高齢化社会に於ける女性労働の経済分析と産業関連を考慮した数値解析的動学一般均衡分析

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The Impact of Population Aging in a Multi-Sector Dynamic Computable General Equilibrium Model*

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Abstract

This paper tries to expand a static computable general equilibrium (CGE) model in a dynamic context, and it explores the dynamic impact of population aging on the Japanese economy with multi-production sectors and overlapping generations. In particular, aging-related sectors such as the pharmaceutical industry, the medical services, the social insurance and welfare, the long-term care insurance sectors, and the public hygiene sector are considered within the combined model of independently developed static and dynamic CGE models. While the impact of population aging on the pharmaceutical industry is not large, the impact on the medical services sector, the social and welfare sector, the long-term care insurance sector, and the public hygiene sector is very large, and demand for these 4 sectors is estimated to increase by 184.08%, 184.13%, 184.01%, and 183.69%, respectively. Note that their peak will come in the same year of 2031, and the corresponding highest demand levels at their peak are 45,198,365.566 billion yen, 7,925,178.340 billion yen, 10,436,330.088 billion yen, and 564,449.738 billion yen, respectively. Such an increase in demand for their products induces a more labor input in these sectors, and labor force in the long-term care insurance sector is particularly expected to smoothly increase from 334 million workers in year 2018 to 371.16 million workers in year 2034 to fulfil the increasing demand for long-term care insurance services.

Keywords: Aging, Japan, Labor, Medical Services, Pharmaceutical Sector, Long-Term Care Insurance, Social Accounting Matrix (SAM), CGE model
JEL Classification: C68, H51, E62, H55, and J16

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1. Introduction

This paper tries to expand a static computable general equilibrium model in a dynamic context, and it explores the dynamic impact of the future demographic change on the Japanese economy with multi-production sectors and overlapping generations[1].

It has been argued that smooth labor mobility among different production sectors would be one of the most important keys to cope with population aging in Japan. An increase in demand by the elderly for products associated with rapid population aging is forecasted in a graying Japan, and sustainable economic growth of Japan would not be achieved without a smooth inflow of labor into such production sectors. In particular, a more shift of labor supply to production sectors such as the medical services, the pharmaceutical industry, the social and welfare sector, and the long-term care insurance services is expected to harmonize with high demand for products of such industries for sustainable future growth. This paper investigates the impact of population aging on labor supply and thus on different production sectors over time.

Since Ballard et al (1985) examined the impact of tax reforms on several different production sectors within a static computable general equilibrium (static CGE) model, the static CGE model has been applied in several different research fields.[2] Auerbach and Kotlikoff (1982 and 1987) numerically investigated the dynamic impact of tax reforms with multi-overlapping generations in a dynamic general equilibrium model, which has now been recognized as a dynamic computable general equilibrium (dynamic CGE) model. Since the research concern of the static CGE model was with the impact of policy changes on several different production sectors, it cannot analyze the impact of changes in the population structure dynamically. On the other hand, a dynamic CGE model was developed to study the dynamic impact of policy reforms over time, and the model has been simplified in a static sense. Utility is defined over consumption of a single good in different periods over time. Thus, the conventional Auerbach and Kotlikoff model cannot investigate the impact on different production sectors in each period. In reality, each household makes a simultaneous decision over consumption of different goods in each period as well as savings over time. The former decision can be examined in a static CGE model, and the latter decision can be analyzed in a dynamic CGE model. In order to explore the effect of population aging on different

1　See Kato (2021) for the detailed model.

2　The GTAP model is considered as one of applied models to the international economy. Naqvi and (1995), Peter et al (1996), and Adams et al (2000) are also applied models of the static CGE model. Hamamoto and Nakatani (2007) studied the impact of government expenditures with the Japanese IO table in the context of population aging of Japan.

production sectors over time, this paper tries to integrate two independently developed computable general equilibrium models in order to overcome disadvantages of each model[3].

Preference over goods depends on age, and the future change in the demographic structure induces the different impact on demand for goods. This implies that each production sector will be affected differently according to population aging. This paper explores the different impact of population aging on each production sector over time. Population aging seems to have relatively stronger impacts on aging-related production sectors. This paper particularly focuses on the dynamic impact of population aging on aging-related 5 production sectors; the pharmaceutical industry, the medical services, the public hygiene, the social insurance & welfare, and the long-term care insurance services sectors. In addition to these 5 aging-related production sectors, 10 other production sectors are considered. The Input-Output (IO) Table of year 2011 with 190 different production sectors is used to construct a social accounting matrix (SAM) with 15 different final consumption goods, over which preference is defined. These 15 final consumption goods are listed in Table 1. Re-categorization of the original IO Table with 190 different production sectors to 15 production sectors was made consistent with the data of Family Income and Expenditure Survey (Kakei Chosa), which provides the information on age specific consumption patterns of different cohorts. In the static part of the model, 15 different profit maximizing production sectors exist in each period, and preference of the household over these 15 different final domestic goods is defined.

In the dynamic part of the model, in addition to the statically optimal behavior of the household to maximize its utility over the 15 different final consumption goods, the household is also assumed to dynamically maximize its lifetime utility, which is defined over composite goods over time. The composite goods consist of the 15 different final consumption goods in each period.

A realistic demographic structure is considered over time. Until year 2015, the actual demographic structure is used. From year 2016, the latest population projection of year 2017 by the National Institute of Population and Social Security Research (IPSS) is used. In the latest population projection, the total population is expected to shrink to less than 60 million in the next 100 years. Reflecting rapid as well as high population aging, the future environment for aging-related sectors will change substantially in a graying Japan.

