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Economic Impacts to Be Brought by the DPRK's Return to International Society: CGE Analysis with the GTAP 9A Data Base

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Abstract

Recent developments on the Korean Peninsula and worldwide may bring an end to the DPRK's isolation from the world economy. Employing the Global Trade Analysis Project (GTAP) Data Base and the standard GTAP Model (the Model), this paper analyzed the expected economic impacts to be brought by the DPRK's return to international society. However, as the DPRK is not a separate GTAP region, but is represented in the database as part of a composite region of the Rest of East Asia (XEA) along with Macao, the DPRK's data was generated using the SplitReg program, and the resulting data was used as the base data in the Model. The generated data indicated that the DPRK's GDP value was higher by about one-third than those commonly reported in the existing publicly available data.

Upon generating the DPRK data, three economic revitalization and integration scenarios: (i) total factor productivity (TFP) growth in the DPRK; (ii) Korean Unification; and (iii) Northeast Asia free trade agreement (FTA), were considered in the analyses.

The simulation results of assuming that the DPRK's total factor productivity would grow by 30% (60% of labor productivity growth of the ROK between 1963 and 1973) as a result of the country's return to international markets indicated that the DPRK would have a welfare gain of $6.6 billion associated mostly with the gains in technical change along with allocative efficiency improvements and terms-of-trade gains in investment and savings. The government services sector would be the largest beneficiary of these gains, followed by agriculture, extraction, heavy and light manufacturing sectors. Most of the other regions in the model would benefit from welfare gains as well, with the European Union (EU28), China and the U.S. being the largest beneficiaries mainly due to their gains in terms-of-trade in goods and services. The other two scenarios also resulted in welfare gains for the DRPK, but on smaller scales. As a result of the Korean Unification scenario, the DPRK would have a welfare gain of $1.7 billion, while it would be equal to $107 billion in the case of a free trade agreement in Northeast Asia. Contrary to the first scenario, most of these welfare gains were associated with the country's gains in terms of trade in goods and services. In terms of impacts on industry, all sectors will benefit from the TFP growth, while there will be winners and losers in the Korean Unification and Northeast Asia FTA scenarios.

Keywords: CGE analysis, the DRPK's economy, Total Factor Productivity
JEL Codes: D580, O530, D24

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1. Introduction and Prior analyses on economic effect of Korean Unification

Recent developments on the Korean Peninsula and worldwide may bring an end to the DPRK's isolation from the world economy. This would encourage economic cooperation in the Northeast Asia region and stimulate investments associated with the revitalization and reform of the DPRK's economy. Employing the Global Trade Analysis Project (GTAP) Data Base and the standard GTAP Model, this paper analyzed the expected economic impacts to be brought by the DPRK's return to international society. However, the DPRK is not a separate GTAP region, instead, it is represented as part of a composite region of the Rest of East Asia (XEA) region in the database. Thus, prior to the analyses, the DPRK data was generated by splitting the XEA region using the SplitReg[1] - a program to create a new region in GTAP database. The resulting data was used as the input data for building the base Model. The data split process is described in Section 2. Then, three economic revitalization and integration scenarios for the DPRK: (i) total factor productivity (TFP) growth in the DPRK; (ii) Korean Unification; and (iii) Northeast Asia free trade agreement, were experimented. The scenario descriptions and simulation results are provided in Section 3 and the conclusions are in Section 4. Discussion of the simulation results are mainly focused on the DPRK impacts. Effects on other countries were mostly omitted from the discussion, but they can be observed from the corresponding tables provided.

There are many academic works on economic effect analyses of Korean Unification. One major branch of the literature is general equilibrium models that simulate unification scenarios. Noland et al. (2000) was one of the earliest works which used a computable general equilibrium model to analyze economic integration between North and South Korea. They show that economic unification generates large welfare gains for North Korea, in contrast to small gains for South Korea. Bradford and Phillips (2005) and Bradford et al. (2011) applied a dynamic general equilibrium model to examine the impacts of economic reform and unification of North and South Korea. Almost all these papers have developed new macroeconomic and sectoral database and input-output tables of the DPRK for their analyses.

For example, McKibbin et al. (2018) follows this series of research and their paper presents analysis on the economic effect of Korean Unification using a dynamic general equilibrium model with current economic statistics. The main contents of the paper were as follows:

- The paper explores the economic impacts of Korean Unification on North and South Korea. It presents a new consistent database on macroeconomic, sectoral and trade data, and an input–output table for the North Korean economy, and then incorporates it into a global intertemporal multi-sector general equilibrium model. Assuming hypothetical scenarios such as North Korea's reform and gradual convergence, its sudden collapse and immediate unification, and chaos and crises in both Koreas, they quantify the consequences of Korean Unification on economic activity, trade and capital flows in the two Koreas. The results

[1] A detailed guide is explained in Horridge, M., 2011 (2016, 2017).

highlight the importance of the unification processes and of alternative policy responses in both Koreas to the economic impacts of the unification.

- The paper has developed a new macroeconomic and sectoral database for North Korea for 2014. The data has then been used to develop a new model of the North and South Korean economies embedded in a widely used global economic model called the G-Cubed model.
- They incorporate North Korea into the G-Cubed model, which is an intertemporal general equilibrium model of the world economy. The main features of the G-cubed model are outlined in McKibbin and Wilcoxen (2013). The model is based on a combination of explicit intertemporal optimization by the agents (consumers and firms) in each economy and rule of thumb behavior. In contrast to static computable general equilibrium (CGE) models, time and dynamics are of fundamental importance in the G-Cubed model. The result of simulations on the economic effects differ by scenarios, however each was between 300% to 500% growth of the North Korean real GDP.

However, the purpose of this paper was not to develop a new macroeconomic and sectoral database or input-output table for the DPRK. As mentioned earlier, this paper aimed at experimenting the expected economic impacts to be brought by the DPRK's return to international society using the GTAP Data Base and extracting the DPRK data by splitting the XEA region in the database.

2. The Model and Data Split

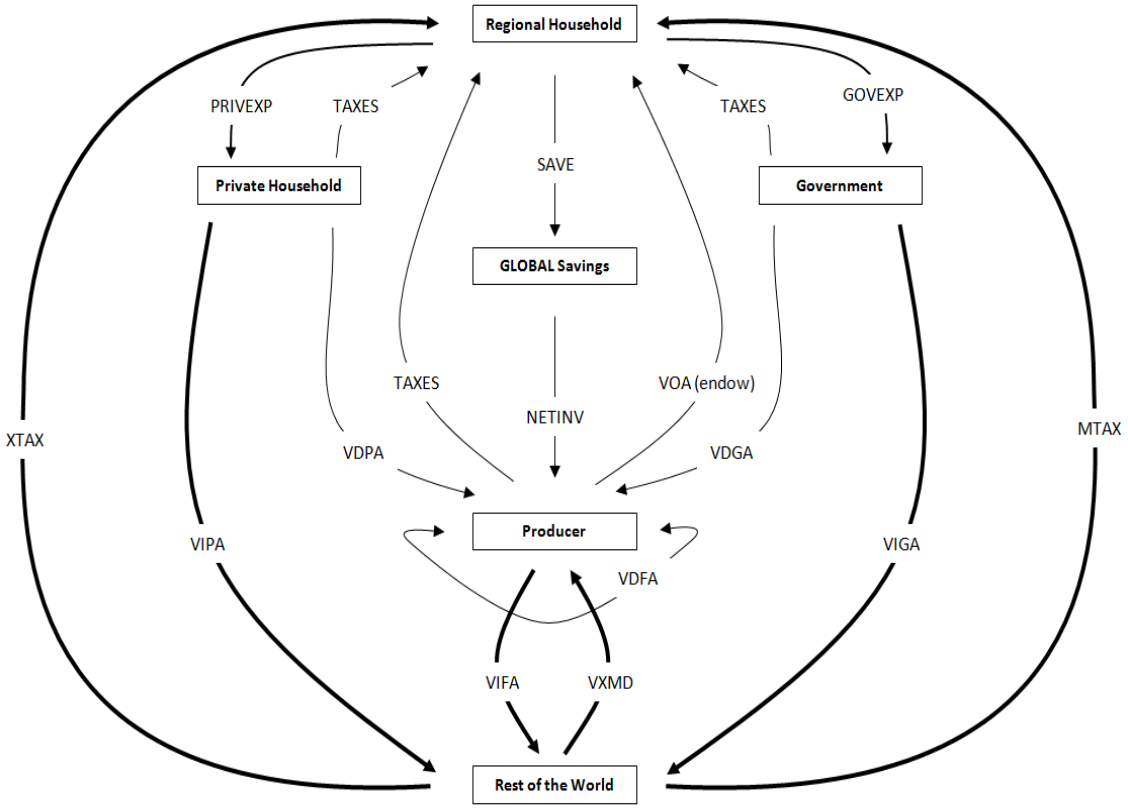
In analyzing the expected economic impacts to be brought by the DPRK's return to international society, we employed the Global Trade Analysis Project (GTAP) Data Base (Version 9A, Apr., 2016, Aguiar, A. et al, 2016) and the standard GTAP Model (Version 6.2, Sep., 2003). The GTAP Model is a multi-region and multi-sector Computable General Equilibrium (CGE) model[2] with perfect competition and constant returns to scale. A CGE model is a system of mathematical equations that describes an economy as a whole and the interactions among its agents. Bilateral trade is handled via the Armington assumption, which provides the possibility to distinguish imports by their origin and explains the intra-industry trade of similar products. It combines detailed bilateral trade, transport and protection data characterizing the economic linkages among regions, together with individual country input–output databases, which account for inter-sectoral linkages. CGE models allow us to quantify economy-wide impacts resulting from shocks to the current economic system in equilibrium.

