Online Appendix for
Fiscal sustainability in Japan: what to tackle?

Selahattin İmrohoroğlu*, Sagiri Kitao†, and Tomoaki Yamada‡

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1 More on Japanese demographics

In this section, we will describe in detail the characteristics of the demographic transition that Japan is projected to experience over the coming decades. The projections of mortality risk, fertility rates and population are based on the 2017 estimates of the National Institute of Population and Social Security Research (IPSS).

Figure 1 shows the age-distribution of population in 2017. The peak of the population is in late 60s, the first baby-boomers reaching the retirement age. The second baby boomers, currently in mid-40s, will follow the wave or retirement in about two decades. The population below mid 40s falls almost monotonically, as a result of a continuous decline in fertility rates since 1970s.

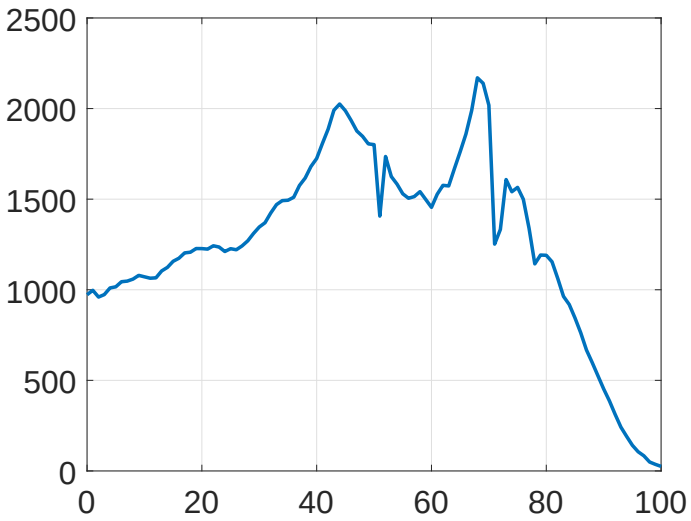


Figure 1: Population by age in 2017

*University of Southern California, Marshall School of Business, selo@marshall.usc.edu.
†University of Tokyo, sagiri.kitao@gmail.com.
‡Meiji University, tyamada@meiji.ac.jp.

Figure 2 shows the historical and projected total fertility rates. The total fertility rate now lies below 1.5 and is projected to remain at a low level until 2065, the last year of the official projections. The IPSS reports high and low scenarios, as indicated in Figure 2. Even a high scenario predicts fertility rates well below the replacement level, around 2, that is needed to keep the population from falling.

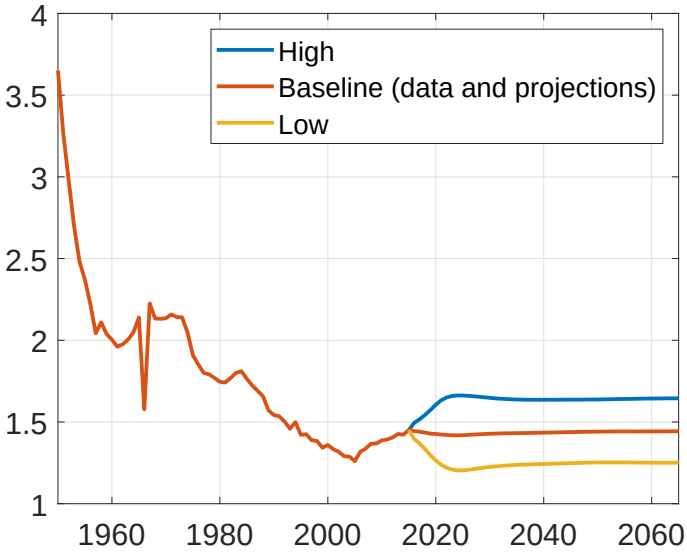


Figure 2: Total fertility rate: data and projections

The IPSS also reports long-run projections of the population beyond 2065, assuming that mortality risks and fertility rates remain constant thereafter. Figure 3 shows the population projections up to 2100 under the three scenarios of fertility rates. Under the baseline scenario, the population will be less than half of the level in 2015, reaching 60 million, by the end of the century. Depending on realized fertility rates, the total population could be higher or lower by about 10 million.