Regarding the scenarios of the future economic policies, the assumptions in the latest version of Economic and Fiscal Projections for Medium to Long-term Analysis (EFPMLA: January 2021) are

3 Peter et al (1996) and Adams (2000) can be considered as the integrated models of the static and dynamic CGE models, but the dynamic optimization behavior has not been considered in their models. Kimura and Hashimoto (2010) explored fiscal consolidation of Japan in an integrated model.

considered as much as possible to specify the future economy. EFPMLA (2021) numerically embodies the so-called growth strategy, the main policy of Abenomics, and the actual policy scenarios for several key indicators such as the future GDP, government deficits and the primary balance are taken into account.

Since Braun and Joines (2015) examined public medical benefits in a graying Japan within the Auerbach and Kotlikoff (1987) model, fiscal sustainability of the public pension, the national medical services, and the long-term care insurance schemes in an aging Japan has been explored within the numerical dynamic model in the literature (Kitao (2015a), Kitao (2015b), Hansen and İmrohoroğlu (2016), İmrohoroğlu et al (2016), Kitao (2017), Kato (2018), İmrohoroğlu et al (2019), and Kitao and Mikoshiba(2020)). While it has commonly been argued in the literature that population aging of Japan will substantially leave financial burdens on these schemes if the current schemes remain unchanged, the dynamic impact of population aging of Japan on different production sectors has not been discussed yet. The main purpose of this paper is to study the dynamic impact of population aging on different production sectors over time, by integrating independently developed static and dynamic CGE models.

Several numerical results are obtained as follows: First, population aging indeed stimulates demand for products of aging-related sectors. While the impact on the pharmaceutical sector is little, the magnitude of the impact on other sectors is quite large. Compared to the demand in year 2020 with their highest value, or their peak value, demand for demand for the medical services, the social insurance & welfare, the long-term care insurance services, and the public hygiene sectors will increase to their peak levels by 184.08 %, 184.13 %, 184.01 %, and 183.69 %, respectively.
Second, their peak will come in the same year of 2031, and their corresponding highest demand levels at their peak are 45,198,365.566 billion yen, 7,925,178.340 billion yen, 10,436,330.088 billion yen, and 564,449.738 billion yen, respectively.
Third, based on the estimated labor force of year 2018 in the long-term care insurance sector by the Ministry of Health, Labor and Welfare (MHLW; 2018), labor force of 371.16 million workers in the long-term care insurance sector is estimated to be needed in year 2034 in order to match higher demand caused by population aging in Japan.

2. Background

2-1. Demographics of Japan

The National Institute of Population and Social Security Research (IPSS) released the latest population projection of Japan in year 2017. Figures 1-1, 1-2, and 1-3 show the difference between the last projection of year 2012 and the latest projection of year 2017, respectively[4]. Note that the IPSS also releases the projected demographic structure for another 50 years in each projection as a reference estimate in the projections[5]. In Figures 1-1, 1-2, and 1-3, all values have been obtained from the projections by the IPSS.

In year 2010 the total population was 128 million at its peak, but it has been decreasing since year 2011. While all figures show that the latest projection was made based on a slightly optimistic assumption, population aging in Japan is still rapid and high enough for currently on-going debates. Even under the relatively optimistic assumption made in the latest projection of year 2017, the total population is expected to shrink to less than 60 million in the next 100 years. Reflecting population aging, the labor force is also expected to drastically decrease as shown in Figure 1-4[6]. The future decreasing trend of labor force suggests a further severe economic environment in a graying Japan.

On the demographic structure, this paper uses the actual data from year 1920 to year 2015, and the future population projection of year 2017 from year 2016 to year 2115 for the specification of parameter values. Note that in the growing literature all studies assume that the Japanese economy converges to a new steady state with a low dependency ratio after experiencing its very high ratio at peak. However, based on the latest population projection of year 2017, a new steady state is described with a quite high dependency ratio. The IPSS estimates that the Japanese economy remains in a steady state with a high dependency ratio. Thus, since the latest population projection of year 2017 by the IPSS only shows the reliable future demographics of a graying Japan, this paper uses the entire estimates by the IPSS until year 2115, rather than imposing any assumption to converge to a new steady state with a low dependency ratio in the next 100 years. Note also that this paper tries to use the oldest data of the past population structure as much as possible, and it uses the actual past demographics from year 1920. Since there are many overlapping generations alive even in a initial state, the past demographics directly affect the initial state. This paper tries to minimize the impact of ad-hoc assumptions on the initial demographic structure on model specification in a benchmark model.

4 In all figures, the actual data has been used until year 2010 for the projection of year 2012 and until year 2015 for the projection of year 2017. On the future projected values, the medium variant values of the fertility rate as well as of the death rate are used for both projections in the figures. The aging rate is defined as the ratio of age 65 and over to the total number of a population, and the dependency ratio is defined as the ratio of age 65 and over to the total number of age 20 to age 64 in each figure.

5 A reference estimate for another 50 years in the last projection of year 2012 starts from year 2061, and also that in the latest projection of year 2017 starts from year 2066.

6 The labor force is calculated based on the total number of age 18 and over of both genders and also on the wage profile of male non-regular workers of age 20 - 24 in year 2012 for calculation of efficiency. The detailed explanation will be given in the next section.

2-2. The Gender Differences in Wage and Time

In order for the Japanese government to cope with fiscal imbalance in a graying Japan, several studies point out the importance of female labor supply (Braun and Joines (2015), Hansen and İmrohoroğlu (2016), and İmrohoroğlu et al (2016)). Figure 2 shows the wage profiles of male and female workers, calculated based on the Basic Survey of Wage Structure (BSWS) of year 2011. In the figure, non-regular workers include temporary, and dispatched workers (hi-seiki). The annual wage of male non-regular workers of age 20 - 24 is used for normalization. The observed wide gap in the wage profiles between male and female regular workers in Japan was pointed out by Lise et al (2014), and Day (2012) argued several reasons for the Japanese case in association with the recently observed positive relationship between the fertility rate and economic growth. Lise et al (2014) empirically estimated inequality in Japan, and they concluded that inequality between male and female workers is becoming wider. Day (2012) tried to answer the puzzle observed in Japan that Japanese female relative wages have remained relatively constant over the last decade in spite of the Japanese economic growth[7], and she explained the gap by gender inequity in firm-specific human capital.

