of these two ratios is the total dependency ratio. The decline in total dependency ratio due to fertility decline is called "demographic gift" or "demographic bonus" (Mason and Lee, 2001:9). While Japan enjoyed this gift between 1970 and 1990, the rapid aging of the population started elevating the total dependency ratio after 1990. According to NIPSSR (2012b), the elderly dependency ratio of 36.1% in 2010 will swiftly reach 54.4% in 2030 and 78.4% in 2060. The total dependency ratio of 2060 implies that there will be 96 net consumers for 100 net producers, compared with 57 net consumers today.

While the total dependency ratio is so easily obtained and compared between countries, the assumption that all the working age population aged 15~64 are net producers and all the children and elderly population are net consumers is too simple. An ideal solution would be the "support ratio" used in the National Transfer Account (Lee 2007:17; Mason and Lee 2012:13). However, per capita income and consumption by age are difficult to obtain and project. Instead, it is attempted here to calculate the ratio of non-laborers to laborers using census and existing projection.

Figure 3 shows the labor force participation rates in 2000 and 2010 censuses and projection for 2030 conducted by the Employment Security Bureau (2007). The projection expects rises in labor force participation due to reduction in income difference by age and sex, improvement in childcare service and delay in retirement. While the labor force participation rate of men aged 65~69 is projected to increase from 54.1% in 2010 to 63.9% in 2030, predicted improvement in female labor force participation in 2010~2030 is relatively mild if compared with the change in 2000~2010.

Figure 3a. Labor Force Participation Rate: Male
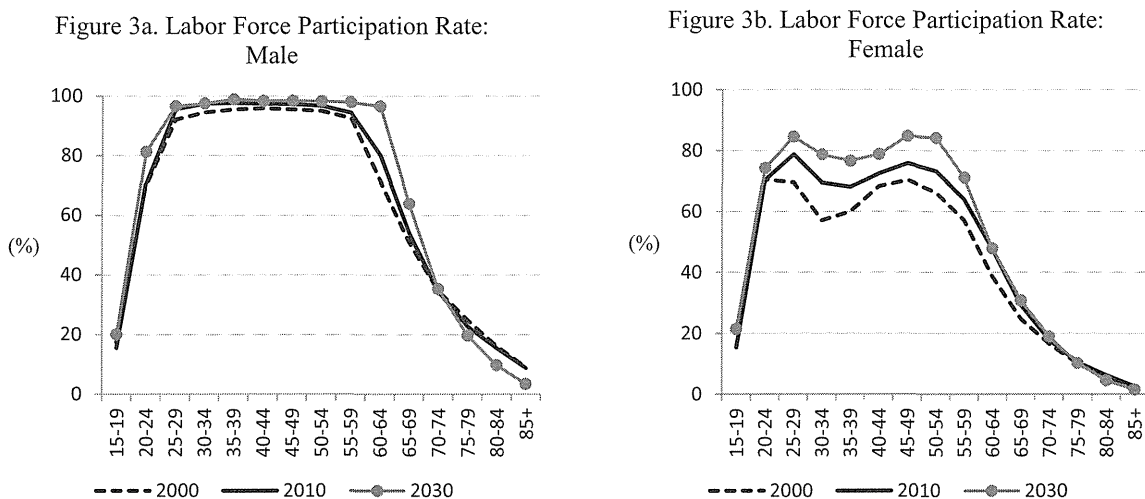
Figure 3b. Labor Force Participation Rate: Female

Figure 4 compares non-labor/labor ratios with constant age-sex labor force participation rate given in the 2010 census and that with projected labor force

participation rates, in addition to the total dependency ratio. For the non-labor/labor ratio with changing labor force participation, it was assumed that the rate changes linearly in 2010~2030. If labor force participation rates are fixed at the level in the 2010 census, the non-labor/labor ratio rises from 87.4% in 2010 to 100.5% in 2030. However, the projected improvement in labor force participation may compensate the demographic deficit and the ratio may be held constant until 2030.