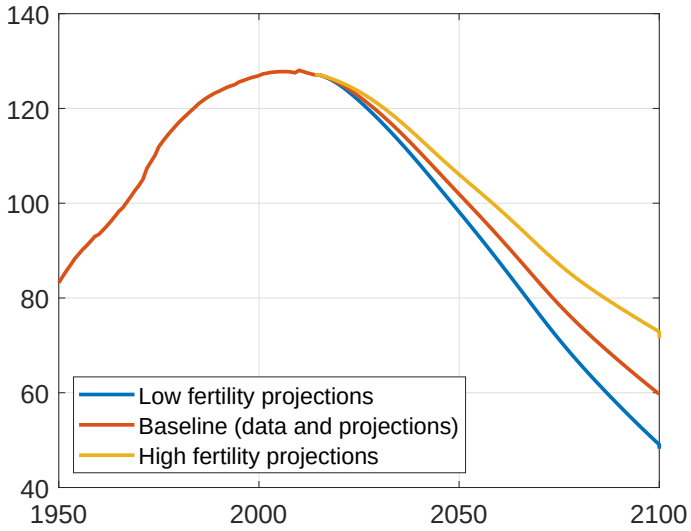


Figure 3: Total population projection (in millions): baseline and alternative fertility projections

While the number of newborns declines, people are living longer, offsetting the decline in population though not strongly enough to dominate the overall direction. Figure 4 shows the life-expectancy in the data and projections. Life-expectancy rose sharply in the last several decades, from about 60 for males and 63 for females in 1950 to 81 and 87 in 2015, respectively. It is expected to reach 85 for males and 91 for females by 2065 according to the IPSS projections.

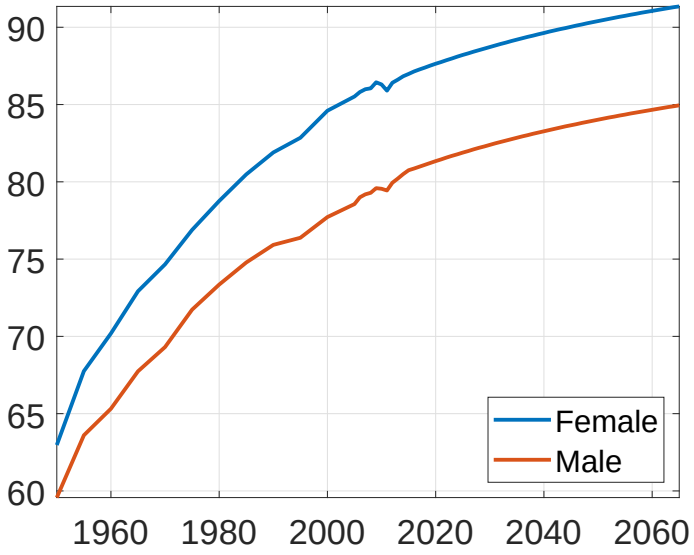
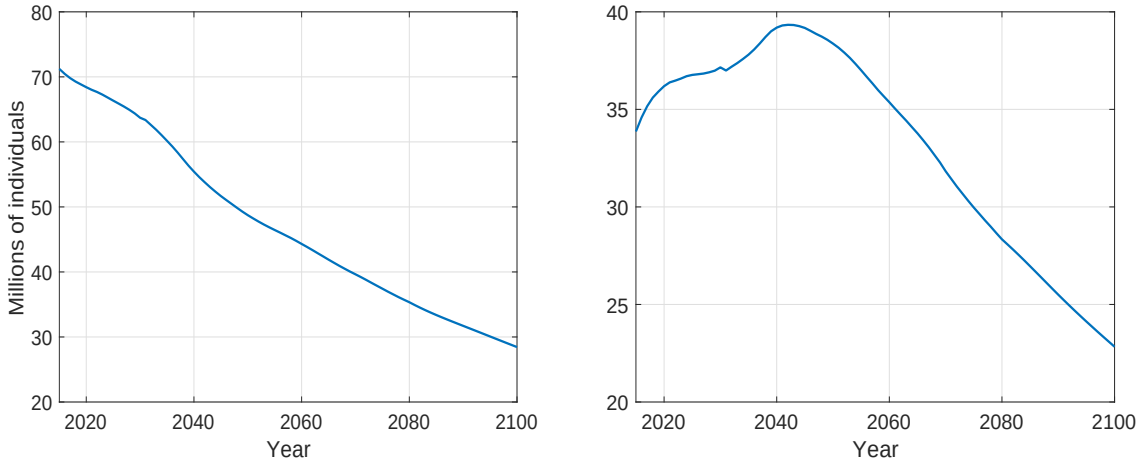


