities of substitution and transformation in the trade and production equations. All parameters are adjusted so that the model can reproduce the benchmark data of 2007, given the values for policy variables, and a unique solution can be found because the number of endogenous variables is the same as the number of the equations under convexity. The exogenous variables include world market prices,

population, and government expenditure, and the numeraire of the model is set as the price of consumer price index in nominal terms.

3. Analysis

As discussed in section 2, the source of the short run effect is a change in the investment demand to directly increase the output through the expansion of aggregate demand, and that of the long run effect is changes in the capital stock and the relative accessibility. There are two steps are involved in estimating the economic impacts of the infrastructure investments in this paper: (1) calculation of a spatial minimum distance matrix and the resulting accessibility index by infrastructure investments, and (2) injection of the investment expenditures into the IO model for the estimation of construction effects and the accessibility index into the production function for that of operation effects

Table 3 provides the effects of the infrastructure investments on the outputs and GDP of North Korea at the construction and operation stages. If the investment amounts (9.35 billion US\$) are injected into the IO model, the output would increase by 20.30 billion US\$ (37.95% of total outputs at 2007) with few effect on the changes in the GDP due to the model assumption. The construction sector would have the largest benefits of the outputs (6.99 billion US\$), and is followed by the heavy industry (5.20 billion US\$). The annual GDP could increase by 0.23 billion US\$ due to the improvement in the accessibility during the operation periods.

Table 3 Construction Effect of Infrastructure Investments on North Korea (unit: Billion US\$)

	2007 level		Construction		Operation	
	Output	Value-added	Output	Value-added	Output	Value-added
Primary industry	8.7647 (17.44)	5.2522 (21.31)	0.6338 (1.26)	0.3798 (1.54)	0.0662 (0.13)	0.0195 (0.08)
Mining	3.9374 (7.83)	2.8113 (11.41)	1.6055 (3.19)	1.1463 (4.65)	0.0195 (0.04)	0.0058 (0.02)
Light industry	5.9486 (11.83)	1.6091 (6.53)	1.8245 (3.63)	0.4935 (2.00)	0.1767 (0.35)	0.0495 (0.20)
Coal and petroleum	0.238 (0.47)	0.0611 (0.25)	0.2926 (0.58)	0.0752 (0.31)	0.0042 (0.01)	0.0011 (0.00)
Heavy industry	10.0839 (20.06)	3.1705 (12.86)	5.2015 (10.35)	1.6354 (6.63)	0.3175 (0.63)	0.0986 (0.4)
Utility	2.0484 (4.08)	1.1297 (4.58)	3.3616 (6.69)	1.8539 (7.52)	0.0111 (0.02)	0.0033 (0.01)
Construction	4.8690 (9.69)	2.1853 (8.87)	6.0993 (12.13)	2.7375 (11.11)	0.0714 (0.14)	0.0217 (0.09)
Sales	0.1367 (0.27)	0.1254 (0.51)	0.5884 (1.17)	0.5399 (2.19)	0.0002 (0.00)	0.0001 (0.00)
Transportation and communication	1.1929 (2.37)	0.7587 (3.08)	0.3917 (0.78)	0.2491 (1.01)	0.0081 (0.02)	0.0023 (0.01)
Government service	11.0842 (22.05)	1.6100 (6.53)	0.0000 (0.00)	0.0000 (0.00)	0.0948 (0.19)	0.0287 (0.12)
Other service	1.9616 (3.9)	5.9361 (24.08)	0.2963 (0.59)	0.2432 (0.99)	0.0052 (0.01)	0.0015 (0.01)
Total	50.2654 (100)	24.6494 (100)	20.2952 (40.38)	9.3538 (37.95)	0.7748 (1.54)	0.2322 (0.94)

Note: The values in parenthesis is a percentage share to total amounts at 2007

The net benefits to the South Korean economies depends on (1) the size of Official Development Assistant (ODA) or financial subsidy and contribution of South Korea to North Korea for the infrastructure construction as total costs and (2) the leakage effects of the infrastructure investments to South Korea as total benefits. In this paper, there are ten alternatives for market shares of South Korean firms in the North Korea economy from minimum level, 10% to 100% in increments of 10% point. If the market share of South Korean firms remains 50% in the North Korea, it implies that then the firms secure orders worth a total of 10.15 billion US\$. It could increase the GDP by 2.16 billion US\$, while the total supplies and demands by 5.56 billion US\$ and 4.88 billion US\$ respectively. The GDP could go up by 0.083 billion US\$ through the operation effect.