Figure 4. Dependency Ratio and Non-Labor/Labor Ratios
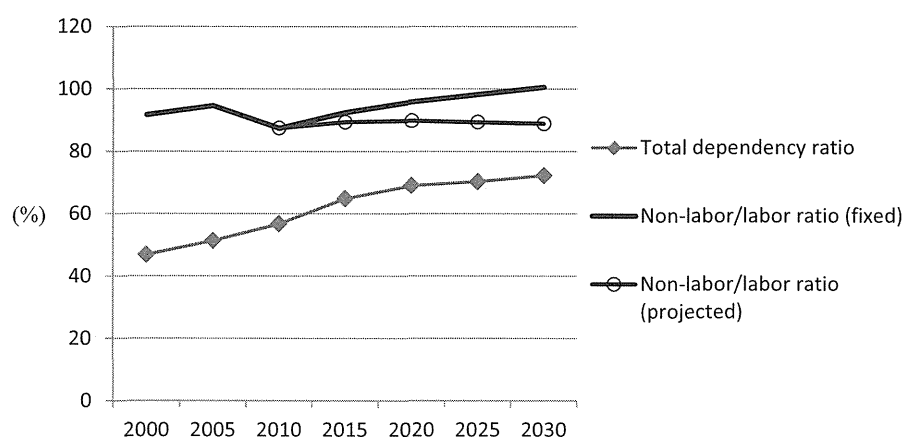
Thus, it could be possible to cope with population aging and to prevent the practical dependency ratio from rising rapidly. However, improvements in male and female labor force participation should contribute to economic growth if the population aging were milder. Thus, the predicted rapid population aging still has negative impact on Japanese economy. In addition, the number of young and middle aged workers will decline more rapidly than old workers. Such a fall in the labor supply of skilled young workers is very problematic, under rapid technological development and globalization (McDonald 2005:1).

It is expected that the aging of the population will eventually boost economic growth because elderly people have more assets than younger generations, and this suggests that capital intensification will occur. However, such a "second dividend" effect would be small in Japan, because only a small portion of consumption by the Japanese elderly comes from asset-based reallocations (Lee 2007:31).

Causes of Demographic Changes

Impacts of fertility and mortality on population aging

Figure 5 compares the total dependency ratio in 2060 in nine different projections conducted by NIPSSR (2012b). The effect of fertility is stronger than mortality, as the

stable population theory expects (Keyfitz and Caswell 2005, chp. 5; Preston, et al. 2001, chp. 7). For example, if we choose the medium fertility variant, the difference between low mortality variant (99.2%) and high mortality variants (93.5%) is 5.7 points. If we choose the medium mortality variant, however, the difference between low fertility variant (101.4%) and high fertility variant (92.7%) is as large as 8.7 points.

Figure 5. Total Dependency Ratio in 2060 by Assumption
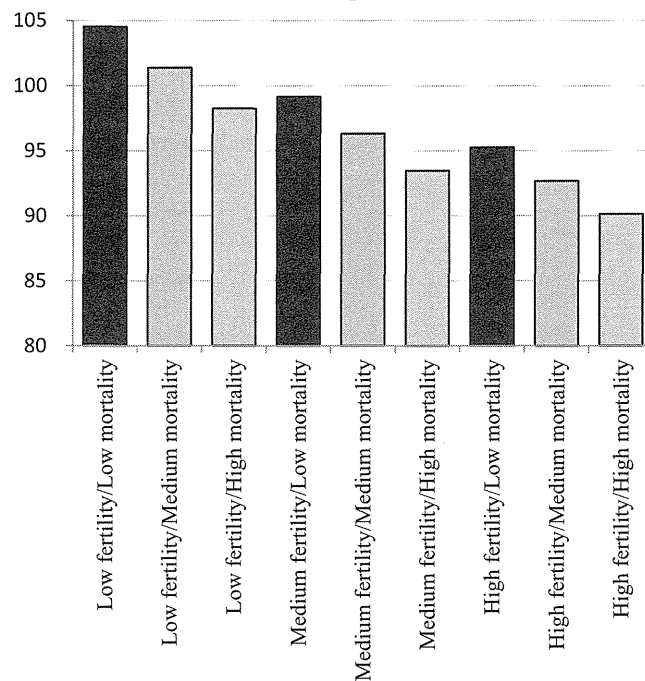
In the case of Japan, the effect of mortality change is not negligible. In a low mortality population as in Japan, there is little room for further mortality decline for younger ages and assumed mortality decline concentrates in old ages. Actually, the projected elderly population aged 65 and over in 2060 is 3,597 thousands in the low mortality variant, which is 8.0% larger than 3,332 thousands in the high mortality assumption. In addition, the population pyramid of a low fertility country is pot-shaped. In such a case, the difference in old age population is emphasized and easily recognized.

The life expectancy at birth of male and female in 2010 was 79.64 and 86.39, respectively. The medium mortality variant assumes that the life expectancy in 2060 will be 84.19 and 90.93 for male and female, respectively. Causes of mortality decline can be classified into medical factors including development in prevention and treatment, socio-economic and institutional factors including health care facilities and

insurance system, and life style factors including diet, drinking, smoking and exercise (Kaneko, 2010b). For longer life expectancy in Japan than other advanced countries, Horiuchi (2010) pointed out Japanese diet characterized with low calorie and fat, cleanliness of Japanese society, genetic property with less ApoE4, and strong social cohesion of a homogeneous society.

