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The economic development and international  
trade of North Korea using the factor  
analysis method

*Bachelor thesis*

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## **Abstract**

In this paper, after reviewing the characteristics of North Korean statistics, I examined how North Korea's trade affects its growth using empirical analyses. There have been many studies that have shown trade has affected economic growth, but there have been few empirical studies on North Korea's case. Cointegration test, regression analysis, and factor analysis were used. The empirical results suggest that even considering economic fluctuations, North Korea's trade has not shown a significant impact on growth.

## **Keywords**

North Korea, Growth, Trade, Cointegration test, Factor analysis



## **Declaration of Authorship**

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

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Prague, 18 May 2017

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Signature

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Last but not least, this thesis could not have been written without my family. I want to thank my esteemed parents and my dear sister for supporting me until the last minute.

# Bachelor's Thesis Proposal

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## Proposed Topic:

The economic development of North Korea and international trade using the factor analysis method.

## Preliminary scope of work:

### *Motivation*

In "Measuring Economic Growth from Outer Space" (Henderson. J) the night light data taken from satellites has been used to measure the real income growth. The image of Korea was used as striking example. While most of the areas were luminous in South Korea at the time, the North Korea appears dimly lit even decade since study's publication.

I'm trying to analyze the peculiar North Korean economic development using several variables. North Korea's trade patterns have changed in certain ways throughout the time and my aim is to analyze how has the economic development changed with it.

First, I will use largely accepted Cointegration method to analyze the relationship between the economic growth and international trade. Second, I will attempt to use an open source factor analysis method to achieve more accurate results. In doing so, I hope to extract the factors which would show common movements within the data consisting of vast number of economic variables and decades of panel data. I will then use these factors to control the economic fluctuation in the analysis. Finally, I will describe North Korea's economic development analyzing the economic growth and international trade together with using the results I will have obtained from both methods.

### *Hypotheses*

1. The international trade takes an important role in North Korea's economy.
2. The cointegration method can describe a relationship between trade and economic growth in North Korea.
3. The factors from the factor analysis can find out shocks among economic variables of North Korea.

### ***Methodology***

First, I will work with a dataset of real value variables including real GDP, real exchange rate and population. Data will be made from PWT (Penn World Table), World Bank, KOSIS (Korean Statistical Information Service) and Bank of Korea. A unit root test will be used to check for stationary process. Should the data prove to be non-stationary, I shall convert it to stationary data. I will perform a simple descriptive statistical analysis to figure out the characteristics of data.

Secondly, I will do the cointegration test and factor analysis using this dataset. A factor model allows us to extract reference variables from a vast sum of discrete economic variables. I will estimate common factors using the method of principal components. Through this data reduction, I will eventually get the factors (principle components) and use them to describe the economic development of North Korea. I will build a linear regression model using these factors to check how international trade can affect North Korea's economic growth. Dependent variables will be the economic growth of North Korea and independent variables (regressor) will be the factors and trade volume (if necessary, I will divide it to import and export).

Finally, I will describe North Korea's economic development analyzing the economic growth and international trade together with using the results I will have obtained from both methods.

### ***Outline***

1. Introduction and motivation
2. Literature review
3. Econometric model and data
4. Empirical results
5. Conclusions
6. References

### **List of academic literature:**

#### ***Bibliography***

Byung-Yeon Kim, Seok-Jin Kim, Keun Lee (2007. 9), Assessing the Economic Performance of North Korea, 1954-1989: Estimates and Growth Accounting Analysis, JOURNAL OF COMPARATIVE ECONOMICS

David N. Weil (2012), Economic growth(3rd edition), Routledge

Bai, J., and S. Ng (2008), "Large Dimensional Factor Analysis," Foundations and Trends in Econometrics, 3(2): 89-163.

Forni, Mario, and Lucrezia Reichlin (1995): "Let's Get Real: A Dynamic Factor Analytical Approach to Disaggregate Busin~s Cycles," CEPR Discussion Paper Series #1244

Kap-Young Jeong, Jun-Eun Kang (2008), Estimation of North Korea's GNI by Principal Components Analysis, 비교경제 연구 제 14 권 제 2 호

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## Introduction

What is the core reason that there have been few empirical studies on the impacts of international trade on the North Korean economy?

The crucial factor is the lack of accessible and reliable data, as any gaps or flaws in data will lead to flaws in study results. In this paper, I will present the available economic data on North Korea, determine which data is the most reliable, and run an empirical study with the selected data to explore the relationship between North Korea's national income and international trade.

The most widely accepted methods to analyze North Korea's trade and growth are the cointegration test and regression analysis. However, most research has not been able to discern a cointegration relationship between trade and growth in North Korea, even when using a regression analysis. Why have previous studies failed to observe a significant impact by trade on growth in the case of North Korea? Could it be because prior research did not take into account economic fluctuations in North Korea? This question has been the catalyst for this paper.

To investigate, after following conventional methods using extended time series data, I will perform factor analysis, a statistical method which provides a description of variability among observed variables with small number of underlying variables, or factors. Using factors, I can summarize the variation of a large number of variables and reflect the economic fluctuation in the regression.

Before the analysis, we return to the basic conundrum. How do we conduct empirical research on trade and growth in North Korea considering the historical and on-going lack of dependable data out of North Korea?

North Korea is a communist country with a singularly restricted trade system. Until the early 1960s, North Korea kept its imports to a minimum in its obsession to create a self-sustaining economy, and exports were only used as a means of acquiring foreign currency needed to purchase imports [33]. However, after confronting the limitations of small economies, it has gradually increased its proportion of trade. It is obvious that trade has an effect on North Korean economy, as it does with every country, but because empirical research is rarely done the impact is difficult to measure.

The last official statistical yearbook of North Korea was published in 1961. Some of those published statistics were written in a different format from the international standards and some data were not reliable. Between 1961 and 1995 the North Korean government published no statistical yearbooks. Due to the overwhelming secrecy of the Democratic People's Republic of Korea (DPRK), empirical research did not progress significantly until 1995.

Since 1995, North Korea has been releasing statistical data in order to receive economic assistance in the form of foreign aid. Based on this material, several institutions have published statistical data and studies on North Korea, but because most of the documents are available exclusively in Korean, the sources are unavailable to the preponderance of economic scholars.

In Chapter 2, I will present a historical overview of the North Korean economy and a discussion of the data sources. I will explore the estimate methods and data characteristics of the external institutions which estimate modern North Korean data. After reviewing all available institutional data I decided to use national income data from the United Nations and trade data from the Korea Trade-Investment Promotion Agency (KOTRA), because they are the most trustworthy. The UN has the longest time series for national income data and it shows the similar figures to the official statistics

from North Korea. It is widely accepted among the research community that KOTRA provides the most accurate data for the trade.

In Chapter 3, I will describe the trend of national income and trade data of North Korea. After the fall of the Soviet Union in early 1990s, the GDP of North Korea declined significantly and did not recover until 1995. Since then, China has become North Korea's largest trading partner, with China accounting for 91.34% of North Korea's total foreign trade by 2015. The foreign aid that began to come in around 1995 has also played a role in the GDP growth, though I am not looking at the role of foreign aid in this paper.

In Chapter 4, an empirical analysis is conducted with the data described above using econometric models. First, using the cointegration test, I will check the long-term relationship between North Korean trade and growth. This is the most widely adopted method to analyze the relationship between growth and trade of a nation. Second, I will use multiple regression analysis to check the short-term relationship of trade and growth. One of the weakness of cointegration analysis and conventional regression analysis is seen when the sample size is small, as in the case of North Korea, and it is therefore infeasible to include large numbers of economic variables. However, using factor analysis, it is possible to perform a regression analysis by summarizing various economic variables. Using the empirical results from the cointegration and factor analyses, the potential impacts of trade on North Korea's economic growth are found.

Finally in Chapter 5, I will discuss the results of the cointegration test and factor test. Using the cointegration test, there was no long-term relationship between trade and growth, and using the regression analysis, there were not any significant results on short-term relationship too, though imports showed significant value within the 10% significance level. When North Korea's imports increase by \$ 1, GDP can be interpreted as rising by \$ 0.57.



When using the factor analysis I was able to obtain factors which describe the fluctuation in the business cycle in North Korea. When I included the factors in the regression, I was able to see trade still did not have significant effect on growth.

## **1 Literature review**

### **1.1 Prior studies on statistics in North Korea**

Because North Korea does not disclose most of its data on its own, attempts to collect and organize available North Korean data have been made since the country's inception by government agencies in South Korea. In 1996, the Board of National Unification (BNU) published the North Korea Economic Statistics Book, a compilation of statistics on North Korea in all areas available at that time.[4] Two years later, the Korea Institute for National Unification (KINU) assembled statistical data related to North Korea's foreign trade.[44] The Korea Statistical Information Service (KOSIS) has been publishing Statistical Indicators of North Korea every year since 1995, and its statistical data are divided into fourteen subjects, including natural environment, population, total economic value, and exchanges between North and South Korea.[28] Since 1990, KOTRA has published a booklet titled Foreign Trade Trends in North Korea and annually compiles statistics on North Korea's trade in detail by trade item and country.[29]

The reliability and evaluation of North Korean statistics have also been studied. In 2007, Seok Lee of the Korea Institute for National Unification assessed the availability of statistical systems and statistics in North Korea, and then detailed the characteristics and problems of statistics in North Korea[39]. After verifying the reliability of major North Korean statistics by economic sector, Lee (2007) argued that he did not find any reason to doubt the reliability of North Korea but did find the Bank of Korea's GDP

estimates had low reliability. He also mentioned that statistics on exports were highly reliable, but import statistics should be reserved.

Sung-Min Moon (2014) from the Bank of Korea analyzed the method of statistical estimation of the institutions that estimate the North Korean national income based on the price and exchange rate standard by adjusting the statistics of each institution using the same standard, in order to compare it with other countries' income level with North Korea.[37] However, there is a limit that he did not test in the reliability of each institution's statistics. Seok-Jin Kim(2014) from the Bank of Korea tested the reliability of North Korea's trade statistics before and after 1990, and showed that KOTRA was more reliable than the statistics of the UN or the International Monetary Fund (IMF); however, KOTRA's statistics were also flawed in some ways.[26] In 2013, Seok Lee of the Korea Development Institute analyzed the statistics on trade with China, North Korea's biggest international trading partner, and compiled a book that interpreted the results through a local survey.[32] They reconstructed the data, after reviewing and criticizing the existing statistical data, and tracked the changes in trade between North Korea and China based on that new data.