Gender inequity in firm-specific human capital seems to be related to the difference in time allocation between male and female workers, as Day (2012) pointed out. Figure 3-1 and 3-2 show the time spent on child-rearing and elderly care, calculated based on the Survey on Time Use and Leisure Activities (STULA) of year 2012, respectively. In both figures, the relative time to working hours at different ages is shown. Both figures show the gaps in the time cost not only in gender but also in the type of jobs (regular or non-regular)[8].

This paper explicitly considers such differences in wage and time between male and female workers, and tries to explore the impact of more female labor force participation in a graying Japan. Several experiments will be conducted when females' time costs of child-rearing and elderly care are reduced so that female workers can work more. If female workers can work more, then gender inequity in firm-specific human capital would become smaller, thus resulting in a smaller gap in the wage profile between male and female workers. The experiment of reduction of the

7 As Day (2012) pointed out, the positive relationship between the fertility rate and economic growth has recently been observed among developed countries, although it was opposite before. Galor and Weil (1996) developed a theoretical framework to explain the negative relationship between the fertility rate and economic growth in the relatively old data, but Day (2012) developed a theoretical framework to explain the positive relationship in the recently observed data.

8 It was argued in the past in Japan that females should look after their children and also their parents-in-law. While the common view keeps changing in Japan, thus more females tend to work, there would still be an old idea that females should stay at home for rearing children and looking after their parents-in-law, particularly among males' idea.

wage gap is also conducted to examine how much the total labor supply changes.

3. Some Assumptions on the Future Economy

Parameter values have been set to reproduce the values of key variables in the model as close to real values in year 2011 as possible in the following benchmark for the static part of the model. Regarding the scenarios of the future economic policies, the assumptions in the latest version of Economic and Fiscal Projections for Medium to Long-term Analysis (EFPMLA: January 2021) have been considered as much as possible to specify the future economy for the dynamic part of the model. For the dynamic part of the model, year 2018 has been assumed to be the benchmark year. EFPMLA (2021) numerically embodies the so-called growth strategy, the main policy of Abenomics, and the actual policy scenarios for several key indicators such as the future GDP, government deficits and the primary balance have been taken into account.

3-1. Demographics

The assumption on the demographics is a key factor. From year 2016 to year 2115, the latest population projection by the IPSS (2017) is used for age groups of 0 to 100[9]. The medium variant values for fertility and mortality rates are used. From year 2116, the same distribution as that of year 2115 is assumed for another 100 years. The latest population projection by the IPSS (2017) shows that the Japanese economy converges to a new steady state with the high dependency ratio as shown in Figure 1-3[10]. In the growing literature all studies assume that the Japanese economy converges to a new steady state with a low dependency ratio after experiencing its very high ratio at peak. However, this paper uses the entire estimates by the IPSS (2017) until year 2115.

Regarding the past demographic structure, the actual data from year 1920 to year 2015 is used[11]. The demographic structure before year 1920 is assumed to have the same distribution as that of year 1920.

Since all parameter values of the total population and the survival rate are calculated by using the actual and projected data, the demographics in the model can perfectly capture the actual and projected demographic structure shown in Figure 1-1.

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9 The population projection by the IPSS consists of the usual estimate for the first 50 years and a reference estimate for another 50 years. This paper uses both estimates for entire 100 years from year 2016 to 2115.

10 The dependency ratio is defined as the ratio of age 65 and over to the total number of age 20 to age 64.

11 The data of age 85 and over from year 1920 to 1946 was calculated based on the actual survival rate of age 85 and over between year 1947 and 1948. The data of all ages from year 1941 to 1943 are missing, and missing data were recursively calculated based on the survival rates of all ages between year 1947 and 1948 with the data of year 1944.

3-2. Preference and Production

For the static part of the model, all parameter values are given from Table 2 to Table 6 for year 2011. Note that year 2011 is assumed to be the benchmark year for the static part. From year 2012, all parameter values for the static part of the model are endogenously calculated consistent to the dynamic part of the model.

For the dynamic part of the model, key parameter values are shown in Table 7 for year 2018. On the values of tax rates and parameter values in the dynamic part of the model, available values from Hayashi and Prescott (2002) as well as Hansen and İmrohoroğlu (2016) are used. Ihori et al (2006) pointed out that all simulation results are quite sensitive to the value of technological progress. Note that in EFPMLA (2021) the future economic growth rates are given as targeted values. This paper exogenously gives the value of technological progress instead, so that the endogenously calculated rate of economic growth in the model becomes close to the targeted value of economic growth rate given in EFPMLA (2021). Figure 1-1 shows that the future total population is forecasted to drastically decrease. This implies that future labor force will drastically decrease as well. While per capita GDP can still increase even with such a drastic decreasing trend in labor force, EFPMLA (2021), however, assumes that the even aggregated Japanese economy grows at a stable rate in any scenario. An assumption of stable growth of GDP seems unrealistic without an assumption of stable technological progress. In this paper, the value of technical progress is exogenously given, in order for the model value of endogenously calculated economic growth rate of GDP to become close to the value assumed in EFPMLA (2021). The exogenously calculated value of technological progress is shown in Figure 4. The model values of economic growth calculated endogenously in the benchmark model will be shown in Section 3-4.

3-3. Government

The Japanese government has been trying to stimulate the Japanese economy based on the so-called growth strategy. In order to accomplish the growth strategy, the government documented concrete figures[12] of several key variables such as the future primary balance and economic growth as targeted figures[13].