Proximate determinants of fertility

Fertility decline and stagnation at far below replacement level draws more concern. As Lesthaeghe (2010) mentioned, only one element of the second demographic transition that cannot be found in Eastern Asia is the increase in extramarital births. The proportion of extramarital birth in Japan was 2.15% in 2010, with very little change from 1.07% in 1990 and 1.63% in 2000. Thus, a large part of fertility decline could be attributed to nuptiality decline. Although some Japanese demographers asserted that nuptiality decline explains whole part of fertility decline using AMFRs (Age-specific Marital Fertility Rates), the method is erroneous (Hirosima, 2001; Kaneko, 2004; Suzuki 2009). More sophisticated demographic analyses have shown that between 35% and 75% of fertility decline in Japan can be explained by nuptiality decline (Hirosima, 1999; 2000; Iwasawa, 2002; Ogawa, 2003; Kaneko, 2004; Suzuki, 2005).

Since marriage does not explain fertility decline in its entirety, there should be other proximate determinants (Bongaarts, 1978) that caused a significant fall in marital fertility. However, neither contraception nor induced abortion is responsible for it in Japan. According to the family planning survey by the Mainichi Newspapers (2005), the proportion of currently married women practicing contraception was 52% in 2004 and was lower than in the early 1990s. The abortion/birth ratio dropped from 37.4% in 1990 to 28.7% in 2000, then to 19.9% in 2010 (NIPSSR 2012a:68).

As expected, the frequency of miscarriages has also been declining. There were 26,560 still births in 2010 in Japan and the ratio to live births was 2.5%. It was significantly lower than the 4.4% in 1990 and 3.2% in 2000 (ibid:67). It is said that many mothers in Japan stop breastfeeding by 1.5 years after giving birth. Thus, neither intrauterine mortality nor postpartum amenorrhea seems to have contributed to the recent fertility decline.

The remaining proximate determinants are frequency of intercourse and sterility. There is no time series data on coital frequency or infecundity of married couples in Japan. It might be possible to assert that sexless couples are increasing due to the long working hours or strengthened mother-child ties. It might also be possible to hypothesize an increase in infecundity due to the rising age at marriage, environmental hormones, and sexually transmitted diseases (Semba, 2002). However, it is difficult to

quantitatively evaluate such hypotheses, due to the lack of necessary data.

Demands for children

An important question on the recent fertility decline is whether it is a result of voluntary choice. The Low Fertility Trap Hypothesis (Lutz et al., 2006) suggested a possibility of positive feedback between attitude and behavior. The mechanism has already started working in German speaking countries where the ideal number of children is extremely low. However, very low fertility in Japan is not the result of very low demand for children. The demand for children in Japan has been declining slowly but was still as high as 2.42 in 2010 (NIPSSR 2012c:28). Thus, the recent fertility decline in both countries should be explained not by demand itself but by obstacles to fulfilling the demand.

Direct cost of children

In the world of post-industrialization, globalization and rapid technological development, there is a growing demand for human capital investment. Thus, parents are more interested in quality for their children and educational costs have become higher (Becker, 1991; Willis, 1994). The rising cost of children, including public and private educational costs, is thought to be the main reason of the recent low fertility rate in Eastern Asia.

Table 2. Percentage of private expenditure on education (2009)

| Rank Country	%	Rank Country	%
1 Chile	41.1	16 Poland	13.3
2 Korea	40.0	17 Spain	12.9
3 Japan	31.9	18 Czech Republic	12.0
4 United Kingdom	31.1	19 Slovenia	11.5
5 United States	28.0	20 France	9.8
6 Australia	26.8	21 Italy	9.3
7 Canada	21.4	22 Iceland	9.2
8 Mexico	21.2	23 Austria	8.6
9 Israel	20.8	24 Portugal	6.5
10 New Zealand	17.4	25 Estonia	5.8
11 Netherlands	16.3	26 Ireland	5.8
12 Slovak Republic	16.1	27 Belgium	5.7
13 Russian Federation	15.2	28 Denmark	4.2
14 Germany	15.0	29 Sweden	2.6
15 Argentina	14.3	30 Finland	2.4

OECD, Education at a Glance 2012, Table B3.1 (p. 257)□

Table 2 shows the proportion of educational expenditure paid by private sources. Governmental support tend to be low in Latin America, Eastern Asia and English

speaking countries. The percentage of Japanese parents spend (31.9%) is only after Chile (41.1%) and Korea (40.0%) in OECD countries.

Economic recession and labor market condition

Young people who grow up in periods of rapid economic growth tend to have high aspirations for their future lives. When the economy slows down, however, labor market conditions for young workers become tight. Those who conceive difficulty in achieving their expected standard of living will hesitate when it comes to marriage and childbearing (Easterlin, 1978; Yamada, 1999; Lutz, et al., 2006).

