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Current Status and Future Challenges of the National Population Projection in South Korea Concerning Super-Low Fertility Patterns*

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South Korea has experienced a rapid fertility decline and notable mortality improvement. As the drop in TFR was quicker and greater in terms of tempo and magnitude, it cast a new challenge of population projection - how to improve the forecasting accuracy in the country with a super-low fertility pattern. This study begin with the current status of the national population projection as implemented by Statistics Korea by comparing the 2009 interim projection with the 2006 official national population projection. Secondly, this study compare the population projection system including projection agencies, projection horizons, projection intervals, the number of projection scenarios, and the number of assumptions on fertility, mortality and international migration among super-low fertility countries. Thirdly we illustrate a stochastic population projection for Korea by transforming the population rates into one parameter series. Finally we describe the future challenges of the national population projection, and propose the projection scenarios for the 2011 official population projection. To enhance the accuracy, we suggest that Statistics Korea should update population projections more frequently or distinguish them into short-term and long-term projections. Adding more than four projection scenarios including additional types of "low-variant"fertility could show a variety of future changes. We also expect Statistics Korea topay more attention to the determination of a base population that should include both national and non-national populations. Finally we hope that Statistics Korea will find a wise way to incorporate the ideas underlying the system of stochastic population projection as part of the official national population projection.

Key Words: Projection scenarios, Stochastic population projection

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Ⅰ. Introduction

Most developed countries in Europe, North America, and Japan of East Asia have experienced a series of huge demographic changes since the second quarter of the 20th century. These changes include drop in fertility and mortality rates, rapid evolution of population aging, and increases in international migration as accompanied by secular trends in regional integration and economic globalization. Meanwhile, the beginning of the "second" demographic transition in the 1960s in most European countries and the emergence of the so-called "lowest-low" fertility patterns in Southern and Eastern Europe in the 1990s have contributed significantly to the heightening of either scholarly or policy-oriented interests in the shape of future populations and its potential impacts on the sustainability of social security and other welfare systems as well as the prospect of national economic development.

In the first half of the 20th century, South Korea was an underdeveloped country in demographic terms. Beginning in the 1960s, Korea experienced an unprecedented demographic change. The total fertility rate (TFR) was 6.0 in the 1960s, but dropped to a replacement-level (2.1) in 1983, and eventually to 1.29 in 2001. Despite its minor fluctuation, TFR has continued to maintain a super-low fertility pattern (i.e., TFR 〈 1.30), recording a TFR of 1.08, the lowest figure in Korean vital statistics history, in 2005 (Jun, 2005). The drop in TFR was quicker and greater in terms of tempo and magnitude when Korea is compared with other major nations in Europe, North America, Oceania, and Japan. On the other hand, life expectancy at birth had increased from 58.7 years in 1970 to 76.5 in 2008 for males, and 65.6 years in 1970 to 83.3 years in 2008 for females. Indeed, both the emergence of a super-low fertility pattern and notable mortality improvement are expected to influence the tempo of population aging in the future. Finally, South Koreawas traditionally an emigrating county, but is changing its status to an immigrating country, particularly influenced by the influx of foreign workers and marriage-related brides from China and Southeast Asia.

In this paper, we will begin with the current status of the national population projection as implemented by Statistics Korea (replacing its old name, Korea National Statistical Office) by comparing the 2009 interim projection with the 2006 official national population projection. Secondly, we will describe the frame of the Korean national population projection system and compare it with the population projection systems for the countries in Europe, North America, Oceania, and Japan. The topics of interests include (1) projection agencies (2) projection horizons (3) projection intervals (4) the number of projection scenarios and (5) the number of assumptions on fertility, mortality, and international migration. In doing so, we hope to reveal the major characteristics of the population projection system in the countries with super-low fertility patterns and highlight what should be improved upon in order for Statistics Korea to launch the 2011 official national population projection, one year after the completion of the 2010 Korean population and housing censuses. Thirdly, we illustrate a stochastic population projection for Korea by transforming the population rates into one parameter series. Finally, we describe the future challenges of the national population projection, and propose the projection scenarios for the 2011 official population projection. Here we will mention some unaddressed issues relating to the determination of the base population, the treatment of the non-national population, and the incorporation of a stochastic population projection in the official national projection series.

Ⅱ. The Korean National Population Projection: 2006 Official and 2009 Interim Projections

Statistics Korea released the third official report on the national population projection in 2006, which was based on the 2005 population and housing censuses and actual registration data on fertility, mortality, and international migration data (Statistics Korea, 2006). According to the agency, the national projection aims to provide a variety of information on the future

population, such as the total population, population composition (by sex and age), the active population, and the elderly population, all of which are needed to establish short- and long-term socioeconomic planning and produce input data for household projections as well as local population projections. Two essential features of the 2006 official national population projection include (1) the wide use of data on registered non-nationals and illegal immigrants and (2) the use of the generalized log gamma model (Kaneko, 1993, 2003) and Lee-Carter method (Lee and Carter, 1992) plus Brass Logit model. According to Statistics Korea, the first was intended to establish a base population which corrects for the foreign population that was undercounted in the 2005 population census while the second was intended to improve the quality of projected vital statistics data and diminish uncertainty elements while producing the final population projection results.

In 2009, three years after the announcement of the 2006 official national population projection, Statistics Korea prepared an interim national population projection which was not released to the ordinary statistics users (Statistics Korea, 2009)[1] The agency cited three reasons for doing so. First, TFR was suddenly on the rise and fall after registering the worst level of 1.08 births per woman in 2005. The TFR rose to 1.13 births in 2006 and 1.29 births in 2007, but fell to 1.19 births in 2008. In 2005, the number of marriages increased due to the so-called "twin-spring year" effect and also the "golden boar" effect[2] contributed significantly to the TFR's modest recuperation in 2006 and 2007. At that time, the Korean government spared little efforts to promote the visible effects of "pronatalist population policy programs" on the rise in TFR, after the initiation of their so-called "SAEROMAJI" project[3]

1) An anonymous reviewer recommends using the name of a person in charge instead of the institution's name in the case of unreleased report. But, as the projection was performed under the auspices of the national statistical agency, it would be better to establish the institution's legitimate responsibility rather than attributing it simply to a staff's intellectual curiosity.