## **1.2 Prior studies on trade and growth**

Research on trade and growth has been modeled mainly on the Solow's neo-classical growth model and the endogenous growth theory, and the fact that there is a correlation between trade and growth. ([18]; [34]; [38]) However, there are still disagreements about the causal relationship between trade and growth. First, there is an export-led growth hypothesis which argues exports promote growth.([12]; [13]; [19]; [36]) Second, there is an import-led growth hypothesis that income drives economic growth.([16]; [31]; [35]) Finally, there is a growth-led export hypothesis that assumes reverse causality([14]; [30]), and a bi-directional causality hypothesis that trade and growth affect each

other in both directions.[9]

Most studies on North Korea's trade and growth are based on export-led growth and import-led growth hypothesis.

In 2004, Young-Hoon Lee of the Bank of Korea Economic Research Institute measured the impact of imports on North Korea's economic growth rate from 1999 to 2003 using an import-augmented production function model with imports added to the Cobb-Douglas function.[33] Lee (2004) did not consider exports because North Korea's imports are the primary factor of production. The analysis found the economic growth rate of North Korea, as a result of the increase of trade between 1999 and 2003, was 2.4% per year. That corresponds to about 85% of the overall annual average economic growth rate of 2.8%. He explains that North Korea economy has growth since 1990 because of the effects of imports and South Korea's support to North Korea.

Soon Chan Park and Myung Chul Cho (2006) analyzed the effects of trade on economic growth and income in North Korea by using time-series data from 1965 to 2002 based on a model that included export and trade in the expanded production function used by Lee (2004).[41] The Johansen cointegration test was performed after the unit root test, but there was no cointegration relationship between trade and GDP. Regression analysis showed that when other conditions were constant, the 1% increase in trade growth increased the economic growth rate by 0.23%. At 10% significance level, exports had a greater impact on GDP than imports.

The most recent study, Byung Yeon Kim (2011) estimated the determinants that determine North Korea's economic growth using the time series data of North Korea from 1990 to 2009.[25] Kim (2011) used the cointegration model to analyze long-term determinants of economic growth and

regression analysis to analyze short-term determinants, but because of the short time series, the unit root test was omitted and the accuracy of the test was reduced. The results showed that there was no cointegration between most of the trade-related variables and GDP and that at a significance level of 10%, trade between North Korea and China had a long-term balance with North Korea's GDP. Seung-Ho Jung (2016) also analyzed the relationship between North Korea's trade and economic growth using the cointegration analysis and the vector error correction model, but he only dealt with the trade with China.[23]

Most of the studies analyzing North Korea's trade and growth have adopted cointegration tests and regression analyses, but most have concluded that there is no cointegration relationship. In this paper, I will try factor analysis, which allows us to summarize the variation of a large number of variables which reflect the business cycle of the North Korea's economy.

### 1.3 Prior studies on factor analysis

Factor analysis is a statistical method which provides a description of variability among observed variables with small number of underlying variables known as factors. The original idea and framework were conceived by Spearman(1904) [42] and the term was first used by Louis L. Thurstone[45]. Factor analysis in this thesis is conducted with reference to Harry H. Harman(1976) [21] and Jushan Bai and Serena Ng(2008) [11], who has defined the static factor model as follows:

$$X_{it} = \lambda'_i F_t + e_{it}$$

$X_{it}$  denotes the  $i$ th cross-section units, where  $i = 1, \dots, N$ , with  $t$  unit of time series observations, where  $t = 1, \dots, T$ .  $F_t$  is a vector of common factors and  $\lambda'_i$  is factor loadings.  $e_{it}$  is idiosyncratic errors. They explained, for

example, that where  $X_{it}$  is the GDP growth for country  $i$  in period  $t$ ,  $F_t$  is a vector of common shocks,  $\lambda_i$  is the heterogenous impact of the shocks, and  $e_{it}$  is country specific growth rate.

Similarly, James H. Stock and Mark W. Watson(2005) [43] and M. Ayhan Kose, Christopher Otrok, and Charles H. Whiteman(2003) [27] used factors to explain the business cycle, while Kose, Otrok, and Whiteman (2003) discovered the existence of a significant common world component that reflects economic fluctuations.

Building on this research, I will first extract the factors and check whether the extracted factors can reflect the business cycle. If the factors are well extracted and can reflect economic fluctuation, I will use these factors to analyze the relationship between trade and growth using regression analysis.

## **2 Historical overview and discussion of the data sources**

Unlike other countries, North Korea does not release most of its data. Generally speaking, there are two sources of data on North Korea's economy: the official statistics of the North Korean authorities and the statistics from external institutions. This chapter examines the current condition of statistics publishing in North Korea, the institutions which estimate North Korean data, and the characteristics of the data from each institution.

### **2.1 Official statistics of North Korea**

The official statistics of North Korea can be divided into three periods according to the format in which the data was presented:

1. from 1945 to early 1960 by the announcements from the Democratic People's Republic of Korea (DPRK) Central Bureau of Statistics,
2. from 1960 to early 1990 through short newspaper articles and speeches

by leaders, and

3. from 1990 through overseas foreign aid organizations.

After the division of Korea into North and South Korea in 1945, North Korea published official statistics in the "DPRK Central Bureau of Statistics through the Appendix to the Chosun Central Statistics" every year until 1960[1]. In 1961, only one official statistical report compiled by the Central Bureau of Statistics was published, Statistics on the Economic Development of the Democratic Chosun People's Republic of Korea[2]. Table 1 and Table 2 show the classifications and contents of these reports.

Classification	Contents
Total	Environment, administrative areas, GDP growth, distribution of population in urban and rural areas, national treasury income growth, price index etc.
Industry	Volume of manufacture cost, government-managed and interorganisational industry's production costs and means of production, production and consumer price index etc.
Agricultural economy	Total agricultural output, fruit tree orchards' area and fruit yield, mulberry and silk cocoon yield etc.
Transportation and communication	Methods of transportation, communication system, Number passengers sorted by type of transportation etc.
Construction	Estimation of construction investment, estimation of construction investment classified by the economic sector etc.
Commerce	Numbers of government-managed and joint party's retail goods price, a retail price index, growth of trade volume etc.
Culture	Number of students in various levels of education, cultural facilities, doctors and health facilities, recreation centers and nursing homes etc.

Table 1: Contents of DPRK Central Bureau of Statistics through the Appendix to the Chosun Central Statistics

Unfortunately, portions of these statistics do not meet international standards. For example, in the case of the national income, the data is not based on the System of National Account (SNA) but on the Material Product System (MPS). It is therefore necessary to make adjustments in order to compare it with other countries' statistics.[37]<sup>1</sup>

<sup>1</sup>Additionally, some of the data appears to contain exaggerated values. According to the IMF report,

Classification	Contents
Total	Environment, administrative areas, distribution of population in urban and rural areas, GDP growth, national treasury income growth, price index etc.
Industry	Volume of manufacture by industrial sector, output of the government-driven and interorganizational industries etc.
Agricultural economy	Agricultural land area, apple yield by province, forests etc.
Transportation and communication	Methods of transportation, Number passengers sorted by type of transportation etc.
Construction	Estimation of construction investment, estimation of construction investment classified by the economic sector etc.
Labour	Number of employees, number of employees classified by the economic sector, number of engineers and specialists etc.
Circulation of commodity	Numbers of government-managed and joint party commercial networks, retail goods distributions, retail price index etc.
Foreign trade	Volume of trade growth, classification of export's composition, classification of import's composition.
Education, Culture, Sanitation	Number of schools, the number of universities by province, publications and circulation of publications etc.

Table 2: Contents of Statistics on the economic development of the Democratic Chosun People's Republic of Korea

Since the mid-1960s, North Korea has not released their complete economic statistics. In the period between 1960 and 1990, statistics can only be found in political speeches, radio broadcasts from Pyongyang Broadcasting Station, or short articles from the newspaper Rodong Sinmun.[39] This fragmentary information should not be treated as reputable data but rather as state propaganda.

Since the mid-1990s, North Korea has begun to disclose at least some of their statistics in order to receive economic aid from the international community. These statistics have been gathered almost entirely from North Korea's submissions to various international organizations.

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statistics of North Korea's fiscal balance seem unrealistic as the government spending to GDP ratio is almost 126%.[6]

In 1996, North Korea Economic Statistics was published by the BNU and includes all the official available data up until that point.<sup>2</sup>

### 2.1.1 National income

In 1996, the BNU collected all of the available national income data from North Korea between 1945 and 1991, including the excerpts from the Chosun Central statistics report. However, this data is not usable for my purpose of analysis, because the time series is not complete and the figures are exaggerated.

The remaining available statistics on national income released by the North Korean authorities are found in three reports: the IMF report Democratic People’s Republic of Korea’s Fact-Finding Report (1997)[6], the DPRK and UN Development Programme (UNDP) report Thematic Roundtable Meeting on the Agricultural Recovery and Environmental Protection for the Democratic People’s Republic of Korea (1998)[7], and the United Nations Children’s Fund (UNICEF) report Analysis of the Situation of Children and Women in the Democratic People’s Republic of Korea (2006)[8]. The following table shows the specific details:

Institute	Year	Data
IMF	1997	GDP per capita of 1996 Nominal GDP of 1992~1996
UNDP	1998	GDP per capita of 1992~1996
UNICEF	2006	GDP per capita of 1997~2004

Table 3: Reports with national income data

Using these data we can get a summarized national income trend in the following way :

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<sup>2</sup>See [4] for more detailed explanations.



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
GDP Per Capita (\$)	990	991	722	587	482	464	458	454	464	478	490	524	546

Table 4: National income published by DPRK from 1992 to 2004

### 2.1.2 Trade

The only official statistics on North Korea’s trade before 1990 are found in Statistics on the Economic Development of the Democratic Chosun People’s Republic of Korea. However, it contains only four years data (1953, 1956, 1959, 1960), the summary of the import and export trade, the total trade value, and a brief description of the composition of imports and exports. The only official trade data since 1990 are the annual data between 1997 and 2004 included in the UNICEF report.[8] The following Table 5 shows the contents:

	1997	1998	1999	2000	2001	2002	2003	2004
Total merchandise export	914	858	859	877	885	908	920	948
Total merchandising import	1,038	917	918	933	939	988	1,008	1,029
Total trade deficit	124	59	59	56	54	80	88	81

Table 5: Data from UNICEF’s report (in millions of dollars)

As there is no information about import and export amount and price, the content is in fact very poor. The UN report only includes data on total merchandise export, total merchandising import, and total trade deficit. Although the time series is short and does not include details, North Korea’s official trade data is meaningful, because it is the only data collected by the North Korean authorities themselves and is the only reference data available to be compared with the mirror statistics produced by external agencies. I will discuss this further in section 2.2.2.

## 2.2 External Statistics

There are more agencies that provide North Korean statistics than one might expect. In Table 6 below, there are lists of institutions providing North

Korea’s statistics according to the different fields of data. Since some institutes only provide information in Korean, I also listed links to the webpages.