A simplified illustration of all economic agents in the model and their interactions is provided in Figure 1, which was taken from Brockmeier (1996). This is a graphical expression of a multi-region open economy with government interventions or taxes. In the GTAP data and model all sectors produce a single output; thus, there is a one-to-one relationship between

[2] For more details on the GTAP model and database, refer to Hertel, T. (ed.), 1997.

producing sectors and commodities. The GTAP model makes a zero-profit assumption for producers, so that all the revenues are completely used on expenditure. All firms are homogeneous. As savings and investment are computed on a global basis in the multi-region version of the GTAP model, the savings in the model are denoted by "GLOBAL Savings" The GTAP model incorporates a regional household (termed an "aggregated household" in the CGE modeling framework), associated with each country (e.g. China) or composite region (e.g. XEA). The regional household collects all the income that is generated in an economy. Expenditures by this household are allocated across three broad categories: private (*PRIVEXP*), government (*GOVEXP*), and savings (*SAVE*) expenditures. These represent final demand in an economy and each component roughly maintains a constant share of the total regional income. Modelling the components of final demand via this regional household has the advantage that it enables the control of the condition that no agent can spend more income than it receives. Besides, this concept of a regional household is best suited to compute equivalent variation as a measure of regional welfare resulting from different policy scenarios (Brockmeier, 1996; Figure 2.1).

Figure 2.1 Multi-Region Open Economy with Government Intervention



Source: Brockmeier, 1996.

The GTAP Data Base 9A has triple reference years (2004, 2007 and 2011) and this analysis used data with the reference year of 2011. Thus, the values indicated in this paper are expressed in constant 2011 US$ terms, unless otherwise specified. There are 140 regions and 57 commodities in the database. The model was implemented using the GEMPACK software suite (Horridge et al., 2018).

However, the DPRK is not a separate GTAP region, but it is represented as part of a composite region of the Rest of East Asia (XEA) region in the database. The XEA region comprises of two countries, the DPRK and Macao, Special Administrative Region of China. Therefore, the XEA was divided into two new regions using the SplitReg - a program to create a new region in a GTAP database. The data needed for this split is a table of value-added by new sub-regions, the DPRK and Macao, by GTAP sectors. Before the split, the original GTAP database was aggregated into 13 regions, and then the data generated by SplitReg by adding a new region was used in building the 14-region Model for this analysis. The process of splitting the XEA region into separate regions of the DPRK and Macao is briefly described below.

2.1 Data Aggregation for Input to SplitReg

Considering limited data availability of both the DPRK and Macao, the original GTAP database was aggregated into a 13-region, 8-sector base model by aggregating the original 140 regions and 57 sectors in the GTAP 9A (2011) Data Base (further, the database). It should be noted that communication, financial services, insurance, health and education sectors were aggregated into the government services sector considering that the these services are still entirely provided by the government in the DPRK, although this might not be true for most of the other regions in the analyses. Also, the original eight factors in the database were aggregated into 4 factors: land, labor, capital and natural resources, where land and natural resources are immobile, and labor and capital are mobile factors. These aggregation mappings are provided in the Appendix Tables I, II, III.

According to the database[3], total value of GDP from the expenditure side for the Rest of East Asia (XEA) region equaled $52.3 billion, where household and government consumptions accounted for 45.4% and 15.5% of the total respectively. Investment was equal to 29.6% of GDP or $15.5 billion, while exports and imports were 43.8% and 34.3% of the total, or equal to $22.9 billion and $18 billion respectively (Table 2.1).

In the bilateral time-series trade data of the database[4], the XEA's total exports at current prices totaled $4,096.4 million, whereas total imports of the XEA were $8,498.2 million in 2011. Almost two-thirds of the XEA's total trade turnover was with China. These figures were

[3] *Header: AG01 Coefficient: GDPEXP Size: REG * GDPEXPEND GDPEXP = C + I + G + X - M, GDP from the expenditure side, in BaseView.har*

[4] *Header: VTTS Coefficient: NTSTRD Size: [Sum over TRAD_COMM] [* Sum over REG] [* XEA] [* Y2011] Bilateral Time-series trade data, in tstrade.har*

consistent with data in the Direction of Trade Statistics (IMF, 2015), where the DPRK's total exports equaled $4,064.1 or 99.2% of total XEA exports, while the DPRK's imports accounted for 59.7% of the XEA's total imports (Table 2.2 and Appendix Table V).

Total value-added by firms or the primary factor purchases by firms at market prices for the XEA equals $45.2 billion in the database[5] and their distribution by commodity and production factors is illustrated in Table 2.3. Accordingly, these total values by commodity of the XEA region were divided by the relevant weights of the two new regions, the DPRK and Macao. The process of defining these weights is described in Section 2.2.

Table 2.1 GDP and Expenditure Composition in 2011

Regions	Value, $ Million, current	Composition				
		Consumption		Investment	Export	Import
		Household	Government			
1 China	7,321,874.6	0.363	0.135	0.461	0.267	-0.226
2 Japan	5,905,633.7	0.597	0.202	0.204	0.16	-0.162
3 ROK	1,202,462.7	0.527	0.144	0.31	0.513	-0.494
4 Mongolia	8,760.8	0.473	0.126	0.477	0.71	-0.786
5 Russia	1,904,794.3	0.495	0.185	0.218	0.292	-0.19
6 XEA	52,322.8	0.454	0.155	0.296	0.438	-0.343
7 EAEU4	272,377.7	0.55	0.127	0.265	0.435	-0.377
8 ASEAN9	2,144,075.0	0.578	0.108	0.282	0.568	-0.536
9 ANZI	3,430,954.5	0.587	0.148	0.302	0.205	-0.242
10 Rest of Asia	1,194,499.3	0.668	0.104	0.205	0.543	-0.519
11 USA	15,533,785.1	0.701	0.165	0.185	0.121	-0.172
12 EU_28	17,666,263.0	0.599	0.22	0.19	0.393	-0.403
13 Rest of World	14,839,340.3	0.584	0.168	0.217	0.306	-0.274
Total	71,477,143.7	0.589	0.176	0.235	0.282	-0.282

Source: GTAP 9A Data Base (2011).

