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AN ESTIMATION OF LONG-TERM HOUSING DEMAND IN NORTH KOREA BASED ON MANKIW-WEIL MODEL

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This paper estimates long-term housing demand and the related housing construction investment in North Korea. First, demographically-driven housing demand is estimated based on the Mankiw-Weil model. We then calculate the demographics-driven aggregate housing demand in North Korea. According to these estimates, the pace of increase in demographically-driven housing demand shows a gradual slowdown, from an annual average of 0.61% to 0.88% between 2001 and 2020, to 0.29% between 2021 and 2030. This paper next forecasts housing demand in North Korea based on the assumption that the country will pursue external openness on a full scale from 2021, and that this will lead to a considerable growth in income. If external openness leads to increases in individual demand, then an additional 0.37%p (in the slight increase scenario) to 1.58%p (in the sharp increase scenario) in the annual rate of growth in total housing demand is likely, compared to the baseline scenario.

Keywords: Demographically-Driven Housing Demand, Mankiw-Weil Model, External Openness, Housing Construction Investment
JEL Classification: E01, E17, J10, R21

1. INTRODUCTION

Housing as an economic good is a representative durable consumer good that produces residential services and supplies them to each household over a long period of time. In the case of North Korea, most industries have been sluggish due to a weakening of the planned economic system since the "Arduous March" period in the 1990s, but the housing construction industry in North Korea seems to be very active, affected by the overall trend of the spread of the private economy. Housing construction has increased significantly in urban areas and is believed to be having a significant impact on

residents' lives. In addition, housing transactions among residents are said to have increased significantly.

The increase in population that has occurred on a considerable scale has been mentioned as the background for the promotion of housing construction and housing transactions. The North Korean market has devised an informal construction method, which was difficult to observe under previous planned economic systems, to meet a significant increase in population and in the number of households.

Transactions of rights to use housing (residential certificates) among residents are becoming more common, while the housing business method in which state-owned construction companies and private investors (donju[1]) jointly participate, as well as the informal construction method in which individuals build for themselves in the name of an institution, are both also becoming more common.

In terms of the macroeconomic aspects of the entire country, North Korea's housing construction has the following characteristics compared to other industries. Due to the business characteristics of procuring intermediate inputs from various industries, it is known to have a great effect on production and employment. In addition, the housing construction industry is a major domestic industry, and serves as a breakwater for the economy to help North Korea's economy grow stably regardless of foreign factors. In urban areas of North Korea, it is said that due to the revitalization of housing construction, housing prices have increased drastically and housing transactions have increased steadily, and related services, such as moving services, real estate brokerage services, home repair, and furniture repair, are also expanding.

The actual situation of various industries surrounding North Korea's housing sector is frequently reported through North Korea-specialized media, such as DailyNK, Asia Press, and the Voice of America (VOA). According to surveys of North Korean refugees, the housing life, housing acquisition method, and housing-related industries of North Korean residents have all changed significantly from those under the planned economic system of the 1980s, before the onset of the "Arduous March" period.

As the root cause of the drastic change in the housing market, the media and previous studies have emphasized demographic factors. No studies seem to have yet analyzed the impact of demographic factors on housing demand in North Korea by considering explicitly demographic factors, including total population and age structure. In addition, it is necessary to prepare an analysis framework that faithfully reflects the relationship between demographic variables and long-term housing demand, in order to forecast future changes in housing demand in North Korea.

The main purpose of this study, which deals with the estimation of long-term housing demand in North Korea, is to provide useful information for understanding

[1] The so-called *donju* private investors refers to a class of people who possess a significant amount of foreign currency and lend or invest funds for real economic activities (South Korea's Institute for Unification Education, 2018, p.167). They can be regarded as private investors. The emergence of private investors and their relationship with housing construction is explained in detail in Hong (2014, p.25).

current macroeconomic trends in North Korea and estimating the scale of investment in North Korean housing construction. However, the analysis of the relationship between the estimates and other macroeconomic variables and the ripple effects are beyond the subject of this study, and this paper also focuses on the problem of measurement.

First, by estimating housing demand over the next 10 to 20 years and the amount of related housing construction investment, it is possible to judge whether the vitalization of housing construction, which is regarded as an important part of North Korea's informal economy, will continue. If housing construction in North Korea shows a steady increase, it is highly likely that the North Korean economy will show relatively good growth in the future.

Second, long-term housing demand estimates can be helpful in judging the possibility of housing construction cooperation projects between the two Koreas, compared with statistics on North Korea's housing supply rate, if economic cooperation between the two Koreas is to be activated.

In addition, the study on the estimation of a quantitative scale of housing demand and related housing construction investment in North Korea is expected to complement the long-term quantitative research results of the housing sector in Korea, such as those undertaken by the Korea Land & Housing Corporation and the Korea Research Institute for Human Settlements. If basic statistical data are continuously discovered and accumulated in such a variety of ways, the results of research into housing demand and housing construction investment in North Korea could be mutually verified to improve the level of statistics. The possibility of analyzing ripple effects on other markets will also increase.

Key factors that determine housing demand are population, income level and housing costs. Of these, demographic factors are the determinants of housing demand trends over the next 10 to 20 years, and many studies have focused on demographic changes in long-term housing demand. In relation to the explanatory variables of long-term housing demand, this paper attempts to estimate housing demand in consideration of population factors. However, in case of scenarios that assume exceptional circumstances, other variables will be covered.

Housing demand in this paper refers to the demand for stock and does not mean the demand for increase in stock. In addition, housing demand in this paper refers to the residential area desired by individuals under a given population, income, and preferences, rather than requirements calculated by setting and obtaining individual minimum residential areas. Next, as a study subject, the amount of housing was measured by the area of the house, not by the number of houses.

The structure of this paper is as follows. Section 1 describes the purpose, scope, and methodology of the research. Section 2 outlines previous studies on the estimation of long-term housing demand and housing construction investment. This study divides and analyzes data from the international economy, including South Korea, and North Korean economic data, and also divides the preceding studies into household-based estimations and individual-based estimations. Section 3 examines the current status of housing in

North Korea and population trends in North Korea. Section 4 introduces Mankiw-Weil's estimation method of demographically-driven housing demand and estimates the demographically-driven housing demand in North Korea using the Mankiw-Weil technique. In Section 5, we assume that North Korea's external openness in the future will lead to a significant improvement in income levels and an increase in individual housing demand. In both the slight increase scenario and the sharp increase scenario in individual housing demand, we additionally estimate how North Korea's housing demand and related housing construction investment will change. Section 6 summarizes the estimation results and describes the limitations of the study and future research tasks.

2. LITERATURE REVIEW

2.1. Liberalization Preceding Research on World Economy and South Korean Economy

Estimation of long-term housing demand and housing construction investment has been extensively conducted, with an emphasis on demographics for the entire nation's economy. Since Mankiw and Weil (1989), studies focusing on demographic factors have been vigorous, based on new methodologies using microdata.

In relation to the methodology for estimating demographically-driven housing demand, traditional methods have been used to estimate long-term housing demand, focusing on the total number, size and characteristics of the household. The Harvard Joint Center (1988) predicted housing demand by applying estimates of household formation rates to population numbers. Myers and Gearin (2001) reflected the age of the head of households in addition to the number of households in estimating housing demand, and also showed that the demand for housing varies depending on the preference of households.

Unlike those traditional household-based approach, Mankiw and Weil (1989) for the first time proposed a method of estimating long-term housing demand that is based on individuals as household members. It can be evaluated that this method considers demographic factors, such as population and age structure, more explicitly and raises the precision of estimation. Mankiw and Weil (1989) estimated the individual demand for housing by age by applying it to U.S. microdata, and published the theory that demographically-driven housing demand, which is based on this, has a significant effect on housing prices.

Since Mankiw and Weil (1989) estimated the demographically-driven housing demand based on U.S. data, as shown in Table 1, subsequent studies using data from other countries were then actively conducted. For example, Engelhardt and Poterba (1991) analyzed the relationship between housing demand and housing prices by estimating demographically-driven housing demand using Canadian data, but did not obtain statistically significant results. In response, Mankiw and Weil (1991) first

commented on the sharp rise and fall of Canadian housing prices and commented on the need to analyze the impact of demographic factors on housing prices.[2] Ohtake and Shintani (1996) applied the Mankiw-Weil technique to Japanese data and analyzed the demographically-driven housing demand effects on housing inventory in Japan.

The Mankiw-Weil estimation method has the advantage of reflecting the demographic characteristics of household members, in that realistic housing demand in units of households is set as the sum of virtual individual demands.[3] In addition, the Mankiw-Weil method transforms household demand into individual demand in terms of methodology, which provides the advantage of facilitating the prospects of housing demand using future population estimation results.

However, the Mankiw-Weil estimation method has the disadvantage that only demographic factors are considered as determinants of housing demand, and other factors, such as wealth, financial market conditions, or government policy, are still not considered. In this regard, Poterba (1991) showed that the individual housing demand by age is not likely to remain fixed in the long run due to changes in taxation and housing costs. Swan (1995) argued that Mankiw-Weil-style demographically-driven housing demand represents only the adult population, and that accurate estimates of housing demand should include real income, relative prices, and real interest rates, in addition to the population.

Meanwhile, in South Korea, aggregate housing demand has been estimated based on changes in the number of households and income. However, recently estimates are also being made based on the Mankiw-Weil methodology. Bae et al. (2007) estimated the aggregate housing demand after estimating the change in number of households and change in income, and predicted that total housing demand will gradually decrease after 2007. Lee et al. (2011) projected aggregate housing demand based on the change in the number of households and the change in income. When estimating the number of households, the increase in the number of single-person households and the change in the main class of household demand were both reflected. Estimates show that after 2011, aggregate housing demand will decrease at a modest pace.