12 Several official documents have been made. This paper follows several assumptions made by the Cabinet Office of Japan (Economic and Fiscal Projection for Medium to Long-term Analysis (January 2020)).

13 Miyazawa and Yamada (2015) examined the growth strategy of Abenomics, and they concluded that the growth strategy seems difficult to be achieved even under very optimistic assumptions made in one of the official documents, Economic and Fiscal Projections for Medium to Long-term Analysis (July 2014). This paper uses several assumptions made in the latest version of EFPMLA (2020) to specify the future government policy, and expands Miyazawa and Yamada (2015) by separately introducing the government accounts in a more realistic way.

In EFPMLA (2021), there are two assumptions on the future economic environment up to year 2029; a recovery case and a baseline case. Figure 5-1 to 5-3 show the different assumptions between two cases. In all figures the actual data is used until year 2018. This paper follows assumptions made in the baseline case in EFPMLA (2021). Note that the future assumptions made in EFPMLA (2021) take into account the impact of COVID-19 pandemic, so that in the following assumptions its strong impact on the government expenditures is observed.

3-3-1. General Account

The future government expenditures and future deficits are both exogenously given. The future government expenditures are assumed to increase according to population aging based on the latest Population Projection by the IPSS (2017).

On the future deficits, the assumption made in the baseline case in EFPMLA (2021) is used until year 2029. After year 2029, the same value as that of year 2029 is assumed to continue. The future scenario is shown in Figure 5-4.

The consumption tax rate is assumed to be endogenously calculated from year 2021 in order to satisfy the budge constraint of its general account[14]. Before year 2021, the consumption tax rate exogenously remains at 10% until year 2019, while the wage income tax rate is endogenously calculated until 2020 to satisfy the budget constraint of the general account[15]. All other tax rates for the dynamic part of the model are exogenously given as shown in Table 7. The tax rates for the static part of the model are given in Table 4. Note that the tax rates shown in Table 4 have been obtained based on the actual SAM of year 2011. From year 2012, all tax rates for the static part of the model are endogenously calculated consistent to the dynamic part of the model.

3-3-2. Public Pension Account

The decreasing trend of the GDP ratio of accumulated public pension fund has already started since year 2003 in reality. Then, by following the actual plan of decreasing the fund in the next 100 years by the MHLW, the public pension fund is assumed to keep decreasing down until year 2115. Figure 5-5 shows the actual past trend and the future values given in the following numerical analysis. Until year 2018, the actual values are used in the figure.

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14 As pointed by Kitao (2015a), the wage income tax is more distortionary to labor supply than the consumption tax, and thus a more welfare loss is generated by the wage income tax. This paper only uses the consumption tax to finance the future government policy.

15 The exogenously given values of the consumption tax rate in all simulations are 0 %, 3 %, 5 %, 8 %, and 10 % for before year 1989, between 1989 and 1997, between 1997 and 2014, between 2014 and 2018, and between 2019 and 2020, respectively. The wage income tax rate is given exogenously from year 2021 at the same value of that of year 2020.

A half of the total amount of basic pension benefits is transferred annually from the general account in reality. This paper incorporates this fact[16].

The contribution rate of the public pension scheme and the replacement rate are used as policy instruments in order to satisfy the budget constraint of the public pension account. In order to reflect the actual policy change, the contribution rate is endogenously calculated until year 2017 with the fixed replacement rate. Until year 2017 the contribution rate is an endogenous policy instrument to satisfy the budget constraint of the public pension account. From year 2018 the contribution rate is exogenously given at 18.3%, and the replacement rate is endogenously calculated to satisfy the budget constraint of the public pension account[17]. From year 2018 the replacement rate becomes a new policy instrument to satisfy the budget constraint of the public pension account.

The MHLW reported that the replacement rate in year 2009 was 62.3 %[18], and the exogenous replacement rate is assumed to be fixed at 62.3 % until year 2017. From year 2018 the replacement rate is endogenously calculated, while the contribution rate is exogenously fixed at 18.3 % afterwards.

3-3-3. Long-term Care Insurance (LTCI) Account

The public long-term care insurance (LTCI) for the elderly was introduced in year 2000. The expenditures basically depend on the demographic structure and population aging, and the expenditures are assumed to be exogenous. According to the future demographic structure, the future expenditures in the LTCI is calculated based on the assumption that the age-dependent cost is time-invariant. For given values of expenditures, this paper endogenously calculates the fixed value of contributions by the first group and the contribution rate for the second group in order to balance the budget of the LTCI account.

On the revenue side, a 10% of the total cost is paid by the insured as co-payments. A half of the remaining cost (90 % of the total cost) is covered by transfers from the general account. Another half of the remaining cost is paid by the insured. A 27 % and a 23% of the remaining cost are currently paid by people belonging to the second group, and the first group, respectively. Note

16 Until year 2003 the actual transfer rate, defined as the ratio of transfers from the general account to the total basic pension benefits, was one-third, and it was gradually increased to 50% from year 2004 to year 2009. Since year 2010, the rate has remained at 50%.

17 In the actual plan by the MHLW, it is assumed that the contribution rate remains at 18.3% from year 2018, and also that the replacement rate is adjusted to balance the budget with the fixed rate of the contribution rate of 18.3%.

18 Note that this is the official replacement rate. See Kitao (2015a) for different definitions of the replacement rate. The official replacement rate used here is different from the definition of the replacement rate used in Kitao (2015a, 2015b, and 2017).

that the scheme is compulsory so that people between age 40 and 64 have to belong to the second group, and people of age 65 and over have to belong to the first group.