Table 4 Construction and Operation Effects of Infrastructure Projects of North Korea on South Korean Economy
(unit: billion US\$)

1) Construction Effects

Market share of South Korean firm (%)		10	20	30	40	50	60	70	80	90	100
GDP		0.433	0.866	1.298	1.731	2.163	2.595	3.027	3.459	3.890	4.322
Total Demand		0.976	1.953	2.929	3.903	4.879	5.852	6.824	7.798	8.766	9.738
Total Supply		1.114	2.226	3.338	4.450	5.560	6.670	7.783	8.891	10.003	11.110
Value-added	Primary industry	0.019	0.038	0.057	0.076	0.095	0.114	0.133	0.152	0.171	0.190
	Mining	0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	Light industry	0.023	0.046	0.069	0.091	0.114	0.137	0.160	0.183	0.206	0.229
	Coal and petroleum	0.037	0.074	0.111	0.148	0.185	0.221	0.258	0.295	0.332	0.369
	Heavy industry	0.073	0.146	0.219	0.292	0.365	0.437	0.510	0.583	0.655	0.728
	Utility	0.014	0.027	0.041	0.054	0.067	0.081	0.094	0.107	0.121	0.134
	Construction	0.024	0.049	0.074	0.099	0.123	0.148	0.173	0.197	0.222	0.246
	Sales	0.047	0.094	0.141	0.188	0.235	0.282	0.329	0.375	0.422	0.469
	Transportation and communication	0.027	0.055	0.083	0.111	0.138	0.166	0.194	0.222	0.249	0.277
	Government service	0.045	0.090	0.134	0.179	0.223	0.268	0.312	0.357	0.401	0.446
	Other service	0.123	0.246	0.369	0.491	0.614	0.737	0.859	0.982	1.105	1.227

2) Operation Effects

Market share of South Korean firm (%)		10	20	30	40	50	60	70	80	90	100
GDP		0.016	0.033	0.050	0.066	0.083	0.099	0.116	0.132	0.149	0.165
Total Demand		0.042	0.080	0.121	0.161	0.203	0.242	0.282	0.322	0.363	0.402
Total Supply		0.042	0.086	0.127	0.169	0.212	0.254	0.298	0.340	0.383	0.426
Value-added	Primary industry	0.001	0.001	0.002	0.003	0.004	0.004	0.005	0.006	0.007	0.007
	Mining	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Light industry	0.001	0.002	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	Coal and petroleum	0.002	0.003	0.005	0.006	0.007	0.009	0.010	0.012	0.013	0.014
	Heavy industry	0.003	0.006	0.009	0.012	0.014	0.017	0.020	0.023	0.025	0.028
	Utility	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.006
	Construction	0.001	0.002	0.003	0.003	0.004	0.005	0.006	0.007	0.008	0.009
	Sales	0.002	0.004	0.005	0.007	0.009	0.011	0.013	0.014	0.016	0.018
	Transportation and communication	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009	0.010
	Government service	0.002	0.004	0.006	0.007	0.009	0.011	0.012	0.014	0.016	0.017
	Other service	0.005	0.010	0.014	0.019	0.024	0.029	0.033	0.038	0.043	0.047

4. Summary and Further Research Issues

The purpose of this paper is to estimate impacts of core infrastructure investments in North Korea on South and North Korea. The investment expenditures of core infrastructure projects in North Korea are calibrated as 9.35 billion US\$ including highway, railroad and industrial complex. Since South and North Korea are based on market and planned economies respectively, the CGE model is applied to the economic analysis of South Korea and an Input-Output Model for that of North Korea. The base year for the analysis is year of 2007 due to the data availability of North Korea. The CGE model for Korean economy accounts for the economic behavior of producers and consumers on the real side economy, following the neoclassical elasticity approach such as market-clearing prices, the maximization of a firm's profit, and a household's utility. This paper finds that the annual total output of North Korea would increase by 20.30 billion US\$ with investments on infrastructure projects. This could result in increases of GDP of Korea by 2.16 billion US\$ as a construction effect and by 0.08 billion US\$ as an operation effect on the annual average.

As the further research issues, it is worthwhile to estimate the impacts of economic cooperation on the reduction in unification costs. The approach requires a few micro-simulation models including population and migration, transportation network and financial sectors of two Korean economies in a form of dynamic and feedback mechanism. In addition, it is possible to examine an optimal level of ODA of South Korea to the counterpart for maximizing GDP level. On the other hand, an integrated organization needs to be established to promote inter-Korean relationship and international cooperation in order to implement the core projects (KRIHS, 2013). The Korean Peninsula Infrastructure Development Organization (KIDO) could be an example for coordination and planning agency, which is concerned with setting up a preliminary plan and program in collaboration with a primary partner of North Korea and other advisory members of the six-party talks and international institutions.

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