Kim (1997) estimated the demographically-driven housing demand for the first time in Korea based on Mankiw-Weil methodology. Mankiw and Weil (1989) estimated housing demand from housing price data, while Kim (1997) estimated housing demand from housing area data, as well as housing price data.

Chung and Cho (2005) estimated aggregate housing demand using a modified model that included income and housing cost factors, in addition to Mankiw-Weil housing demand as an explanatory variable in the housing demand estimation regression equation. As a result, the basic model shows that long-term housing demand decreases, while the modified model considering income factors does not show a declining trend.

Kim et al. (2014) estimated individual housing demand by age every year to reflect

[2] They think slow fluctuations in population may not have caused housing prices to rise and fall sharply.

[3] Choi and Lee (2009) p.120.

the change in residential consumption area over time. However, since the change in individual housing demand by age is caused by the total effects of wealth, the financial market situation, and government policy, there is still a limit in that the contribution of each cannot be decomposed by each cause. In other words, it could be said that there were not enough explicit considerations for individual factors.

2.2. Preceding Research on the North Korean Economy

According to related literature on long-term housing demand and housing construction investment in North Korea, there are not many studies focused on demographic factors. Most studies have estimated housing demand based on the number of households. No studies have explicitly considered demographic factors, such as using the Mankiw-Weil technique.

Zchang et al. (1998) estimated for the first time housing demand in North Korea after unification based on the number of households. They showed that in order to achieve 100% of the housing supply rate, demand for housing construction occurs as much as the difference between the number of households and the number of existing houses. However, as a presumption of the housing demand estimation, it is assumed that any population movement after unification is controlled, so that the population and households in North Korea are fixed. The size of each house supplied per household was 72 square meters.

Kim (2008) estimated North Korean housing investment demand by considering changes in the number of households and population movements to development areas as the causes of change in housing demand and construction. When North Korea opens its doors to the external world, additional housing demand for 150,000 households is expected to appear annually due to rising incomes and population shifts to developing regions.

Choi et al. (2018) estimated North Korea's housing demand using the estimation method of housing demand per capita based on residential area, the estimation method of housing demand based on households, and the income/price change model. Per capita residential area was estimated based on the GDP growth rate of North Korea based on 15 square meters per capita as set at the International Housing Conference held in 2015. It is assumed here that per capita housing demand increases by the real economic growth rate. In the estimation method based on households, the number of individuals per household was 4.8 in 1995 and 4.1 in 2008. Based on current North Korean data, the number of households is equal to the number of houses, so the number of houses is estimated based on the number of households. In the income/price change model, the increase in total housing demand was estimated by adding the increase in households and the increase in individual housing demand. Any increased rate of individual housing demand due to the change in income and price was difficult to obtain from the North Korean data. The rate of increase in housing demand in South Korea in comparative years was used. Based on these findings, it is expected that housing construction in

North Korea will continue to grow in the future.

On the other hand, in relation to the actual situation of North Korean housing, Chung (2012) analyzed the results of a survey of the North Korean Population Census in 2008. The relationship between the North and South Korean population and housing was heterogeneous, considering the high proportion of large families, large number of individuals per household, and high proportion of grouped populations.

Hong (2014) systematically analyzed the phenomenon that North Korea's apartment construction and sales were stagnant in the planned economic sector, but was informally activated. In addition, an emphasis was placed on the number of people in the background of the huge increase in housing construction investment after the "Arduous March" period of the 1990s.

3. HOUSING STATUS AND POPULATION TRENDS IN NORTH KOREA

3.1. Housing Status in North Korea

In North Korea, most houses are built and owned by the state, and the state would provide housing to the people free-of-charge. North Korea's housing allocation system is a one-generation, one-home housing assignment system, where, after adolescents finish their studies, they get a fixed number of years of employment or get married.[4]

In terms of housing status in North Korea, the share of multiplex houses and detached houses is high, and the share of apartments is relatively low. According to North Korea's Population Census results, as of 2008, there were 2.58 million households living in multiplex houses, 1.99 million households living in detached houses, 1.26 million households living in apartments, and 50,000 households living in some other type of structure. In South Korea, the proportion of households living in apartments is more than 50%, while in North Korea, the proportion of households living in apartments is slightly over 20% (see Table 1).

A look at the housing type by region finds that there are some differences in the form of housing structure between urban and rural areas. In cities, multiplex houses account for 49.5% and apartments 32.5%. However, in Pyongyang city, apartments account for 54.6% of dwellings. That share of apartments is very high. In rural areas, detached houses account for 59.4% of dwellings and multiplex houses account for 35.1%. In rural areas, the share of detached houses represented by "rural cultural housing" is very high, and is much higher than the share of multiplex houses.

[4] According to North Korea's own House Act and City Management Act, housing assignments are made by the People's Committee of each province, city and county. The house should be allocated in consideration of the number of families, commute time, occupational characteristics, and the required building area (Song (2013), p.62).

As shown in Table 2, North Korea's housing supply rate is broadly estimated at 70%, although the estimate varies greatly depending on the research institute. The Korea Land & Housing Research Institute estimated the inventory to be 4.5 million and found that housing demand exceeded housing inventory by about 1.5 million.

Table 1. Number of Households in North Korea by Housing Type

	Detached Houses	Multiplex Houses	Apartments	Other	Total
Whole country	1,988,415	2,584,435	1,261,709	52,912	5,887,471
	(33.8)	(43.9)	(21.4)	(0.9)	(100.0)
Cities	616,955	1,773,314	1,164,767	24,490	3,579,626
	(17.2)	(49.5)	(32.5)	(0.7)	(100.0)
Pyongyang	95,804	266,194	444,672	7,099	813,769
	(11.8)	(32.7)	(54.6)	(0.9)	(100.0)
Rural Areas	1,371,460	811,021	96,942	28,422	2,307,845
	(59.4)	(35.1)	(4.2)	(1.2)	(100.0)

Source: Korean National Statistical Office KOSIS, DPRK 2008 Population Census Results
Note: The figures in parentheses are the percentage of the total by housing type.

Table 2. Estimates of Housing Supply Rate in North Korea

	Land & Housing Institute	North Korean Economy Forum	Korea Research Institute for Human Settlements	Construction & Economy Research Institute
Number of Individuals (within Household)	4.8 persons (1999)	4.2 persons (2002)	4.3 persons (2006)	4.1 persons (2008)
Number of Households	4.9 million (1995)	4.8 million	5.4 million (2006)	5.9 million (2008)
Number of Houses	2.7-3.0 million	2.9-3.8 million	4.1-4.5 million (2006)	4.5-4.8 million (2013)
Housing Supply Rate	55-63%	70%	77-83%	74-80%

Source: Choi et al. (2015), p.67.

3.2. Housing Construction in North Korea

In North Korea, housing has been regarded as an important commodity for one's basic life and for the reproduction of the labor force.

After the "Arduous March" period in the 1990s, the state's housing supply ceased. However, since the 2000s, housing construction in North Korea began to come to life as a result of the widespread private economy and acquiescence by North Korean authorities.

As shown in Table 3, the GDP of North Korea's construction industry[5] posted negative growth of 5% per year in the 1990s, and the construction industry's growth rate was worse than the overall economic growth rate (minus 2.5%). However, after returning to an average annual growth of 1.4% in the 2000s, the economy grew at 1.4% in the 2011-2016 period, which is better than North Korea's overall economic growth rate (1.1%) and the growth rate in the manufacturing industry (0.3%).

Previous studies have shown that housing construction in North Korea has shown relatively good growth rates recently, suggesting the emergence of private investors (donju in Korean) and the formation of property rights[6], along with the long-term growth of the population.

Meanwhile, as shown in Table 8, the construction industry's share of GDP was 8.5% and 8.3% in 2001-2010 and 2011-2016, respectively. The construction industry, including housing construction, is an important part of the macroeconomy in North Korea.

Table 3. Growth Rate of Construction in North Korea

	1991-2000	2001-2010	2011-2016
Growth Rate of Total GDP	-2.7%	1.2%	1.1%
Construction	**-5.0%**	**1.4%**	**1.4%**
Manufacturing	-6.7%	1.0%	0.3%
Mining	-4.2%	1.4%	1.8%
Share of construction industry in total GDP	7.0%	8.5%	8.3%

Source: Bank of Korea, ECOS

Since 1949, the construction of housing in North Korea has been led by the state through housing construction plans that reflect official socialist ideology and residents' demand. Since 1987, however, the budget for housing construction deteriorated, leading to a sharp drop in housing construction, with only 11%-15% of buildings being built, compared to what was planned (see Table 4). After the "Arduous March" period in the 1990s, the collapse of the planned economic systems caused housing construction to cease.

Since the year 2000, an informal business method has been introduced in which

[5] Currently, GDP statistics for North Korea are only published for the upper category of construction (i.e., housing construction and construction of Other buildings and structures), while the lower category of housing construction is not published separately. In this section, the construction industry's GDP was used to outline trends in the housing construction industry.

[6] Kim, S.J. (2015), p.57.

state-owned enterprises and private investors participate in overcoming housing shortages caused by paralyzed planned economic systems.