The current ratios of the distribution of the cost between the first group (age 65 and over) and the second group (ages between 40 and 64) are 23 % and 27%, respectively. While the total ratio paid by the insured remains at 50% (=23 % + 27 %) of the 90 % of the total cost, the ratios between two groups will be modified according to the future demographic structure in the actual future plan by the MHLW. The MHLW announced that the ratios will be modified every 3 years, and indeed the actual ratios have been changed since its launch in year 2000. Table 8 shows the actual ratios in the past as well as the future calculated ratios based on the guideline made by the MHLW. This paper endogenously calculates the contribution rate for the second group and the fixed value of contributions for the first group to satisfy the budget constraint of the LTCI account, based on the given ratios in Table 8.

3-4. Benchmark and Calibration

Year 2011 is assumed to be a benchmark year for the static part of the model. This is because parameter values were calibrated by using the actual SAM of year 2011 for the static part of the model. Table 9-1 shows the comparison of the final domestic consumption goods between actual and model values[19]. Note that the model values in Table 9-1 have been obtained with the parameter values given in Table 2 to 6.

For the dynamic part of the model, the model was calibrated based on the actual values of year 2018, since the latest actual values for key variables for the dynamic part of the model can be obtained up to year 2018. Table 9-2 shows the comparison of such variables between actual and model values. Note that until year 2017 the contribution rate of the public pension is endogenously calculated under the assumption of the exogenous value of the replacement rate of 62.7 %, while it is assumed to be exogenously given at 18.3 % from year 2018 with the assumption that the replacement rate is endogenously calculated to satisfy the budget constraint of the public pension account within the model.

In the following numerical experiments, technological progress (Ω) is assumed to follow the value given in Figure 4, in order to realize the assumption of the baseline case in EFPMLA (2021).

19 The data set of consumption of the household contains 1215 observations of each of the actual and model values, and it can be provided upon request.

4. Impact of Population Aging

4-1. On Demand for Domestic Products

Since the household has age specific preference over consumption goods, the future change in the demographic structure affects an economy through the change in demand for goods. It is expected that population aging stimulates more demand for goods which aged people prefer. This paper particularly pays more attention to the impact on aging-related production sectors. Figure 6-1 to 6-4 show the impact of population aging on demand for these production sectors. Note that the negative impact of COVID-19 pandemic in years 2020 and 2021 is shown in all figures. While demand for the 4 sectors such as the medical services sector, the social insurance & welfare sector, the long-term care insurance services sector, and the public hygiene sector all increases by population aging, the demand for the pharmaceutical sector declines. This implies that the impact of population aging is relatively small on the pharmaceutical sector, and the impact of the drastic decrease in the total population in the future on the pharmaceutical sector overweighs the impact of population aging.

Compared to the demand level in year 2020, demand for the medical services, the social insurance & welfare, the long-term care insurance services, and the public hygiene sectors will increase to their peak levels by 184.08 %, 184.13 %, 184.01 %, and 183.69 %, respectively. Note that their peak will come in the same year of 2031. The corresponding highest demand levels at their peak are 45,198,365.566 billion yen, 7,925,178.340 billion yen, 10,436,330.088 billion yen, and 564,449.738 billion yen, respectively.

Note that demand for these 4 sectors will start decreasing after their peak levels due to the fact that the total population will drastically shrink in the future. The effect of a shrinking population overweighs the impact of population aging on demand even for these 4 sectors[20] in the future.

4-2. On Total Labor Income

Since demand for these 4 sectors (the medical services, the social insurance & welfare sector, the long-term care insurance sector, and the public hygiene sector) will increase in a graying Japan, the impact of population aging on labor in these 4 sectors is further examined. In these 4

20 While the per capita GDP is forecasted to increase due to the strong assumption in EFPMLA (2021), the total GDP will start decreasing due to a drastically shrinking future population. The effect of the shrinking total population can be observed in a decrease in demand not only for these 5 sectors but also for other 10 sectors in a graying Japan.

sectors, more labor inputs are needed to cope with higher demand. In other words, the argument in the previous section can be plausible only when more supply of goods of these sectors matches higher demand. In order to increase supply of these products, these production sectors need more labor. Figure 7-1 to 7-3 show the total labor income needed to produce more outputs to match higher demand in these 4 sectors. Note that labor income is the product of labor force with the wage rate. In the short-run, labor is more sector specific so that labor is less mobile. This implies that an increase in the total labor income mainly comes from an increasing wage rate in these sectors in the short run. On the other hand, in the long-run labor becomes more mobile as long as a wage gap exists among different production sectors, and an increase in the total labor income comes with the change in the amount of labor supply in production sectors as well. Figure 7-1 to 7-3 all show mixed changes of increasing labor supply as well as the increasing wage rate in the total labor income caused by population aging among these 4 sectors.

4-3. On Labor Force

The total labor income of each sector depends on labor force and the wage rate in each sector. Thus, higher labor income does necessarily not imply more labor force in each sector. If friction is strong and thus labor cannot move between production sectors smoothly, then higher total labor income would be caused by higher wage rates. In this case, even though it is anticipated that population aging results in higher total labor income, higher demand for goods of these sectors could not be fulfilled. This implies that stable economic growth of a graying Japan depends on the extent to which the labor market is smooth enough without friction, in order to have enough labor force to fulfill increasing demand for goods elderly people prefer. To see how much labor force is needed for such sectors, the long-run assumption is imposed in the following experiment; no change in the wage rate. If any other costs do not change with the inflow of labor force into such sectors, then more labor keeps moving into such sectors until the wage rate settles down to the original level in the long-run, as long as the wage rate is higher than other sectors. Figure 8-1 and 8-2 show the impact of population aging on labor force under the assumption of the smooth inflow of labor force.