Figure 4: Life expectancy: data and projections

Chronically low fertility rates and a rise in longevity that Japan has experienced and

will continue to see imply a rapid rise in the size of the elderly relative to the working age individuals. As shown in Figure 5, the number of individuals at ages 20 to 64 will fall from 70 million in 2015 to less than 30 million by the end of the century. At the same time, the number of the elderly at and above 65 will rise until mid-2040s and generate a sharp increase in the old-age dependency ratio, as shown in Figure 6. The ratio is already high at 48% in 2015 and will rise to 80% by early 2050s and stay at around 80% during the second half of the century.



(a) Young (age 20-64)

(b) Old (age 65 and up)

Figure 5: Population by age group

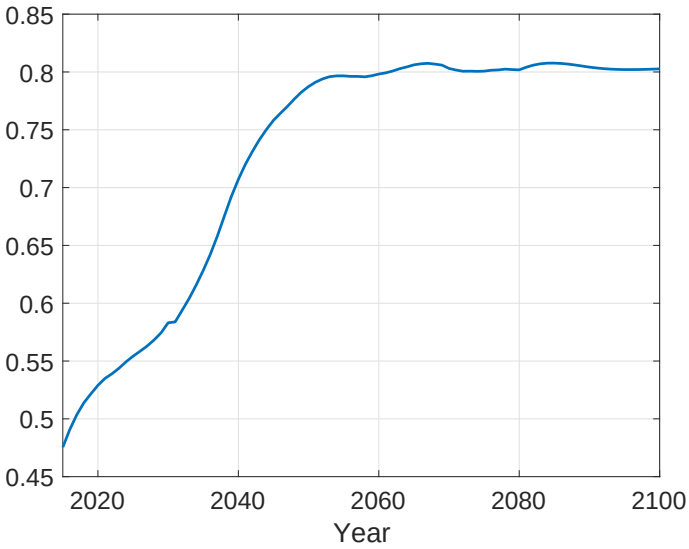
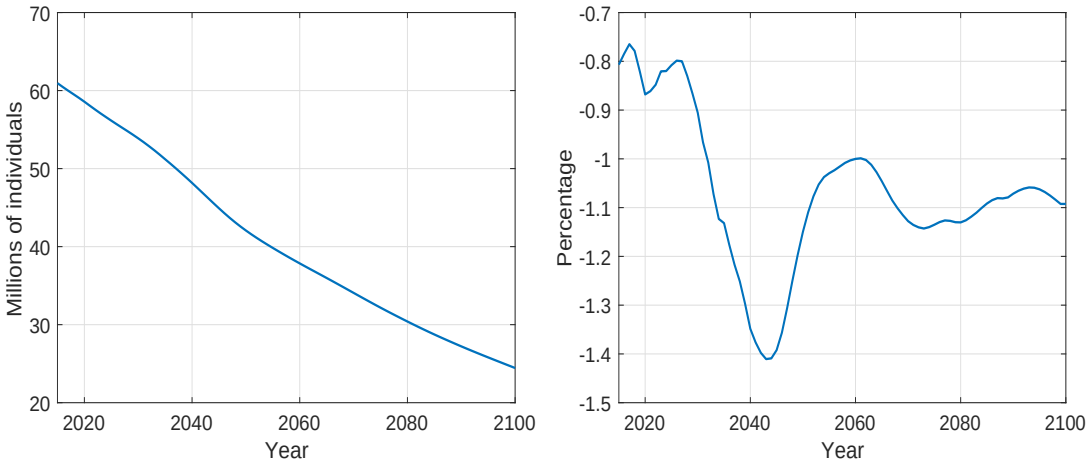