Fields	Institutes	Sources
National accounts	BOK (Bank of Korea)	<a href="http://www.bok.or.kr/broadcast.action?menuNavild=2236">http://www.bok.or.kr/broadcast.action?menuNavild=2236</a>
	UN	<a href="https://unstats.un.org/unsd/snaama/introduction.asp">https://unstats.un.org/unsd/snaama/introduction.asp</a>
	CIA(Central Intelligence Agency)	<a href="https://www.cia.gov/library/publications/the-world-factbook/geos/kn.html">https://www.cia.gov/library/publications/the-world-factbook/geos/kn.html</a>
Trade	KOTRA	<a href="http://news.kotra.or.kr/user/globalBbs/kotranews/10/globalBbsDataList.do?setIdx=247">http://news.kotra.or.kr/user/globalBbs/kotranews/10/globalBbsDataList.do?setIdx=247</a>
	Korea International Trade Association	<a href="http://stat.kita.net/stat/nks/nksMain.screen">http://stat.kita.net/stat/nks/nksMain.screen</a>
	UN Comtrade	<a href="https://comtrade.un.org/data/da">https://comtrade.un.org/data/da</a>
	IMF	<a href="http://data.imf.org/">http://data.imf.org/</a>
Food and Agriculture	WFP (World Food Programme)	<a href="http://www.wfp.org/food-security/assessment-bank?type%5B%5D=1655&amp;tid.1=222&amp;tid.6=All">http://www.wfp.org/food-security/assessment-bank?type%5B%5D=1655&amp;tid.1=222&amp;tid.6=All</a>
	FAO (Food and Agriculture Organization)	<a href="http://www.fao.org/giews/countrybrief/country.jsp?code=PRK">http://www.fao.org/giews/countrybrief/country.jsp?code=PRK</a>
Energy	IEA (International Energy Agency)	<a href="http://www.iea.org/countries/non-membercountries/koreademocraticpeoplesrepublic/">http://www.iea.org/countries/non-membercountries/koreademocraticpeoplesrepublic/</a>
Others	KOSIS (Korean Statistical Information Service)	<a href="http://kosis.kr/bukhan/index.jsp">http://kosis.kr/bukhan/index.jsp</a>
	UN Departments of Economic and Social Affairs	<a href="https://esa.un.org/unpd/wpp/">https://esa.un.org/unpd/wpp/</a>
	Daily NK	<a href="http://www.dailynk.com/korean/market.php">http://www.dailynk.com/korean/market.php</a>
	KDI (Korea Development Institute)	<a href="http://www.kdi.re.kr/forecast/forecasts_north.jsp">http://www.kdi.re.kr/forecast/forecasts_north.jsp</a>

Table 6: Sources from external institutions

Data on trade are provided in detail by Korea Trade-Investment Promotion Agency (KOTRA), Korea International Trade Agency (KITA), UN Comtrade, and the International Monetary Fund (IMF). Food and agriculture data are available from a special report by the UN Food and Agriculture Organization (FAO) and the UN World Food Programme (WFP) and FAO’s Global Information and Early Warning System (GIEWS). Energy-related data is available from the International Energy Agency (IEA). In addition, the UN Departments of Economics and Social Affairs provide population-related data, and Daily UK shows the market exchange rate and rice price trends. Since 1999, the Korea Development Institute (KDI) has been publishing monthly reports on North Korean economic trends and analysis. Finally, the Korean Statistical Information Service (KOSIS) provides an up-to-date database of nearly all the data that can be obtained by institution and by subject.

This paper deals with the relationship between trade and growth, so I will only go through the discussions of national accounts and trade-related data.

### 2.2.1 National income

As mentioned above, since North Korea does not publish its own statistics properly, North Korea's national income is estimated by external agencies such as the Bank of Korea, the UN, and the CIA. Penn World Table (PWT) and the Economist Intelligence Unit (EIU) also report North Korean statistics, but PWT has not published North Korea's statistical figures since 2004 and EIU cites the Bank of Korea and CIA's data as well. I will not cover these data in this paper. The national income data released by North Korea (denoted as "DPRK"), the UN, the CIA, and the BOK is shown in Table 7 and Figure 1 .

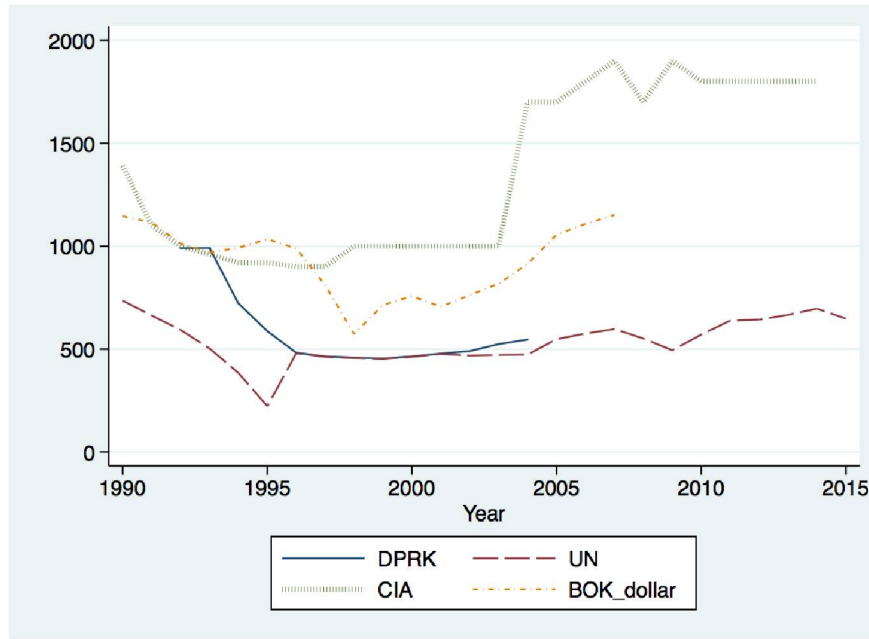


Figure 1: National income of North Korea

Looking at the graphs and tables, it can be seen that North Korea's national income estimates vary by institute because each institute applies different standards for price and exchange rate. The UN's estimation is based on North Korea's price and exchange rate while the Bank of Korea uses South Korea's price for calculation. The CIA uses purchasing power parity (PPP) and GDP estimates made by Angus Madisson in a study for

	GDP per capita			GNI per capita	
	US Dollar			Korean Won (10,000Won)	
	DPRK	UN	CIA	BOK	BOK
1970		384			
1971		413			
1972		443			
1973		477			
1974		515			
1975		558			
1976		571			
1977		587			
1978		604			
1979		622			
1980		639			
1981		653			
1982		808			
1983		794			
1984		745			
1985		722			
1986		805			
1987		836			
1988		764			
1989		811			
1990		735	1,390	1,146	81
1991		663	1,100	1,115	82
1992	990	593	1,000	1,013	79
1993	991	503	.	969	78
1994	722	384	920	992	80
1995	587	222	920	1,034	80
1996	482	479	900	989	80
1997	464	462	900	811	77
1998	458	456	1,000	573	80
1999	454	452	1,000	714	85
2000	464	462	1,000	757	86
2001	478	476	1,000	706	91
2002	490	468	1,000	762	95
2003	524	471	1,000	818	97
2004	546	473	1,700	914	105
2005		548	1,700	1,056	108
2006		575	1,800	1,108	151
2007		597	1,900	1,152	107
2008		551	1,700		117
2009		494	1,900		119
2010		570	1,800		124
2011		638	1,800		133
2012		643	1,800		137
2013		666	1,800		138
2014		696	1,800		139
2015		648			139

Table 7: National income of North Korea

the Organization for Economic Co-operation and Development (OECD). In this respect we can understand the gaps in the graph. Since low-income countries such as North Korea generally have lower price levels, the UN's estimation, which is based on North Korea's price and exchange rate, presents the lowest statistical value. The CIA's estimation will present the highest statistical value because the PPP applies the same purchasing power to wealthy countries with high incomes as to North Korea.

In the case of the UN's estimation, the GDP estimation method is not described in detail. It is based on North Korea's official announcements and submitted reports. From the graph, it can be seen that the estimates of national income since 1996 are quite similar to the official statistics of North Korea. The UN seems to be converting the national income in North Korean Won to US Dollars using the official exchange rate just as the North Korean authorities did for the official statistics. The statistics before 1996 are different from the official statistics, but they show similar figures in terms of the proportion of the GDP's industrial compositions. This implies that the estimates of the UN statistics are reconstructed or re-estimated based on certain standards or assumptions from the official announcements of North Korea.[37] These characteristics make the UN's estimation useful for researchers, because it expands the time series and provides figures similar to official statistics.

The Bank of Korea estimates the nominal gross national income (GNI) by putting North Korea's real production data into the system of the national accounts of South Korea using South Korea's price level. Because the bank is unable to obtain North Korea's value added ratio, South Korea's data are used. In other words, the bank uses the total value added data obtained by multiplying the North Korea's output data by South Korea's price and value added ratio.

When North Korea's national income is computed in this way it is denoted by the South Korean Won. Until 2007, this figure was then converted to US Dollars using South Korea's exchange rate, but this practice has since been discontinued to avoid confusion over the currency. The weakness of this estimation method lies in any appearance of movement in North Korea's national economy that is in fact caused solely by fluctuations in South Korea's exchange rate.<sup>3</sup>

The CIA announces North Korea's GDP annually through The World Factbook, using the purchasing power parity by Maddison (2001) and taking into consideration US inflation. However, some values have not changed over several years, and the estimated value is too high compared to official statistics and the UN's estimation. The majority view is that it is hard to consider the CIA's North Korean data as a consistent time series data.

Because there is not enough evidence to determine the reliability of North Korea's official national income data after 1990, I will use the UN's estimation in my analysis to allow for an expanded time series providing the most similar figures to the official statistics. Recently, studies have been conducted comparing the values of each institution by matching the price and exchange rates standard.<sup>4</sup>

### **2.2.2 Trade**

The nature of foreign trade has largely changed since the collapse of the Soviet Union in the early 1990s, as the way in which statistics can be obtained has altered. Statistics on trade in North Korea are relatively rich and detailed in comparison to other North Korean statistics such as national income, because even if they are not released by the North Korean authorities, it is possible to estimate the statistics from its trading partners. In

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<sup>3</sup>See [24] for more detail about Bank of Korea's estimation.

<sup>4</sup>See [37] for compared results.

this sense, North Korea's trade statistics from external institutes are called mirror statistics.

Since 1990, North Korea's foreign trade has increased and with it the amount of data it is possible to gather from trading partners. Institutions such as KOTRA, the UN, and the IMF have been able to estimate North Korea's trade data. It is not easy to obtain data on North Korean trade before this time as none of these agencies collected data on North Korean trade prior to 1990.