As shown in Figure 1, State-owned enterprises are responsible for land use approval, construction permits and the supply of heavy equipment, and private investors (donju) are responsible for supplying the labor force and raw materials, such as the cement needed for housing construction. The construction and sale of homes by private investment is illegal in North Korea, but the housing shortage cannot be resolved in urban areas where demand is increasing. This leads to acquiescence from North Korean authorities.[7]

Table 4. Goal and Performance of Housing Construction in North Korea

	Goal (households)	Performance (households)	Degree of Performance
1957-1960	Cities: 400 thousand, Rural Areas: 200 thousand	150 thousand	25%
1961-1970	1,200 thousand	800 thousand	67%
1971-1976	1,000 thousand	880 thousand	88%
1978-1984	1,400-2,000 thousand	750-1,050 thousand	50%
1987-1993	1,050-1,400 thousand	160 thousand	11-15%

Source: Sung-won Hong (2014), p.17

Table 5. Housing Construction in North Korea Since 2000

Period	Housing Completion (Units)	Example		
		Region	Number of Households	Time of Completion
2000-2005	29,692 (4,949)	Kim Jong-Il Idolization Village	-	2003
2006-2010	25,417 (5,083)	Pyonganbuk-do Rural housing	8,000	2007
2011-2017	45,754 (6,536)	Pyongyang Changjeon Street	2,784	2012
		Pyongyang Eunha Scientist Complex	1,022	2013
		Namheung Youth Combinat	500	2013
		Rajin Sunbong District	1,300	2015
		Pyongyang Mirae Scientist Street	300	2015
		Pyongyang Ryomyong Street	4,800	2017

Source: Author's calculations based on data from Choi et al. (2015) and Choi et al. (2018).
Note: Figures in parentheses are based on annual averages.

[7] Hong S.W (2014), p. 5-28.

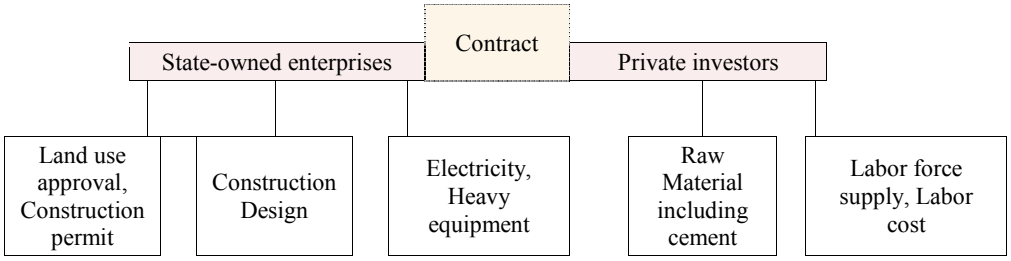


Figure 1. Housing Construction Method in which State-owned Enterprises and Private Investors Participate

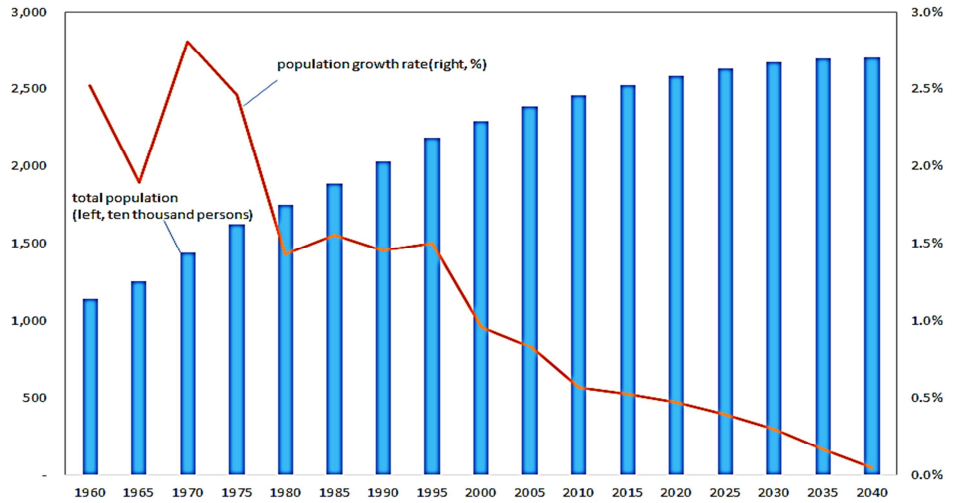
3.3. Population Trends in North Korea

According to the U.N. World Population Prospects, North Korea's population growth rate has gradually decreased from 0.7% annually in 2001-2010 to 0.5% and 0.3% in 2011-2020 and 2021-2030, respectively. It rate is expected to stagnate at 0% by 2040 (see Figure 2).

The population of North Korea is 25.6 million as of 2018, which is 50.1% of that of South Korea. Since the birth rate in North Korea is considerably higher than that in South Korea, the population proportion between North and South Korea will gradually increase, reaching 50.7% and 51.5% in 2030 and 2040, respectively (see Table 6).

The total fertility rate in the two Koreas in the 1990-2015 period has generally declined, with North Korea showing 0.5 –to 0.8 people higher levels than South Korea (see Table 7). According to Lee (2018), the change in the total fertility rate is determined by the change in the percentage of the female population with spouses of each age, the fertility rate of females with spouses of each age, and the fertility rate of females without spouses of each age. Considering that there are no differences in the fertility rate of females with spouses between the two Koreas,[8] differences in the total fertility rate seem to be mainly due to differences in the percentages of females with spouses.

[8] When we calculate the ratio of annual births to the number of 20- to 44-year-old females with spouses using the KOSIS data from the National Statistical Office, both Koreas are similar at 0.1 per person levels (2010 South Korea Census, 2008 North Korea Census).



Source: U.N. World Population Prospects (2017)

Figure 2. Trends in Population in North Korea

Table 6. Population Trends in South and North Korea

(Million persons)

	1950	1970	1990	2018	2030	2040
North Korea (A)	10.55	14.41	20.29	25.61	26.74	26.97
South Korea (B)	19.21	32.21	42.92	51.16	52.70	52.41
Ratio (A/B, %)	54.9	44.7	47.3	50.1	50.7	51.5

Source: U.N. World Population Prospects (2017).

Table 7. Trends of Total Fertility Rates in South and North Korea

(Person)

	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015
North Korea (A)	2.25	2.01	2.00	2.00	1.95
South Korea (B)	1.68	1.50	1.21	1.17	1.23
Ratio (A/B, %)	+0.57	+0.51	+0.79	+0.83	+0.72

Source: U.N. World Population Prospects (2017).

The proportion of females with spouses in North Korea is significantly higher, ranging from 8.6% to 44.6%, depending on the age group. In particular, in the age group of 25- to 34-year-olds, the proportion of females with spouses in South Korea is only half that of North Korea (see Table 8).

The age structure of the population shows that the proportion of 50 to 59-year-olds is

high due to the baby boom after the Korean War (1950-1953) and the proportion of that age group is also relatively high due to the end of World War II[9] (see Figure 3).

As of 2018, three peaks have emerged as of 2018: 2.45 million people aged 45 to 49-years-old, 1.98 million people aged 20 to 24–years-old, and 0.80 million people aged 70 to 74–years-old. On the other hand, there are three troughs: 1.69 million people aged 35 to 39–years-old, 1 million people aged 5 to 9-years-old, and 0.67 million people aged 65 to 69-years-old. The high proportion of 45 to 49-year-olds is presumably because they were born as children to the group of 70 to 74-year-olds. In North Korea, a birth control policy has also been in operation since 1970, so the proportion of those under the age of 40- to 44-years-old is decreasing. However, the proportion of 20 to 29-year-olds born as offspring of the Baby Boomers is relatively high.[10]

Compared with South Korea's age structure, we see that its shape is very similar to that of North Korea, considering that South Korea also has a high proportion of 50 to 59-year-olds due to the end of the Korean War (1950-1953), and a high proportion of 45 to 49-year-olds, an echo generation of the generation born after the end of World War II with the number of people under the age of 44 continuing to decrease due to the birth control policy. However, in South Korea, as shown in Figure 4, because of the effects of the low fertility rate due to a decrease in the percentage of females with spouses, the proportion of the population under 19 is sharply lower.[11] That makes a little difference.

Table 8. Comparison of Total Fertility Rates in South and North Korea

(%)

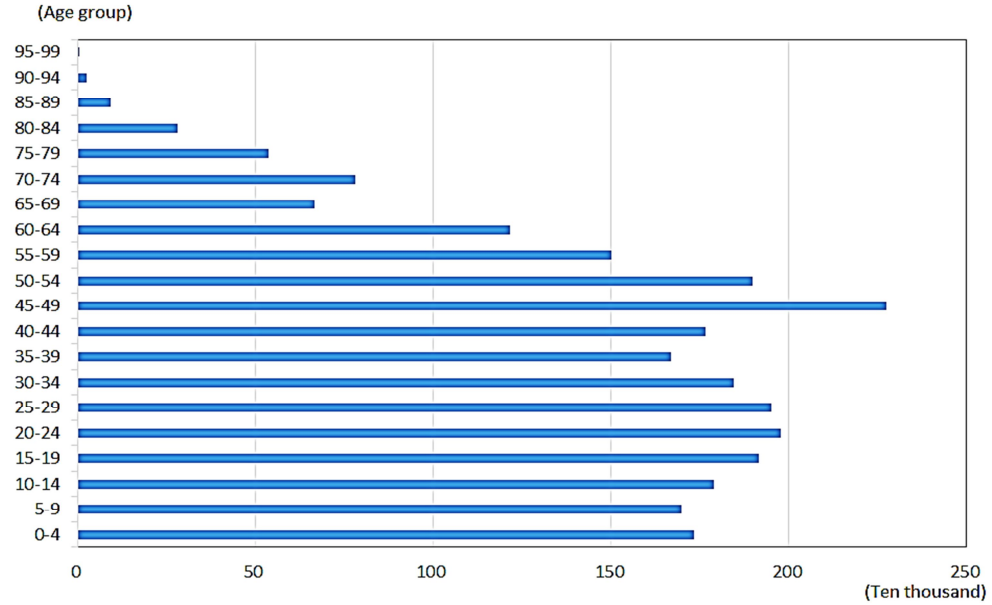
	20-24	25-29	30-34	35-39	40-44	20-44
North Korea (A)	19.1	74.6	93.9	94.1	92.6	75.8
South Korea (B)	3.9	30.0	68.5	81.6	84.0	57.4
Difference (A-B)	+15.2	+44.6	+25.4	+12.5	+8.6	+18.4

Source: Korean National Statistical Office KOSIS.