2) This recent fertility increase was concurrent with the Year of the Golden Boar in the Asian lunar calendar. As in some other East Asian countries (e.g. China), children, especially boys, born during this year are thought to be prosperous and lucky.Moreover, because the lunar calendar is based on a cycle of 60 years (12 animals and five characteristics), meaning that the next Year of the Golden Boar will not come till 2067, it is likely that many Mongolian parents wanted to bear their child during this favorable year, producing hence a tempo distortion in Korean fertility.

whose basic purpose was to cope with super-low fertility and the aging of population. Second, the crude death rate was relatively stable at 5.0 per thousand, and the annual number of deaths was between 240 and 268 thousand in the years between 2000 and 2008. Third, there was a significant shift of international migration from net emigration (42 thousand) to net immigration (13 thousand) in the years between 2005 and 2008. Korea is now changing from an emigrating country to an immigrating one as a result of the increased inflow of foreign workers and nubile women, compared with the nearly constant or slightly decreasing outflow of people with Korean citizenships to other countries.

It might be tempting to shorten the 5-year projection interval in the countries that have experienced rapid and unexpected sudden changes in each of the demographic components that have uncertain effects on the shape of future populations. Indeed, Statistics Korea had to prepare and release the 2005 interim population projection, four years after the announcement of the 2001 official national population projection, which in turn was constructed one year after the completion of the 2000 population and housing censuses. There have been greater concerns by policy planners and parliamentarians about the official projection determined by the projection exercise designated by the Korean statistics ordinance when fertility dropped sharply from 1.47 births in 2000 to 1.08 births in 2005. Statistics Korea had been under great pressure to produce more accurate predictions and surpass straightforward projections or "forecasting" while the other government agencies have done little policy efforts to stop rapid drop in fertility to a super-low level, as we have seen in some parts of Europe.

In the 2006 interim national projection, Statistics Korea aimed to update the forecasted values on fertility rate and death rates, using the actual vital statistics data whose quality is being rapidly improved in recent years. The national statistical agency has done a careful examination of the 1970-2008

3) This project was established during the tenure of President Roh Moo-Hyun (2003-2008) and continues during the administration of President Lee Myung-Bak (2008-2013). To cope with the persistence of a super-low fertility pattern, it tries to foster the environment favorable to marriage formation, to build child-rearing infrastructure, extend the after-regular-class schools, improve work-life balances, and increase domestic adoption relative to overseas adoption.

vital statistics data by distinguishing the vital events that occurred in the country proper from those that occurred abroad. Also it decided to continue exploiting the merits of new basic methodology adopted for the 2006 official national population projection, such as the generalized log gamma distribution model for fertility projection, the Lee-Carter method and the Brass Logit model for mortality projection, and the ARIMA model for migration projection (Statistics Korea, 2009).

〈Table 1〉 shows the difference between the 2009 interim national projection and the 2006 official national projection in the values forecasted for the assumptions on fertility, mortality, and international migration. For the 2006 official projection, the target fertility (TFR) at the end of projection horizon is 1.28 births per woman, but it increases moderately to 1.30 births per woman in the 2009 interim projection. Between the two national projections, the difference in life expectancy at birth (for both male and female) tend to increase to a maximum of 0.6 years (in 2015), but gradually decreases or in fact the life expectancy at birth is a little lower in the 2009 interim projection

<Table 1> Assumed Values of 2006 and 2009 Korean Population Projections

	2005	2006	2007	2008	2010	2015	2020	2025	2030	2040	2050
TFR (per woman)											
2009	1.08	1.12	1.25	1.19	1.15	1.18	1.23	1.26	1.29	1.30	1.30
2006	1.08	1.13	1.14	1.15	1.15	1.17	1.20	1.25	1.28	1.28	1.28
(2009-2006)	-0.01	-0.01	0.11	0.04	0.00	0.02	0.03	0.01	0.01	0.02	0.02
Male life expectancy at birth (in years)											
2009	75.1	75.7	76.1	76.2	76.5	77.7	79.1	79.7	80.4	81.6	82.7
2006	75.1	75.3	75.5	75.7	76.1	77.1	78.0	78.9	79.8	81.4	82.9
(2009-2006)	0.0	0.4	0.6	0.5	0.4	0.6	1.0	0.8	0.6	0.2	-0.2
Female life expectancy birth (in years)											
2009	81.9	82.4	82.7	83.0	83.5	84.4	85.5	86.1	86.6	87.6	88.6
2006	81.9	82.1	82.3	82.5	82.9	83.8	84.7	85.5	86.3	87.7	88.9
(2009-2006)	0.0	0.3	0.4	0.5	0.6	0.6	0.8	0.6	0.3	0.0	-0.3
International migration (thousand)											
2009	50	7	118	2	5	12	16	15	14	13	13
2006	-40	-39	-39	-38	-36	-32	-27	-25	-24	-21	-16
(2009-2006)	90	46	157	40	41	44	43	40	38	34	29

than in the 2006 official projection. Finally, international migration is also forecasted differently between the two national projections: during the entire projection horizon the 2006 national projection is characterized by a net outflow of 16 thousands but the 2009 interim national projection is characterized by a net inflow of 13 thousands. This reflects both the recent trend of decrease in the outflow of Korea's domestic population and increase in the inflow of foreign workers and nubile women, both of whom came from mainland China as well as Vietnam and the Philippines in Southeast Asia.

According to the 2009 interim projection result, the total population size reaches its peak at 50.6 thousands in 2025 (Table 2). On the other hand, the projected total population size at its peak for the 2006 official national population projection is 49.0 thousand in 2018, and 50.0 thousands for the 2005 interim population projection.

In both of the projection exercises (plus the 2006 projection with the assumption of zero international migration), the persistence of a super-low fertility pattern has the strongest effect on reducing the size of the peak population and accelerating the timing to reach it. However, the shift of international migration from net outflow to net inflow tends to increase the size of the peak population and delay its timing.