[5] *Header: VFM Coefficient: VFM Size: ENDW_COMM * PROD_COMM [* XEA] primary factor purchases, by firms, at market prices, in BaseData.har.*

Table 2.2 Rest of East Asia (XEA) Trade in 2011, $ Million, current

Regions	Export to	Import from	Turnover	Share, %
1 China	2,629.9	5,121.5	7,751.4	61.5%
2 Japan	34.2	208.1	242.3	1.9%
3 ROK	5.2	47.7	52.9	0.4%
4 Mongolia	-	-	-	0.0%
5 Russia	16.1	97.0	113.1	0.9%
6 Rest of East Asia (XEA)	-	-	-	0.0%
7 EAEU4	2.7	1.1	3.8	0.0%
8 ASEAN9	96.2	174.9	271.1	2.2%
9 ANZI	26.7	224.0	250.7	2.0%
10 Rest of Asia	247.9	667.5	915.4	7.3%
11 USA	108.5	302.7	411.2	3.3%
12 EU_28	259.1	891.2	1,150.3	9.1%
13 Rest of World	669.9	762.5	1,432.4	11.4%
Total	4,096.4	8,498.2	12,594.6	100.0%

Source: GTAP 9A Data Base (2011).

Table 2.3 Rest of East Asia (XEA): Primary Factor Purchases, by Firms, at market prices (VFM), $ Million

Sectors	Land	Labor	Capital	Natural Resources	Total
1 Agriculture	1,124.3	1,227.3	345.4	-	2,697.0
2 Extraction	-	278.1	1,199.6	763.7	2,241.4
3 Light Manufacturing	-	1,224.6	922.9	-	2,147.5
4 Heavy Manufacturing	-	1,237.2	899.0	-	2,136.3
5 Utility	-	364.3	482.7	-	847.0
6 Construction	-	1,943.6	660.8	-	2,604.4
7 Government Services	-	6,572.3	4,370.8	-	10,943.1
8 Other Services	-	9,572.7	11,979.3	-	21,552.0
9 Capital Goods	-	-	-	-	-
Total	1,124.3	22,420.0	20,860.6	763.7	45,168.7

Note: VFM= variable in GTAP Model representing firms' primary factor purchases at market prices.
Source: GTAP 9A Data Base (2011).

2.2 User Weights in the SplitReg

The relevant weights or shares of the firms' primary factor purchases (or value-added) at market prices (VFM) to be used to split the XEA region into two new regions, the DPRK and Macao, were estimated based on various available data and the steps were as follows:

i) According to the National Accounts Main Aggregates Database (NAMAD) released by the Statistics Division of the Department of Economic and Social Affairs (DESA) of the United Nations, the respective total value-added of the DPRK and Macao in 2011 was $15,689.3 million and $23,540.9 million at current prices, totaling $39,230.2 million. However, the primary factor purchases by firms at market prices for the Rest of East

Asia region [VFM (XEA)] in the GTAP database that represent total value-added at current prices equaled $45,168.7, which is higher than those reported in the NAMAD. Thus; assuming that the value-added data for Macao in the NAMAD might be the more reliable data, the DPRK's total VFM [VFM (DPRK)] value can be estimated as the difference between the VFM (XEA) in the GTAP database and that of Macao in the NAMAD, which is equal to $21,627.8 million[6]. The discrepancy between the DPRK's data in the NAMAD and the GTAP database was $5,938.6 million, which is equal to 37.8% of the country's commonly reported GDP value in 2011. This suggests that the DPRK's commonly reported GDP value might be 37.8% lower than its actual figure (Table 2.4);

ii) The aggregated sectoral shares of the DPRK's GDP in 2011 was obtained from the Northeast Asia Economic Databook 2018 (ERINA, 2018) and these shares were applied to estimate sectoral distribution of the DPRK's total value-added of $21,627.8 million, obtained in step (i) (Table 2.5);

iii) However, some values were higher than those of VFM (XEA) values; thus, further adjustments were carried out as below (Table 2.6):

- Assuming that Macao has no significant activities in (1) agriculture, (2) extraction and (4) heavy manufacturing sectors, the corresponding total values of the VFM (XEA) in the GTAP database were assigned directly to the VFM (DPRK);
- For (3) light manufacturing, (5) utility and (6) construction sectors, Macao's value-added from the NAMAD were used, and their differences with the corresponding values of VFM (XEA) in the GTAP database were assigned to the VFM (DPRK);
- For (8) other services, the DPRK's share of 8.2% in the NEA Economic Databook was used to estimate this value and it resulted in $1,773.5 million [8.2% of total VFM (DPRK), which is $21,627.8 million]. The difference between this value and that of the corresponding value for the VFM (XEA) was assigned to VFM (Macao), which equaled $19,701.4 million;
- The remaining values were assigned to the (7) government services in each region accordingly. It made up 40.1% or $8,681.4 million of the DPRK's total value-added, while it accounted for $2,307 million or 9.8% of Macao's total value-added.

The resulting values, which are illustrated in Table 2.6, were incorporated into the input of the SplitReg program as the value-added weights by new sub-regions. Comparison of sectoral composition of the DPRK's GDP and Value-Added in 2011 in the Northeast Asia Economic Databook (2018) and those used for the data split is illustrated in Table 2.7. The discrepancies between these data indicate that the value-added of the agriculture, mining and heavy manufacturing sectors of the current commonly reported data are rather over-estimated, while

[6] VFM (DPRK) = VFM (XEA) - VFM (Macao) = $45,168.7 - $23,540.9 = $21,627.8

those of other sectors are under-estimated, especially for the government services sector. The total amount of discrepancy was equal to -$6,015.1 million, or 38.5% of the DPRK's commonly reported GDP of $15,612.8 million in 2011 (Table 2.7).

Table 2.4 DPRK and Macao Value Added by Economic Activity in 2011

Economic Activity	DPRK		Macao	
	Share, %	Value, at current prices, $ Million	Share, %	Value, at current prices, $ Million
Agriculture, hunting, forestry, fishing (ISIC A-B)	23.1	3,616.9	0.0	0.0
Mining, Manufacturing, Utilities (ISIC C-E)	39.7	6,225.0	1.57	369.2
Manufacturing (ISIC D)	21.9	3,443.2	0.72	169.5
Mining*			0.0	0.0
Utility*			0.85	200.1
Construction (ISIC F)	7.9	1,240.0	4.94	1,162.9
Wholesale, retail trade, restaurants and hotels (ISIC G-H)		-	14.8	3,479.2
Transport, storage and communication (ISIC I)		-	3.27	769.5
Other Activities (ISIC J-P)	29.4	4,607.4	75.4	17,760.1
Total	100.0	15,689.3	100.0	23,540.9

Notes: 1. ISIC=International Standard Industrial Classification;
Source: Compiled from NAMAD, 2019.

Table 2.5 Sectoral Composition of Value-Added in 2011

No	Sectors	DPRK's GDP		VFM (XEA) in GTAP 9A (2011) Data Base (Column "Total" in Table 2.3)
		Share in the NEA Databook, %	Estimated values using the NEA Databook shares, $ million, current	
1	Agriculture	23.1	4,996.0	2,697.0
2	Mining	14.6	3,157.7	2,241.4
3	Light manufacturing	6.6	1,427.4	2,147.5
4	Heavy manufacturing	15.3	3,309.1	2,136.3
5	Electricity, gas, water (Utility)	3.1	670.5	847.0
6	Construction	7.9	1,708.6	2,604.4
7	Government service	21.2	4,585.1	10,943.1
8	Other service	8.2	1,773.5	21,552.0
	Total	100	21,627.8	45,168.7

Note: VFM (XEA) - primary factor purchases by firms at market prices for the Rest of East Asia region.
Source: ERINA, 2018 (NEA Economic Databook) and GTAP 9A (2011) Data Base

Table 2.6 User Weight: Value-added by New Regions, $ Million (should add to VFM)

Sectors	1 DPRK	2 Macao	Total (VFM)
1 Agriculture	2,703.5	0	2,703.5
2 Extraction	2,240.6	0	2,240.6
3 Light Manufacturing	1,968.1	169.5	2,137.6
4 Heavy Manufacturing	2,141.2	0	2,141.2
5 Utility	670.5	200.1	870.6
6 Construction	1,449.1	1,162.9	2,612.0
7 Government Services	8,681.4	2,307.0	10,988.4
8 Other Services	1,773.5	19,701.4	21,474.9
Total	21,627.9	23,540.9	45,168.8

Note: The results reported here were obtained using the SplitReg program developed by Mark Horridge (2011).

Source: GTAP 9A (2011) Data Base.