Figure 6. States ofCollege Graduates
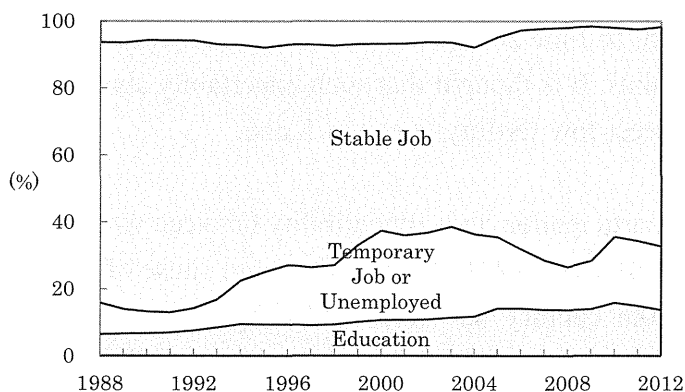
Ministry of Education, School Basic Surveys.

Figure 7. Expectation on Future Life
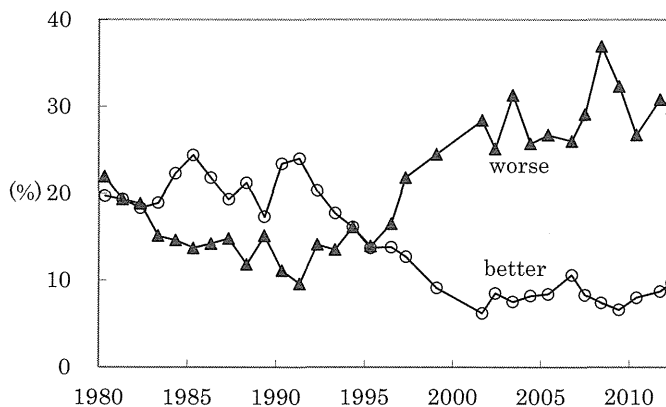
Cabinet Office, Opinion Survey on People's Lives.

In the case of Japan, the economy was bad throughout the 1990s. The unemployment rate rose sharply from 2% in 1990 to 5% in 2003. The tight labor market conditions seriously discouraged youth career achievements. Figure 6 shows the labor

force status of college graduates immediately after graduation. The proportion who had obtained a stable job decreased from 77.8% in 1988 to 55.0% in 2003, and then recovered to 71.5% in 2008. The proportion of those who had obtained a temporary job or who were unemployed increased from 9.4% to 27.1% between 1988 and 2003. Although the labor market condition for new graduates was temporarily improved in 2006~2008, was worsened again due to the global financial crisis in 2008.

The economic recession is thought to have affected people not only through employment status itself, but also through expected future income. Figure 7 shows the result of an opinion survey conducted by the Cabinet Office regarding expectations on one's future life. In the late 1980s and the early 1990s, there were more respondents who answered "(my life) will get better" than those who answered "will get worse." During the 1990s, however, the answer "worse" continuously increased and exceeded "better" around 1995. In June 2012, the pessimistic attitude surpassed the optimistic one by 20 percentage points. It is thought that such uncertainty about the future is one of the major sources of lowest-low fertility in recent Japan.

Female labor force participation and compatibility between work and family

According to Becker (1991:50-354), the main cause of family changes since the latter half of the 20th century has been the rising economic power of women. The expanding occupational opportunities for women increased the time spent on market activities and raised the opportunity cost of children. The declining return from the gender-based division of labor reduced the merit of marriage and promoted the rise in the divorce rate. These changes resulted in the increase in female-headed households, cohabitation, and extramarital births.

Figure 8. Female Labor Force Participation
Rates in Censuses of Japan
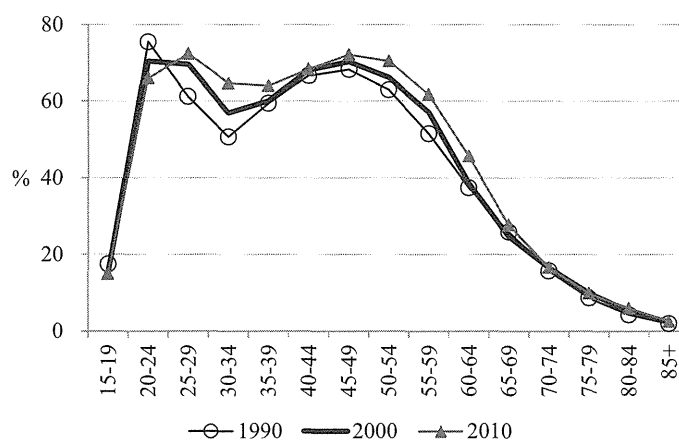
The Japanese way of management until the 1980s was characterized by the lifetime employment of male workers and the early retirement of female workers. Although the male breadwinner model was considerably eroded today, many women still quit jobs because of the incompatibility between work and childbearing. This situation is expressed in the so-called M-shaped curve of female labor force participation rates shown in Figure 8. Many analyses using micro data also shows that mother's work still has the negative effect on fertility (Asami et al., 2000; Oi, 2004; Oyama, 2004; Sasai, 1998; Shichijo and Nishimoto, 2003; Tsuya, 1999; Fukuda, 2004; Fujino 2002; Yashiro, 2000; Yamagami, 1999; Yamaguchi, 2005).