Population composition by major age groups (14 years and younger, 15-64 years, and 65 years and older) reveals little significant differences between the 2006 official projection and the 2009 interim projection (Table 3). In both projections, the percentage shares of those aged 14 and younger and those aged 15-64 years decline from 17.4 percent and 72.3 percent in 2009 to 8.9 percent and 53 percent in 2050, respectively. On the other hand, the percentage

<Table 2> Peak Population and Peak Year in Recent Korean Population Projections

	2005 Projection (interim)	2006 Projection (official)	2009 Projection (interim)
Population in 2008 (thousand)	48,877	48,607	48,972
Peak Population (thousand)	49,956	49,340	50,672
Peak Year	2020	2018	2025

<Table 3> Population Composition by Major Age Groups in Recent Korean Population Projections

		2009	2010	2080	2020	2030	2040	2050
2006 projection (A)	0-14	17.4	16.2	12.7	12.4	11.4	10.3	8.9
	15-64	72.3	72.9	72.9	72.0	64.4	57.2	53.0
	65+	10.3	11.0	14.3	15.6	24.3	32.5	38.2
2009 projection (B)	0-14	17.4	16.1	12.8	12.5	11.3	10.3	8.9
	15-64	72.4	72.9	72.8	71.9	64.4	57.3	52.9
	65+	10.3	10.9	14.3	15.6	24.3	32.5	38.2
2009 projection (C) (no migration)	0-14	17.4	16.2	13.0	12.7	11.6	10.7	9.4
	15-64	72.4	72.9	72.8	71.8	64.5	57.7	53.7
	65+	10.3	10.9	14.2	15.5	23.9	31.6	36.9
Difference B-A	0-14	0.0	0.0	0.1	0.1	0.0	0.0	0.0
	15-64	0.1	0.1	-0.1	-0.1	0.0	0.0	-0.1
	65+	-0.1	0.0	0.0	0.0	0.0	0.0	0.1
Difference C-A	0-14	0.0	0.0	0.2	0.3	0.3	0.4	0.5
	15-64	0.1	0.0	-0.1	-0.1	0.2	0.4	0.7
	65+	-0.1	-0.1	-0.1	-0.1	-0.4	-0.8	-1.2

share of those aged 65 years and over increases from 10.3 percent in 2009 to 38.2 percent in 2005. Comparing the 2006 official projection with the 2009 interim projection, the percentage shares of those aged 14 and younger and those aged 15-64 decrease a little more slowly from 17.4 percent and 72.4 percent in 2009 to 8.9 percent and 52.9 in 2050, respectively. On the other hand, the percentage share of those aged 65 years and over increases from 10.3 percent in 2009 to 38.2 percent in 2050. With the assumption of no migration at 2009 projection, the percentage shares of those aged 14 and younger and those aged 15-64 increase a little bit. In 2050, the percentage share of those aged 14 and younger will be 9.4 percent, those aged 15-64 53.7 percent and those aged 65 years and over 36.9 percent.

The percentage share of the elderly population does not reveal any major differences between the 2006 official projection and the 2009 interim projection (Table 4). In both 2006 and 2007 projections, the percentage share of those aged 75 years and over increases from 6.6 percent in 2009 to 30.2 percent in 2050, and the percentage share of those aged 85 years and over increases

from 1.7 percent in 2009 to 14.5 percent in 2050. Comparing the 2009 interim projection which assumes no migration with the 2006 official projection, the percentage share of those aged 75 years and over increases a little more slowly from 6.5 percent in 2009 to 29.2 percent in 2050 and the same is true for those aged 85 and over showing an increase from 1.7 percent in 2009 to 13.9 percent in 2050. In Korea, where the total fertility rate is very low, the shift of international migration from net outflow to net inflow does not have any noticeable effect on the tempo of population aging. South Korea will be one of the countries that have the highest share of elderly population in the world by the middle of the 21st century.

Statistics Korea made a decision that it would not officially release the 2009 interim population projection to the ordinary statistical users for three main reasons. First, the sudden rise of TFRs to 1.17 and 1.25 births in 2006 and 2007 might not be sustained in the aftermaths of the global economic crisis which began with the subprime mortgage crisis in the United States. Indeed, TFR dropped again to 1.19 births in 2008 and 1.15 births in 2009. Since 2001, when TFR fell to 1.30 births after the millennium's baby boom

<Table 4> The Structure of Elderly Population in Recent Korean Population Projections

		2009	2010	2080	2020	2030	2040	2050
2006 projection (A)	65+	10.3	11.0	14.3	15.6	24.3	32.5	38.2
	75+	6.6	7.3	9.7	10.4	16.5	24.1	30.2
	85+	1.7	1.9	3.3	3.6	5.3	9.5	14.5
2009 projection (B)	65+	10.3	10.9	14.3	15.6	24.3	32.5	38.2
	75+	6.5	7.2	9.7	10.4	16.5	24.2	30.2
	85+	1.7	1.9	3.3	3.6	5.3	9.5	14.5
2009 projection (C) (no migration)	65+	10.3	10.9	14.2	15.5	23.9	31.6	36.9
	75+	6.5	7.2	9.6	10.3	16.2	23.5	29.2
	85+	1.7	1.9	3.2	3.6	5.2	9.3	13.9
Difference B-A	65+	-0.1	0.0	0.0	0.0	0.0	0.0	0.1
	75+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	85+	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Difference C-A	65+	-0.1	-0.1	-0.1	-0.1	-0.4	-0.8	-1.2
	75+	0.0	0.0	-0.1	-0.1	-0.3	-0.6	-1.0
	85+	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.5

(TFR=1.47) in 2000, the average TFR between 2002 and 2008 was 1.28 births, and it was most probable that TFR would continue to fall below the current level. In this case, there has been great uncertainty about the prospect that the total fertility would rise to 1.30 births. In addition, many demographers believe that TFR will continue to fall below 1.0 in the near future, considering that the government does not pay attention to strong family support programs, such as cash support, which help those who wish to have more children.