Table 2.7 Comparison of Sectoral Composition of the DPRK's GDP and Value-Added in 2011 used for the User Weight Estimations

		NEA Economic Databook 2018 (a)		GTAP 9A (VFM for DPRK) (b)		Discrepancy (a-b)	
	Sectors	Share (%)	Value, $ million, current	Share (%)	Value $ million, current	Share (%)	Value, $ million, current
1	Agriculture	23.1	3,606.6	12.5	2,703.5	10.6	903.1
2	Mining	14.6	2,279.5	10.4	2,240.6	4.2	38.9
3	Light manufacturing	6.6	1,030.4	9.1	1,968.1	-2.5	(937.7)
4	Heavy manufacturing	15.3	2,388.8	9.9	2,141.2	5.4	247.6
5	Utility	3.1	484.0	3.1	670.5	0.0	(186.5)
6	Construction	7.9	1,233.4	6.7	1,449.1	1.2	(215.7)
7	Government service	21.2	3,309.9	40.1	8,681.4	-18.9	(5,371.5)
8	Other service	8.2	1,280.3	8.2	1,773.5	0.0	(493.2)
	Total	100	15,612.8	100.0	21,627.9	0.0	(6,015.1)

Source: ERINA, 2018 and GTAP 9A (2011) Data Base.

2.3 Selected Outputs of the SplitReg and New Base Data of the Model

Upon running the SplitReg program, the composite region Rest of East Asia (XEA) in the GTAP database was split into two regions (DPRK, Macao) bringing the number of regions in the Model to 14 from the initial aggregation of 13. The number of sectors and factors was unchanged. Accordingly, the 14-region, 8-sector, 4-factor CGE model created was used for the analyses.

The newly generated values of the VFM and GDP are provided in Tables 2.8-2.11. The endowments' purchases of the DPRK and Macao were $19,995 million and $24,659 million respectively. The newly generated total value of the DPRK and Macao's GDP was consistent with that of the Rest of Northeast Asia (XEA) region before splitting the data. The DPRK's

GDP from the expenditure side was $23,508.7 million, while it equaled $23,509 million from the source side (Tables 2.8-2.10).

In terms of GDP composition, the new GDP share of government consumption for the DPRK was 19.6%. The DPRK's export and import shares of GDP totaled 39.1% and 33.1% respectively. These were relatively on par with the currently reported data of 32.3% and 25.9% respectively (Table 2.10 and Appendix Table IV). The GDP composition from the source side for all 14 regions is provided in Table 2.11 (Tables 2.10-2.11).

Table 2.8 Endowments - Firms' Purchases at Market Prices (VFM), $ million

Endowments	DPRK	Macao
1 Land	1,068.3	51.6
2 Labor	10,235.1	11,908.7
3 Capital	7,983.7	12,664.3
4 Natural Resources	707.9	34.4
Total	19,995.0	24,659.0

Note: The results reported here were obtained using the SplitReg program developed by Mark Horridge (2011).
Source: GTAP 9A (2011) Data Base.

Table 2.9 Endowments - Firms' Purchases at Market Prices by Sectors (VFM), $ million

Sectors	DPRK	Macao
Agriculture	2,562.6	123.7
Mining	2,077.6	101.0
Light manufacturing	1,774.4	292.3
Heavy manufacturing	2,067.9	52.6
Utility	620.0	211.7
Construction	1,235.3	1,356.5
Government service	7,184.5	3,428.1
Other service	2,472.7	19,093.1
Total	19,995.0	24,659.0

Note: The results reported here were obtained using the SplitReg program developed by Mark Horridge (2011).
Source: GTAP 9A (2011) Data Base.

Table 2.10 GDP of the New Regions: the DPRK and Macao

	Consumption	Investment	Government	Export	Import	Total
	Value, $ million					
DPRK	10,553.64	6,948.38	4,600.27	9,198.65	(7,792.21)	23,508.73
Macao	13,206.29	8,554.23	3,503.17	13,705.47	(10,734.63)	28,234.52
Total	23,759.92	15,502.61	8,103.44	22,904.13	(18,526.85)	51,743.25
XEA*	23,759.9	15,502.6	8,103.4	22,903.9	(17,947.1)	52,322.8
	Share, %					
DPRK	44.9	29.6	19.6	39.1	-33.1	100
Macao	46.8	30.3	12.4	48.5	-38.0	100

Notes: 1. The results reported here were obtained using the SplitReg program developed by Mark Horridge (2011).
2. *-Values for XEA before splitting data;
Source: GTAP 9A (2011) Data Base.

Table 2.11 GDP from Source Side, by regions, $ million

GDPSRC	Net factor Income	Net Taxes	Depreciation	Total
1 China	5,566,429	714,857	1,040,783	7,322,069
2 Japan	3,490,313	1,589,730	825,613	5,905,656
3 ROK	806,493	219,729	176,249	1,202,470
4 Mongolia	4,601	2,935	1,225	8,761
5 Russia	992,800	642,473	269,532	1,904,805
6 DPRK	16,010	5,705	1,793	23,509
7 Macao	22,232	3,158	2,844	28,235
8 EAEU4	177,701	59,916	34,762	272,379
9 ASEAN9	1,604,785	262,309	277,002	2,144,095
10 ANZI	2,380,793	653,168	397,013	3,430,974
11 ROAsia	846,002	215,620	132,903	1,194,525
12 USA	8,864,940	4,746,174	1,922,729	15,533,842
13 EU_28	8,324,110	7,115,453	2,226,839	17,666,402
14 Rest of World	9,643,782	3,473,643	1,721,999	14,839,424
Total	42,740,989	19,704,870	9,031,285	71,477,144

Note: The results reported here were obtained using the SplitReg program developed by Mark Horridge (2011).
Source: GTAP 9A (2011) Data Base.

3. The Simulations

Three scenarios were considered in the analyses as follows:

a) Scenario 1: The DPRK's total factor productivity (TFP) would grow as a result of the country's economic reform and return to the international markets. The scenario is:

- The DPRK's Total Factor Productivity (TFP) grows by 30%: [The shock statement is: *Shock avareg ("DPRK")* = 30, where *avareg ("REG")* is the value-added technical change variable for the region "r"].

The scale of the TFP growth has been chosen in consistency with the ROK's non-agricultural labor productivity growth during the period 1963-1973. Estimation of this growth was

provided by Takayasu Yuichi[7]. According to it, the ROK's non-agricultural labor productivity or the output per worker became 51.8% higher in 1973 in real terms on its level in 1963. William Easterly and Ross Levine (2001) estimated that the TFP accounts for 60% of growth of output per worker for an average country. Thus, TFP growth in the DPRK assumed to be equal to 30%, which is about 60% of non-agricultural labor productivity growth in the ROK during the country's export-led industrialization and rapid economic growth in the 1960s.

b) Scenario 2: Korean Unification: Bilateral import tariffs between the DPRK and ROK were removed as a result of the Korean Unification. The shock statements are:

Shock tms(TRAD_COMM,"DPRK","ROK") = target% 0 from file tms.shk;

Shock tms(TRAD_COMM,"ROK","DPRK") = target% 0 from file tms.shk; whereas, variable "*tms (i,r,s)"* is the source-specific change in tax on imports of commodity "*i*" from region "*r*" into country "*s*" in the Model. The statements indicate that shocks were applied for a target rate of zero for this variable.

c) Scenario 3: The DPRK joins Northeast Asia Free Trade Agreement (NEA6FTA). Although there are only two bilateral free trade agreements in effect currently (China-ROK FTA and Mongolia-Japan EPA), this scenario considers that a region-wide free trade agreement would emerge in Northeast Asia region covering all six countries in the region: China, Japan, the ROK, Mongolia, Russia and the DPRK. Similar to the previous scenario, the shock statements are:

Shock tms(TRAD_COMM,NEA5,"DPRK") = target% 0 from file tms.shk;
Shock tms(TRAD_COMM,"DPRK",NEA5) = target% 0 from file tms.shk;
Shock tms(TRAD_COMM,NEA5,NEA5) = target% 0 from file tms.shk;

In order to simplify the shock statements, a subset of the Northeast Asian region, consisting of five countries in the database, was created by adding statements illustrated as in Table 3.1 in the CMFSTART file of the GEMPACK (General Equilibrium Modelling PACKage). GEMPACK is a suite of economic modelling software that solves AGE (Applied General Equilibrium) models and is used to solve the Model (Table 3.1).