Pronatal Policy Interventions in Japan

Table 3 summarizes the development of pronatal policy measures in Japan. The Japanese government was surprised by the historically low TFR of 1.57 in 1989 and started an inter-ministry committee to create measures to cope with the declining fertility in 1990. The amount of the child allowance was raised in 1991, while the period of payment was shortened to keep to the budget. The Childcare Leave Law (formally "Law Concerning the Welfare of Workers Who Take Care of Children or Other Family Members Including Child Care and Family Care Leave") was established in May 1991 and enforced in April 1992.

Table 3. Pronatal Policy Interventions in Japan

Year	Policy Measures
1991	Government's Guideline "Toward Satisfactory Conditions for Healthy Childbearing"
	Amendments to Child Allowance Law
	Childcare Leave Law
1994	Angel Plan (1994~1999)
	Amendments to Childcare Leave Law
1997	Amendments to Child Welfare Law
1999	New Angel Plan (2000~2004)
2000	Amendments to Childcare Leave Law
	Amendments to Child Allowance Law
2002	Ministry of Health "Measures for Decreasing Children Plus One"
2003	Law for Measures to Support the Development of the Next Generation
	Law for Measures to Cope with Decreasing Children Society
	Amendment to Child Allowance Law
2004	Support Plan for Parents and Children (2005~2009)
2006	New Policy to Cope with Low Fertility
2007	Important Strategy to Support Children and the Family
2010	Visions for Children and Childrearing (2010~2014)
2012	Three New Laws for Childcare

In December 1994, the government publicized the Angel Plan for the period between 1994 and 1999. The program emphasized the compatibility between work and childcare and public support for childrearing. As a part of this program, amendments to the Childcare Leave Law were made to support income and exempt social security premium payment in 1994. In 1997, a major reformation was made to the Child Welfare Law to provide working mothers with satisfactory daycare services.

In December 1999, the government released the New Angel Plan for the period between 1999 and 2004. This document asserted the need to improve gender equity and working conditions.In May 2000, an amendment to the Childcare Leave Law determined that 40% of wages should be paid during the leave. The child allowance, which was previously available only for children less than three years old, was expanded to also cover preschoolers. The cabinet adopted the "Zero Waiting List for Daycare Program" as a political goal in July 2001. As a result, the daycare center enrollment rate of children under age two increased from 15.6% in 2001 to 20.3% in 2007. At least a part of the difference from Northern European countries, where the rate is higher than 40%, should be attributed to the cultural pattern that emphasizes the mother's supreme role of childrearing.

The Next Generation Law, enacted in July 2003, required local governments and large companies to submit their own programs to foster new generations. At the same time, the Law for Measures to Cope with Decreasing Children Society ordered the Cabinet Office to prepare new measures to prevent further rapid decline in fertility. An expansion of the child allowance, to cover children in the third grade of primary school, was enforced in April 2004.

In December 2004, the government declared the Support Plan for Parents and Children (New-New Angel Plan) for the period between 2004 and 2009. The document emphasized the role of local governments and companies in providing childcare supports and improving gender equity. In addition, the document pointed out the importance of economic independence of the youth. From fiscal year 2006, the child allowance was expanded again to cover children in the sixth grade of elementary school. In addition, the Support Plan for Mothers' Reentry to Labor Market was implemented. The plan includes such measures as starting a course at vocational schools for mothers reentering the work force, helping mothers who attempt to start businesses, and running "Mothers' Hello Works" for job-seeking mothers.

In June, 2006, the government announced the New Policy to Cope with Low Fertility. The monthly cash benefit of the child allowance was raised from 5,000 yen to 10,000 until the third birthday of a child. However, Japan's child allowance was

means-tested until 2010, and approximately 15% of children were eliminated in 2003 because of their parents' high income (Suzuki 2006:10). The cash benefit during childcare leave was raised from 40% to 50% of wages. According to the Basic Survey of Employment Management of Women in 2005, 72.3% of eligible female workers actually took the leave. The ratio of the number of leave-takers to annual births in 2005 was 11.1% (Suzuki 2007:21).

The Important Strategy to Support Children and the Family in 2007 focused on the issue of compatibility between work and the family and aimed at the materialization of the "work-life balance." The agreed Work-Life Balance Charter proposed to raise the employment rate and productivity while reducing the number of temporary workers, to shorten working hours while seeking better family life, and to improve flexibility and gender equity in workplaces.

These measures were mainly introduced by the coalition government of Liberal Democratic Party (LDP) and New Komei Party (NKP) that took the power between 1999 and 2009. In 2009, however, the Democratic Party of Japan (DPJ) won the election and formed the coalition with People's New Party and Social Democratic Party, although the latter withdrew in May, 2010.