With regard to mortality, crude death rates likely before 2020 were relatively stable at 5.0 deaths per thousand, which is somewhat earlier than the year of its peak population. However, the compilation of death statistics has revealed that life expectancy at birth has increased more rapidly than what was assumed in the 2006 national population projection. On the basis of the 2006 official and 2009 interim population projections, Statistics Korea expects that the decreasing number of deaths will delay the exact timing of depopulation. Yet this will reinforce the negative effect on the workings of Korean society by accelerating the tempo of population aging, defined as the percentage share of the population aged 65 and over, and the elderly dependency ratios, defined as those aged 65 years and over divided by those aged 15-64 years.

With regard to international migration, Statistics Korea believes that the national population projection results cannot be used to predict a long-term direction of immigration and emigration policies although the Korean government shifts its policy focus to the importation of foreign workers and marriage-related immigrants to overcome the shortage of the domestic workforce in the manufacturing and tertiary sectors and the shortage of Korean brides who wish to marry with Korean grooms in rural and medium-sized cities. According to recent migration statistics, the net outflow of Korean nationals will continue since they leave Korea in order to obtain overseas job and study abroad. On the other hand, the net inflow of Korean non-nationals will continue because they wish to get jobs and live with their marriage partners in Korea, and particularly when the Korean government sticks to the current direction of immigration policy for people from China

(including ethnic Korean) and various countries in Southeast Asia.

From both of the 2006 and 2009 population projections, Statistics Korea concludes that the overall effect of the total fertility rate and the number of deaths on the reduction of the total population size will be fairly stable and limited in its magnitude. With the persistence of a super-low fertility pattern and gradual rise in life expectancy at birth, the projection results indicate that international migration should be an option for directing the future total population size to a sustainable one. However, this does not clarify the genuine effect of the super-low fertility pattern on the eventual size of the national population and the tempo of population aging.

Ⅲ. The Korean National Population Projection in Comparison with Other Countries

In this part, we discuss a broad strategy for population projection implementation in order to understand the current status of Korea's national population projection while comparing it with the national population projections determined by developed countries and international organizations, such as the United Nations and the European Union (United Nations, 2008; Eurostat, 2009). The national population projections are usually implemented by the national statistical agencies or departments, which release their major projection results either through paper publications or on official websites.

〈Table 5〉 summarizes the name of the national projection agencies, projection horizon, and projection interval for a selected number of countries and two international organizations. According to our review, the projection methods are essentially the same, namely, the cohort component method. This method projects future populations by calculating the annual changes due to the aging of individuals from each age bracket for each component (birth, death, and international migration). As for the preexisting individuals, the future population is calculated by subtracting the number of deaths due to aging and international migration. The new born population is determined

<Table 5> Projection Outline for Selected Countries and International Organizations

Country	Population Projection Agency / Department	Projection Horizon[1]	Projection Interval
Korea, Republic of	Statistics Korea	2006-2050	5 years
Japan	National Institute of Population and Social Security Research	2006-2055	5 years
Austrailia	Austrailian Bureau of Statistics	2005-2101	2-3 years
Austria	Statistics Austria	2007-2050	1 year
Canada	Statistics Canada	2006-2031	5 years
Denmark	Statistics Denmark	2007-2050	2 years
France	National Institute of Statistics and Economic Studies	2006-2050	5 years
Germany	Federal Statistical Office	2006-2050	irregular interval (or 3-5 years)
Italy	Italian National Institute of Statistics	2008-2051	4-5 years
New Zealand	Statistics New Zealand	2009-2061	2-3 years
Norway	Statistics Norway	2010-2060	1 year (since 2009) 3 years (prior to 2009)[2]
Portugal	Statistics Portugal	2008-2060	2 years
Spain	Statistics Spain	2002-2060 (long-term) 2008-2012 (short term)	5 years (long term) 1 year (short term)
Sweden	Statistics Sweden	2007-2050	5 years
Switzerland	Statistics Switzerland	2005-2050	5 years
United Kingdom	UK Office for National Statistics	2006-2081	2 years
United States	US Bureau of Census	2001-2050	10 years[3]
Europeam Union	Eurostat (Statistical Office of the European Commission)	2005-2051	3-5 years
United Nations	United Nations Population Division	2009-2050	2 years

Note: 1) The length of projection horizon is relevant to the national population projection only.
2) Statistics Norway began to release the national projection once every year since 20009, but the interval was 3 years before 2009.
3) The US Census Bureau releases the national projection results every 10 years, each time one year after decennial census is completed. In the meantime, interim projections are carried out irreguarly.

by calculating the number of live births from the female population in the reproductive ages (15-49 years) and the number of babies remaining after death while international migration is also added to the population of the following year.

In the projection process, the cohort component method requires the

following input data: (1) the base or launch population, (2) the future fertility rate (and the sex ratio at birth), (3) the future survival rate, and (4) the future international migration rates (numbers). This projection method requires a set of assumptions by implementing projection techniques based on actual statistics for each component. Given that future changes in fertility and mortality are inherently indeterminate or uncertain, the national statistical agency or international organization believes that this routine practice provides a range of population projections based on alternative assumptions.

To establish the base population or the starting point for the national population projection, Statistics Korea uses population flow data on births, deaths, and international migration as well as census data on the total population by age and sex. Statistics Korea uses the post-enumeration survey and civil population register data as well as data from registered non-citizen population and illegal immigrants in correcting for the census population figures and preparing the mid-year base population. In the countries reviewed in this paper, there are different practices in preparing the base population. For example, the United Kingdom conducts the census coverage survey to adjust for enumeration errors in the main census survey, and the Nordic countries widely use their population registers along with results from register-based censuses in establishing the base population. In Japan, the national population projection accepts the population census figures as they are in establishing the base population. In general, however, the accuracy of the base population becomes more and more problematic in the era of globalization and borderless migration.