[9] According to North Korea's People's Economic Development Statistics (1961), the number of births per 1,000 residents rose from 31.3 in 1944 to 41.2 in 1949, and from 25.1 in 1953 to 31.0 in 1956 and then to 39.3 in 1959.

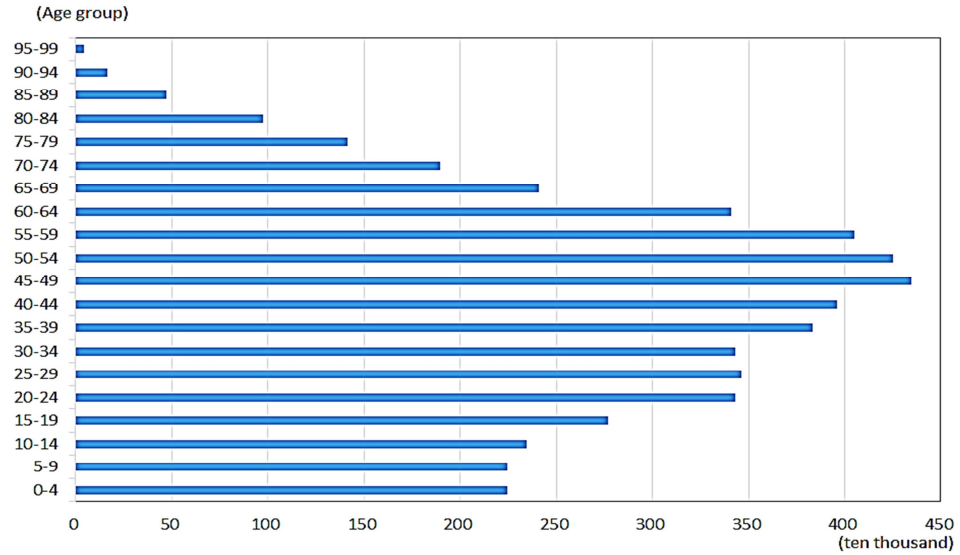
[10] The children born to Baby Boomers are said to be part of the echo generation (National Statistical Office, 2002, p.3).

[11] As of 2018, the population in its teens is 75% of the population in its 20s and the population under 9-years-old is 65% of the population in its 20s.



Source: U.N. World Population Prospects (2017).

Figure 3. Age Structure of Population in North Korea (2018)



Source: U.N. World Population Prospects (2017)

Figure 4. Age Structure of Population in South Korea (2018)

4. ESTIMATION OF DEMOGRAPHICALLY-DRIVEN HOUSING DEMAND IN NORTH KOREA

4.1. Overview of Mankiw-Weil's Housing Demand Estimation Techniques

Mankiw and Weil (1989) developed for the first time a housing demand estimation method that explicitly considered demographics and estimated long-term housing demand in the United States. As a result, the large increase in U.S. housing prices in the 1970s was attributed to the entry of the baby boom generation born in the 1950s into the main housing market. In addition, in the 1990s home prices were expected to drop sharply as the baby bust generation entered the main housing market. Mankiw and Weil (1989) estimated individual housing demand and demographically-driven aggregate housing demand in order to grasp the impact of such demographic changes on aggregate housing demand.

4.1.1. Estimation of Housing Demand of Each Individual by Age

To understand how housing demand is affected by the size of the age group, cross-sectional data is first used to identify the relationship between individual age and housing demand. Household demand (h) for homes is modeled as a sum of the housing demand (h_j) of the members in the household.

$$h = \sum_{j=1}^{n} h_j, \tag{1}$$

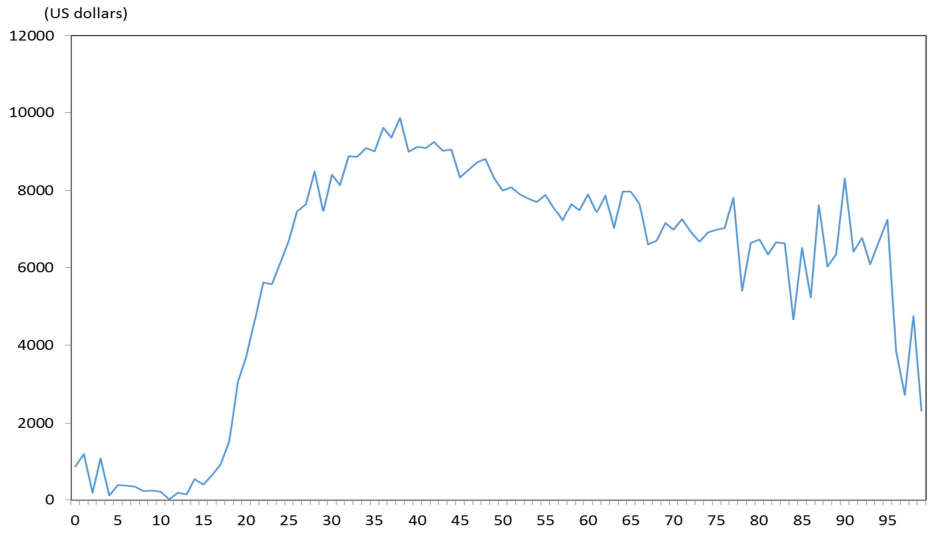
where h_j: housing demand of the jth member of a household,
n: number of household members.

In general, individual housing demand is assumed to be a function of age, income, and other household characteristics. But here it is assumed to be only a function of age because here we are interested in finding the best estimate of household housing demand given only information about individual ages.

If each age is allowed to have a housing demand parameter, then one individual's housing demand, hereinafter referred to as "individual housing demand by age" and "individual housing demand", is given by:

$$h_j = \alpha_0 DUMMY0_j + \alpha_1 DUMMY1_j + \cdots + \alpha_n DUMMYn_j, \tag{2}$$

where h_j: housing demand of the j^{th} member of a household,
α_i: housing demand by a person of age i,
$DUMMY0 = 1$ if age = 0, $DUMMY1 = 1$ if age = 1, $DUMMYn = 1$ if age = n.



Source: Mankiw and Weil (1989).

Figure 5. Estimated Housing Demand by Age in U.S. based on Mankiw-Weil Technique

Combining Equation 1 and Equation 2 gives the equation for housing demand by a household.

$$h_j = \alpha_0 \sum DUMMY0_i + \alpha_1 \sum DUMMY1_i + \cdots + \alpha_{99} \sum DUMMY99_i + \epsilon, \quad (3)$$

where h is housing demand by a household.

Mankiw-Weil sampled 53,518 households or 1/1,000 of all households from the 1970 census and estimated Equation (3) by regression analysis. Housing demand was measured using the dollar value. Mankiw and Weil's (1989) estimates are shown in Figure 5. The M-W estimates of the α value in the U.S. show a sharp increase in housing demand in among people in their 20s. On the other hand, those under the age of 19 are shown to have little impact on housing demand. After the age of 40, housing demand gradually decreases by 1% per year. Overall, in the United States there is a big gap in the housing demand between major classes and minor classes.

4.1.2. Calculation of Demographically-Driven Aggregate Housing Demand

Demographically-driven aggregate housing demand (H_t) for year t is calculated as:

$$H_t = \sum_i \alpha_i N_{i,t}, \quad (4)$$

where α_i: housing demand by age estimated from Equation 3,
$N_{i,t}$: the number of people of age i in year t.

As shown in Table 9, in the 1980s, the average annual rate of increase in housing demand exceeded 1%, which was expected to lead to a sharp rise in housing prices. In the 1990s, however, the average annual rate of increase in housing demand continued to fall below 1%, which was expected to cause a slowdown or fall in housing prices.

Table 9. Trends of Demographically-driven aggregate housing demand in U.S.

(Million US Dollars)

1960	1970	1980	1990	2000	2010	2020
944,395	1,075,162	1,267,075	1,446,637	1,548,612	1,639,640	1,712,960
-	(1.3)	(1.7)	(1.3)	(0.7)	(0.6)	(0.4)

Source: Mankiw and Weil (1989).

Note: The figures in parentheses are average annual growth rate.

As shown in Equation (4), the Mankiw-Weil type demographically-driven housing demand is a new time series of housing demand that combines the results of a cross-sectional estimation of individual housing demand by age and the time series of the age structure of the population.[12]

4.1.3. Index of Demographically-Driven Aggregate Housing Demand

When the base year is 0, the demographically-driven aggregate housing demand index for year t is calculated by the following Equation (5)

$$H_t/H_0 = \sum_i \alpha_i N_{i,t} / \sum_i \alpha_i N_{i,0}, \quad (5)$$

where $N_{i,0}$: the number of people of age i in year 0 (base year),
$N_{i,t}$: the number of people of age i in year t (comparative year).

Mankiw and Weil (1989) analyzed the growth rate of demographically-driven housing demand in the base year and the comparative year, but did not explicitly state its nature as an index. However, this rate of change can be expressed as a demographically-driven housing demand index, which has the property of an index, as shown in Equation (5). Swan (1995) understood the growth rate of the M-W housing demand as an index of population weighted by estimates of individual housing demand by age. Swan (1995) sees the Mankiw-Weil housing demand time series as a measure of population change with income and housing prices fixed. However, as Ohtake and

[12] Mankiw and Weil (1989), p.243.

Shintani (1996) understand the rate of change in the M-W housing demand as the housing demand index, it is reasonable to understand this index as the housing demand index rather than the population index.