Figure 6: Dependency ratio (age 65 and up / age 20-64)

A high old-age dependency ratio implies a heavy fiscal burden to finance government

transfer programs that are operated as a pay-as-you-go system. As shown in Figure 7, working population will decline even faster than working age population as the distribution of the working-age population will become more concentrated among those closer to the retirement age because of the aging of baby boomers and the low fertility rates below the replacement rate. The growth rate of working age population remains negative throughout the century, lying below -1% for most years as shown in Figure 7(b).



(a) Working population (b) Growth rate

Figure 7: Working population and growth

2 More on numerical results

This section presents figures and tables in the baseline transition and sensitivity analysis, which are not included in İmrohoroğlu et al. (2019).

2.1 Benchmark economy and transition

Aggregate GDP and Living Standards Figure 8 displays the time path of GDP of our baseline simulations, starting from 2015. Figure 9 shows path of per capita GDP, as well as the path adjusted for growth, where effects of the balanced growth rate of 1.5% is removed.

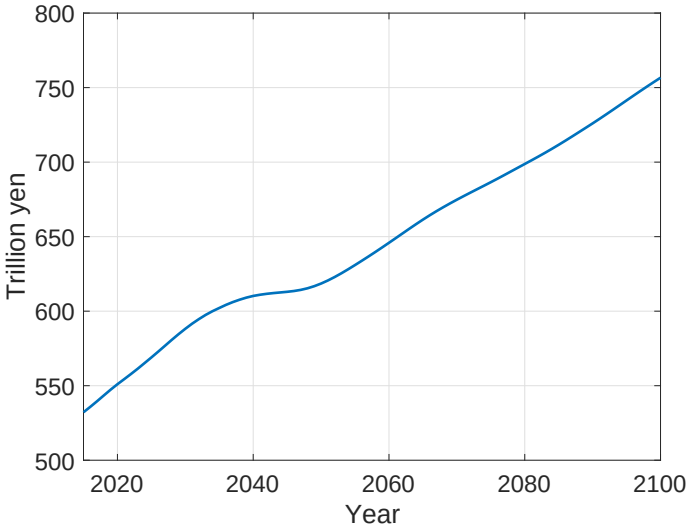
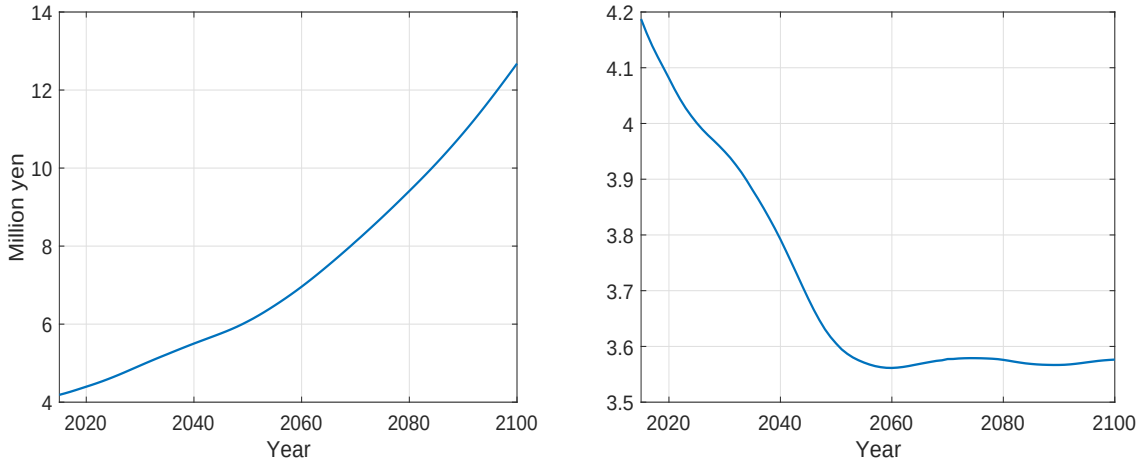