Table 4. Child Allowance in Japan

Age	Birth Order	2007.4~2010.3	2010.4~2011.9	2011.10~2012.3	2012.4~
0~2	All	10,000 yen	13,000 yen	15,000 yen	15,000 yen
3~12	1st and 2nd	5,000 yen	13,000 yen	10,000 yen	10,000 yen
3~12	3rd +	10,000 yen	13,000 yen	15,000 yen	15,000 yen
13~15	All	0 yen	13,000 yen	10,000 yen	10,000 yen
	Means text	Yes	No	No	Yes

In January 2010, the government publicized a new action program called Visions for Children and Childrearing. It included election promises of the Democratic Party such as expansion of child allowance program. The party promised to raise the monthly benefit from 10,000 yen to 26,000 yen and to abandon the means test. It turned out that, however, such an increase is impossible due to the budget constraint. The new act passed in March 2010 decided that 13,000 yen will be paid without means test until a child graduates junior high school (Table 4). The failure to keep promise gave a serious damage to the Democratic Party. The government decided to give up the Democratic Party's formula and to return to the former formula with means test from the fiscal year of 2012. During the president election in Korea, Park Geun-hye criticized Moon Jae-in's plan to introduce child allowance program referring to this failure in Japan (News1, 2012-12-16).

Table 5. Public Expenditure of Childcare Services (2008)

Country	% of GDP	Country	% of GDP
Denmark	0.85	Iceland	0.18
Finland	0.70	Italy	0.15
Norway	0.67	Czech Republic	0.12
Sweden	0.64	Canada	0.12
United Kingdom	0.44	Hungary	0.10
France	0.37	New Zealand	0.09
Luxembourg	0.36	Israel	0.09
Netherlands	0.34	Mexico	0.09
Belgium	0.24	Slovak Republic	0.08
Korea	0.24	United States	0.07
Japan	0.24	Germany	0.06
Australia	0.19		

OECD, Economic Policy Reforms 2012.

In August 2012, the Act for Total Reform of Tax and Social Security passed at the Upper House. According to the act, the consumption tax rate will be raised from current 5% to 8% in April 2014 and to 10% in October 2015. Three parties (DPJ, LDP and NKP) agreed to spend 2.7 trillion yen from increased revenue into family and social security areas. While 2 trillion yen will be spent for the elderly people, remaining 0.7 trillion yen will be spent for children. Since the governmental spending for children in 2012 is estimated to be 4.8 trillion yen (NIPSSR 2013:127), 0.7 trillion yen implies an increase by 14.6%.

According to Table 5, Japan spent only 0.24% of GDP on childcare services in 2008. Even if the figure were increased by 14.6%, the new figure of 0.28% would not considerably change the rank of Japan.

Conclusion

The effectiveness of pronatal policy has not been confirmed among policy makers. Korean president Park Geun-hye asserted that child allowance has no effect on a TV debate against Moon Jae-in on December 16th, 2012. Monetary incentive is less effective than anti-natal policy because pronatal policy is taken in richer countries. It is more difficult to induce childbearing in advanced countries than to induce sterilization in developing countries with monetary benefit.

Relatively high fertility in the United States without governmental effort to raise fertility is another source of skepticism. However, it is said that fertility is sustained by low quality childcare service provided by illegal immigrants. Parents in other countries including Japan cannot give up high quality services guaranteed by the government

(McDonald, 2002). Since Japan cannot switch to the U.S. style, there is no choice other than to improve quantity and quality of public support to raise fertility as in welfare states in Northern/Western Europe. It is important that expected parents can believe that sufficient support is given if they have a child. In this sense, the failure of DPJ in child allowance program was harmful for trust on governmental family policies.

Another remedy to reduce the impact of population decline and aging is accepting immigrants. In 2008, a group of LDP members proposed to accept 10 million immigrants in coming 50 years. However, there was no significant development in the DPJ government. Japan has accepted 1,562 candidates for nurse and care workers from Indonesia, Vietnam and Philippines between 2008 and 2012. Candidates for nurse need to pass the national qualification within three years and candidates for care workers within four years. Sakanaka (2011) criticized this program as superficial acceptance and practical exclusion. It is ambiguous if the interest of business side to accept foreign workers can resolve the anxiety of labor side.

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일본의 저출산율과 정책적 대응

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일본의 합계출산율은 20년 정도 치환수준부근에 있었다가 1970년대중반부터 저하를 시작했다. 그 후 40년 가까이에 걸쳐 치환수준을 크게 밑도는 합계출산율이 계속되고 있다. 최신의 장래인구추계는 합계출산율이 현재의 낮은 수준에 머무른다고 가정하고 있어 심각한 인구감소와 고령화가 예상된다. 노동력참가율의 상승에 의해 소비자/생산자 비율의 상승은 회피할 수 있지만 급속한 인구고령화가 일본경제에 주는 타격은 클 것이다. 인구고령화의 원인으로서는 출산율 저하의 영향이 더 크지만 출생율이 낮을 경우는 사망율의 영향도 무시할 수 없다.