Since the Mankiw-Weil estimation method of aggregate housing demand has the estimates of individual housing demand by age fixed for a long time, this type of index may appear to be an index that measures population change. However, the index is basically a housing demand index that measures the part that is attributable to population factors in the change in aggregate housing demand. If the demand for individual housing demand is estimated periodically, the change in the housing demand index can be broken down into parts that are attributable to changes in population factors and parts that are attributable to changes among individual housing demand factors. Meanwhile, when the rate of change in the Mankiw-Weil housing demand is expressed in index form, it has properties such as invariance[13], transitivity[14] and product.[15]

4.2. Estimation of Demographically-Driven Housing Demand and Related Housing Construction Investment in North Korea

4.2.1. Characteristics of Basic Statistical Data

In order to estimate housing demand in North Korea based on the Mankiw-Weil method, this paper used basic statistics based on surveys of North Korean refugees' residence of origin, age of the individual within the household, and their residential area. The baseline for the survey was based on 2007 when those surveyed had lived in North Korea. The surveys were conducted among residents who had lived in North Korea in 2007, in order to have a sufficient number of survey subjects.

The survey was conducted between the fourth quarter of 2017 and the first quarter of 2018 by a surveying company commissioned by the author. As shown in Table 10, a total of 470 households were surveyed, including 210 households in Ryanggang-do, 125 households in Hamgyongbuk-do, 32 households in Hamgyongnam-do, and 103 households in other regions. The share of answers from the North Korea-China border is high, considering that People from Ryanggang-do and Hamgyong-do account for 44.7% and 33.4%, respectively, of those surveyed. Taking into account the characteristics of North Korean refugees, who tend to be very much concentrated in the border areas

[13] For example, if we multiply α_i by λ, then, $H_t = \sum_i \lambda\alpha_i N_{i,t} = \lambda \sum_i \alpha_i N_{i,t}$, $H_0 = \sum_i \lambda\alpha_i N_{i,0} = \lambda \sum_i \alpha_i N_{i,0}$. Therefore, $H_t/H_0 = \sum_i(\lambda\alpha_i)N_{i,t}/\sum_i(\lambda\alpha_i)N_{i,0} = \sum_i \alpha_i N_{i,t}/\sum_i \alpha_i N_{i,0}$ (ILO CPI Manual (2004), p.294).

[14] $H_t/H_0 = (H_n/H_0).(H_t/H_n)$. In other words, the index comparing period 0 and period t directly and the index comparing period 0 and period t indirectly through the period n are identical. (ILO CPI Manual (2004) p.306)

[15] The ratio of nominal amounts can be expressed as the product of the price index and the quantity index (ILO CPI Manual (2004), p. 293).

where escape is relatively easy[16], there is also room for regional bias of this sample to be relatively low. This is because this study tried to include as much as possible refugees from North Korean areas that have fewer refugees.

Among the North Korean refugees surveyed, there were 470 households. The population surveyed was 1,572 people, the total number of household or family members who lived with the refugees. The average number of individuals per household is 3.3, with little difference between 3.0 and 3.5 by region. However, the number of household members in North Korea's population survey in 2008 is somewhat smaller than 3.9. The average residential area is 72.9 square meters, which differs slightly across regions, from 53.1 to 90.4 square meters.

When we look at the dispersion measure of the basic data, the number of individuals per household has a standard deviation of 1.0 with a maximum of 9 people and a minimum of 1 person. Residential area per household has a standard deviation of 21.5 with a maximum of 165.0 square meters and a minimum of 19.8 square meters (see Table 11).

When we look at the age distribution of the population surveyed, they were in their 20s, 30s and 50s, and the population of those in their 60s and 70s was less than 10%. The North Korean refugee survey data were used as basic data for estimating individual housing demand by age (see Table 12).

Table 10. Basic Statistical Data (2007)

Province of Origin	Number of Households Surveyed		Population Surveyed	Average Number of Persons per Household	Average Residential Area (m^2)
Ryanggang-do	210	(44.7)	741	3.5	76.6
Hamgyongbuk-do	125	(26.6)	397	3.2	68.3
Hamgyongnam-do	32	(6.8)	97	3.0	77.6
Jagang-do	7	(1.5)	23	3.3	53.1
Pyonganbuk-do	23	(4.9)	75	3.3	69.6
Pyongannam-do	21	(4.5)	72	3.4	64.4
Pyongyang-city	16	(3.4)	55	3.4	90.4
Hwanghae-do	23	(4.9)	68	3.0	72.6
Gangwon-do	13	(2.8)	44	3.4	56.1
Total	470	(100.0)	1,572	3.3	72.9

Note: The figures in parentheses are the percentage share of the total number of households by province of origin. Pyongannam-do includes Nampo-city and Hwanghae-do includes Gaesong-city.

[16] As of the end of 2018, 85.1% of all North Korean refugees came from Ryanggang-do and Hamgyong-do (Ministry of Unification (2019), p.207).

Table 11. Average Residential Area per Household Surveyed (2007)

Province of Origin	Average Residential Area (m^2)	Standard Deviation	Maximum	Minimum
Ryanggang-do	76.6	19.1	132.0	26.4
Hamgyongbuk-do	68.3	20.5	132.0	26.4
Hamgyongnam-do	77.6	31.7	165.0	33.0
Jagang-do	53.1	11.2	66.0	36.3
Pyonganbuk-do	69.6	16.5	115.5	49.5
Pyongannam-do	64.4	18.5	99.0	39.6
Pyongyang-city	90.4	29.7	132.0	19.8
Hwanghae-do	72.6	18.2	99.0	39.6
Gangwon-do	56.1	16.8	82.5	66.0
Total	72.9	21.5	165.0	19.8

Table 12. Age Distribution of Individuals Surveyed (2007)

(Individuals)

0~9	10~19	20~29	30~39	40~49	50~59	60~69	70 or more	Total
198	175	305	248	201	219	146	80	1,572
(12.6)	(11.1)	(19.4)	(15.8)	(12.8)	(13.9)	(9.3)	(5.1)	(100.0)

Note: The figures in parentheses are the percentages.

4.2.2. Estimation of Individual Housing Demand by Age

In consideration of the small number of samples by age, the age range was set at 10-year intervals, wider than the normal five-year intervals, in order to increase the statistical significance of the estimates. The regression estimation equation was set as shown in Equation (6).

$$H = \alpha_0 \sum DUMMY0_i + \alpha_1 \sum DUMMY1_i + \cdots + \alpha_7 \sum DUMMY7_i + \epsilon, \quad (6)$$

where:

in case of age 0~9, $DUMMY0 = 1$, in case of age 10~19, $DUMMY1 = 1$,
in case of age 20~29, $DUMMY2 = 1$, in case of age 30~39, $DUMMY3 = 1$,
in case of age 40~49, $DUMMY4 = 1$, in case of age 50~59, $DUMMY5 = 1$,
in case of age 60~69, $DUMMY6 = 1$, in case of age 70+, $DUMMY7 = 1$,

$\sum DUMMY0$ is number of household members belonging to 0~9 age group,...
$\sum DUMMY7$ is number of household members belonging to 70+ age group.

The data structure is as follows. In the case of a couple in their 40s having one teenage child, the data structure is (0, 1, 0, 0, 2, 0, 0, 0). If a couple in their 30s lives

together with one of their mothers, the data structure is (0, 0, 0, 2, 0, 0, 0, 1).

Table 13 shows the individual housing demand by age in North Korea as of 2007, estimated by regression analysis based on the Mankiw-Weil method. The dependent variable was residential area. The area occupied by each household member was estimated by age group. However, the 70- to 79-year-olds, 80- to 89-year-olds, and 90+-year-olds, a very low proportion of the population surveyed, were combined into one category called the 70+-year-olds.

As a result of the estimation, all coefficients showed statistical significance at the significance level of 1%. Also, the coefficient of determination (R2) was 0.88, indicating that 88% of the total variability of the dependent variable was explained by the regression line. Here, the coefficient of determination (R2) is obtained by the uncentered coefficient of determination applied to the estimation of the regression model without the constant term.[17]

As shown in Table 13, the characteristics of the values of α, an estimate of individual housing demand by age, are as follows. First, housing demand continues to rise between the 20s and 40s. In particular, housing demand is rapidly increasing in one's 20s. This can be seen as coinciding with the time of marriage, to form an independent family. Second, demand declines after one's 50s. After retirement, a significant reduction in housing demand was seen. Third, for those under 19–years-old and over 70–years-old, the residential area was less than 16 square meters, which is about half of the young adults in their 20s and 50s.

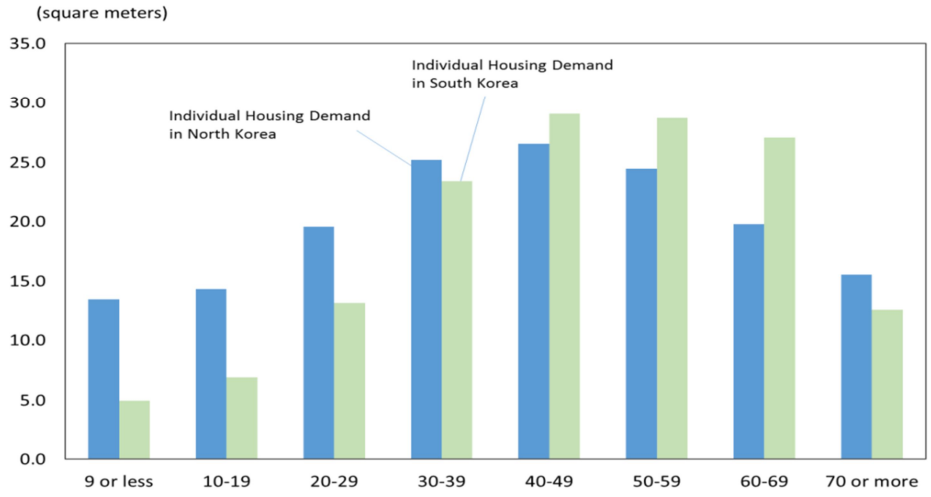
For reference, according to a study by Chung and Cho (2005), in the case of South Korea (as of 2003), residential areas for people 30-years-old or older (24.1 square meters) are wider than those of people in North Korea in the same age bracket (22.4 square meters), and residential areas for people under 20-years-old (8.3 square meters) are narrower than those for people in North Korea in the same age bracket (15.8 square meters) (see Figure 6). In other words, the difference in housing demand between the main age group and the non-main age group is relatively large, which acts to increase the effects of age structure changes on housing demand.