Table 3.1 Added Statements for Creating NEA5 Subregion in the CMFSTART file

```
XSET NEA5 #NEA5 regions#
(China, Japan, ROK, Mongolia, Russia);
XSUBSET NEA5 is subset of REG;
```

The default value of the Model parameter "RORDELTA", which is the investment allocation binary coefficient in the Model, was used in all scenarios. The default value is 1,

[7] The raw data is provided by the Korean Statistical Information Service (KOSIS). Available at: http://kosis.kr

where investment is allocated across regions to equate the change in the expected rates of return, *rore (r*) which implies international capital mobility. When RORDELTA equals 0, investments are allocated across regions to maintain the existing composition of capital stock (no international capital mobility) and it effectively fixes the trade balance for each country/region. However, this case was not considered in this experiment. The solution method was Gragg, or a multiple step extrapolation method.

3.1 The Results

3.1.1 Welfare Effects

In terms of the equivalent variation (EV), which is an indicator for measuring effect on public welfare, the simulation results demonstrated that the DPRK would have a welfare gain of $6.6 billion as a result of the TFP growth scenario, while it equaled $1.73 million and $107.2 million in the Korean Unification and Northeast Asia FTA (NEA6FTA) scenarios. However, the ROK may experience a welfare loss of $0.844 million, associated mostly with terms of trade losses in investment and savings in the Korean Unification scenario (Table 3.2).

As expected in the TFP growth scenario, most of the DPRK's welfare gain was associated with gains in technical change, i.e. due to the TFP growth, the country would be better off by $6.4 billion. Also, the DPRK's allocative efficiency and terms of trade in investment and savings were improved by $558.1 million and $130.9 million, respectively. Most of the gains were represented by gains in government services, as it is the largest sector in the country. However, the DPRK may experience a loss of $502.2 million in its terms of trade in goods and services. This was associated with price changes in tradable commodities. The results indicated that the index of prices received for tradable commodities produced (*psw*) in the DPRK declined by 4.365%, while the index of prices paid for tradable commodities used (*pdw*) in the DPRK dropped by 0.008% only. In other words, the prices of the DPRK's exports became lower than those of the country's imports. Following the government services sector, other services, agriculture, heavy manufacturing and extraction were the next largest beneficiaries due to this productivity growth. Also, heavy and light manufacturing and other services sectors would be the largest beneficiaries in terms of their allocative efficiency improvements. At the same time, many of the other regions, except for Russia, EAEU4, Mongolia and the Rest of World, would also benefit from welfare gains ranging from $0.1 million (for Macao) to $275.1 million (for the EU_28). China and the USA would have $213.1 million and $101.5 million in welfare gains respectively (Tables 3.2; 3.3; Figures 3.1; 3.2; 3.3).

In contrast to the TFP growth scenario, the DPRK may have terms of trade gains in goods and services, but terms of trade losses in investment and savings in the Korean Unification and Northeast Asia FTA scenarios. The country's terms of trade gains in goods and services totaled $115.4 million as a result of the NEA6FTA, while it equaled $1.844 million in the case of Korean Unification. Japan would be the largest beneficiary in the NEA6FTA scenario, having a welfare gain of $19.4 billion, followed by China and the ROK with $7.7 billion and $7.5

billion welfare gains respectively (Tables 3.4; 3.5).

Table 3.2 Welfare Changes (Equivalent Variation, $ Million)

Regions	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 China	213.1	-0.345	7,717.9
2 Japan	36.9	-0.182	19,396.6
3 ROK	24.6	-0.844	7,490.6
4 Mongolia	-1.8	0.004	19.5
5 Russia	-60.6	0.087	1,315.7
6 DPRK	6,586.4	1.730	107.2
7 Macao	0.1	0.001	-33.0
8 EAEU4	-6.9	0.013	-257.1
9 ASEAN9	8.9	-0.054	-4,439.1
10 ANZI	7.2	0.009	-2,113.8
11 Rest of Asia	42.4	-0.026	-3,226.5
12 USA	101.5	-0.232	-8,065.8
13 EU_28	275.1	-0.628	-7,670.1
14 Rest of the World	-186.0	0.343	-6,325.3

Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.3 Welfare Effects of the DPRK's TFP Growth: EV Decomposition Summary ($ Million)

Regions	Allocative Efficiency	Technical Change	Terms of Trade in Goods and Services	Terms of Trade in Investment and Savings	Total Welfare
1 China	74.3	0.0	204.7	-65.8	213.2
2 Japan	-3.3	0.0	46.2	-5.9	36.9
3 ROK	0.9	0.0	28.9	-5.2	24.6
4 Mongolia	-0.2	0.0	-1.6	-0.1	-1.8
5 Russia	-21.9	0.0	-31.0	-7.7	-60.6
6 DPRK	558.1	6,399.5	-502.2	130.9	6,586.3
7 Macao	0.0	0.0	0.4	-0.3	0.1
8 EAEU4	0.1	0.0	-5.8	-1.3	-6.9
9 ASEAN9	0.3	0.0	18.6	-10.1	8.9
10 ANZI	6.6	0.0	5.4	-4.9	7.2
11 Rest of Asia	-1.4	0.0	47.8	-4.0	42.4
12 USA	10.9	0.0	58.6	32.0	101.5
13 EU_28	26.8	0.0	258.0	-9.6	275.1
14 Rest of World	-0.1	0.0	-141.2	-44.7	-186.0
Total	651.2	6,399.5	-13.2	3.4	7,041.0

Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.4 Welfare Effects of the Korean Unification: EV Decomposition Summary ($ Million)

Regions	Allocative Efficiency	Terms of Trade in Goods and Services	Terms of Trade in Investment and Savings	Total Welfare
1 China	-0.127	-0.437	0.219	-0.345
2 Japan	-0.016	-0.185	0.02	-0.182
3 ROK	-0.22	-0.671	0.047	-0.844
4 Mongolia	0	0.003	0	0.004
5 Russia	0.035	0.027	0.025	0.087
6 DPRK	0.39	1.844	-0.503	1.73
7 Macao	0	0	0.001	0.001
8 EAEU4	0.001	0.008	0.004	0.013
9 ASEAN9	-0.004	-0.088	0.038	-0.054
10 ANZI	-0.005	-0.007	0.021	0.009
11 Rest of Asia	0.009	-0.045	0.011	-0.026
12 USA	-0.017	-0.131	-0.084	-0.232
13 EU_28	-0.217	-0.465	0.054	-0.628
14 Rest of the World	0.048	0.147	0.148	0.343
Total	-0.124	0	0	-0.124

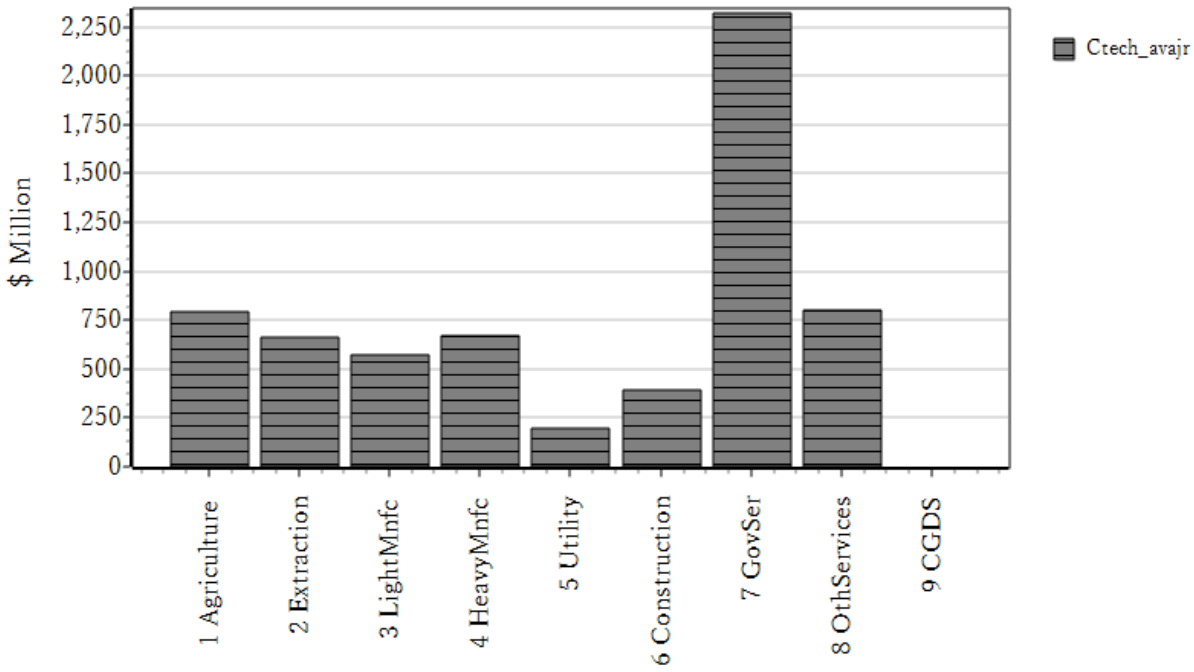
Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.5 Welfare Effects of the NEA6 FTA: EV Decomposition Summary ($ Million)