In the deterministic projection model, the core of the cohort component method is how to establish the main assumption on future changes in fertility, mortality, and international migration, but in most cases alternative assumptions are established along with the main assumption to cope with the uncertain issue governing the future demographic trends. In the projection exercises, Statistics Korea combines the main and alternative assumptions on each of the three demographic components to provide broader insight into the shape of future populations.

In most countries, probably except Japan, the national statistical agency or department produces the official national projection results on behalf of the national government. In Japan, the National Institute of Population and Social Security Research, as a government research institution affiliated with the Ministry of Health, Labor, and Welfare, is responsible for producing projection statistics on the behalf of the Japanese government. The horizon length or range of the official projection usually lasts between 45 and 55 years in the majority of selected countries, but often extends to 100 years in the United States, Japan, and Australia. In recent years, Statistics Korea has released 50-year length official projection results, but the other government agencies, such as the National Pension Fund, extend them for only for the additional 50-year population projection when they are needed. In some very low-fertility countries, like Spain, the national statistics agencies tend to classify the official national population projections into two classes, short-term (10 years) and long-term (40 years) projections, and update the long-term projection once every three years on the basis of annual short-term projections.

The intervals of national population projections are varied. Projections are produced once every year in Austria, Denmark, Norway (since 2009), and Sweden; once every 2-3 years in Australia, New Zealand, the United Kingdom, and the United Nations, and the European Union, and once every 5 years in the rest of the selected countries. The United States produces the official national population projections once every ten years, but the interim projections once every 2 years to process it as an input data for the projection of the social security funding requirement. By statistical ordinance, Statistics Korea produces the official projection results once every five years, usually one year after the completion of population and housing censuses which are conducted every five years in the calendar years ending with zeros and fives. In Germany, the Federal Statistical Office had once produced the official population projection at irregular intervals, but in recent years produces projection results more regularly at 3-5 year intervals. In general, more and more countries try to shorten the length of projection intervals to reduce projection error due to uncertainty elements in the trend

of fertility, and mortality, and fertility. In addition, statistics Korea hopes to produce the official population projection results once every year by compiling improved vital statistics data probably after the completion of a register-based population census planned in 2015.

Among the international organizations which produce national population projections are United Nations Population Division and Eurostat, the official statistical department of the European Union. The United Nations population projections are revised once every two years, and the horizon of the most recent projection lasts 43 years (2008-2050). In 2004, the Eurostat began to produce the first official, single-framework population projection for each of its member states plus acceding countries (Bulgaria and Romania). The Eurostat releases its revised projection once every two or three years and the horizon in the most recent projection lasts 63 years (2008-2060). The international organizations produce a single-frame, unified approach to the national population projection for each of their member countries, while each country's national statistical agency or department produces its official national population projections after carrying out a detailed analysis of vital statistics trends and establishing alternative assumptions on fertility, mortality, and international migration. The national population projections produced by the international organizations will be helpful for demographers and policy administrators who wish to gain access to data on future populations for its member countries which do not produce their own national population projection.

In 〈Table 6〉, we summarize the number of assumptions the selected countries have established for each of the three demographic components (fertility, mortality, and international migration) and the number of projected scenarios they produce by sorting out each of the assumptions on future demographic change. In most countries, the main standard projection scenario often called the "medium-variant" projection is made by using a combination of medium-variant assumptions on fertility, mortality, and international migration. In addition, the basic alternative projection scenarios are high-variant and low-variant scenarios which combine high-variant and low-variant assumptions on fertility, mortality, and international migration.

<Table 6> Projection Scenarios in the National Population Projections for Selected Countries and International Organizations

Country	Number of Scenarios in the Projection	Number of Assumptions on:		
		Fertility	Mortality	Int'l Migration
Korea, Republic of	4	3 (Co)	1	1
Japan	9	3	3	1
Australia	24	3	2	3 (0)
Austria	10	3 (Co)	3 (Co)	3 (0, Co)
Canada	6	3	3	3
Denmark[1)]	1	1	1	1
France	30	3 (EU average)	3 (Co)	3 (0)
Germany	15	3 (Re, Co)	2	2 (0, 1 other)
Italy	3	3	3	3
New Zealand	14	3 (very high)	3 (very low)	3 (0, 2 others)
Norway	14	3	3 (Co)	3
Portugal	4	3	2	3 (0)
Spain	2 (long term)	1	1	2
Sweden[2)]	1	1	1	1
Switzerland	14	3 (Re)	3 (Co)	3 (0)
United Kingdom	20	3 (Re, Co)	3 (Co)	3 (0)
United States	10	3	3	3 (0)
Europeam Union	7	3	3	3 (0)
United Nations	11	3 (Re, Co)	1 (3 HIV/AIDS assumptions, Co)	1 (0)

Note: For the number of assumptions on fertility, mortality, and migrations, what is written in parenthesis refers to special assumptions other than three main assumptions (medium variant, low variant, and high variant). Re = replacement level fertility, Co = constant (fertility, mortality, or international migration), 0 = zero migration, other = migration assumptions other than zero migration or constant migration.

1) In 2004, Statistics Denmark established 3 fertility assumptions, but they were simplified to one fertility assumption.

2) In 2004, Statistics Sweden established seven projection scenarios by making three assumptions on each component (fertility, mortality, and international migration).

In most selected countries, the national statistical agency develops additional scenarios that combine main and alternative assumptions on future demographic changes in addition to the three major projection scenarios.

Sweden and Denmark develop one single, main projection scenario without either low-variant or high-variant scenarios because they produce the national population projection once every year. In a sense, this single

scenario approach to population projection may provide easier access to ordinary statistical users. Among the countries and international organizations with more than 20 projection scenarios are France (32 scenarios), Australia (24 scenarios), and the United Kingdom(20 scenarios). Among those with the projection scenarios ranging between 10 and 15 are Germany (15 scenarios), Switzerland (14 scenarios), New Zealand (14 scenarios), Norway (14 scenarios), the United Nations (11), Austria (10 scenarios), and the United States (10). Finally, among those with the projection scenarios smaller than 10 are Japan (9 scenarios), Sweden (7 scenarios), the European Union (6 scenarios), Canada (6 scenarios), Korea (4 scenarios), Poland (4 scenarios), Italy (3 scenarios), and Spain (3 scenarios). In general, the countries with a super-low fertility pattern, such as Italy and Spain in Southern Europe and South Korea in East Asia tend to develop a smaller number of projection scenarios compared to the countries of Western Europe, North America, and Oceania, probably due to the lack of concern with regards to the potential impact of mortality and international migration on the shape of future populations.