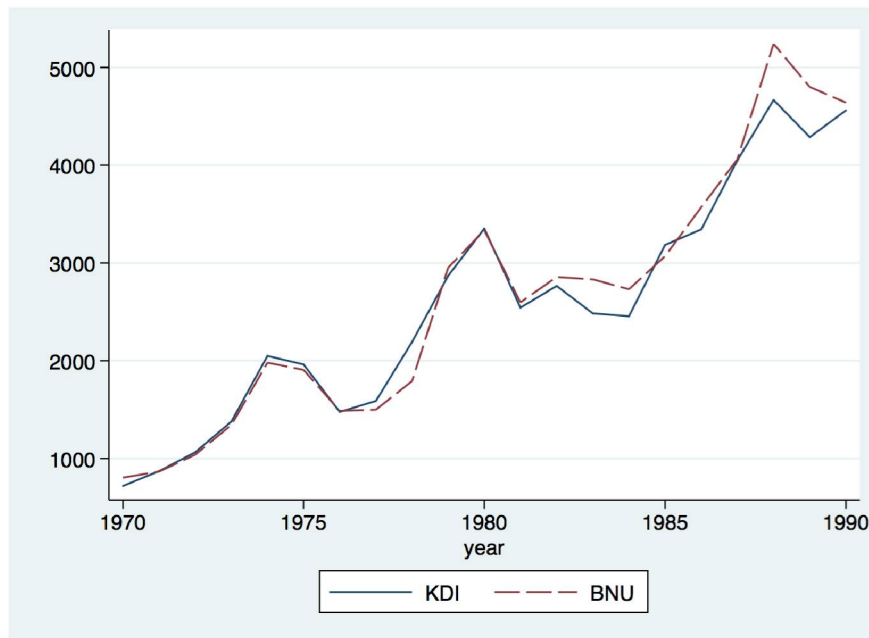


Figure 2: KDI and BNU's trade data from 1970 to 1990 (in millions of dollars).

The South Korean government and South Korean researchers have been able to compile detailed North Korean trade statistics for pre-1990 data from the statistics of major trading partners. Data from BNU (1986)[3], the Korea Development Institute (KDI 1996)[5], Choi Soo Young (1991)[15], and Gang Taek Lim(1998)[44] contain time series data on import and export, trade structure of each country, and trade structure of each item. In addition, there are several South Korean studies analyzing North Korea's foreign trade prior to 1990, but the most detailed trade statistics are from

the BNU (1986)<sup>5</sup>. The BNU and the KDI sources are the two most representative for time series data, and their contents are shown in Table 8 and Figure 2.

	Export		Import	
	BNU	KDI	BNU	KDI
1970	366	341	439	378
1971	302	313	564	558
1972	399	400	640	664
1973	500	484	843	894
1974	677	692	1,303	1,357
1975	814	807	1,093	1,155
1976	659	572	829	905
1977	680	752	820	837
1978	866	1,190	926	1,002
1979	1,458	1,489	1,494	1,380
1980	1,528	1,642	1,806	1,710
1981	1,068	1,095	1,529	1,448
1982	1,236	1,300	1,620	1,465
1983	1,317	1,137	1,515	1,347
1984	1,340	1,186	1,391	1,269
1985	1,350	1,285	1,720	1,900
1986	1,510	1,368	2,060	1,975
1987	1,670	1,558	2,390	2,491
1988	2,030	1,767	3,210	2,899
1989	1,910	1,617	2,890	2,670
1990	2,020	1,820	2,620	2,741

Table 8: KDI and BNU's trade data from 1970 to 1990 (in millions of dollars).

Both data sets are similar because the primary data used for estimation are similar, but KDI used adjusted statistics whereas BNU used original statistics without adjustments. In most countries, exports exclude freight and insurance costs but with imports freight and insurance premiums are included. If North Korea's trade statistics are compiled without adjustments,

<sup>5</sup>See [3] pp.733-795



their exports will be overestimated and the imports will be underestimated.<sup>6</sup> For the purposes of this paper, I will therefore use KDI’s data on North Korean trade before 1990.

Since the collapse of the Soviet Union in the early 1990s, North Korea’s trade has realigned away from the former communist countries. Because of this, more institutions have been able to compile better North Korean trade statistics. Since 1990, KOTRA has published the most widely used annual trade statistics on North Korea. The UN and IMF also have published North Korea mirror statistics in the UN Commodity Trade Statistics Database (COMTRADE) and the Direction of Trade Statistics (DOTS) respectively. Each institution’s data are described in Table 9 and Figure 3.

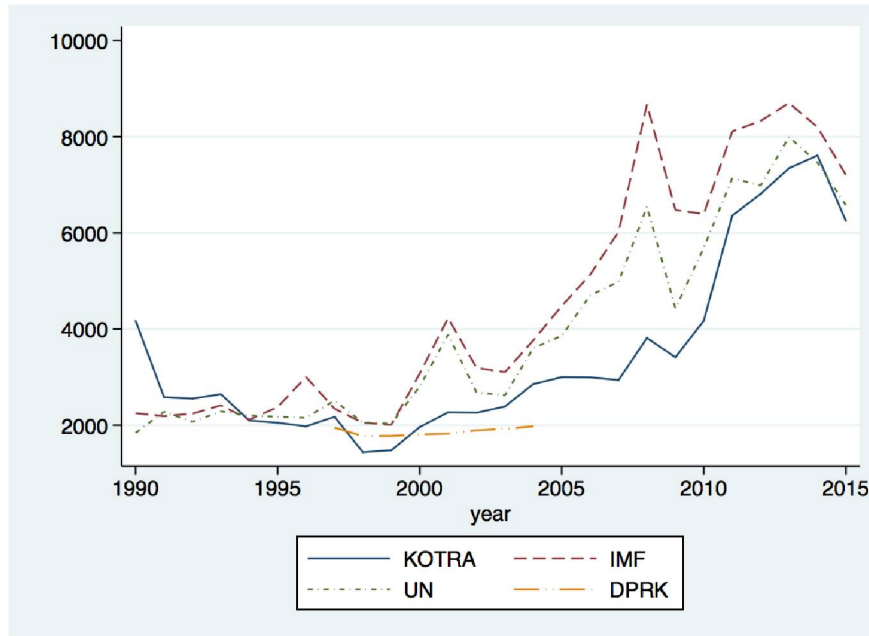


Figure 3: DPRK, KOTRA, IMF and UN’s trade data after 1990 (in millions of dollars).

In Figure 3, each external institution’s trade data and the DPRK’s official data are described. The graph shows that the KOTRA estimates are most similar to the official announcements of North Korea. On the other hand, UN and IMF show much higher estimates because the number of trading

<sup>6</sup>See [26] p.161 for details on how KDI made the adjustments.

	Export			Import		
	KOTRA	IMF	UN	KOTRA	IMF	UN
1990	1,733	924	784	2,437	1,326	1,059
1991	945	688	1,002	1,639	1,504	1,279
1992	933	846	851	1,622	1,395	1,221
1993	990	887	972	1,656	1,528	1,317
1994	858	849	1,138	1,242	1,268	1,066
1995	736	829	926	1,316	1,549	1,251
1996	727	1,019	888	1,250	1,985	1,270
1997	905	884	1,183	1,272	1,461	1,330
1998	559	881	969	883	1,171	1,088
1999	515	784	871	965	1,224	1,165
2000	556	976	1,153	1,407	2,099	1,652
2001	650	936	973	1,620	3,294	2,914
2002	736	936	1,029	1,524	2,257	1,654
2003	777	883	975	1,614	2,222	1,649
2004	1,020	1,150	1,289	1,837	2,618	2,317
2005	998	1,206	1,406	2,003	3,275	2,454
2006	947	1,525	1,834	2,049	3,605	2,866
2007	919	1,624	1,728	2,022	4,401	3,255
2008	1,130	1,959	2,245	2,685	6,710	4,298
2009	1,063	1,440	1,440	2,351	5,037	2,991
2010	1,513	2,203	2,077	2,661	4,190	3,614
2011	2,789	3,543	3,366	3,568	4,566	3,772
2012	2,880	3,354	2,889	3,931	4,974	4,098
2013	3,218	3,494	3,623	4,126	5,206	4,371
2014	3,165	3,317	3,413	4,446	4,882	4,051
2015	2,697	2,957	3,064	3,555	4,249	3,514

Table 9: KOTRA, IMF and UN's trade data after 1990 (in millions of dollars).

partners in KOTRA trade statistics is sixty to seventy, but in UN and IMF statistics the number is ninety to one hundred forty. Also, all institutions tend to include more trading partners over time. This is a result of increasing availability of trade statistics around the world, rather than a increase in the number of North Korean trading partners.

Although the UN and IMF include a large number of trading partners, this does not mean the statistics are necessarily more accurate. Rather, as the number of counter parties increases, the likelihood of inaccuracies increases. In particular, trading partners sometimes use South Korean data when they mean to use North Korean data. This causes overestimation of North Korean trade, because the number of trading partners and the total amount of trade transactions in South Korea are much larger. SeokKi Lee, Seok-jin Kim, and GyeHwan Kim (2009) of the Korea Institute for Industrial Economics and Trade pointed out that there is a high possibility of this type of error occurring with countries that have little trade with North Korea as well as with distant countries with insufficient statistical systems.[40] In addition, as a result of examining the export statistics of North Korea extracted from UN statistics by country and item, they found that the composition of some items reported were quite different from the data reported to South Korea, China, and Japan.

In order to avoid such errors, KOTRA excludes statistics from countries with lower trade frequency with North Korea, low-income developing countries with insufficient statistical systems, and mistakenly included data on South Korean trade. The KOTRA statistics show a larger value of trade than the UN and IMF statistics in early 1990s because the UN and IMF statistics do not include trade data from the former Soviet Union, North Korea's main trade partner at the time. Therefore, KOTRA's trade statistics on North Korea will be more accurate than the UN and IMF data. For this reason, I will use KOTRA's trade data after 1990.

### 3 Trends in North Korea's trade and economic growth

Table 10 shows North Korea's national income estimated by the UN. Even though North Korea has had a trade deficit since the 1970s, the country's GDP steadily increased from 1970 until 1990, when the GDP reached 14,702 million dollars. The collapse of the Soviet system in 1995 caused the GDP to drop to 4,849 million dollars. Since then, the GDP has increased by three times, including an especially rapid growth period between 1995 to 1997 due to a concerted political effort inside and outside North Korea to reverse its economic collapse. North Korea's exports and imports also increased until 1990 but decreased between 1990 and 2000. The volume of trade has again increased since 2000 although the country is still showing a deficit, last measured in 2015 at 858 million dollars. Table 11 summarizes North Korea's exports, imports, and trade balance estimated by KOTRA.