Figure 8: Aggregate output (GDP)(in 2015 yen)



(a) GDP per capita

(b) GDP per capita adjusted for growth

Figure 9: Output (GDP) per capita (in 2015 yen)

Total Government Receipts, Outlays, Budget Deficit, and Debt Figure 10 shows the ratio of total government deficit to GDP, which implies an increasing debt to GDP ratio to finance these deficits.

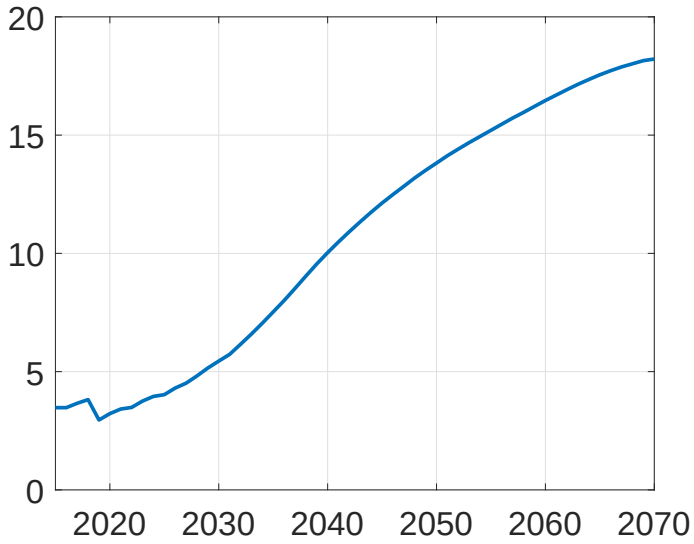


Figure 10: Total government budget deficit (% of GDP)

Table 1 shows the contributions of different components for total deficits and accumulation of debt and provides decennial snap shots starting from 2020.

Table 1: Sources of Net Borrowing

Year	d_1	d_2	d_3	d_4	d_5	deficit	debt
2020	−0.0391	0.0250	0.0260	0.0110	0.0094	0.0322	1.3100
2030	−0.0380	0.0261	0.0353	0.0188	0.0123	0.0545	1.6204
2040	−0.0349	0.0459	0.0437	0.0262	0.0194	0.1003	2.2872
2050	−0.0341	0.0561	0.0525	0.0310	0.0327	0.1382	3.4331
2060	−0.0336	0.0536	0.0579	0.0391	0.0476	0.1646	4.7571
2070	−0.0331	0.0518	0.0576	0.0434	0.0625	0.1822	6.2539

basic primary deficit: $d_1 = (G_t + TR_t - T_t - TC_t)/Y_t$
pension deficit: $d_2 = (P_t - PR_{p,t})/Y_t$
heath insurance deficit: $d_3 = (M_t^g - PR_{m,t})/Y_t$
long-term care deficit: $d_4 = (LC_t^g - PR_{lc,t})/Y_t$
net interest payment: $d_5 = (r_{b,t}B_t - r_{f,t}F_t)/Y_t$
deficit: $D_t/Y_t = d_1 + d_2 + d_3 + d_4 + d_5$
debt: $(B_t - F_t)/Y_t$

Public Pension Fund Figure 11 displays the path of the public pension fund and its ratio to GDP under our baseline simulations. The public pension fund would be depleted in 2057 without any reform.