In most countries, the national statistical agency develops three major fertility assumption, say, medium, high, and low-variant assumptions as well as comparing cohort fertility with period fertility and establishing target fertility at the end of the projection horizon. In the 2006 official national projections, Statistics Korea adopted another additional, so-called "constant" fertility assumption, which highlights the continuity of currently super-low TFR lower than 1.3 births per woman to the end of the entire projection horizon. In some countries of Western Europe and Oceania, the national statistical agency develops another supplementary fertility assumption that the current fertility will recuperate to the replacement level at a given time within the entire projection horizon.

The number of assumptions on mortality and international migration is mainly three (medium, high, and low variant), which reveal smaller variations than the number of assumptions on fertility. For mortality assumptions, the national statistical agency and the international organization often establishes the so-called "no mortality change" assumption that

highlights the continuity of the current mortality pattern to the end of the entire projection horizon. In addition, the United Nations develop various HIV/AIDS-related mortality assumptions to measure the HIV/AIDS effects on the evolution of future populations. For international migration, many countries in Western Europe develop the "zero migration" assumption to measure the pure effects of natural growth (births minus deaths) on the shape of future population.

Ⅳ. A Stochastic National Population Projection: Illustration for Korea

The 2006 official and 2009 interim population projections rest on deterministic models. In these models, today's population and assumptions on the development of demographic rates determine future population. To account for forecast uncertainty, the 2006 official projections used four major scenarios, based mainly on "high", "medium", "low", or "constant" assumptions of fertility rate. This technique -though common practice - suffers mainly from two shortcomings: First, it does not provide information on the probability of a certain projection scenario. Second, modeling uncertainty by means of different projection scenarios is necessarily inconsistent.

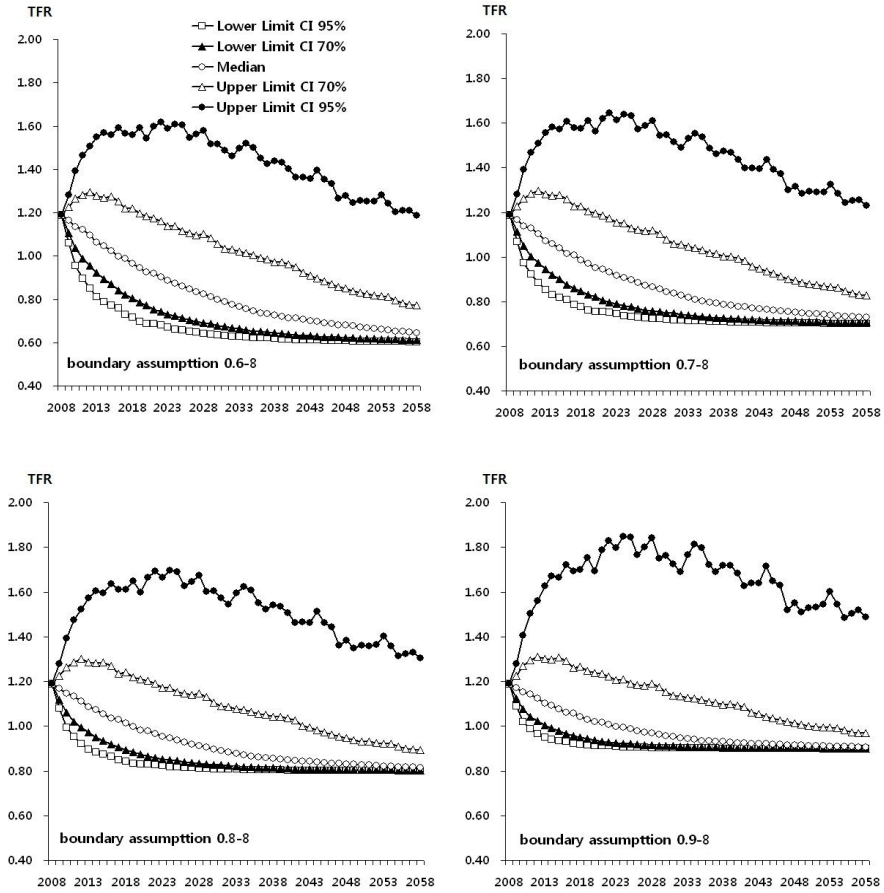
To overcome these problems, probabilistic approaches to population forecasting have been developed in recent years (Lee, 1998; Choi, 2004). The main goal of probabilistic population projections is to obtain prediction intervals of demographic variables and thus to measure projection uncertainty. Probabilistic projections make use of historical forecast errors (Keyfitz, 1981), rest on expert opinion (Lutz, Sanderson, and Scherbov, 1998) or rely on time series analysis to project future population parameters (Lee, 1998).

We illustrate a stochastic projection for Korea in which we use a time series analysis to project future demographic parameters using actual statistics on fertility from 1984 to 2008, which was below a replacement level of 2.1 births and actual data on mortality from 1970 to 2008. The length of the projection horizon is 50 years which ranges between 2009 and

2058. In the projection, the first stepis to transform raw input data. We first establish the fertility boundary, using TFR. The upper boundary is 8 births, approaching the so-called natural TFR found in pre-industrial populations, while low boundaries are set to 0.6, 0.7, 0.8, and 0.9 births. Mortality is projected using the Lee-Carter method, by gender and two age groups (0-64 years, and 64 years and over). The second step is to find the ARIMA model of input data (simple exponential smoothing with growth is selected). The third step is to predict the future input considering the error term distribution. The fourth step is to apply the cohort component method. The fifth step is to iterate step 3 and step 4, 1000 times. The sixth and final step is to find a median and 70% and 95% confidence interval. In this projection exercise, international migration is not considered (no migration is assumed), and the base population is the 2009 mid-year registered population, which comes from the Korean Statistical Information System (Statistics Korea, 2010).