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
GDP	4,927	8,081	9,879	12,075	14,702	4,849	10,608	13,031	13,945	16,283
GDP per capita	384	558	639	722	735	222	462	548	570	648
GDP growth		10.4	4.1	3.7	-4.3	-4.37	0.41	3.76	-0.47	-1.14

Table 10: National income estimated by UN (GDP: in millions of dollars, GDP per capita: dollar).

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015
Export	341	807	1,642	1,285	1,820	736	556	998	1,514	2,697
Import	378	1,155	1,710	1,900	2,741	1,316	1,413	2,003	2,661	3,555
Trade Balance	-37	-348	-68	-615	-921	-580	-857	-1,005	-1,147	-858

Table 11: Trade balance estimated by KOTRA (in millions of dollars).

Figure 4 depicts total trade volume, exports, imports, and GDP. As shown in Table 10 and Table 11 above, trends increase in all four variables until 1990, but they show sharp declines since 1990. This seems to be related to the collapse of the Soviet Union and the socialist states, upon which North

Korea was largely economically dependent. The GDP begins to increase again in 1995, seemingly because of economic aid and trade with China and not because of policies inside of North Korea. From 2008 to 2010, both GDP and trade declined, but for now, they seem to be recovering.

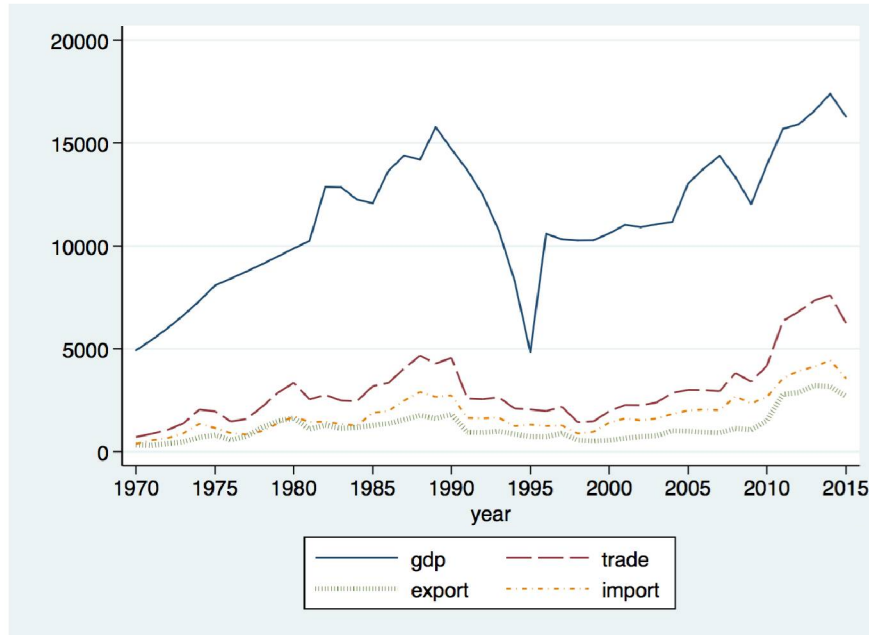


Figure 4: National income and trade (in millions of dollars).

Table 12 and Table 13 show the export and import ratio of product with classification from 1970. Since 1970, North Korea has been mainly exporting industrial products, while imports have focused on products used in manufacturing and agricultural productions. From 1990 to 2005, food imports increased substantially due to the severe food shortages. Data from 1970 to 1990 were taken from Lim (1998) [44] and data since 1990 were taken from KOTRA. Because the data before 2000 are based on the Standard International Trade Classification (SITC) and data after 2000 use the Harmonized Commodity Description and Coding System (HS) classification, I reclassified the products according to the classification standard of Lee (2004)[33].<sup>7</sup>

Figure 5 shows the proportion of North Korea's total exports in 2015.

<sup>7</sup>See [33] for a detailed taxonomy.

	Animal & Vegetable Products	Industrial products	Machinery & Transport	Textiles & Other products	Unclassified	Total
1970	12%	52.90%	4.80%	10.00%	20.60%	100%
1975	24.90%	53.20%	3.90%	4.60%	13.30%	100%
1980	12.90%	60.70%	4.80%	5.20%	16.40%	100%
1985	9.60%	50.10%	9.30%	9.60%	21.50%	100%
1990	10.60%	27.60%	13.90%	27.50%	20.30%	100%
1995	18.30%	15.20%	14.20%	32.00%	20.30%	100%
2000	22.90%	7.70%	18.50%	24.60%	26.20%	100%
2005	16.88%	33.17%	13.30%	12.35%	24.30%	100%
2010	5.92%	52.82%	7.66%	15.74%	17.86%	100%
2015	7.29%	53.41%	3.56%	31.09%	4.65%	100%

Table 12: Export products classification

	Animal & Vegetable Products	Mineral products	Textiles & Industrial products	Machinery & Transport	Unclassified	Total
1970	11.00%	16.80%	8.40%	47.40%	16.40%	100%
1975	4.10%	6.40%	13.90%	58.30%	17.30%	100%
1980	10.20%	15.90%	16.70%	31.60%	25.60%	100%
1985	3.40%	30.60%	14.70%	28.60%	22.80%	100%
1990	7.60%	15.20%	22.20%	28.00%	26.90%	100%
1995	10.50%	16.30%	20.40%	20.20%	32.60%	100%
2000	19.10%	12.20%	12.20%	25.00%	31.50%	100%
2005	20.47%	7.97%	18.72%	19.20%	33.64%	100%
2010	13.40%	7.71%	27.84%	27.85%	23.20%	100%
2015	14.63%	9.28%	34.03%	24.03%	18.02%	100%

Table 13: Import products classification

North Korea's largest export items in 2015 were mineral products such as coal and iron ore, accounting for 49.62% of total exports, and totaling 13.38 billion USD. Textile products account for 835 million USD, or 30.97% of total exports. Exports also included animal products, steel and metal products.

Figure 6 shows the proportion of North Korea's total imports in 2015. North Korea's main imports are mostly mineral products such as crude oil, but textile products overtook mineral products in 2015 for the first time, with textile products accounting for 17.7% of the total imports (6.29 billion USD) and mineral products accounting for 14.8% of total imports (5.25 billion USD). In addition, machinery and electronic products account for 16.84% of total imports, perhaps due to the steady import of electronic products such as mobile phones from China and equipment related to the construction projects.

Figure 7 shows the top twenty countries that traded with North Korea

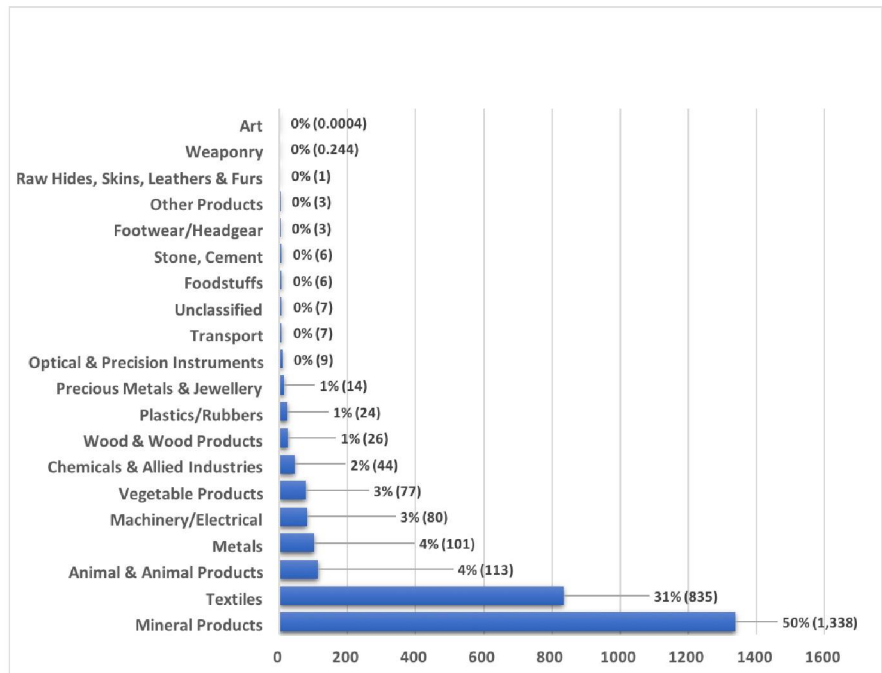


Figure 5: Composition of exports in 2015 (in millions of dollars).

in 2015, including Russia, India, Thailand, and Ukraine. North Korea's largest trading partner was China, and in 2015 China accounted for 5.71 billion USD and 91.34% of total foreign trade, an increase of 1.14% from 2014.

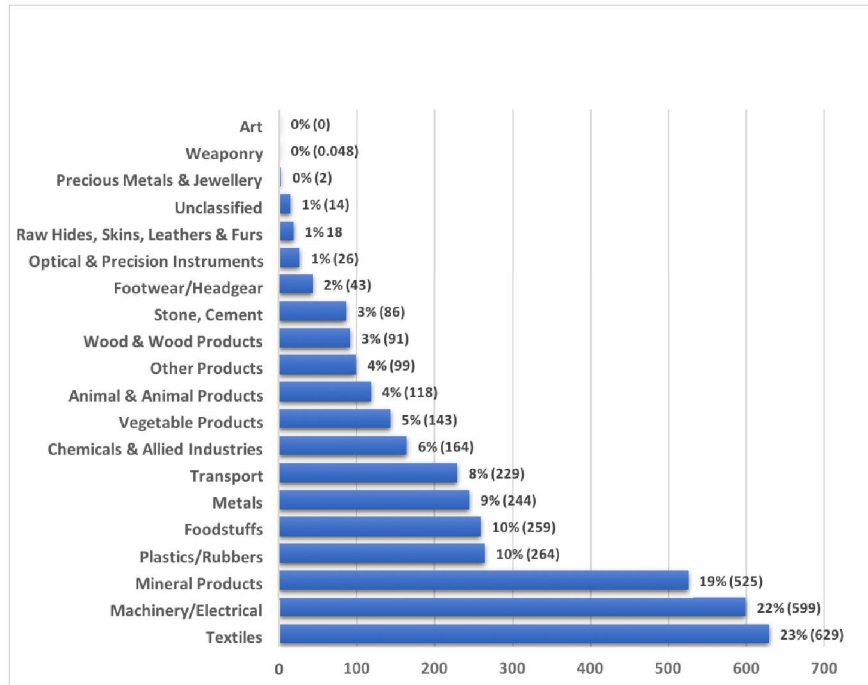


Figure 6: Composition of imports in 2015 (in millions of dollars).