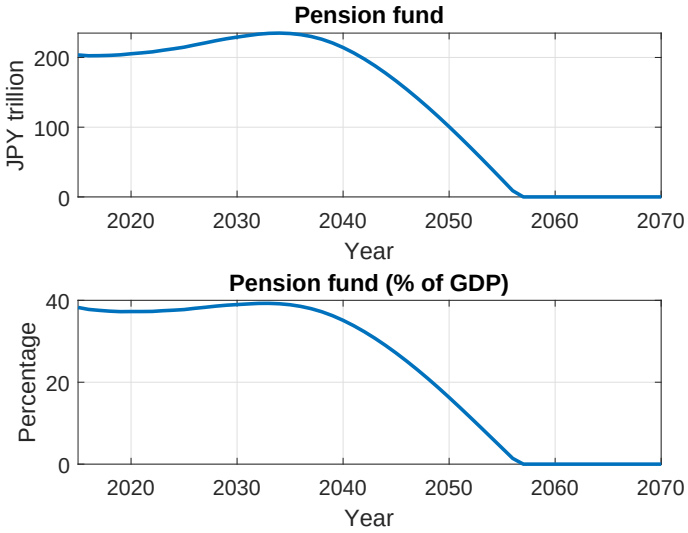
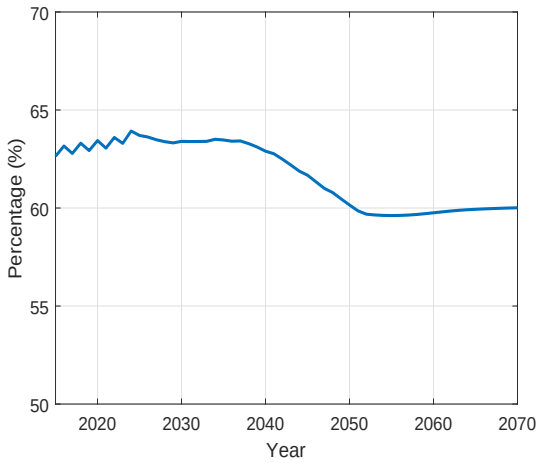
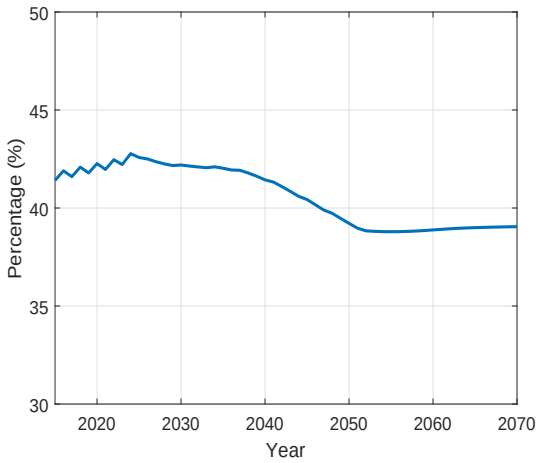


Figure 11: Pension fund (% of GDP)

Public Pension Replacement Rates Figure 12 shows the projected pension replacement rates using two definitions. The first frame shows the replacement rate according to the Japanese official definition. It is the total pension benefit for what the government calls a 'typical' household at the age of 65 that consists of a husband who is category 2 insured and a housewife who receives the basic pension only, expressed as a ratio to the cross-sectional average disposable earnings of category 2 insured male workers. This replacement rate falls from about 63% to about 60%. Using a different definition, where the replacement rate is taken as the ratio of category 2 insured male to the cross sectional average earnings of category 2 male, we again see a reduction from about 42% to about 39%. According to our model's projections, while the dependency ratio rises rapidly, there is little change in the replacement rates regardless of which definition one uses. This suggests that pension reform would greatly help achieve fiscal sustainability.



(a) Japanese official definition



(b) Standard definition: category-2 male

Figure 12: Pension replacement rate

2.2 Sensitivity Analysis

Alternative Wage Growth Rates Table 2 shows paths of government deficit and debt with alternative wage growth rates, which are set to 0.5%, 1.0%, 1.5% (baseline), 2.0% and 2.5%.