It is a very hard question to establish the lower fertility boundary in Korea with a super-low fertility pattern, particularly since there is prevalent pessimistic mood with respect to the future direction of fertility (Golini, 1998; Bongaarts and Feeney, 2000). Thus, it would be desirable for the stochastic projection to prepare not a single model, but four models that assume 4 different limits and then compare the predicted results. The future TFRs are different by the fertility boundary assumptions. If the boundary is assumed to range between 0.6 and 8 then the medium TFR will be 0.646, if between 0.7 and 8 then it will be 0.728, if between 0.8 and 8 then it will be 0.815, and if between 0.9 and 8 then it will be 0.90 (Figure 1). All of them are lower than the assumptions by Statistics Korea in both the 2006 official projection and the 2009 interim projection. Statistics Korea assumes the TFR at the end of the projection horizon (here 2050) will be a little higher than the TFR in 2005 or 2008, where this time series projection assumes the current decreasing trend will persist until the end of the projection horizon. The 95% probabilities of future TFRs show the effect of the boundary assumption. The highest plausible TFRs are almost identical. The TFR will increase in the near future, and then by 2058 it will decrease a little. As the

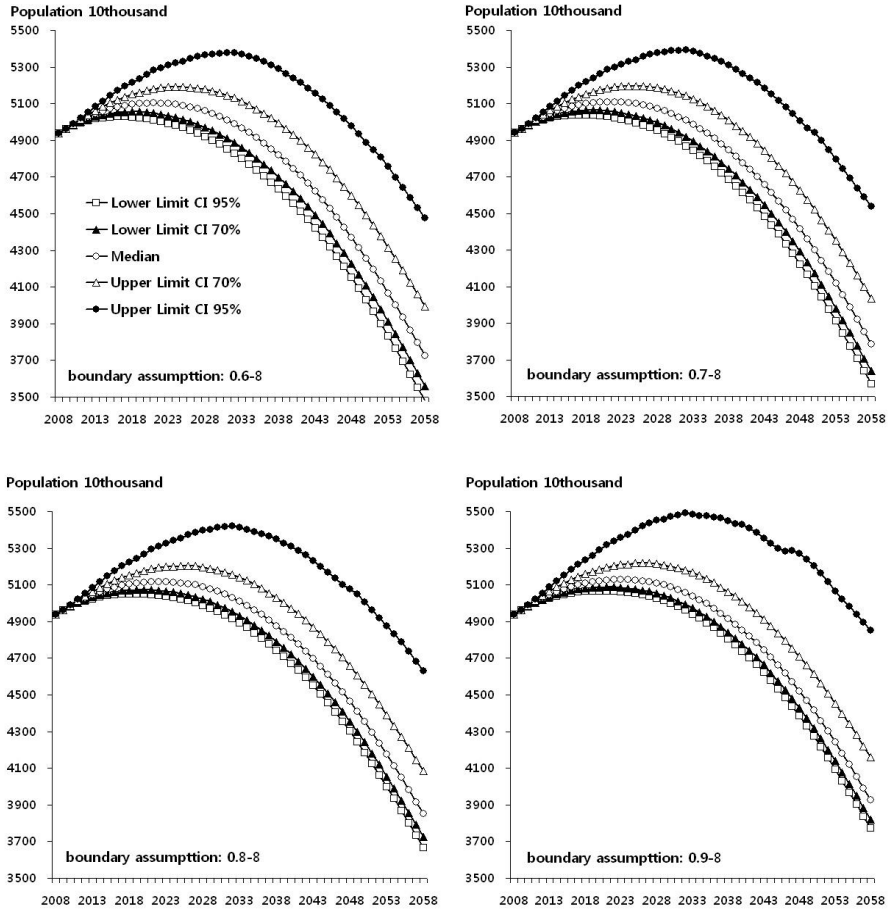
<Figure 1> Confidence Interval (95% 70%) of the forecasted TFR of Korea from 2009 to 2058



upper boundary (8) is far from the projected fertility rates and the effect of boundary limitation increases as the rate approach to the boundary, the upper boundary effect here is small. However the lower boundaries of the confidence interval are changed by the ultimate boundary assumption. 〈Figure 1〉 shows that the lower boundaries compress the confidence interval and that they make the median projection approach the lower boundary.

Based on these assumptions, future populations are like those found in 〈Figure 2〉. The total population size will start to decrease soon. The overall patterns are similar but according to the fertility assumption, the lower

<Figure 2> The Confidence Interval (95% 70%) of the forecasted population of Korea



limits of the confidence intervals are somewhat different. When the lower TFR boundary is 0.6, the population will be more likely to shrink quickly. The future population is expected to decrease by more than 25 percent. The median population in 2058 will be 77 percent of the population in 2009 if the boundary is 0.7 to 8. Also, if the boundary is 0.8 to 8, then it will be 78 percent, and if 0.9 to 8 then it will be 80%.

This illustrative stochastic projection provides useful insights into the significance of fertility assumptions for the determination of the future

population size. When the lower TFR boundary is 0.6, the size of the median total population in 2050 will be 3.8 percent smaller in this illustrative projection than in the 2009 interim national population projection assuming zero migration; the size of the median total population in 2050 will be 2.7 percent smaller than in the 2009 interim projection if the boundary is 0.7 to 8. If the boundary is 0.8 to 8, then it will be 1.5 percent smaller, and if 0.9 to 8, then it will be nearly identical as the figure in the interim projection. This indicates that the shape of the future population is more likely to be determined by the direction of a super-low fertility pattern in Korea, and it might be unreasonable to put more emphasis on the total population impact of international migration, which assumes growing importance as repeated by some scholars and policy administrators in the slogan of multiculturalism or multi-ethnic society in Korea.