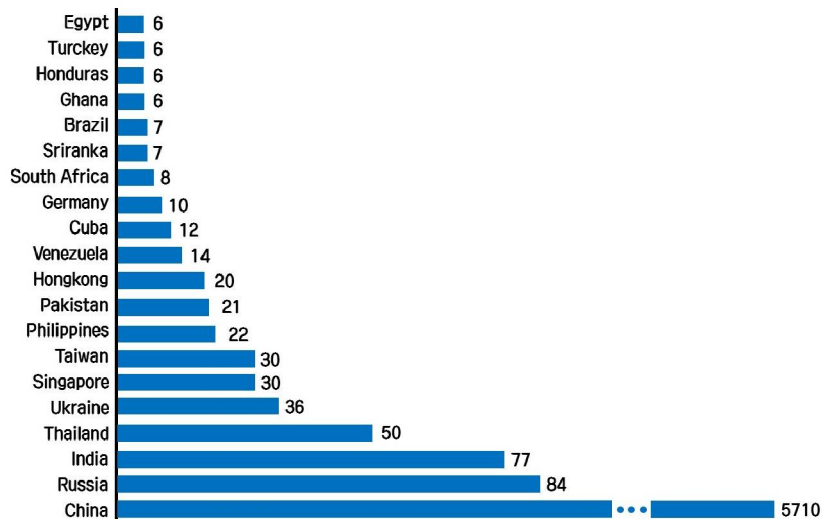


Figure 7: Top 20 trade partners in 2015 (in millions of dollars).



## 4 Econometric Methods

The data used for the analysis are as follows. As noted in Part 2, I will use the UN's dataset for the national accounts because it has the longest time series and similar figures to the official statistics from North Korea. For trade, I will use trade data from KDI before 1990 and from KOTRA after 1990. In addition, data such as food, population, and CO2 emissions used in factor analysis are based on data from FAO, the most commonly used resource among researchers. See Table 14 for a description and source of detailed variables.

First, I will conduct a cointegration test, which is the most widely accepted method by researchers to analyze the relationship between growth and trade in North Korea. The cointegration test can be used to check the long-term relationship between the time series data with non-stationary trends. Through the test, I will check whether there is a long-run equilibrium relationship, called cointegration, between North Korea's GDP and export and income. Since the cointegration test is performed with nonstationary time series data, the Johansen cointegration test<sup>8</sup>, which is the most commonly used cointegration test method, is performed after confirming the non-stationarity of the data through the unit root test.

Second, even if there is no cointegration or long-term equilibrium relationship, the short-term relationship will be estimated using the ordinary least squares (OLS) regression, since exports and imports may affect economic growth in the short-term.

Finally, another regression analysis will be performed by adding factors extracted through factor analysis. Since North Korea's time series data are relatively short, adding a large number of economic variables to regression analysis can reduce accuracy. However, using factor analysis, we can sum-

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<sup>8</sup>See more on [22]

marize the various major macroeconomic variables of North Korea and use them as variables which reflects economic fluctuations in North Korea. I will identify the relationship between North Korea's growth and trade through this stage of testing.

#### 4.1 Factor analysis

Bai and Ng (2002) pointed out that "Factor analysis is a large number of economic variables that can be modeled by a small number of reference variables"<sup>9</sup>. Using factor analysis, we can extract a number of factors that capture the variation between the major macro variables in North Korea. Factor analysis in this thesis is conducted with reference to Stock and Watson (2005)[43], Bai and Ng (2002)[10], and Bai and Ng (2008)[11]. The factor model is defined as follows:

$$X_{it} = \lambda'_i F_t + e_{it}$$

$X_{it}$  denotes the  $i$ th cross section units, where  $i = 1, \dots, N$ , with  $t$  unit of time series observations, where  $t = 1, \dots, T$ .  $F_t$  is a vector of common factors and  $\lambda'_i$  is factor loadings.  $e_{it}$  is idiosyncratic errors. The common factors contribute to the variation in all variables  $X$ .<sup>10</sup>

Unlike the cointegration analysis, the factor model uses stationary data, whereby a time series has constant statistical properties over time. Therefore, the data are converted into stationary data using first difference, which means the difference at lag 1, and then analyzed. In addition, if the variables are used as they are, it is likely that large variables such as GDP will affect the factor even more. Therefore, in order to reflect the true influence of all variables properly, the variables are subtracted from the mean and divided into standard deviations to be standardized.

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<sup>9</sup>[10]pp.191

<sup>10</sup>For more information about factor method, see [11]

Short name	Description	Time series	Source
GDP	Gross Domestic Product (Real, at constant 2005 prices)	1970~2015	UN
GDPgrth	Gross Domestic Product growth rate	1971~2015	UN
GDPcapt	Per capita GDP	1970~2015	UN
GDPdef	GDP Implicit Price Deflator	1970~2015	UN
GNI	Gross National Income	1970~2015	UN
GNIcapt	Per capita GNI	1970~2015	UN
Expend	Value Added - Final consumption expenditure	1970~2015	UN
Agr	Value Added - Agriculture, hunting, forestry, fishing	1970~2015	UN
Mining	Value Added - Mining, Manufacturing, Utilities	1970~2015	UN
Manfc	Value Added - Manufacturing	1970~2015	UN
Constr	Value Added - Construction	1970~2015	UN
Other	Value Added - Other Activities	1970~2015	UN
Tot val	Total Value Added	1970~2015	UN
Ex rate	Exchange rate	1970~2015	UN
Exports	Exports	1970~2015	KOTRA
Imports	Imports	1970~2015	KOTRA
Tot pop	Total population	1970~2015	FAO
Urb pop	Urban population	1970~2015	FAO
Rurl pop	Rural population	1970~2015	FAO
Fpop	Female population	1970~2015	FAO
Mpop	Male population	1970~2015	FAO
Agr area	Agricultural area	1970~2014	FAO
Cer area	Cereal Area harvested	1970~2014	FAO
Cer prod	Cereal Production	1970~2014	FAO
Cer yield	Cereal Yield	1970~2014	FAO
CO2	CO2 emissions	1970~2014	FAO

Table 14: Description of variables used in Factor analysis

North Korea's macro variables and sources used in the model are described in Table 14. In addition to major macro variables such as national accounts<sup>11</sup>, value added, exchange rate, population, import and export, and variables related to cereal production were also used, since grain production is also an important economic variable in North Korea.

I will check whether the extracted factors can reflect the economic fluctuation of North Korea by comparing time series data and history. If the factors are able to reflect significant changes in the economy, I can put factors into regression with growth and trade variables, which will ultimately determine how exports and imports affect growth when economic fluctuations are taken into account.

## 5 Empirical results

### 5.1 Unit root test and cointegration test

Since the cointegration test is performed with the stationary time series, I first performed a unit root test to check for stationarity. The most commonly used unit root test is the Augmented Dickey-Fuller (ADF) test<sup>12</sup>, which adds an augmented term to the DF (Dickey-Fuller) test equation to handle more complex models. Because ADF testing does not allow the possibility of structural changes, the Zivot-Andrew (Z-A)<sup>13</sup> unit root test was also performed to include one structural break in time series data in both intercept and trend.

The null hypothesis is  $I(1)$ , which indicates the existence of unit root. If the variable contains a unit root, data are non-stationary. Optimal time lag was selected through the Bayesian information criterion (BIC). Table 15

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<sup>11</sup>For the Gross Domestic Product, real GDP was used, at constant 2005 prices

<sup>12</sup>See [17] for more about the ADF test

<sup>13</sup>See [46] for more about the Zivot-Andrew test

reports the results:

		GDP	Export	Import
		lag	1	0
ADF	test statistics	-2.671	-1.326	-1.728
	critical value(5%)	-3.524	-3.520	-3.520
Z-A	test statistics	-4.521	-3.237	-4.195
	critical value(5%)	-5.080	-5.080	-5.080

Table 15: Result of unit root test

To reject the null hypothesis,  $I(1)$ , we need a large negative t-value even larger than critical values. Table 15 shows that I cannot reject the null hypothesis for all variables in both tests in 90% at 0.05 significance level. In fact, I cannot reject the null hypothesis in all levels of significance, therefore the unit root exists and the data are non-stationary.

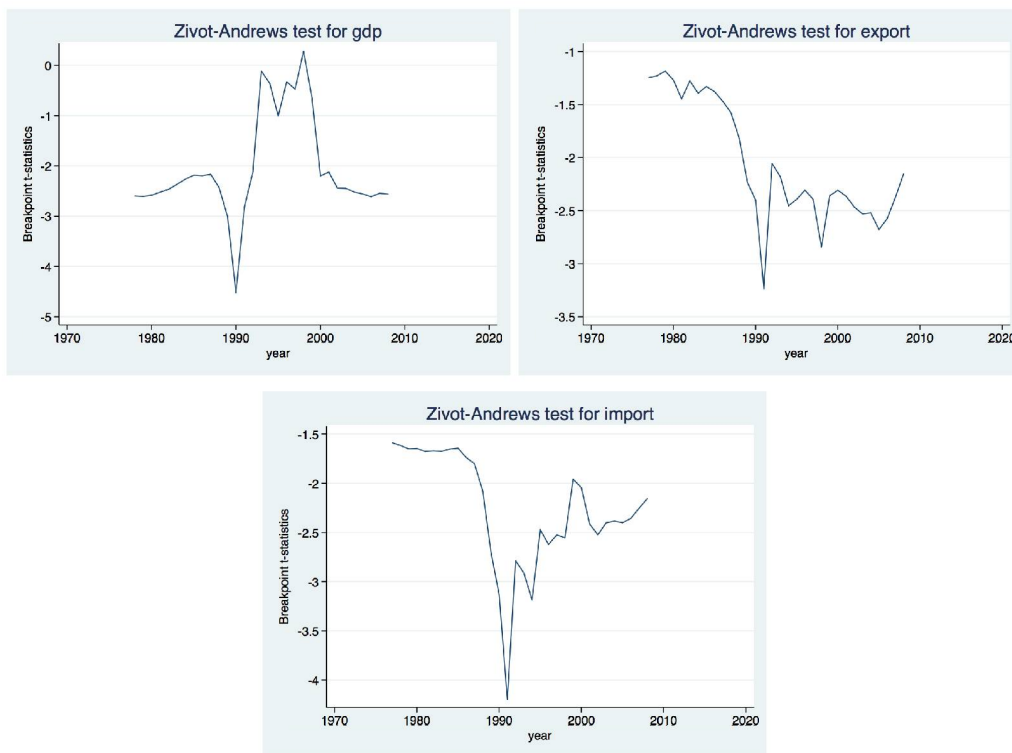


Figure 8: Breakpoint of Zivot-Andrews test

Figure 8 shows the breakpoint t-statistics in the Z-A test. A structural

break was found in 1990 and 1991. In our case, the 1990s corruption of Soviet Union may have caused a structural break in our data set.

Table 16 shows the results of the cointegration test with a cointegration rank of 0, which means there is no cointegration among variables in the long-term balance between economic growth and exports and imports. The trace statistic is under 5% of critical value, so I cannot reject the null hypothesis.