출산율저하의 원인으로서는 결혼율 저하의 영향이 크지만 결혼출생율의 저하도 영향을 주고 있다. 일본의 출생율저하는 아이에 대한 수요가 저하했기 때문이 아니고 수요 실현을 막는 장해가 크기 때문이다. 그런 장해에는 아이의 직접 비용 상승, 젊은이 노동시장의 악화, 일과 가정의 양립가능성이 낮은 것등이 있다.

일본은 1990년대 초두에 출생 촉진책에 전환했다. 채용된 수단은 아동수당, 육아 휴업, 워크-라이프-밸런스 캠페인, 육아 서비스 개선등이다. 2009년의 정권교대시에 민주당은 아동수당 확충이라는 선거공약을 지킬 수 없고 정책에 대한 국민의 신뢰를 훼손했다.

A multistate lifetable analysis for the effects of the 1st marriage and marital reproduction on fertility in Singapore

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This study examines the patterns and demographic factors underlying the fertility changes by major ethnic group in Singapore for 1980-2010, with focusing on the differential role of the 1st marriage by ethnic group. In order to derive the 1st marriage effects on annual changes in a period fertility measure during 1980-2010 in Singapore, we need to overcome the fact that the necessary data are not available in most of years during the period. We develop a numerical model to construct multistate lifetables each year for 1980-2010. Results show ethnic differentials and similarities in the 1st marriage and marital fertility effects.

Singapore has drawn demographers' attentions for intensive population control policies and their effects on fertility (Saw 2005; Wong and Yeoh 2003; Yap 2009; Straughan et al. 2009). Around ten years after the fertility rates attained the replacement level in 1975, Singapore government started relaxing and abolishing anti-natalist policies, and then introducing restrictive pro-natalist policies. To these policy interventions, TFRs responded differently by the ethnic group.

Figure 1 shows period TFR by ethnic group in Singapore for 1975-2010. On the one hand, Malays' TFR turned to increase at 1979, when anti-natal policies continued, and stayed above the replacement level throughout the 1990s, but is rapidly declining after 2000. On the other hand, Chinese's TFR stopped to decline in 1983 when pro-natal policies selectively targeting highly educated females were introduced. It increased from 1986 to 1988, but declined steadily since the 1990s. It also has fluctuations for tiger years(1986, 1998, 2010) and dragon years(1988, 2000). In short, TFRs recovered about the replacement reproduction in the late 1980s. However, fertility rates resumed to decline from the early 1990s. As a reaction to the prolonged fertility declines, the government strengthened and enhanced the pro-natalist policies under three rounds of "Marriage and Parenthood Package" since the 2000.

One of the most frequently mentioned policy interventions in Singapore is a promotion of marriage and its distinct effects by education attainment levels. Ethnic differentials of fertility are also argued from this perspective as an extent that Chinese females are relatively better educated. Nevertheless, there are few studies directly analyzing either an effect of nuptiality on fertility changes or its ethnic differentials in Singapore, partly because of limited data availability.

With utilizing only statistical tables publicized by Singapore government, this paper estimates multistate lifetables regarding the 1st marriage and parity specific childbirths by ethnic group each year for 1980-2010. Then, we derive the 1st marriage effect on annual fertility changes by a decomposition method for a difference in a period measures. In Singapore, population at risk for the multistate lifetable (i.e. female population by marriage and birth state) is available only in the decennial census years. Still, we are able to construct multistate lifetables each single year, if the size of the total population and the number of demographic events during the period are known; the situation that we often encounter in many other countries. The reason is that the number of demographic events has strong correlation to hazard rates and information from vital statistics scaled by total population is enough to recover the transition probability matrix. Furthermore, more information gives better estimates; we are able to improve the lifetable estimates, if we observe the populations at risk in more than two times and the number of demographic events during interim years. Finally, the decomposition results reveal ethnic differentials and similarities: for overall changes of fertility changes from 1980 to 2010, nuptiality accounted completely for Malay's fertility changes, while both nuptiality and marital fertility affected Chinese fertility; negative nuptiality effects have increasingly impacts both on Malay's and Chinese fertilities in recent years.