Table 2: Alternative Wage Growth Rates: Deficits and Debt to Output

	0.5%		1.0%		Baseline: 1.5%		2.0%		2.5%	
Year	deficit	debt	deficit	debt	deficit	debt	deficit	debt	deficit	debt
2020	0.038	1.335	0.034	1.322	0.032	1.310	0.030	1.297	0.029	1.284
2030	0.068	1.878	0.061	1.745	0.055	1.620	0.048	1.503	0.042	1.391
2040	0.124	2.950	0.112	2.600	0.100	2.287	0.090	2.009	0.080	1.761
2050	0.174	4.755	0.155	4.041	0.138	3.433	0.124	2.916	0.111	2.477
2060	0.209	6.981	0.185	5.759	0.165	4.757	0.147	3.935	0.131	3.263
2070	0.238	9.680	0.207	7.765	0.182	6.254	0.161	5.060	0.144	4.112

Increases in the Relative Price of Health and Long-term Care Services Table 3 shows results of experiments in which costs of medical and long-term care services rise by either 10% or 20% over a 10 or 20-year period.

Table 3: Medical and Long-term Care Inflation: Deficits and Debt to Output

	Baseline		Med: 10% in 10		Med: 20% in 20		LTC: 10% in 10		LTC: 20% in 20	
Year	deficit	debt	deficit	debt	deficit	debt	deficit	debt	deficit	debt
2020	0.032	1.310	0.036	1.316	0.036	1.316	0.033	1.311	0.033	1.311
2030	0.055	1.620	0.062	1.687	0.067	1.697	0.057	1.641	0.059	1.644
2040	0.100	2.287	0.110	2.435	0.119	2.522	0.104	2.340	0.108	2.372
2050	0.138	3.433	0.150	3.682	0.161	3.871	0.143	3.529	0.148	3.603
2060	0.165	4.757	0.178	5.116	0.191	5.417	0.171	4.902	0.177	5.025
2070	0.182	6.254	0.196	6.731	0.211	7.155	0.189	6.458	0.197	6.642

Alternative Demographic Assumptions Table 4 shows results where we assume low and high scenarios about fertility and mortality rates by the IPSS. For these four alternative demographic projections, the depletion years for the public pension fund are 2056, 2058, 2053, and, 2062, respectively.

Table 4: Alternative Demographic Assumptions: Deficits and Debt to Output

	Baseline		Low Fertility		High Fertility		Low Mortality		High Mortality	
Year	deficit	debt	deficit	debt	deficit	debt	deficit	debt	deficit	debt
2020	0.032	1.310	0.032	1.309	0.033	1.311	0.034	1.313	0.030	1.307
2030	0.055	1.620	0.053	1.611	0.056	1.631	0.060	1.659	0.048	1.581
2040	0.100	2.287	0.098	2.264	0.103	2.313	0.110	2.399	0.091	2.175
2050	0.138	3.433	0.142	3.477	0.135	3.386	0.152	3.657	0.125	3.209
2060	0.165	4.757	0.177	4.990	0.153	4.532	0.181	5.114	0.148	4.397
2070	0.182	6.254	0.209	6.875	0.158	5.692	0.203	6.775	0.162	5.732

Comparison with 2012 Demographic Projections The IPSS releases demographic projections every five years. We make comparison of the projections and changes in implied fiscal outcomes under the new projections. There has been improvement in fertility rates over the last several years and new projections reflected upward shifts in the fertility projections, as shown in Figure 13. Although the change is relatively small at about 0.1, the improvement makes long-run projections of the population and old-age dependency ratio brighter. Figure 14(a) shows that the population would be higher by about 10 million by 2100 and the dependency ratio is lower by 4 to 5 percentage points. In the medium term, however, over the next few decades, the projection does not show a major difference.