Variable	$H_0$	Trace Statistics	5% Critical Value
GDP-Export-Import	Cointegration rank = 0	21.1850*	29.68

Table 16: Result of Johansen Cointegration test

Table 17 shows the result of a regression analysis of the GDP with exports and imports using first differenced values. In the short-term, exports did not have a notable impact on economic growth, though imports were found to contribute to GDP with a p-value of 0.059, which is significant within the 10% significance level. When North Korea's imports increase by \$ 1, GDP can be interpreted as rising by \$ 0.57, while exports show negative coefficients.

	Coeff.	Std. Err.	t	P
Export	-0.2453618	0.3507779	-0.70	0.488
Import	0.5717738	0.2943804	1.94	0.059
Constant	1.31E+08	6.75E+07	1.93	0.060

Table 17: Result of regression

This result can be interpreted as a result of the characteristics of the import-oriented trade structure within North Korea. North Korea has adhered to a policy of using their exports, most of which are raw materials and oil, only as a means of earning foreign currency. This may be because it is more cost effective to increase production using imports rather than to

grow GDP through increasing exports. Since most of North Korea's crude oil comes from China, there is a possibility that more meaningful results would be obtained if the test only included trade with China. Kim (2011) showed that export and import to China had a significant impact on North Korea's growth at 10% significance level.[25]

## 5.2 Factor analysis

	Eigenvalue	Difference	Proportion	Cumulative
Factor1	10.02787	5.45573	0.4085	0.4085
Factor2	4.57214	1.61557	0.1862	0.5947
Factor3	2.95657	0.66902	0.1204	0.7151
Factor4	2.28755	1.13349	0.0932	0.8083
Factor5	1.15405	0.20958	0.047	0.8553
Factor6	0.94447	0.20272	0.0385	0.8938
Factor7	0.74176	0.06829	0.0302	0.924
Factor8	0.67347	0.29192	0.0274	0.9515
Factor9	0.38154	0.08028	0.0155	0.967
Factor10	0.30126	0.06805	0.0123	0.9793
Factor11	0.23321	0.07548	0.0095	0.9888
Factor12	0.15773	0.07225	0.0064	0.9952
Factor13	0.08547	0.03452	0.0035	0.9987

Table 18: Extracted factors

Using the variables in Table 14, I extracted the factors that are the linear combination of original variables that summarize the data in the most efficient way. The results are in Table 18. Twenty-six factors which explain the full variation of the data were extracted from twenty-six variables. All factors after factor thirteen were omitted in the table as their values are very close to zero. The first factors explains the biggest portion of the covariance of variables, the second factors explains the next biggest portion, and so on. The first five factors account for about 86% of the variation of variables, and the first three factors account for about 72%, which means that with

the first three factors, I can explain 72% of the total variability of variables.

A scree plot<sup>14</sup> of the Eigenvalues is shown in Figure 9. A significant factor is a factor with an eigenvalue equal to or greater than one, since an eigenvalue of one or more means that the factor is at least as descriptive as the variation of the original variable. Although all five factors showed an eigenvalue value of one or more, only the top three factors will be used because the rate of variability that can be explained from factor four and five were too small for my purposes.

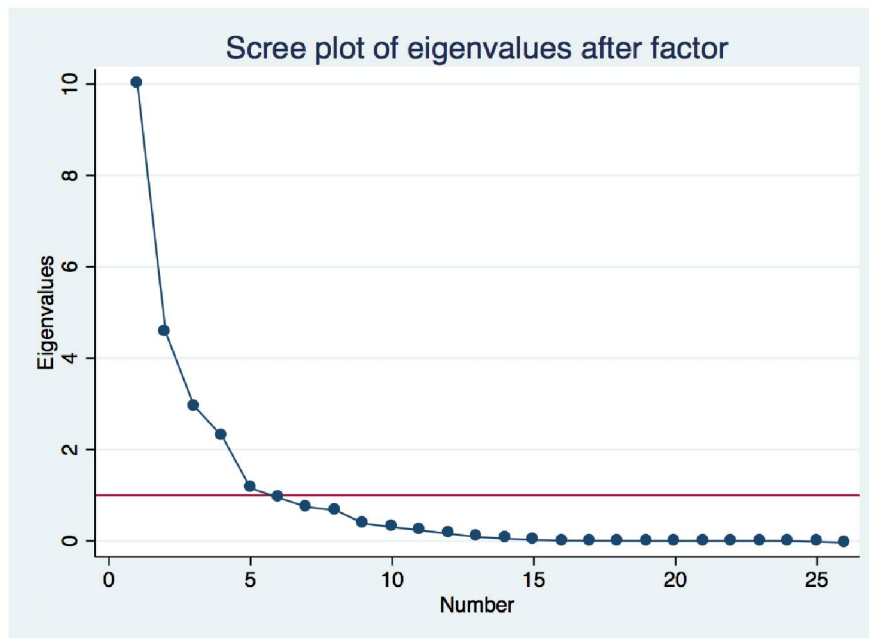


Figure 9: Scree plot of the Eigenvalues

Factor loading represents the correlation between the factor and the original variable. Table 19 shows variables and factor loading. Factor uniqueness is unexplained variation in the extracted factor. The blank part of the table is an abbreviated value because the absolute value of loading is less than 0.3. The value of the entire loading is shown in Table 21 in the Appendix.

<sup>14</sup>See [20] for more explanation about the scree plot



	Factor 1	Factor 2	Factor 3	Uniqueness
GDP	0.3409		0.7386	0.306
GDPgrth				0.9002
GDPcapt	0.9613			0.0361
GDPdef	0.9092		-0.3105	0.0503
GNI			0.8319	0.2537
GNIcapt	0.9584			0.0503
Expend	0.9752			0.0099
Agr	0.9229			0.0834
Mining	0.9458			0.097
Manfc	0.8958			0.181
Constr	0.88			0.204
Other	0.8167			0.2178
Tot val	0.9738			0.0087
Ex rate				0.9875
Exports	0.3576			0.7852
Imports	0.3061			0.7891
Tot pop	-0.3417	0.931		0.0165
Urb pop		0.8992		0.1048
Rurl pop	-0.3798	0.7999		0.2022
Fpop	-0.349	0.9265		0.0194
Mpop	-0.334	0.932		0.019
Agr area	-0.5156		0.345	0.6088
Cer area			0.4781	0.7421
Cer prod			0.6173	0.5981
Cer yield			0.5629	0.6605
CO2	0.396		0.5724	0.5119

Table 19: Factor loadings higher than 0.3

Factor 1 captures the variability of many variables most extensively. In particular, it shows high values especially related to the national accounts variables. This means Factor 1 was able to explain the variability of these national accounts variables. On the other hand, Factor 2 effectively explains the variation of population-related variables. Finally, Factor 3 is characterized by variations in variables related to grain production and can account for most of the changes in GDP and GNI.

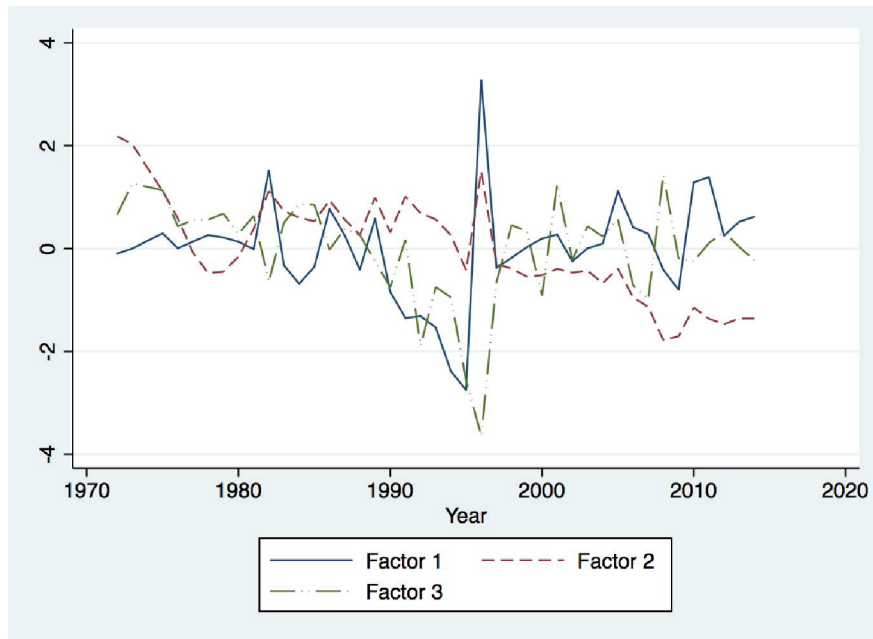


Figure 10: Graphical representation of the Factor 1,2, and 3

Figure 10 is a graphical representation of the Factor 1, 2, and 3 in time series. All three factors are similar in trends and movement, and they are related to North Korea's economic situation. All three factors began to decline in 1990 around the start of the collapse of the Soviet Union. In the mid-1990s, North Korea began accepting economic aid from abroad and China replaced the role that the Soviet Union had played within North Korea's economy. This is the most likely cause of the sharp increase of the value of the three factors. Table 19 and Figure 10, Factor 1, 2, and 3 effectively summarize various major macroeconomic variables and confirm that they can be used as variables which reflect the economic fluctuations in North

Korea. The results of the regression analysis using these factors are shown in Table 20.

		No factor	1 factor	2 factors	3 factors
Export	Coeff.	-0.2453618	-0.3531601	-0.2808927	-0.1649036
	t	(-0.70)	(-0.99)	(-0.80)	(-0.76)
Import	Coeff.	0.5717738	0.5343861	0.5945843	0.2985453
	t	(1.94)	(1.73)	(1.96)	(1.55)
Factor 1	Coeff.		1.40E+08	1.26E+08	1.45E+08
	t		(1.95)	(1.78)	(3.29)
Factor 2	Coeff.			1.17E+08	9.77E+07
	t			(1.69)	(2.27)
Factor 3	Coeff.				3.27E+08
	t				(7.84)
Constant	Coeff.	1.31E+08	1.29E+08	1.19E+08	1.38E+08
	t	(1.93)	(1.87)	(1.76)	(3.28)

Table 20: Results of regression with factors

As a result of regression with the factors reflecting the economic fluctuations, both export and import showed no significant results. Exports still had a negative coefficient in all cases, and imports seemed to have an impact when put into Factors 1 and 2, but when all of the factors were put in, they were less influential and statistically insignificant. Notably, when all three factors were analyzed, all of the factors were significant. Especially Factor 3 had a p value of 0, which was very significant. Factor 3, as shown in Table 19, was mostly correlated with economic variables related to food and grain production. In Factor 3, GDP and GNI were also highly correlated as Factor 1, but also had a much higher t-value than Factor 1. This means that North Korea's food and grain production has some influence on growth.