Data and Methodology

Multistate lifetable analysis of fertility with limited data

In general, a multistate lifetable requires, for construction, transition probabilities for all state transitions, each of which is calculated by (1) the number of demographic events by states (i.e. the number of demographic events that risk population experiences) for numerator and (2) population by states (i.e. population at risk) for denominator. The latter is obtained by the state distribution multiplied by total population of all states. For the case of Singapore, the number of marriages and live births by the order (numerators for the state transition probabilities) can be obtained

from vital statistics each year [i]. The state distributions (distributions of the nevermarried and parity specific evermarried females) by ethnic group are computable from the results of population census[ii] only in the decennial census years after 1980 but not available in other interim periods. Thus, we need to estimate states distributions for interim periods to construct multistate lifetables for each year 1980-2010. Once, with the intervening state distributions between census years at hand, we are able to calculate the state transition probabilities with the number of marriages and childbirths divided by the state distributions scaled to mid-year population estimates, then the multistate lifetable is constructed via a standard procedure (e.g. Pollani 2001).

Figure 2 shows overview of the multistate lifetable construction that employs an estimation for the state distribution between census years. First, notice that state transition rates in a particular year t correspond with probabilities for age x~x+4 population moving from state i to other states j until age x+1~x+5 for the year t. For instance, the 1st marriage hazard of age x~x+4 in year t may be treated as a probability of female population being evermarried by age x+1~x+5 conditional on the cohort being nevermarried at age x~x+4 in year t. We take advantage of this nature of state transition rates to estimate the state distribution of age x~x+4 in year t+1 with the state distribution of age x~x+4 in year t multiplied by the transition probability for the age and a transformation of age x+1~x+5 to x~x+4 of newly calculated state distribution for year t+1. Furthermore, with a state distribution from year-t census taken as an initial value and forward recursive estimations of state distributions, we have an estimate for the next census in year T, when another state distribution is observed. We improve state distribution estimates from year t+1 to T-1 with an additive adjustment term by age and state, which is identified by means of minimizing mean squared errors of the state distribution estimate for year T from the census distribution. Figure 3 depicts the detail of the adjustment strategy for the 1st marriage of a birth cohort whose age was 20-24 in year t as an example. See appendix 1 for the mathematical details of solving the adjustment problem.

The adjustment for the state distribution estimates between census years has four advantages. First, the state distributions obtained from the *Singapore Census of Population* could be erroneous, because the results for the state distribution calculations are obtained based on 10-20% sample surveys. We need to smooth the connections between the state transition rates before and after census years, and the smooth connections are automatically accomplished by the adjustment. Second, in estimation of the state distribution in year t+1 from the distribution in year t, we need to apply the half of the hazard rates for year t and the half of year t+1(from midyear of t

to midyear of t+1) but not the hazard rates for year t as in the present procedure. Third, data are available only by the five-year age category. When estimating state distributions for age x~x+4 in year t+1, we need to retrieve state distributions for age x~x+4 from those of age x+1~x+5 by an age transformation. Here we assume uniformities of the rates among age x~x+4 and age x+1~x+5 and obtain rates for age x~x+4 by 1/5 of junior cohorts plus 4/5 of senior cohorts. This uniformity assumption gives only rough estimates. Finally, these discrepancies are cumulated forward.

Decomposition method

As a measure of completed period fertilities which summaries the multistate lifetables, we calculate the total period average parity (TPAP), which is a weighted sum of a lifetable function, $l_x(parity)$ for parity 1 and over, at the end of the reproduction age with their parities as the weight. It is evident from the construction of the multistate lifetables that TPAP is a function of hazard rates for the 1st marriage and order-specific births given by married women. To achieve a decomposition of the components, this study extends an analysis in Suga(2012) by employing a generalized Kitagawa's decomposition method to a difference of the function (Das Gupta 1993). It can be shown that a difference of TPAP in year T from a year of reference (t=0) is decomposed into two components as in Eq. [1], from which Eq.[2] follows.

$$TPAP_t - TPAP_{t-1} = A_t + B_t \qquad \text{Eq.[1]}$$

$$\frac{1}{T}(TPAP_T - TPAP_0) = \frac{1}{T}(TPAP_T^\alpha - TPAP_0) + \frac{1}{T}(TPAP_T^\beta - TPAP_0). \qquad \text{Eq.[2]}$$

Where $\quad TPAP_T = TPAP_0 + \sum_{\tau=1}^{T} A_\tau + \sum_{\tau=1}^{T} B_\tau \qquad$ Eq.[3]

$$TPAP_T^\alpha = TPAP_0 + \sum_{\tau=1}^{T} A_\tau \qquad \text{Eq.[4]}$$

$$TPAP_T^\beta = TPAP_0 + \sum_{\tau=1}^{T} B_\tau \qquad \text{Eq.[5]}.$$

In Eq. [1], A_t measures an effect of a change in the 1st marriage hazard on the difference of TPAP, and B_t quantifies a contribution of a change in marital childbirth hazards, and TPAP calculated by the multistate lifetable for year T is decomposed into the sum of TPAP in the year of reference ($TPAP_0$), total first marriage effects over the period from year 0~1 to year T-1~T ($\sum_{\tau=1}^{T} A_\tau$) and total effects of childbirth hazards over