Ⅴ. Future Challenges of the Korean National Population Projection

In the country, like Korea with a super-low fertility pattern, we believe, the national population projections can improve their forecasting accuracies by updating them more frequently or distinguishing them into short-term and long-term projections. In the case of minor fluctuations in fertility or international migration, it might be more desirable to update a short-term national projection on an annual basis (as seen in the Spanish system of national population projection) than to restructure an entire long-term national projection. Also, the national population projections should develop means on how to improve the quality of data on vital statistics for the non-national population, particularly, those who immigrate to the country for marital reasons, and how the assumed values of births and deaths for the non-national foreign population should be taken into consideration in relation to those among population whose nationalities are Korean. This is because many policy administrators believe that the influx of foreign workers and marriage-related immigrants, rather than the persistence of a super-low

fertility pattern, might contribute more significantly to the delay of both the timing of depopulation and the speed of population aging in Korea.

In preparing for the 2011 official population projection, Statistics Korea will hopefully develop more than four projection scenarios and take into account more than four assumptions on fertility, more than one mortality assumption, and more than one international migration assumption. Similar to the system of population projection in France, Australia, and the United Kingdom, Statistics Korea will need to prepare and release a total of 27 population projection scenarios, which consider (1) three fertility assumptions (medium, low, high) (2) three mortality assumptions (medium, low, high) and (3) three migration assumptions (medium, low, high). In addition, we may add "constant" assumptions on fertility, mortality, and international migration. However, both of the 2006 official and 2009 interim national population projections indicate that the "constant" and "medium-level" fertility assumptions will not make any large differences in the final projection results, since in the "medium-variant" assumption the level of target fertility at the end of the projection horizon is a little larger than the level of fertility observed at the beginning of the projection horizon. In such a case, it would be more desirable for the national fertility projection to pay more attention to additional types of "low-variant" fertility assumptions by taking into consideration the notion that the current super-low fertility pattern may deteriorate to its much worse level, say, a TFR lower than the target fertility forecasted for the "low-variant" assumption in the 2006 official national population projection.

In preparing the 2011 official national population projection, we expect Statistics Korea to pay more attention to the determination of a base population that should include both national and non-national populations. We believe that various demographic techniques must be used to determine the base population, since Korea is changing rapidly to an immigrating country, and since the census undercounts the non-national population. Statistics Korea wishes to implement a register-based population census beginning in 2015 and the determination of the base population will be facilitated by the adoption of a one-number-census approach in the United

Kingdom or the dual-system estimation approach used in the 2008 Israel's integrated population census.

The long-term fertility which is often the target fertility forecasted for the end of the projection horizon in the national population projection is an important element in determining details for the population projection results (Jun, Kim, and Cho, 2005). In both the 2006 official projection and the 2009 interim projection, the quantum and tempo of cohort fertility is taken into consideration to establish the target fertility in period terms (Bongaarts and Feeney, 2000). In the study commissioned by Statistics Korea, the medium -variant assumption establishes the target fertility of the cohort born in 1991 as 1.28, which is a little smaller than in the 2005 interim population projection. This clearly signifies that marital fertility continues to decline together with a steady rise in marriage age and increasing proportions of single or divorced women during the reproductive span. We expect that the target fertility of the 2011 official national population projection can be more reasonably determined by using the result from the 2010 population and housing censuses, which include the topics on marital status, age at first marriage, actual number of children born, and the number of children whom the female respondents plan to have. These census topics, as well as actual vital statistics data, will have to be fully exploited to avoid the error of input parameters in the national population projection, while refining the generalized log gamma distribution which is used in the Japanese system of population projection.

Finally, we hope that Statistics Korea will find wise ways to incorporate the ideas underlying the system of stochastic population projection as part of the official national population projection. One merit of the stochastic population projection model is to use it as a framework for assessing the value of demographic sensitivity tests with various "pronatalist" population policy models. More specifically, they will be used to describe particular problems, such as (1) how the omission of random shocks in each component of demographic change, particularly, fertility (e.g., increase in births due to millennium baby boom, twin-spring years and golden swine years), or international migration (e.g., increase in immigration of foreign-born brides

resulting from imbalances of gender composition in the rapid drop of fertility over past 30 years) will lead to population sizes growing beyond all projected population sizes as soon as the projections are released; (2) to what extent the practice of restricting demographic changes at the beginning of the projection horizon leads to confusing results for trends in age structure; and (3) with a discussion of the value of stochastic population projections, which are a promising alternative to the current deterministic approach.

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국제비교를 통해 바라본 한국의 장래인구추계 현황과 전망

전광희 · 최슬기

한국사회가 최근 초저출산율이 지속되고, 사망율이 괄목할만큼 개선되면서 장래인구추계는 새로운 도전을 받고 있다. 이 연구는 장래 인구를 보다 정확한 예측하고, 양질의 정보를 제공하기 위한 방안을 한국의 경우를 중심으로 여타 저출산국가들가 비교연구를 통해 논의하였다. 구체적으로 이 연구는 1) 통계청이 실시한 2009년도 인구추계를 2006년도 공식 인구추계와 비교분석하였고, 2) 한국의 인구추계방식을 다른 나라의 경우와 비교 분석하였다. 비교에는 어떤 기관이 인구추계를 담당하는지, 얼마나 먼 장래까지 추계하는지, 얼마나 자주 행해지는지, 그리고 추계에 사용되는 출산, 사망, 이주에 관련된 가정과 시나리오의 수를 고려하였다. 3) 향후 50년간 장래인구를 확률적 인구추계 방식을 도입하여 예측해 보았다. 4) 마지막으로 2011년 장래인구추계에 사용될 시나리오를 살펴보았다. 이러한 논의를 바탕으로 이 연구는, 장래인구추계의 정확성을 높이기 위해서 인구추계를 좀더 자주 실시할 것과, 단기와 장기추계의 구분, 시나리오 수를 기존 네가지에서 더 늘릴 것을 제안하였다. 또한 기준인구 산정에 있어 국내 체류중인 외국인 인구을 고려할 것과 확률적 인구추계 방식도 도입할 것을 제안하였다.

핵심단어: 인구추계, 인구시나리오, 초저출산, 확률론적 인구추계