Table 13. Estimates of Individual Housing Demand by Age (α_i) (as of 2007)

(Square meters)

	9 or less	10~19	20~29	30~39	40~49	50~59	60~69	70 or more
Coefficient	13.5	14.4	19.6	25.2	26.6	24.5	19.8	15.6
t-value	(6.3)	(5.9)	(14.4)	(14.1)	(13.4)	(15.7)	(10.3)	(6.0)
R^2	0.88	Number of samples		470				

[17] Wooldridge (2009), p.235.



Source: Chung and Cho (2005), p.42.

Figure 6. Comparison of Individual Housing Demand by Age in South and North Korea.

4.2.3. Estimation Results of Demographically-Driven Housing Demand

Demographically-driven housing demand using the Mankiw-Weil method is estimated as follows.

$$H_t = \sum_i \alpha_i N_{i,t}, \tag{7}$$

where i the age range set at 10-year intervals

Regarding the North Korean population statistics, the Korea National Statistical Office and the U.N. Population Bureau estimate the North Korean population based on North Korea's civil registration statistics and population census. There seems to be no significant difference in the overall change in pattern.[18]

However, when looking at the age structure of the population data, which plays an important role in the analysis of this paper, there is a problem with the data from 2029 to 2030 in Statistics Korea's future population estimations. The National Statistical Office's estimate of future population shows that the total population of North Korea is increasing, but the level of data shows a fault of –minus 30% in 2030 and then back to a positive 0.5% in 2031.

The step also seems to exist between 2039 and 2040, and the same type of step

[18] Choi (2015), p.3.

occurs in the number of people by age. As such, the future population estimates from the National Statistical Office are not suitable for the analysis of this paper due to the presence of these steps. Therefore, this paper analyzes the data using the world population prospects published by the United Nations.[19]

On the other hand, in terms of housing demand, North Korea's military service period is very long, ranging from 10 to 13 years. It is important to consider that much of the population in their late teens and early twenties lives in military barracks, not houses. According to Lee (2011), the number of compulsory soldiers in North Korea is estimated to be 189,000 in their teens and 462,000 in their twenties. In North Korea, only 20% of soldiers went to their parents' homes during military service.20 That means the relationship with the house is broken after enlistment. Therefore, there is no need for parents to provide a living space for their enlisted children. Taking this into consideration, this study estimated the housing demand by excluding the obligatory soldiers from the number of residential residents.

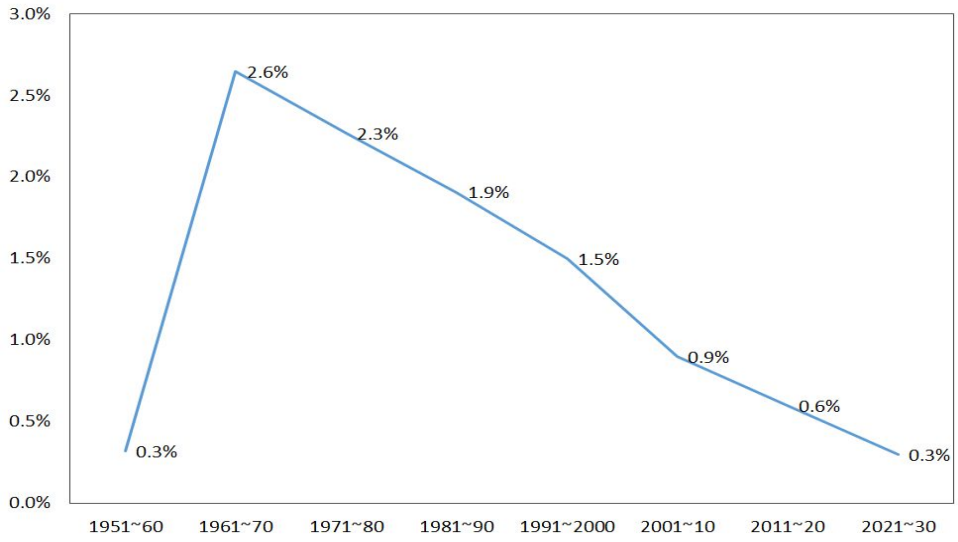


Figure 7. Trends of Growth Rate of Demographically-driven Housing Demand (annual average)

Figure 7 shows the trends of demographically-driven housing demand in North Korea estimated by the above equation. The growth rate of demographically-driven

[19] World Population Prospects: The 2017 Revision.

[20] Institute for Unification Education (2018), p.110.

housing demand peaked in the 1960s and has continued to slow down since the 1970s. The average annual growth rates of demographically-driven housing demand during the 2001-2010 and 2011-2020 periods are 0.9% and 0.6%, respectively. The growth rate of demographically-driven housing demand has the following meaning. Assuming North Korea's demographically-driven housing demand in 2019 is 1 million square meters, if the 2020 growth rate is 0.6%, the demographically-driven housing demand in 2020 will be 1.006 million square meters.

Meanwhile, the rate of change during the period can be expressed in the form of an index for the estimate of the Mankiw-Weil demographically-driven housing demand. This indexing has the advantage of decomposing the rate of change in demographically-driven housing demand into a total population factor and an age composition factor. In other words, the change in the housing demand index can be broken down into parts that are attributable to changes in population factors and parts that are attributable to changes in individual housing demand factors.

The growth rate of demographically-driven aggregate housing demand during periods 0 and t can be decomposed as follows.

$$H_t/H_0 = \sum_i \alpha_i N_{i,t}/\sum_i \alpha_i N_{i,0} = [N_t/N_0] \cdot \sum_i \alpha_i (N_{i,t}/N_t)/\sum_i \alpha_i (N_{i,0}/N_0), \quad (8)$$
$$= [\text{Impact of population change}] \cdot [\text{Impact of age composition change}]$$

where α_i is estimate of housing demand by a person of age i from 2007 cross-sectional data, N_0 is the population in year 0, $N_{i,0}$ is the number of people of age i in year *t*, N_t is the population in year *t*, $N_{i,t}$ is the number of people of age i in year *t*.

Based on Equation (8), we estimated the demographically-driven housing demand in North Korea and then compared the effects of the total population factor and the age component factor. Here, the influence of the total population factor is a measure of the effects of population growth on the aggregate housing demand under the assumption that the age ratio is invariant, and the influence of age components is a measure of the influence of changes in age composition on the aggregate housing demand under the assumption that the total population is invariant. As a result of the decomposition, the demographically-driven housing demand in North Korea since 2001 seems to be more affected by the change in total population than the change in age composition. On the other hand, the influence of age compositional fluctuation was about 0.1% to 0.2% in the 2001-2020 period, but it is insignificant after 2021.

By period, housing demand in the 2001-2020 period is estimated to increase by 0.6% to 0.9% per year, mainly due to the increase in total population (see Table 14). The increase in the share of people who are 30- to 59-years-old, the main housing demand class, is also contributing to the increase in housing demand. However, in the 2021-2030 period, the average annual growth rate of housing demand will be lowered to 0.3%, as the total population increases slightly and the share of people aged 30- to 59 falls.

In this way, in North Korea, the share of the main housing demand class is expected to decrease. So the unification of the two Koreas is expected to have only a slight effect of delaying the decrease in South Korea's demographically-driven housing demand.

Meanwhile, a study by Choi et al. (2018) predicted that housing demand would increase to 5.89 million units in 2008, 7.74 million units in 2030, and 7.74 million units in 2040 by using the change in the total population and the change in the number of individuals per household (see Table 24). As the data released by North Korea shows that the number of households is the same as the number of houses, Choi et al. (2018) estimate that the number of households is equal to the number of houses. These household-based estimates are from the logistic model results that estimates of the number of households are 3.68 and 3.59 in 2030 and 2040, respectively, given that the number of individuals per household is 4.8 in 1995 and 4.1 in 2008.

Table 14. Analysis of impact of demographic change on housing demand in North Korea

(Average annual growth rates, %)

	2001~2010	2011~2020	2021~2030
Rate of change in Demographically-driven housing demand (A+B)	0.88	0.61	0.29
Impact of change in population (A)	0.70	0.50	0.34
Impact of change in age composition (B)	0.18	0.09	-0.05

Note: (A) is the impact of change in population estimated under the assumption that age composition is invariant and (B) is the impact of change in age composition estimated under the assumption that total population is invariant.

If we compare the growth rate of demographically-driven housing demand with the study of Choi et al. (2018), the demographically-driven aggregate housing demand growth rate was estimated to be 0.43% per year during the 2009-2030 period, 0.45 percentage points lower than the 0.88% found in previous studies. In addition, the average rate of annual growth was 0.11% during the 2031-2040 period, 0.04 percentage points lower than that found in previous study. Overall, the estimates of this paper based on individuals were somewhat lower than those of Choi (2018) based on the number of households (see Table 15).

Table 15. Comparison with the study of Choi et al. (2018)

(Average annual growth rates, %)

	2009~2030	2031~2040
Growth Rate of Housing demand in Choi et al. (A)	0.88	0.15
Growth Rate of Housing demand in this study (B)	0.43	0.11
Difference (B-A, %p)	-0.45	-0.04

Note: (A): Estimate of housing units based on household.

On the other hand, when compared with the study by Chung and Cho (2005) on South Korea's housing demand, North Korea's housing demand growth rate slows relatively slightly during the 2001-2030 period, while South Korea's housing demand growth rate slows rapidly during the 2001-2030 period. Thus, as shown in Table 16, the growth rate of South Korea's housing demand is higher than that of North Korea's housing demand during the 2001-2020 period, but the average annual growth rate of South Korea's housing demand was estimated to be 0.2%p lower than that of North Korea's housing demand during the 2021-2030 period.