## Conclusion

There have been few empirical studies on North Korea's trade and growth due to the accessibility and reliability of the data. In this paper, I examined the impact of trade on growth in North Korea using most widely accepted methods the cointegration test, conventional regression analysis, and factor analysis. Like the majority of the prior research papers which studied North Korea's trade and growth using the cointegration method, I have demonstrated no cointegration relationship between trade and growth in North Korea. Using regression analysis, there was no significant result on the 5% significance level, but imports showed significant values within the 10% significance level. I was able to extract the factors which can reflect the economic fluctuations in North Korea. However, even using factors in the regression, trade did not show any significant effect on growth.

These unlikely results can be interpreted in several ways. First, since North Korea receives economic aid, it can be inferred that the influence of international support has a great impact on the economy, and that the influence of trade is relatively low. In 2015, North Korea's trade volume was 6,252 million USD, which is only 1.16% of South Korea's 541,216 million USD. Meanwhile, the total amount of aid and supplies sent from South Korea to North Korea has been around 10,361 million USD since 1995. During the Roh Moo-Hyun administration, between 2003 to 2007, the South Korean government provided about 4,256 million USD which accounted for 46% of North Korea's exports and 7% of their GDP.

Second, as mentioned above, North Korea minimized exports and imports before 1990, and most trade was only conducted through the Soviet system of exchange. The fact that 90% of North Korea's trade has been conducted with China since 1990 may also contributed to the decline in the influence of trade on growth.

Finally, there may also be a problem with the data itself. If the parameters used in the analysis were inaccurate, the results of the analysis would also be unreliable. Discussions and studies on the reliability of variables such as national income are still being conducted.

Overall, there is also room for causality. As mentioned in the literature review, discussions on the causal relationship between growth and trade are still in progress. Since there was no cointegration relationship between the variables, I could not carry out the Granger causality test to check causal relationship. Therefore, this paper has utilized the export-led and import-led hypothesis following the previous studies of growth and trade in North Korea.

Until we have a full disclosure of data from North Korea, researchers will continue to be frustrated. I was able to show that the factors extracted from twenty-six economic variables can describe the common variation of variables and reflect the economic fluctuations. If we had a higher quality and a better quantity of data, the factor method would be able to more fully describe North Korea's business cycle, and those factors could better explain the relationship between trade and growth in North Korea.

## References

- [1] *DPRK Central Bureau of Statistics through the Appendix to the Chosun Central Statistics*. Central Bureau of Statistics, 1960.
- [2] *Statistics on the economic development of the Democratic Chosun People's Republic of Korea*. Central Bureau of Statistics, 1961.
- [3] *North Korea Economic Statistics*. Board of National Unification, 1986.
- [4] *North Korea Economic Statistics*, volume 617. Board of National Unification, 1996.
- [5] *North Korean Economic Index*. KDI, Korea Development Institute, 1996.
- [6] *Democratic People's Republic of Korea's Fact-finding Report*. IMF, 1997.
- [7] *Thematic Round Table Meeting on Agricultural Recovery and Environmental Protection For the Democratic People's Republic of Korea(DPRK)*. DPRK/UNDP, 1998.
- [8] *Analysis of the Situation of Children and Women in the Democratic People's Republic of Korea*. UNICEF, 2006.
- [9] Mohsen Bahmani-Oskooee, Hamid Mohtadi, and Ghiath Shabsigh. Exports, growth and causality in ldc's: A re-examination. *Journal of Development Economics*, 36(2):405–415, 1991.
- [10] Jushan Bai and Serena Ng. Determining the number of factors in approximate factor models. *Econometrica*, 70(1):191–221, 2002.
- [11] Jushan Bai, Serena Ng, et al. Large dimensional factor analysis. *Foundations and Trends® in Econometrics*, 3(2):89–163, 2008.
- [12] Bela Balassa. Exports and economic growth: further evidence. *Journal of development Economics*, 5(2):181–189, 1978.

- [13] Jagdish N Bhagwati. Anatomy and consequences of exchange control regimes. 1978.
- [14] Jagdish N Bhagwati. *Protectionism*, volume 1. MIT press, 1989.
- [15] Soo-Young Choi. *Foreign trade of North Korea, 1946-1988: structure and performance*. PhD thesis, [Sl: sn], 1991.
- [16] David T Coe and Elhanan Helpman. International r&d spillovers. *European economic review*, 39(5):859–887, 1995.
- [17] David A Dickey and Wayne A Fuller. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association*, 74(366a):427–431, 1979.
- [18] Juergen B Donges, Anne O Krueger, and Jagdish N Bhagwati. Foreign trade regimes and economic development: Liberalization attempts and consequences, 1978.
- [19] Sebastian Edwards. Openness, productivity and growth: what do we really know? *The economic journal*, 108(447):383–398, 1998.
- [20] A Ralph Hakstian, W Todd Rogers, and Raymond B Cattell. The behavior of number-of-factors rules with simulated data. *Multivariate Behavioral Research*, 17(2):193–219, 1982.
- [21] Harry H Harman. *Modern factor analysis*. University of Chicago Press, 1976.
- [22] Søren Johansen. Estimation and hypothesis testing of cointegration vectors in gaussian vector autoregressive models. *Econometrica: Journal of the Econometric Society*, pages 1551–1580, 1991.
- [23] Seung-Ho Jung. Economic growth and trade of north korea with china: Cointegration and granger causality test. *The Comparative Economic Review.*, (23), 2016.
- [24] Byung Yeon Kim. North korean gdp: Estimates and evaluation. *Su-Un North Korean Economy*, 2008.

- [25] Byung Yeon Kim. The determinants of north korean economic growth. *POSRI Business Review*, (11), 2011.
- [26] Seok-Jin Kim. North korea trade statistics: Commentary and evaluation. In *Understanding the North Korean Economy Using Statistics*, volume 195, chapter 2-3, pages 157–195. Bank of Korea, 2014.
- [27] M Ayhan Kose, Christopher Otrok, and Charles H Whiteman. International business cycles: World, region, and country-specific factors. *The American Economic Review*, 93(4):1216–1239, 2003.
- [28] KOSIS. Statistical indicators of north korea. Korea Statistical Information Service, annual.
- [29] KOTRA. Foreign trade trends in north korea. Korea Trade-Investment Promotion Agency, annual.
- [30] Paul Krugman. Import protection as export promotion: International competition in the presence of oligopoly and economies of scale. *Monopolistic competition and international trade*, pages 180–93, 1984.
- [31] Robert Z Lawrence and David E Weinstein. Trade and growth: import-led or export-led? evidence from japan and korea. *Rethinking the East Asian Miracle*, pages 379–408, 2001.
- [32] Seok Lee. *Determinants of Trade between North Korea and China: Analysis of Trade Statistics and Survey Data*, volume 438. Korea Development Institute, 2013.
- [33] Young-Hoon Lee. An analysis of the effect of north korea’s international and inter-korean trade on its economic growth. *Bank of Korea Economic Research Institute*, 2004.
- [34] Ross Levine and David Renelt. A sensitivity analysis of cross-country growth regressions. *The American economic review*, pages 942–963, 1992.



- [35] Joy Mazumdar. Imported machinery and growth in Idcs. *Journal of Development Economics*, 65(1):209–224, 2001.
- [36] Michael Michaely. Exports and growth: an empirical investigation. *Journal of Development economics*, 4(1):49–53, 1977.
- [37] Sung-Min Moon. Introduction of statistics on income in north korea and comparison of income levels. In *Understanding the North Korean Economy Using Statistics*, volume 195, chapter 1-1, pages 11–38. Bank of Korea, 2014.
- [38] Jeffrey D Sachs, Andrew Warner, Anders Åslund, and Stanley Fischer. Economic reform and the process of global integration. *Brookings papers on economic activity*, 1995(1):1–118, 1995.
- [39] Lee Seok. *Statistics of North Korea: Availability and Reliability*, volume 196. Korea Institute for National Unification, 2007.
- [40] GyeHwan Kim SeokKi Lee, Seok-jin Kim. *North Korea Export Industry Promotion and Inter-Korean Economic Cooperation*. Number 559. Korea Institute for Industrial Economics and Trade, 2009.
- [41] Myung Chul Cho Soon Chan Park. The effects of north korea’s trade on economic growth and income. *Koreanische Zeitschrift fuer Wirtschaftswissenschaften (KZfW)*, (24):1–15, 4 2006.
- [42] Charles Spearman. ” general intelligence,” objectively determined and measured. *The American Journal of Psychology*, 15(2):201–292, 1904.
- [43] James H Stock and Mark W Watson. Implications of dynamic factor models for var analysis. Technical report, National Bureau of Economic Research, 2005.
- [44] Gang taek Lim. *Features of North Korean international trade and Outlook for Its Trade Policy Change*, volume 172. Korea Institute for National Unification, 1998.

- [45] Louis L Thurstone. Multiple factor analysis. *Psychological Review*, 38(5):406–427, 1931.
- [46] Eric Zivot and Donald W K Andrews. Further evidence on the great crash, the oil-price shock, and the unit-root hypothesis. *Journal of business & economic statistics*, 20(1):25–44, 2002.

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## Appendix

	Factor1	Factor2	Factor3	Uniqueness
GDP	0.3409	0.1795	0.7386	0.306
GDPgrth	0.0973	-0.0633	0.2938	0.9002
GDPcapt	0.9613	0.1886	-0.0656	0.0361
GDPdef	0.9092	0.163	-0.3105	0.0503
GNI	0.2112	0.0975	0.8319	0.2537
GNIcapt	0.9584	0.1765	0.0075	0.0503
Expend	0.9752	0.1807	-0.0807	0.0099
Agr	0.9229	0.2489	-0.0533	0.0834
Mining	0.9458	0.0852	0.0335	0.097
Manfc	0.8958	0.1046	0.0743	0.181
Constr	0.88	0.1317	-0.0657	0.204
Other	0.8167	0.2259	-0.2533	0.2178
Tot val	0.9738	0.1883	-0.087	0.0087
Ex rate	-0.1062	-0.0193	-0.0294	0.9875
Exports	0.3576	-0.2793	0.0946	0.7852
Imports	0.3061	-0.2831	0.1926	0.7891
Tot pop	-0.3417	0.931	0.0052	0.0165
Urb pop	-0.2863	0.8992	0.0682	0.1048
Rulr pop	-0.3798	0.7999	-0.1169	0.2022
Fpop	-0.349	0.9265	-0.0206	0.0194
Mpop	-0.334	0.932	0.0287	0.019
Agr area	-0.5156	-0.0789	0.345	0.6088
Cer area	-0.1574	0.0674	0.4781	0.7421
Cer prod	0.1402	0.0349	0.6173	0.5981
Cer yield	0.1501	0.0088	0.5629	0.6605
CO2	0.396	0.0603	0.5724	0.5119

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