Note that the experiment was conducted based on the actual data of Labor Force Survey until year 2020. In Labor Force Survey, labor force of the social insurance & welfare and the long-term care insurance sectors is not shown separately, so that in Figure 8-1 the integrated values of both sectors are shown. As Figure 8-1 shows, the labor force needed in both of the social insurance & welfare and the long-term care insurance sectors will drastically increase due to population aging. The latest available data of labor force of both sectors is 431 million workers in year 2020. The needed number of workers of both sectors at its peak is forecasted to be 470.07 million workers in year 2034.

While it seems difficult to decompose the labor force between the social insurance & welfare sector and the long-term care insurance sector, the Ministry of Health, Labor and Welfare (MHLW; 2018) estimated the labor force of 334 million workers in the long-term care insurance sector for year 2018 in its simulation analysis. Based on this value of year 2018 estimated by the Ministry of Health, Labor and Welfare (MHLW; 2018) in accordance with the future trend in Figure 8-1, the separated value of labor force in the long-term care insurance sector can be calculated. The separated value of future labor force in the long-term care insurance sector is shown in Figure 8-2. Then, in year 2034, the labor force needed in the long-term care insurance sector is estimated to be 371.16 million workers.

5. Concluding Remarks

This paper integrated independently developed static and dynamic CGE models, and studied the dynamic impact of population aging on the Japanese economy with multi-production sectors and overlapping generations.

Numerical results show that population aging indeed stimulates demand for products of aging-related sectors. The paper focused on the impact on the 5 production sectors; the pharmaceutical sector, the medical services sector, the public hygiene sector, the social insurance & welfare sector, and the long-term care insurance sector. Then, the paper showed that the impact of population aging is quite strong particularly on the 4 sectors such as the medical services sector, the social & welfare sector, the long-term care insurance sector, and the public hygiene sector. Compared to the demand in year 2020 with their highest value, demand for these 4 sectors will increase by 184.08 %, 184.13 %, 184.01 %, and 183.69 %, respectively. Note that their peak will come in the same year of 2031. The corresponding highest demand levels at their peak are 45,198,365.566 billion yen, 7,925,178.340 billion yen, 10,436,330.088 billion yen, and 564,449.738 billion yen, respectively, if labor mobility among such sectors is smooth enough to match higher demand caused by population aging.

These numerical results indicate that labor mobility among different production sectors should be smooth enough without friction to cope with an expansion of demand for products of aging-related sectors in a graying Japan in order to have stable economic growth.

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Figure 1-1

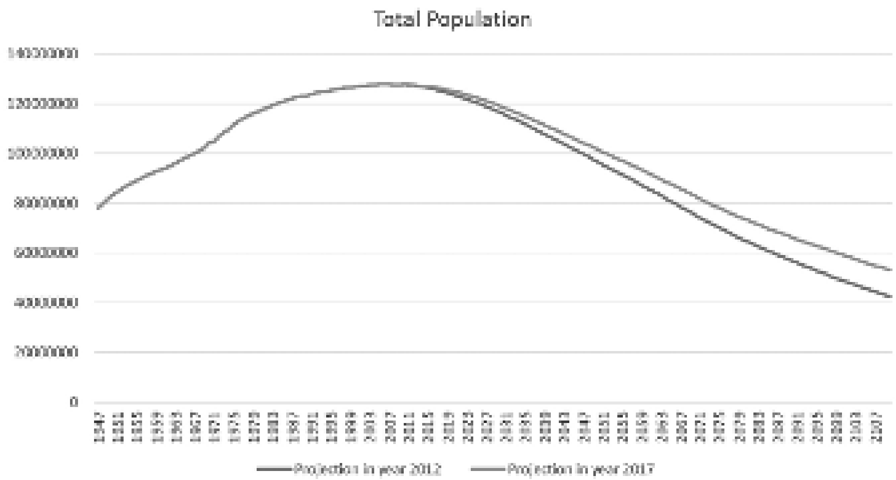
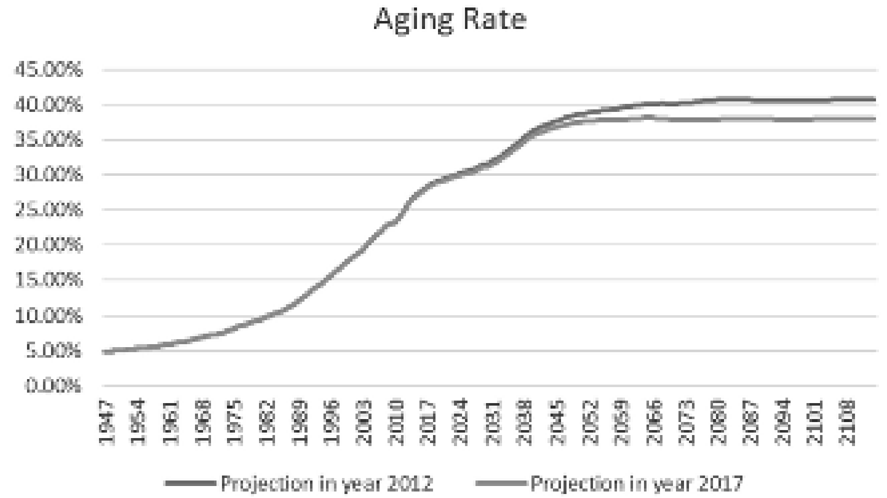
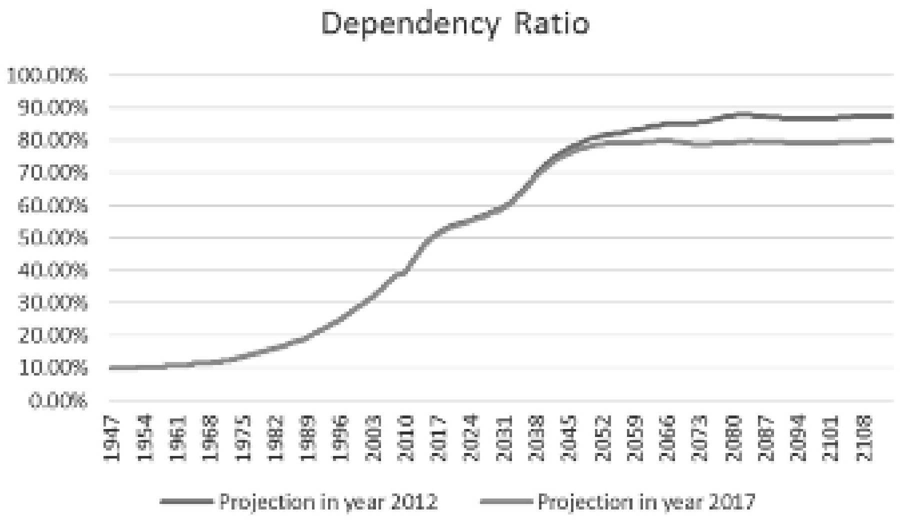