Regions	Allocative Efficiency	Terms of Trade in Goods and Services	Terms of Trade in Investment and Savings	Total Welfare
1 China	5,241.5	3,177.8	-701.0	7,718.2
2 Japan	1,954.4	17,028.1	416.1	19,398.7
3 ROK	942.8	6,795.7	-247.8	7,490.6
4 Mongolia	11.6	17.9	-9.9	19.5
5 Russia	815.8	-1,357.0	1,856.9	1,315.7
6 DPRK	24.4	115.4	-34.3	105.5
7 Macao	-1.6	-31.5	0.9	-32.3
8 EAEU4	-79.7	-223.3	45.9	-257.1
9 ASEAN9	-815.8	-3,670.9	47.6	-4,439.1
10 ANZI	-349.1	-1,569.9	-194.7	-2,113.8
11 Rest of Asia	-204.0	-3,055.9	35.0	-3,224.9
12 USA	-403.6	-6,013.1	-1,649.0	-8,065.7
13 EU_28	-1,106.0	-6,288.1	-275.8	-7,669.9
14 Rest of the World	-1,838.7	-5,205.3	718.9	-6,325.2
Total	4,191.7	-280.2	8.7	3,920.2

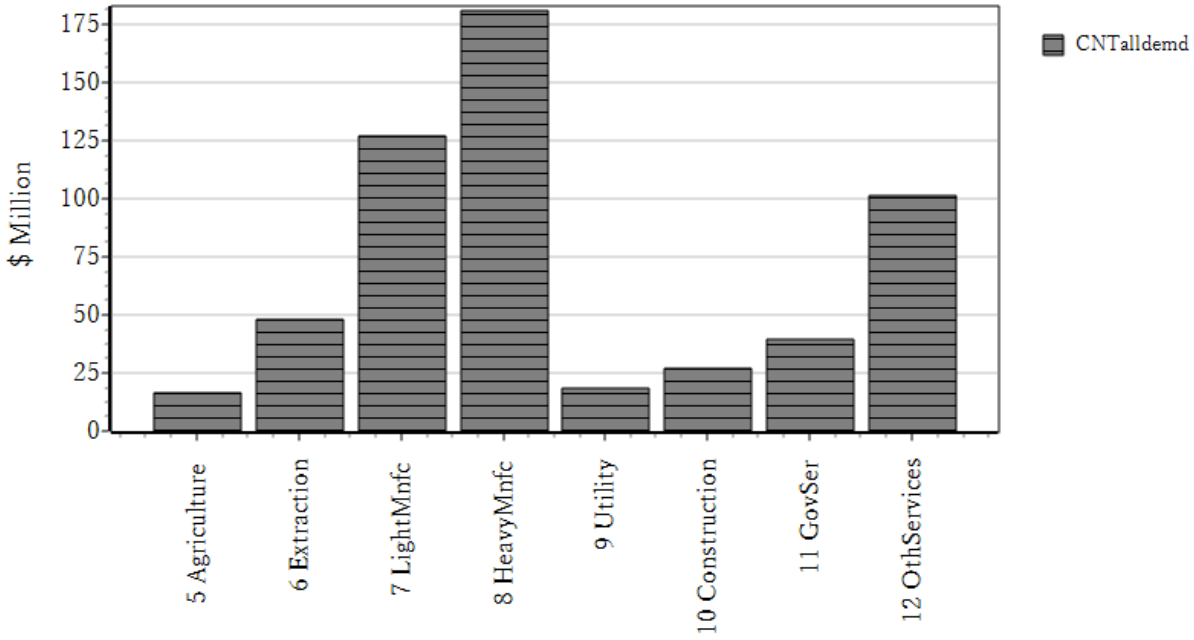
Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.1 DPRK's Technical Change Effect by Commodity (Scenario 1)



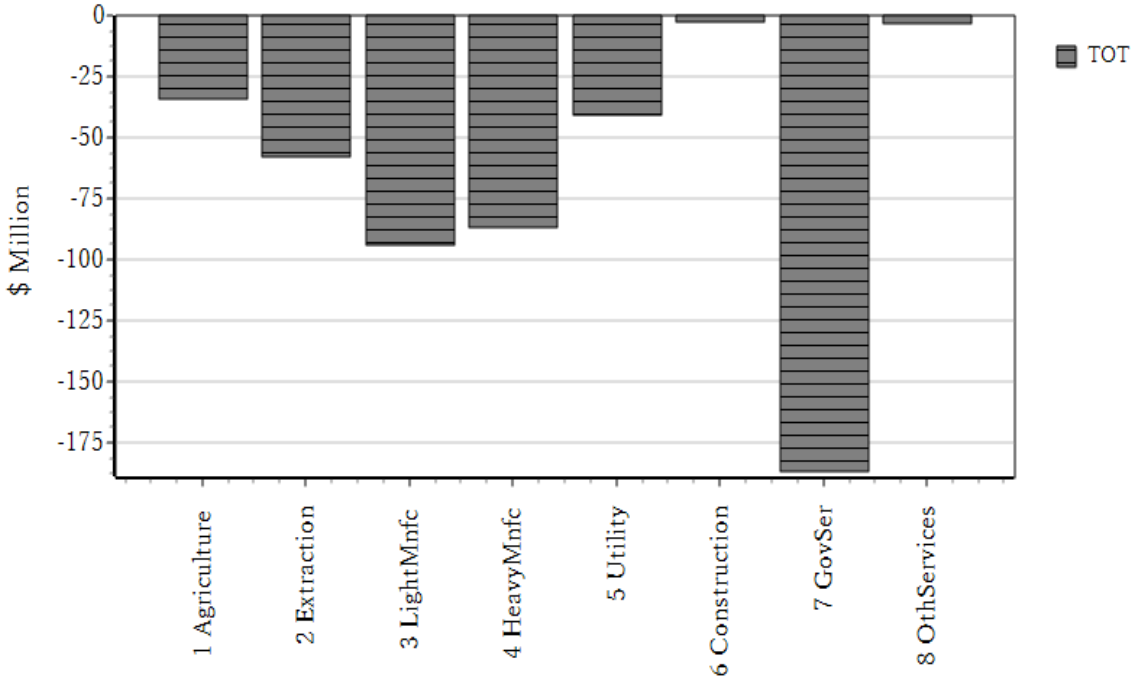
Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.2 DPRK's Allocative Efficiency Effect by Commodity (Scenario 1)



Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Figure 3.3 DPRK's Terms of Trade Effect by Commodity (Scenario 1)



Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

As expected, the DPRK's real GDP may experience almost 30% growth in the TFP growth scenario, while the country would have 0.002% and 0.104% real growths in case of the Korean Unification and Northeast Asia FTA. In the latter scenario, Mongolia would experience the highest real GDP growth among the countries in Northeast Asia, estimated at 0.132%. Also, the Korean Unification scenario would have no impact on the ROK's real GDP. (Table 3.6).

Real export growth of the DPRK accounted for 31.485% in the TFP growth scenario, while it equaled 0.018% and 1.101% in the Korean Unification and Northeast Asia FTA scenarios respectively. The ROK's real exports would change positively in the Korean Unification scenario, increasing by 0.001%. In the case of the Northeast Asia FTA scenario, the ROK was the largest beneficiary, with its real exports growing by 3.323%, followed by China (3.119%) and Russia (2.001%). Japan's real exports may experience 1.81% growth in the Northeast Asia FTA scenario as well (Table 3.7).