The following is a forecast of housing construction investment related to estimated housing demand. With a lack of North Korean statistics, housing construction investment was estimated using long-term housing demand estimations. There is a rather strong assumption that all differences in long-term housing demands over the period lead to investment in housing construction.

Table 16. Comparison with the study on South Korea's housing demand

(Average annual growth rates, %)

	2011~2020	2011~2020	2021~2030
Growth Rate of Housing Demand in North Korea(A)	0.88	0.61	0.29
Growth Rate of Housing Demand in North Korea (B)	1.40	0.85	0.06
Difference (B-A, %p)	+0.52	+0.24	-0.23

Source: Korean National Statistical Office KOSIS.
Note: (B) based on housing demand estimated by Chung and Cho (2005).

Housing construction investment is composed of new investment and replacement investment, i.e., rebuilding. New investment figures are obtained from the difference between the previous year's figure and the current year's figure of aggregate housing demand, which is estimated by population and age structure. In this paper, it is assumed that replacement investments will be made as much as new investments 50 years ago.[21]

As shown in Table 17, housing construction investment in North Korea is estimated at 43.3 million square meters in the 2001-2010 period on a 10-year cumulative basis. In the 2011-2020 period, as replacement investment increases significantly, total investment is expected to increase to 96.0 million square meters on a 10-year cumulative basis. In the 2021-2030 period, as new investments are greatly reduced, total housing construction investment is estimated to be somewhat lower at 84.2 million square meters on a 10-year cumulative basis.

[21] Choi et al. (2018) assumes a house's average life expectancy to be 50 years.

Table 17. Estimation of Related Housing Construction Investment
(10-year cumulative, million square meters)

	2001-2010	2011-2020	2021-2030
Housing Construction Investment	43.3	96.0	84.2
New investment	37.0	30.0	17.2
Replacement investment	6.4	66.0	67.0

4.3. Comparison of Estimates of Individual Demand Between 2007 and 2017

Here, we additionally estimate individual housing demand by age as of 2017 to reflect recent trends in individual demand. In the next Section, we seek to link these findings to existing demographically-driven housing demand estimation techniques.

The survey examined basic data on the age of household members and residential area in Ryanggang-do and Hamgyongbuk-do provinces, which are relatively easy to investigate, considering the difficulty of surveying refugees from inland North Korea. As of 2017, a total of 302 households were surveyed, including 202 households in Ryanggang-do Province and 100 households in Hamgyongbuk-do Province (see Table 18). The data as of 2017 corresponding to survey data as of 2017 were from Ryanggang-do Province and Hamgyongbuk-do Province. Regarding data as of 2007, a total of 335 households were reused, including 210 households in Ryanggang-do Province and 125 households in Hamgyongbuk-do Province

As of 2017, the average number of persons per household decreased by 0.1 and the average residential area per household increased by 2.0 square meters compared to that of the sample as of 2007 (see Table 18).

According to the age distribution of the survey subjects, the proportion of each age group under 50 is more than 10%, and the number of samples is relatively large, but the population of people in their 60s and over 70-years-old is less than 10% (see Table 19).

Table 18. Basic Statistical Data of North Korea-China border region (2007 and 2017)

	Number of Households Surveyed	Population Surveyed	Average Number of Persons per Household	Average Residential Area (m^2)
2007	335	1,138	3.4	22.2
Ryanggang-do	210	741	3.5	23.2
Hamgyongbuk-do	125	397	3.2	20.7
2017	302	1,002	3.3	22.9
Ryanggang-do	202	669	3.3	24.0
Hamgyongbuk-do	100	333	3.3	20.6

Table 19. Age Distribution of Individuals in North Korea-China Border region

(Persons)

0~9	10~19	20~29	30~39	40~49	50~59	60~69	70 or more	Total
<2007>								
144	130	217	184	145	156	106	56	1,138
(12.7)	(11.4)	(19.1)	(16.2)	(12.7)	(13.7)	(9.3)	(4.9)	(100.0)
<2017>								
121	140	114	191	169	116	90	61	1,002
(12.1)	(14.0)	(11.4)	(19.1)	(16.9)	(11.6)	(9.0)	(6.1)	(100.0)

Note: The figures in parentheses are the percentages.

As a result of estimating individual housing demand by age in 2007 and 2017, the estimated coefficients were statistically significant at the significance level of 1%. The coefficient of determination (R2) is 0.90 and 0.91, respectively, in 2007 and 2017. It can be said that the part explained by the regression line among the total variation of the dependent variable is very high.

Comparing the 2017 estimate with the 2007 estimate, the residential area for people under 19 years of age has narrowed, while that for people over 20 has widened (see Table 20).

Demographically-driven housing demand growth rates were calculated by applying individual demand estimates for 2007 and 2017. Comparing the average annual growth rate of the demographically-driven housing demand calculated from individual demand as of 2007 and 2017, the growth rate of aggregate demand in 2017 was slightly higher than the growth rate of aggregate demand in 2007. However, the gap between the two growth rates is 0.06%p to 0.16%p, which is only a small margin (see Table 21).

In this case, if both of the individual demand estimates are rapidly increasing after one's 20s and peaking in one's 40s, the growth rates of demographically-driven housing demand, which is a weighted sum, have similar figures according to the index's invariance property.

Table 20. Comparison of Estimates of Individual Demand as of 2007 and 2017

(Square meters)

	2007 estimate		2017 estimate	
	coefficient	t-value	coefficient	t-value
9 or less	13.5	5.7	10.2	3.6
10~19	15.2	5.8	12.5	5.0
20~29	21.5	13.6	23.1	10.2
30~39	24.8	12.4	25.4	11.9
40~49	25.7	11.8	28.4	14.8
50~59	23.8	13.2	27.7	14.6
60~69	19.1	8.8	21.5	10.4
70 or more	14.9	5.0	19.1	7.2
R2	0.9		0.91	
Number of Samples	335		302	

Table 21. Comparison of Impact of Estimates of Individual Demand as of 2007 and 2017

(Average annual growth rates, %)

	2001~2010	2011~2020	2021~2030
Demographically-driven housing demand calculated from individual demand as of 2007 (A)	0.83	0.62	0.34
Demographically-driven housing demand calculated from individual demand as of 2017 (B)	0.96	0.78	0.40
Difference (B-A)	0.13	0.16	0.06

5. IMPACT OF CHANGES IN INDIVIDUAL HOUSING DEMAND UNDER THE ASSUMPTION OF NORTH KOREA'S EXTERNAL OPENNESS

This Section further estimates how North Korea's housing demand and housing construction investment will change, assuming a scenario in which North Korea will pursue external openness and economic growth in earnest after 2021, and through which income levels will improve significantly. As seen in the cases of Vietnam, Laos and Cambodia, if the conditions for North Korean authorities to actively promote foreign opening policies are created, there is a high possibility of full-fledged trade and foreign investment, and economic growth.

In this paper, the increase in income due to economic growth has an effect on the aggregate housing demand through an increase in individual housing demand. If North Korea's full-fledged opening leads to economic growth, a decline in mortality rates is likely to affect housing demand as North Koreans improve access to health care services and improve their nutritional status. However, we did not consider the possibility that North Korea's total population and age-specific population would be higher than previously estimated.

In this paper, we analyzed the impact of external openness using only the increase in individual housing demand. The aggregate housing demand reflecting income growth was estimated by changing the individual housing demand by age over time. Currently, the North Korea-China border region is known to have a viable economy, unlike other regions of North Korea, and it is assumed that after external openness the rate of increase in individual demand across all of North Korea would be equal to the rate of increase in individual demand currently seen in the North Korea-China border area today. In addition, a scenario in which North Korea's individual housing demand surges similar to that of South Korea's during its "Rapid Growth Age" is also assumed. For the increase in individual housing demand by age, we assumed a slight increase scenario and a sharp increase scenario, and forecast North Korea's housing demand and housing construction investment by scenario. Based on this, the related new housing investment was estimated and the total housing investment was calculated by combining it with the replacement investment of the existing housing.

5.1. Analysis of Impact of Increase in Individual Demand

In the Mankiw-Weil model, economic growth effects can be captured by changes in estimates of individual demand by age. Considering the changes in demand estimates, the increase in housing demand can be decomposed into demographic factors and individual demand factors. The decomposition is as follows. Assuming that the housing demand estimates of 1-year-old population changes between periods 0 and 1, the rate of the increase or decrease in total housing demand can be expressed as

$$H_1/H_0 = \sum_i \beta_i N_{i,1}/\sum_i \alpha_i N_{i,0} = \left[\sum_i \alpha_i N_{i,1}/\sum_i \alpha_i N_{i,0}\right] \cdot \left[\sum_i \beta_i N_{i,1}/\sum_i \beta_i N_{i,1}\right] \quad (9)$$

= [Impact of demographic change] · [Impact of individual demand change],

where α_i: housing demand by a person of age i from period 0 cross-sectional data,

β_i: housing demand by a person of age i from period 1 cross-sectional data.

Here, if the individual housing demand by age increases by p% between periods 0 and 1, it can be expressed as

$$\beta_i = (1 + p/100)\alpha_i. \quad (10)$$

Substituting Equation (10) into Equation (9), the aggregate housing demand index is:

$$H_1/H_0 = \sum_i \beta_i N_{i,1}/\sum_i \alpha_i N_{i,0} = \left[\sum_i \alpha_i N_{i,1}/\sum_i \alpha_i N_{i,0}\right] \cdot [1 + p/100]. \quad (11)$$

In other words, the rate of change in the aggregate housing demand is expressed by applying the change in population by the change in individual housing demand.

In the following, it is assumed that the economic growth will start in earnest after 2021, and the two scenarios, the slight increase scenario and the sharp increase scenario of individual housing demand, are assumed, and the effects are projected.