Figure 1-2: Aging Rate



Data: the actual data from Statistics Bureau, Ministry of Internal Affairs and Communications, and the future projections from the National Institute of Population and Social Security Research (IPSS)

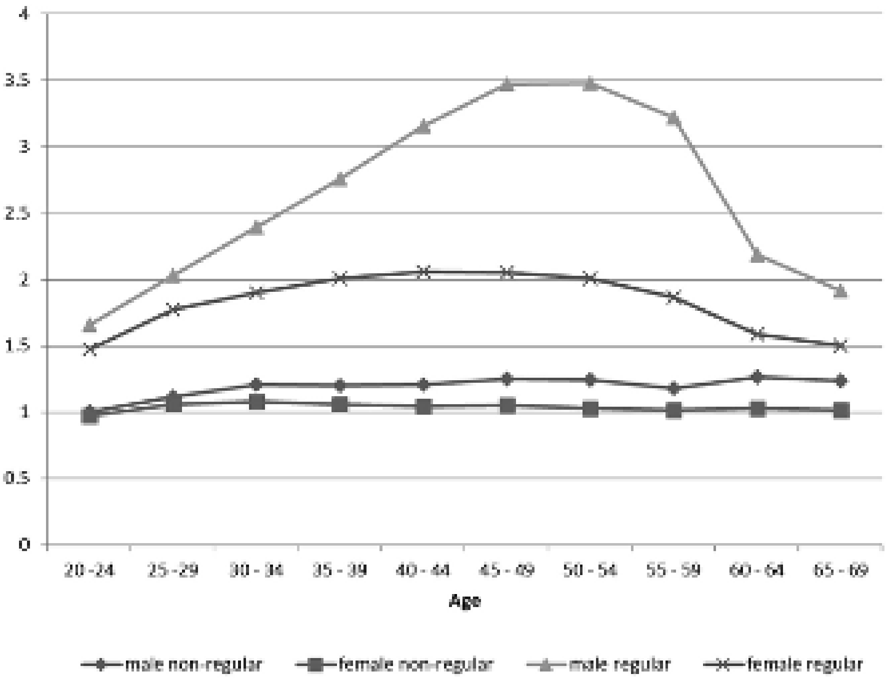
Figure 1-3: Dependency Ratio



Data: the actual data from Statistics Bureau, Ministry of Internal Affairs and Communications, and the future projections from the National Institute of Population and Social Security Research (IPSS)

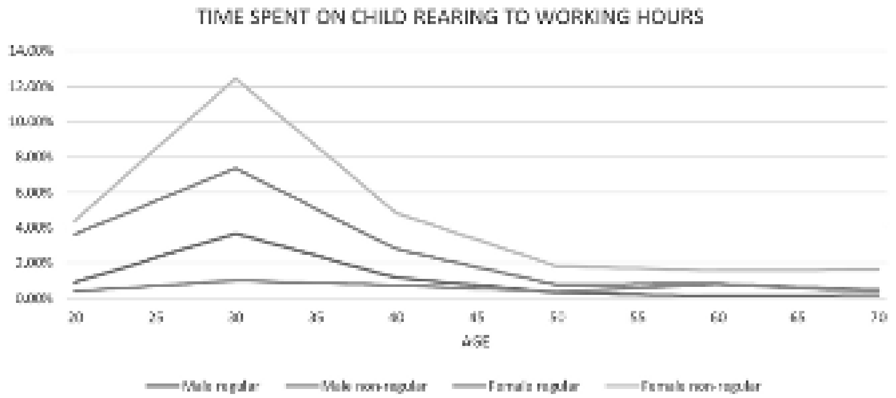
Figure 1-4: Labor Force

Figure 2: Wage Profiles



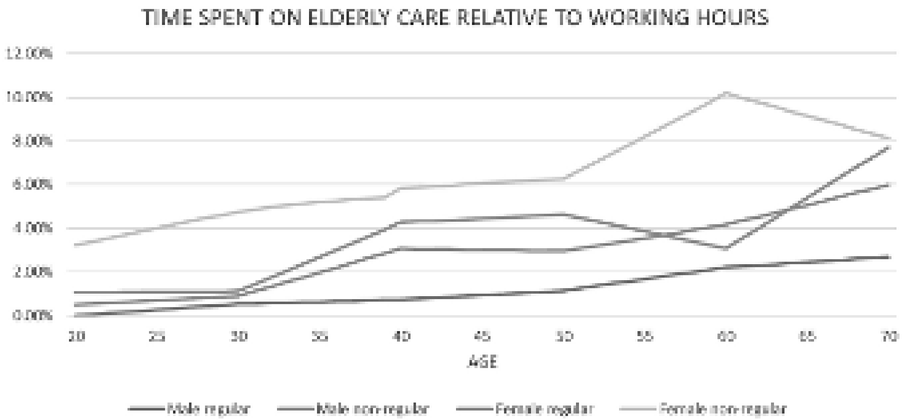
Data: the actual data from Statistics Bureau, Ministry of Internal Affairs and Communications, and the future projections from the National Institute of Population and Social Security Research (IPSS)