In terms of real imports, the DPRK's imports would increase by 22.5% in the TFP growth scenario owing to its increased domestic economic activities. Also, it would stimulate China's imports, resulting in a 0.023% rise. In the case of Korean Unification, the DPRK's imports may increase by 0.039%, while those of the ROK would grow by 0.001%. As for the FTA in Northeast Asia, it would stimulate trade between these countries due to the removal of their import tariffs, and real imports of all six countries in the region would increase at rates ranging from 2.175% (DPPK) to 7.733% (ROK) (Table 3.8).

Also, total factor productivity growth in the DPRK may stimulate investments worldwide, except in Mongolia. Investments in the DPRK would increase by 21.9% or $1.5 billion. The other largest investment destinations in this scenario were China and the EU_28, and total global investment could reach $2.3 billion. The negative investment in Mongolia may suggest that some current investors in the country may divest their investments, e.g. in the extraction sector, from Mongolia into the DPRK as the latter became open and more competitive due to its TFP growth (Table 3.9).

Table 3.6 Real GDP (qgdp) Changes, % change

Regions	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 China	0.001	0	0.072
2 Japan	0	0	0.033
3 ROK	0	0	0.078
4 Mongolia	-0.002	0	0.132
5 Russia	-0.001	0	0.043
6 DPRK	29.856	0.002	0.104
7 Macao	0	0	-0.006
8 EAEU4	0	0	-0.029
9 ASEAN9	0	0	-0.038
10 ANZI	0	0	-0.01
11 Rest of Asia	0	0	-0.017
12 USA	0	0	-0.003
13 EU_28	0	0	-0.006
14 Rest of the World	0	0	-0.012

Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.7 Changes in Real Exports (qxwreg), % change

Regions	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 China	0.006	0	3.119
2 Japan	-0.005	0	1.810
3 ROK	-0.005	0.001	3.323
4 Mongolia	0.016	0	0.396
5 Russia	0.001	0	2.001
6 DPRK	31.485	0.018	1.101
7 Macao	0	0	0.210
8 EAEU4	0.003	0	-0.056
9 ASEAN9	0	0	-0.013
10 ANZI	-0.002	0	0.104
11 Rest of Asia	-0.001	0	-0.353
12 USA	-0.004	0	0.333
13 EU_28	-0.002	0	0.088
14 Rest of the World	0.003	0	0.059

Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.8 Changes in Real Imports (qiwreg), % change

Regions	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 China	0.023	0	4.103
2 Japan	0.003	0	5.426
3 ROK	0.002	0.001	7.733
4 Mongolia	-0.017	0	3.181
5 Russia	-0.002	0	4.497
6 DPRK	22.521	0.039	2.175
7 Macao	0.001	0	-0.138
8 EAEU4	0	0	-0.556
9 ASEAN9	0.003	0	-0.523
10 ANZI	0.002	0	-0.367
11 Rest of Asia	0.009	0	-1.128
12 USA	0.005	0	-0.661
13 EU_28	0.005	0	-0.198
14 Rest of the World	0.001	0	-0.261

Note: The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.9 Effects on Investment by Regions (qo [CGDS*])

Regions	% change			Level change, $ Million		
	TFP growth in the DPRK	Korean Unification	NEA6 FTA	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 China	0.007	0	0.347	234.5	-0.5	11,712.8
2 Japan	0.003	0	1.591	30.8	-0.1	19,158.8
3 ROK	0.005	0	5.718	19.8	0.9	21,296.3
4 Mongolia	-0.03	0	5.241	-1.3	0.0	219.0
5 Russia	0.002	0	1.283	6.7	0.0	5,336.3
6 DPRK	21.897	0.011	0.399	1,521.5	0.8	27.7
7 Macao	0	0	-0.301	0.0	0.0	-25.7
8 EAEU4	0.002	0	-0.559	1.3	0.0	-403.3
9 ASEAN9	0.004	0	-0.597	25.0	-0.1	-3,613.1
10 ANZI	0.003	0	-0.256	27.3	0.0	-2,649.3
11 Rest of Asia	0.011	0	-0.965	27.1	0.0	-2,360.6
12 USA	0.004	0	-0.574	121.0	-0.3	-16,499.3
13 EU_28	0.007	0	-0.426	229.8	0.0	-14,300.8
14 Rest of World	0.001	0	-0.321	21.3	0.0	-10,346.3
Global				2,264.6	0.7	7,552.7

Notes: 1. qo(NSAV_COMM,REG) [%-change]: industry output of commodity i in region r: "CGDS" row;

2. The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

2.3.1 Other Effects on the DPRK Economy

As expected, all sectors of the country would benefit by increasing their outputs in the TFP growth scenario, while there will be losers and winners among the DPRK industries in the other two scenarios, the Korean Unification and the Northeast Asia FTA. Output of the DPRK's other services and extraction sectors would have higher than TFP growths, implying that these sectors would get more investments in labor and capital in the TFP growth scenario. Light manufacturing, construction, heavy manufacturing and other services sectors will be the beneficiaries in the Korean Unification scenario, with their outputs growing by 0.002% (other services) to 0.115% (light manufacturing). However, the government service sector, which includes financial services, would be the largest loser in the Korean Unification scenario, with its output dropping by 0.023%. In the Northeast Asia FTA scenario, the light manufacturing sector would benefit most owing to an 8.412% increase in output, followed by agriculture (0.579%) and construction (0.186%). Also, investments (capital goods) in the country would grow by 0.399%. However, all other sectors would expect drops in their outputs, with the largest decline of 1.454% to occur in the government services sector (Table 3.10).

Moreover, technological and efficiency improvements in the country would lead to reductions in market prices of all producing sectors, ranging from 2.636% in extraction to 8.987% in agriculture, while those for primary factors would increase substantially in the TFP growth scenario. For example, the market price of labor in this scenario would become 20.7% higher, implying higher wages, and thus, stimulate the improvement of living standards in the country. The simulation results indicated that the regional private consumption expenditure (*yp*) in the DPRK would increase by 21% in the TFP growth scenario. In the other two scenarios, the Korean Unification and the Northeast Asia FTA, the market prices of all sectors would increase, except those of natural resources. The scales of these changes were larger in the latter scenario (Table 3.11).

Table 3.10 DPRK: Output Changes by Industry (qo[*DPRK], Percentage change)

Sectors	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 Agriculture	27.489	-0.003	0.579
2 Extraction	32.213	-0.015	-0.980
3 Light Manufacturing	29.061	0.115	8.412
4 Heavy Manufacturing	30.791	0.004	-1.145
5 Utility	28.465	-0.039	-3.006
6 Construction	22.994	0.007	0.186
7 Government Services	30.075	-0.023	-1.454
8 Other Services	34.501	0.002	-0.018
9 Capital Goods	21.897	0.011	0.399

Notes: 1. qo(NSAV_COMM,REG) [%-change]: industry output of commodity i in region r: "DPRK" column;
2. The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

Table 3.11 DPRK: Market Price Changes by Commodity (pm[*DPRK], Percentage change)

Commodity	TFP growth in the DPRK	Korean Unification	NEA6 FTA
1 Land	10.779	0.023	4.741
2 Labor	20.677	0.036	2.077
3 Capital	21.79	0.034	1.860
4 Natural Resources	38.357	-0.078	-5.286
1 Agriculture	-8.987	0.028	2.744
2 Extraction	-2.636	0.004	0.007
3 Light Manufacturing	-4.783	0.022	1.317
4 Heavy Manufacturing	-4.227	0.020	1.068
5 Utility	-4.053	0.019	1.037
6 Construction	-5.093	0.025	1.385
7 Government Services	-5.835	0.029	1.650
8 Other Services	-4.698	0.023	1.280
9 Capital Goods	-4.766	0.021	1.286

Notes: 1. pm(NSAV_COMM,REG) [%-change]: market price of commodity i in region r: "DPRK" column 2.The results reported here were obtained using the GEMPACK economic modelling software [Horridge et al. (2018)].