The slight increase scenario assumes that the growth rate of individual housing demand across North Korea converges with the case of the North Korea-China border zone, where incomes are steadily increasing thanks to trade and distribution businesses. Estimates for the North Korea-China border zone, where external openness is most active in North Korea, showed that individual demand increased by 0.4% per year (the average annual growth rate in 2017 compared to that in 2007). The slight increase scenario assumed that this growth rate would expand across all of North Korea. In this slight increase scenario, aggregate housing demand is expected to increase by 0.4%p annually on average during the 2021-2030 period.

The sharp increase scenario, on the other hand, assumes that the growth rate of individual housing demand in North Korea is the same as the growth rate of individual housing demand during South Korea's "Rapid Growth Age." As a result of estimating the average residential area of individuals based on the housing census, released by the

Korean National Statistical Office since 1980, we see that the average rate of increase was 1.6% annually in the 1981-1990 period. This was used as basic data for the projections of the sharp increase scenario. In the sharp increase scenario, aggregate housing demand is expected to increase by 1.6%p annually on average during the 2021-2030 period.

According to these scenarios, the growth rate in aggregate housing demand in North Korea is expected to show additional increases of 0.4%p (slight increase scenario) to 1.6%p (sharp increase scenario) in the 2021-2030 period. Table 22 summarizes the increase in housing demand, including the income increase expected when North Korea pushes forward with an active opening of the country. Considering the income increase effect, the growth rate of the aggregate housing demand is estimated to be 0.7% to 1.9% per year during the 2021-2030 period, which is 0.4%p to 1.6%p more than the 0.3% estimated under the basic scenario. On the other hand, assuming that North Korea's current housing inventory is estimated at 4.5 million units[22], the estimation result that housing demand will increase by 0.66% to 1.87% on an average annual basis means that the units of housing stock will increase by 33 to 94 thousand units on an annual average basis.

Table 22. Increased Housing Demand When North Korea Opens its Doors in Earnest

(Average annual growth rate)

	2011~2020	2021~2030				
		Basic scenario	Slight increase scenario after external openness	Sharp increase scenario after external openness	Difference	Difference
		(A)	(B)	(C)	(B-A)	(C-A)
The existing effect of demographic change (D)	0.61%	0.29%	0.29%	0.29%	-	-
< Change in aggregate housing demand after external openness>						
The effect of change in individual demand (E)	-	-	0.37%	1.58%	-	-
The rate of aggregate housing demand (D+E)	0.61%	0.29%	0.66%	1.87%	0.37%p	1.58%p

Note: The aggregate housing demand estimated under the assumption that the individual demand is invariant.

[22] It is based on Lee (2015).

As a preliminary study of mid- and long-term housing demand estimation, Choi et al. (2018) calculated the aggregate housing demand for the target year by adding the aggregate housing demand change to the housing inventory in the base year (2008). The growth rate in individual demand is calculated by using income elasticity and housing price elasticity.[23] In North Korea, income elasticity and housing price elasticity are not available, so the GDP growth rate is used as a substitute.[24] It is forecasted that the number of housing units will increase continuously from 5.09 million in 2008 to 8.26 million in 2030 and to 9.21 million in 2040 (see Table 23).

Table 23. Mid- and Long-term Housing Demand Estimates from Land & Housing Research Institute

(Housing unit)

	2008	2030	2040
Aggregate housing demand	5,887,471	8,256,431	9,206,644
Impact of increase in individual demand		1,118,617	1,825,111
Impact of increase in the number of households		1,250,343	1,494,062

Source: Choi et al. (2018), p.126.

Note: - Aggregate housing demand as of 2030 = 5,887,471 (aggregate housing demand as of 2008) + 1,118,617 (impact of increase in individual demand) + 1,250,343 (impact of increase in the number of households).

-Aggregate housing demand as of 2040 = 5,887,471 (aggregate housing demand as of 2008) + 1,825,111 (impact of increase in individual demand) + 1,494,062 (impact of increase in the number of households).

When we look only at the 2021-2030 period, Choi et al. (2018) predicted that the rate of increase in aggregate housing demand would average 1.55% during the 2021-2030 period. This forecast can be seen in the middle of the slight increase scenario forecast and the sharp increase scenario forecast for individual housing demand. In the case of Choi et al. (2018), the growth rate of the residential area per capita was assumed to be 0.9%, which is similar to the middle of the slight increase scenario (0.4%) and the sharp increase scenario (1.6%) for individual demand.

[23] Choi et al. (2018), p.120.

[24] Choi et al. (2018) applied GDP growth rate of 0.9% over the last decade to the growth rate of residential area per capita.

5.2. Change in Long-term Housing Construction Investment

Under the basic scenario, housing construction investment is estimated to be somewhat lowered to 84.2 million square meters during the 2021-2030 period. However, both new and replacement investments are expected to be active in North Korea after North Korea's external opening. If North Korea's external openness and economic growth are in full swing, housing construction investments are expected to reach 109.8 million square meters (slight increase scenario) to 179.0 million square meters (sharp increase scenario) on a 10-year cumulative basis. In other words, it is estimated that an additional housing investment of 25.6 million square meters to 94.8 million square meters is needed on a cumulative 10-year basis compared to the basic scenario during the 2021-2030 period (see Table 24).

Table 24. Housing Construction Investment Outlook by Scenario with Full Opening of North Korea
(10-year cumulative, million square meters, trillion KRW)

	2011~2020	2021~2030				
		Basic scenario	Slight increase scenario after external openness	Sharp increase scenario after external openness	Difference	Difference
		(A)	(B)	(C)	(B-A)	(C-A)
Housing Construction Investment	96.0	84.2	109.8	179.0	+25.6	+94.8
Monetary Amount	(65)	(57)	(75)	(122)	(+18)	(+65)
New investment	30.0	17.2	42.8	112.0	+25.6	+94.8
Replacement investment	66.0	67.0	67.0	67.0	0.0	0.0

Note: Monetary Amount in Housing construction area * 2.25 million KRW.

In terms of the Korean won, it is estimated that KRW 18 trillion (slight increase scenario) to KRW 65 trillion (sharp increase scenario) will be invested additionally, compared to KRW 57 trillion, which will be invested under the basic scenario, on a 10-year cumulative basis during the 2021-2030 period. Here, the construction cost per square meter was applied to KRW 682,000, which is an average of KRW 606,000 to KRW 758,000 per square meter estimated by the Land and Housing Corporation.[25] This should be interpreted as the maximum, taking into account that North Korea's labor and

[25] Lee (2015), p.46.

construction materials costs will be somewhat cheaper.

6. CONCLUSION

6.1. Summary and Implications

This study estimates the long-term demand for housing in North Korea using the metric method of Mankiw and Weil (1989), which is the first of the studies that explains long-term housing demand based solely on demographic factors. Mankiw and Weil's (1989) estimation method of housing area is a method of estimatinging individual demand from a sample and then applying it to an age structure of population. In order to use it as the basic data for the estimation, a survey was conducted of North Korean refugees covering 470 households. Through the estimation result, the change in demographically-driven housing demand was estimated, and the change was decomposed into the part attributable to the increase in the total population and the part attributable to the change in the age structure of population. In addition, by allowing changes in individual demand over time, aggregate housing demand, which reflects the effects of income growth, in addition to population effects, was estimated. In order to reflect the recent change in individual demand, the basic estimation model is to identify long-term housing demand through demographically-driven housing demand using the Mankiw and Weil (1989) model. By reflecting the change in other variables, such as income or government policy, this paper attempted to improve the realistic suitability of long-term housing demand.

North Korea's demographically-driven housing demand is expected to slow down gradually. Among these, the demographically-driven housing demand is estimated to increase by 0.6% to 0.9% per year during the 2001-2020 period. However, as the annual average growth rate of housing demand gradually slows down to 0.3% between 2021 and 2030, it was estimated that the effect of population factors on housing demand would gradually decrease. Under the basic scenario, the share of the main housing demand class in North Korea is expected to decrease slowly.

On the other hand, assuming a scenario in which North Korea pursues external opening in earnest after 2021 and people's income levels significantly improve, we further estimated how the increase in aggregate housing demand in North Korea could change. If external openness leads to increases in individual demand, then an additional 0.37%p (in the slight increase scenario) to 1.58%p (in the sharp increase scenario) in the annual rate of growth in total housing demand is likely, compared to the baseline scenario. The related housing construction investment is anticipated to show additional increases of 25.6 million square meters (in the slight increase scenario) to 94.8 million square meters (in the sharp increase scenario) in terms of area, and of KRW 18 trillion (in the slight increase scenario) to KRW 65 trillion (in the sharp increase scenario) in terms of amount during the 10 years from 2021. This suggests that, if North Korea's efforts to open to the world reach full swing, housing demand is likely to grow

significantly and more housing construction investment will be needed than is currently projected.

6.2. Limitations of Research

In this study, we can see the significance of estimating the demand for housing in North Korea in terms of individual age rather than implicitly considering population factors, such as the number of households and age of household heads. Also, by understanding the rate of change in demographically-driven housing demand in the form of an index, it is possible to explain the change in housing demand by decomposing it into the factors of total population and age composition, and to reflect changes in other factors outside the population by changing individual demand. This can improve the Mankw-Weil method in terms of methodology.

However, this study has limitations in considering other factors as determinant of housing demand, such as North Korea's income and housing policy. In countries where rapid socioeconomic changes are occurring, such as North Korea, estimating aggregate housing demand with fixed individual demand estimates can be problematic in relation to realistic fitness. If the conditions for collecting statistics and information related to North Korea improve in the future, the precision of estimation needs to be improved by periodically re-estimating individual housing demand by age. In addition, it is necessary to solve the problem of the sample that is somewhat biased to certain geographic parts of North Korea.

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