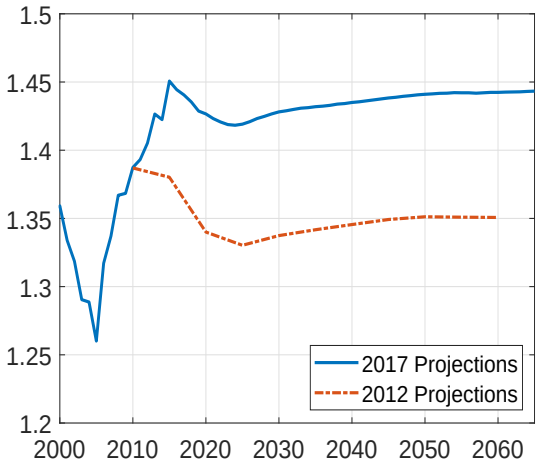
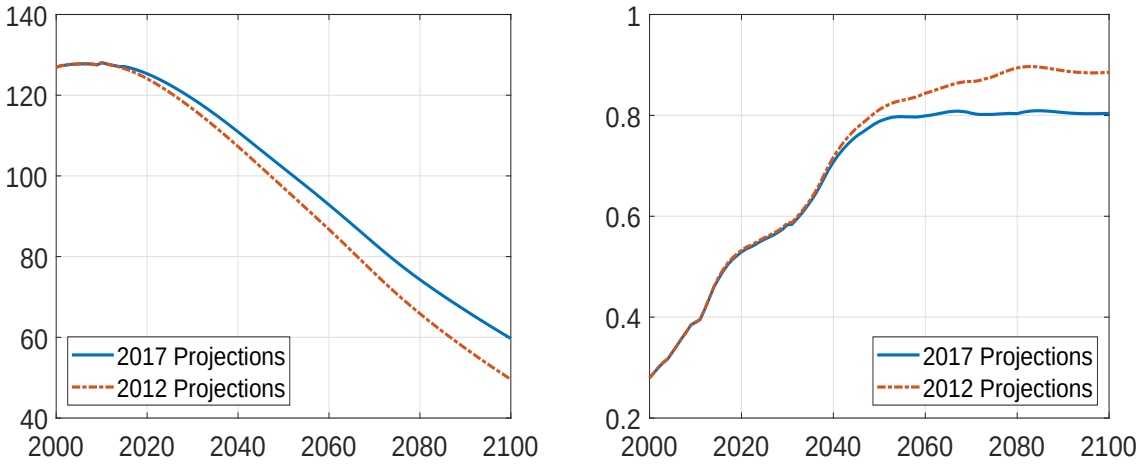


Figure 13: Total fertility rates: 2012 vs 2017 projections



(a) Population (millions)

(b) Old-age dependency ratio (age 65 and up/20-64)

Figure 14: 2012 vs 2017 demographic projections

Table 5 compares the fiscal situations under the two demographic projections. The difference between the two demographic projections appears to be small as far as the deficit to GDP ratios are concerned. However, the 2017 projections seem to have slightly improved the fiscal outlook. For example, the debt to GDP in 2060 is about 30 percentage points lower than that implied by the 2012 demographic projections. The year in which the public pension fund depletes under the older, 2012 projections, is 2056, one year earlier than implied by the newer 2017 demographic estimates.

Table 5: 2012 IPSS Projections: Deficits and Debt to Output

	Baseline			
	2017 projections		2012 projections	
Year	deficit	debt	deficit	debt
2020	0.032	1.310	0.033	1.317
2030	0.055	1.620	0.054	1.637
2040	0.100	2.287	0.101	2.323
2050	0.138	3.433	0.144	3.554
2060	0.165	4.757	0.178	5.066
2070	0.182	6.254	0.205	6.909

2.3 Policy Experiments

Extension of Full Retirement Age Table 6 shows pension deficits to output, $(P_t - PR_{p,t})/Y_t$ under the three experiments of raising the FRA from 65 to 67, 69 and 71 years old, respectively.

Table 6: Extending FRA: Pension Deficits to Output

Year	Baseline	FRA 67	FRA 69	FRA 71
2020	0.025	0.024	0.024	0.024
2030	0.026	0.024	0.016	0.016
2040	0.046	0.034	0.023	0.015
2050	0.056	0.047	0.038	0.028
2060	0.054	0.045	0.037	0.029
2070	0.052	0.043	0.034	0.025

References

İmrohoroğlu, S., S. Kitao, and T. Yamada (2019). Fiscal sustainability in Japan: what to tackle? Working paper.