An Empirical Analysis of the Effect of Fertility Measurement Choice on Subnational Population Projections: A Case Study of 47 Prefectures in Japan

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The cohort component method is the most widely used for making subnational population projections. With this approach, three components of population change are included: births, deaths, and migration. Of these, many researchers have been concerned with the migration components, which are clearly critical to the preparation of subnational population projections. Some models, such as multiregional, migrant pool, and two-regional, have been used for cohort component projections (Smith et al., 2001).

Few studies have considered the fertility components, however, which have a cumulative impact on both the size and age structure of the population over time as well as more impact on subnational population projections than the mortality components. In this study, we investigate how the choice of fertility measurement affects the outcomes of subnational population projections.

Some fertility measurements can be taken as part of the cohort component projection models. The age-specific birth rate (ASBR) is a widely used measurement for subnational population projections. However, in some cases it is difficult to calculate the ASBR by geographic area due to the availability of statistics and population size. In these cases, one solution is to estimate the region-specific ASBR by using an indirect standardization method, such as that used by EUROPOP2008 (Giannakouris, 2010). Other fertility measurements are also available. In official Japanese regional population projections, the child–woman ratio (CWR) was used to project the future 0–4 age-group population (National Institute of Population and Social Security Research, 2013). Although the choice of fertility measurement depends on both the purposes for which projections will be used and any constraints imposed on the producers of those projections, the effect of the fertility measurement choice on the outcomes of projections should still be assessed.

Smith and Tayman (2003) conducted one of the few research studies relating to the impact of fertility measurement on the accuracy of subnational population projections. Taking the projections by age group at state level in the United States and county level in Florida, they compared projections derived from the sophisticated cohort component method with those derived from the simpler Hamilton–Perry method. They showed that the accuracy of the 0–4 age-group projections derived from the simpler CWR method was similar to those derived from the more complex ASBR method at both

geographic levels, implying that the choice of fertility measurement did not affect the accuracy of subnational population projections. However, the accuracy of 0–4 age-group population projection in Smith and Tayman's (2003) study was affected by differences in not only the fertility measurement but also the projected at-risk female population and projected survival and migration rate from birth to target year. Thus, we examine in-depth the impact of the choice of fertility measurement on the accuracy of subnational projections.

We consider four kinds of fertility measurements—age-specific birth rate (ASBR), child–woman ratio (CWR), general fertility rate (GFR), and standardized birth rate (SBR)—for subnational population projections. As mentioned earlier, ASBR is the most commonly used measurement; however, it requires more data for its calculation than other measurements. CWR is neither a rate nor a true fertility measurement, but it can be very useful for geographic areas that lack vital statistics data because it requires only population data by age. However, CWR does not account for the differences in age distribution of the female population, and neither does GFR, which relates the number of births to the number of females most likely to give birth and is sometimes used instead of ASBR for projections. We define SBR as the ASBR that can be derived from the indirect standardization method used by EUROPOP2008: SBR can be calculated by using ASBR at a national level, region-specific number of births, and female population by age.

We develop four different models of cohort component projections, which are identical except for the fertility measurement. Actual survival and net migration rates are used to provide projections for the population aged five years and older; the population under five years old is projected by using not only actual survival and net migration rates but also assumed fertility measurement values. For each fertility measurement, we assume that regional variations from the respective national figure in the base period remain stable over the projection period. Using data from the periods 1980–85, 1985–90, and 1990–95, we use these models to produce 15-year population projections in five-year age groups for 2000, 2005, and 2010 for each of the 47 prefectures in Japan.

From these projections, the 0–14 age-group population is compared with the census counts for 2000, 2005, and 2010. Percentage errors are calculated by subtracting the census count from the corresponding projection, dividing the difference by the census count, and multiplying by 100. We then use algebraic percentage errors (ALPE) and absolute percentage errors (APE) to evaluate the projection errors.

Table 1 summarizes projection errors for each fertility measurement and target

year. Errors vary between both fertility measurements and target years, but the smallest difference emerges from the model using the standardized birth rate; among the other three models, the identified differences are similar.

Table 1. The distribution of algebraic percentage errors and absolute percentage errors for 47 prefectural 0–14 age-group population projections by fertility measurement

Target Year	Fertility Measure	ALPE (%)					APE (%)				
		Minimum	1st Quartile	Median	3rd Quartile	Maximum	Minimum	1st Quartile	Median	3rd Quartile	Maximum
2000	ASBR	-10.2	-5.3	-3.9	0.4	10.5	0.3	2.4	4.6	5.6	10.5
2000	CWR	-6.0	-1.3	0.4	2.5	9.8	0.0	0.8	2.2	4.2	9.8
2000	GFR	-7.5	-1.9	0.0	1.8	8.2	0.0	0.7	1.9	4.3	8.2
2000	SBR	-6.6	-3.9	-2.3	-0.1	6.4	0.0	2.0	3.0	4.1	6.6
2005	ASBR	-7.8	-5.1	-3.0	-0.7	11.3	0.2	1.7	3.5	5.4	11.3
2005	CWR	-7.3	-2.2	2.1	6.4	13.7	0.3	2.2	4.4	7.0	13.7
2005	GFR	-7.4	-2.0	1.7	6.0	13.3	0.2	2.0	3.7	6.1	13.3
2005	SBR	-5.8	-3.5	-1.6	0.1	4.7	0.1	0.8	2.1	3.7	5.8
2010	ASBR	-8.2	-3.4	0.3	1.9	7.0	0.2	1.4	2.7	4.3	8.2
2010	CWR	-7.1	-2.4	0.9	4.4	9.0	0.0	1.6	3.2	5.0	9.0
2010	GFR	-7.5	-1.8	1.3	4.8	9.5	0.4	1.6	2.9	6.1	9.5
2010	SBR	-4.8	-2.0	0.0	2.0	4.3	0.0	0.7	2.1	2.7	4.8

The standardized birth rate model performs better because the regional variation in fertility measured by the standardized birth rate is the most stable between the base and projection periods. On theoretical grounds, we cannot specify which measurement provides the most stable trend for future regional variation in fertility. Accordingly, if regional fertility patterns and trends are considerably different to those of the population used in this study, the performance of the standardized birth rate model could be worse than if another fertility measurement is used. Instead, this study shows that the choice of fertility measurement does not directly affect the outcome of subnational population projections.

References

Giannakouris, K. (2010) “Regional population projections EUROPOP2008: Most EU Regions Face Older Population Profile in 2030”, *Statistics in Focus* 1/2010 (http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-SF-10-001/EN/KS-SF-10-001-EN.PDF)

National Institute of Population and Social Security Research. (2013) “Regional Population Projections for Japan: 2010-2040”, Population Research Series No.330 (in Japanese)

Smith, S. K., and Tayman, J. (2003) “An Evaluation of Population Projections by Age”,

Demography, vol.40, pp.741-757.

Smith, S.K., Taynan, J., and Swanson, D. A. (2001) *State and Local Population Projections: Methodology and Analysis*, New York, Kluwer Academic.