3. Conclusions

CGE analyses of the economic impacts to be brought by the DPRK's return to international society using the GTAP Model and Data Base 9.0a (2011) was carried out upon splitting a composite region of the Rest of East Asia (XEA) in the database using the SplitReg program. Three scenarios, (i) 30% TFP growth of the DPRK; (ii) Korean Unification; and (iii) Northeast Asia Free Trade Agreement (FTA) have been simulated. The experiments demonstrated that productivity growth in a country will benefit not only the country in question, but it will have positive spillover effects on their trading partners. Also, openness and removal of trade barriers will stimulate economic growths of the trading partners, the effects of which will be enhanced with larger coverage of the FTA area. The main results of the simulation were as follows:

a) The DPRK may benefit from each scenario, with the largest welfare gain of $6.6 billion being in the TFP scenario. Most of this gain was associated with gains in technical change of all sectors, with the largest gain forecast for the government services sector. In this scenario, technological and efficiency improvements in the DPRK would lead to market prices reductions in traded commodities, which may encourage growth in the country's exports, while attracting $1.5 billion of foreign investments. Also, wages and salaries would increase due to productivity growth, and stimulate improvements in living standards in the country. Increased consumption, investment and exports would also spark growth in DPRK imports. At the same time, the TFP growth scenario would stimulate $2.3 billion of additional investments worldwide, including those of the DPRK. China and the EU_28 were the largest investment destinations;

b) Within the Korean Unification scenario, the DPRK would have a welfare gain of $1.73 million, while the ROK may experience a welfare loss of $0.844 million. Most of the DPRK's welfare gain was associated with gains in terms of trade in gods and services, while the ROK's welfare loss was mostly due to its terms of trade losses in investment and savings. As for real GDP, there would be no impact on the ROK, while that of the DPRK would grow slightly. Also, both countries would see their investments increase by about a billion US$ each. Light and heavy manufacturing, construction and other services sectors would benefit from the unification, while the remaining sectors would see their outputs decline.

c) The Northeast Asia FTA scenario will benefit all the economies in the region, including welfare gains ranging from $19.5 million for Mongolia to $19.4 billion for Japan and positive changes in their real GDP. The DPRK's welfare gain was estimated as $107.2 million in this scenario. Most of these gains were associated with terms of trade gains in goods and services, and allocative efficiency improvements were prominent. Also, the Northeast Asia region would attract large investment pools into the region, ranging from the 27.7 million in the DPRK and $21.3 billion in the ROK. Light manufacturing, agriculture and construction sectors of the DPRK would benefit in this scenario, while other sectors may experience a decline in their outputs.

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Appendix Table I: Classification of Regions in the Model

The Model (13 regions)	GTAP 9.0a (140 regions)
China	China
Japan	Japan
ROK	Republic of Korea
Mongolia	Mongolia
Russia	Russian Federation
XEA	Rest of East Asia: - Korea, Democratic People's Republic of - Macao, Special Administrative Region of China
EAEU4	Kazakhstan, Kyrgyzstan, Armenia, Belarus
ASEAN9	ASEAN9 members, except Myanmar: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Vietnam
ANZI	Australia, New Zealand, India
Rest of Asia	Hong Kong, Taiwan, Rest of Southeast Asia, Bangladesh, Nepal, Pakistan, Sri Lanka, Rest of South Asia
USA	United States of America
EU_28	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, United Kingdom, Bulgaria, Romania, Croatia
Rest of World	Rest of Oceania, Canada, Mexico, Rest of North America, Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean, Switzerland, Norway, Rest of EFTA, Albania, Ukraine, Rest of Eastern Europe, Rest of Europe, Rest of Former Soviet Union, Azerbaijan, Georgia, Bahrain, Islamic Republic of Iran, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Turkey, United Arab Emirates, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa, Benin, Burkina Faso, Cameroon, Côte d'Ivoire, Ghana, Guinea, Nigeria, Senegal, Togo, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe, Rest of Eastern Africa, Botswana, Namibia, South Africa, Rest of South African Customs, Rest of the World

Source: GTAP 9.0a Data Base and Model Aggregation output

Appendix Table II: Classification of Production Factors in the Model

No.	The Model (4 factors)	GTAP 9.0a (8 factors)	Description
1	Land	Land	Immobile
2	Labor	Technicians/Associates, Professional; Clerks; Service/Shop workers; Officials and Managers; Agricultural and Unskilled	Mobile
3	Capital	Capital	Mobile
4	Natural Resources	Natural Resources	Immobile

Note: The original factors in the GTAP Data Base 9A start with capital letters.
Source: GTAP 9.0a Data Base and Model Aggregation output

Appendix Table III: Classification of Sectors in the Model

No.	The Model (8 sectors)	GTAP 9.0a (57 sectors)
1	Agriculture	Paddy rice; Wheat; Cereal grains nec.; Vegetables, fruit, nuts; Oil seeds; Sugar cane, sugar beet; Plant-based fibers; Crops nec.; Cattle, sheep, goats, horses; Animal products nec.; Raw milk; Wool, silk-worm cocoons; Meat: cattle, sheep, goats, horse; Meat products nec.; Processed rice;
2	Extraction	Forestry; Fishing; Coal; Oil; Gas; Minerals nec.
3	Light Manufacturing	Vegetable oils and fats; Dairy products; Sugar; Food products nec.; Beverages and tobacco products; Textiles; Wearing apparel; Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec.; Manufactures nec.
4	Heavy Manufacturing	Petroleum, coal products; Chemical, rubber, plastic products; Mineral products nec.; Ferrous metals; Metals nec.; Electronic equipment; Machinery and equipment nec.;
5	Utility	Electricity; Gas manufacture, distribution; Water;
6	Construction	Construction;
7	Government Service	Communication; Financial services nec.; Insurance; Public administration, defense, health, education;
8	Other Services	Trade; Transport nec.; Sea transport; Air transport; Business services nec.; Recreation and other services; Dwellings;

Notes: 1. The original sectors in the GTAP Data Base 9A start with capital letters;
2. nec.= not elsewhere cited.
Source: GTAP 9.0a Data Base and Model Aggregation output

Appendix Table IV: Foreign Trade of the DPRK, $ Million

Regions	2011		2014	
	Import from	Export to	Import	Export
China	3,481.51	2,240.17	3,874.77	2,583.16
Japan	-	-	-	-
ROK	N/d	N/d	N/d	N/d
Mongolia	-	0.06	-	0.07
Russia	105.37	12.96	90.37	9.12
EAEU4	0.66	2.91	0.42	5.39
ASEAN9	63.37	40.87	226.09	19.4
ANZI	194.14	16.3	82.81	99.31
Rest of Asia	170.75	471.12	107.54	183.27
USA	10.35	-	26.43	-
EU28	63.38	146.01	25.57	19.03
Rest of Word	492.8	566.85	448.37	374.32
Total	5,075.13	4,064.1	5,330.74	3,667.39
Share of GDP, %	32.3	25.9		

Notes: 1. A dash (-) indicates that a figure is zero or less than half a significant digit; N/d - No data.
Source: Computed based on IMF (2015) data.

Appendix Table V: Foreign Trade of the DPRK and Macao in 2011, $ Million

Regions	DPRK		Macao		Total (XEA)	
	Import from	Export to	Import from	Export to	Import from	Export to
China	3,481.51	2,240.17	1,639.99	389.73	5,121.50	2,629.90
Japan	-	-	208.10	34.20	208.1	34.2
ROK	-	-	47.70	5.20	47.7	5.2
Mongolia	-	0.06	0.00	-0.06	-	-
Russia	105.37	12.96	-8.37	3.14	97	16.1
EAEU4	0.66	2.91	0.44	-0.21	1.1	2.7
ASEAN9	63.37	40.87	111.53	55.33	174.9	96.2
ANZI	194.14	16.3	29.86	10.40	224	26.7
Rest of Asia	170.75	471.12	496.75	-223.22	667.5	247.9
USA	10.35	-	292.35	108.50	302.7	108.5
EU28	63.38	146.01	827.82	113.09	891.2	259.1
Rest of Word	492.8	566.85	269.70	103.05	762.5	669.9
Total	5,075.13	4,064.10	3,423.07	32.30	8,498.20	4,096.40
Share	59.7%	99.2%	40.3%	0.8%	100%	100%

Note: Data for Macao estimated from Tables 2.2 & Appendix Table IV.
Sources: IMF, 2015 and GTAP 9A (2011) Data Base.

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