Figure 3-1: Time Spent on Child Rearing



Data: Survey on Time Use and Leisure Activities (STULA) of year 2012, Statistics Bureau, Ministry of Internal Affairs and Communications

Figure 3-2: Time Spent on Elderly Care



Data: Survey on Time Use and Leisure Activities (STULA) of year 2012, Statistics Bureau, Ministry of Internal Affairs and Communications

Figure 4: Technological Progress

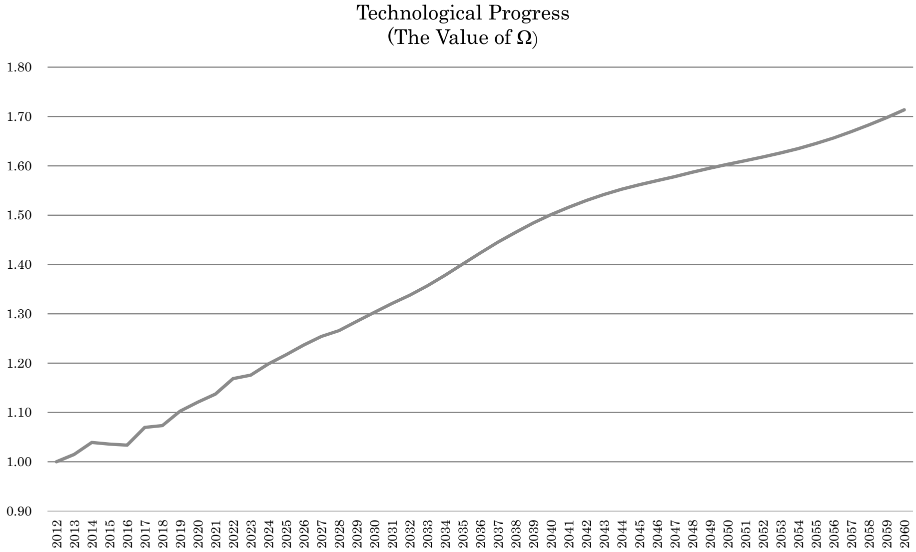


Figure 5-1

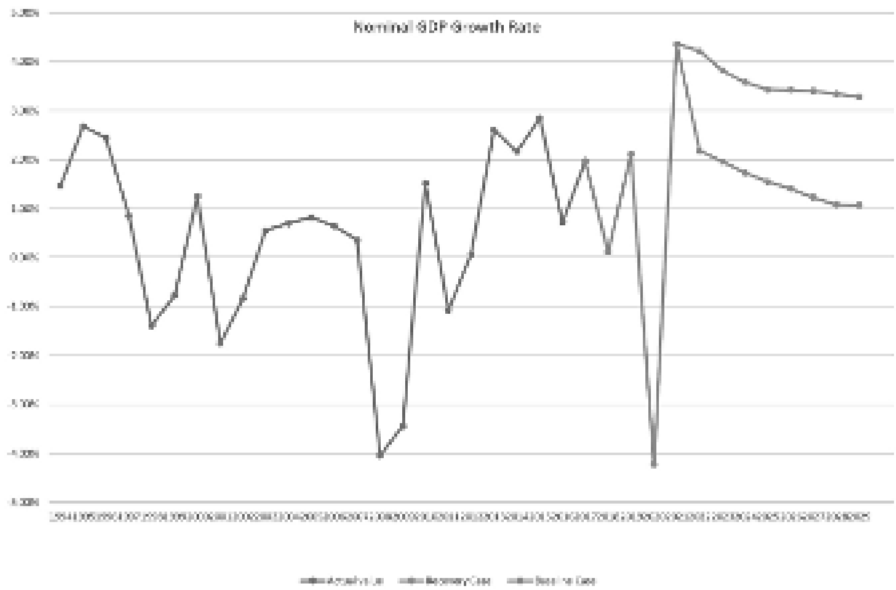


Figure 5-2

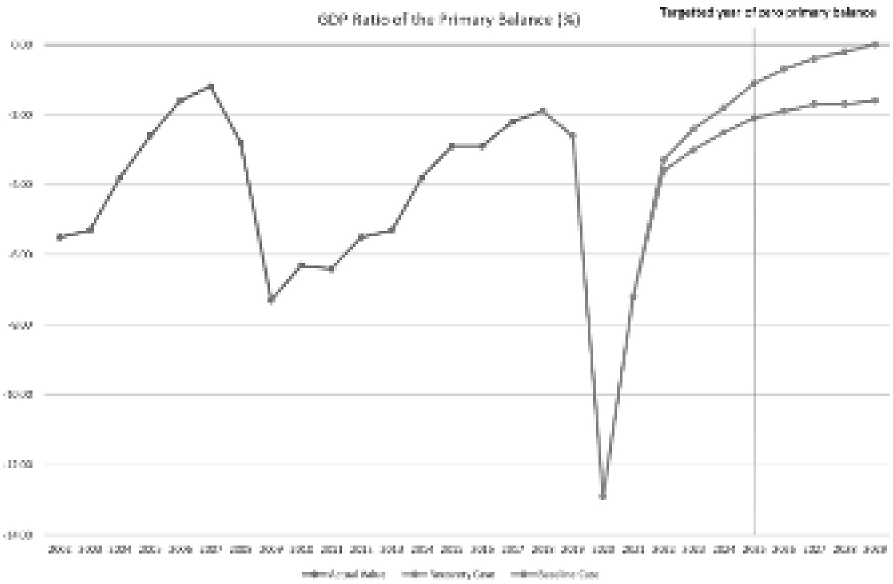


Figure 5-3

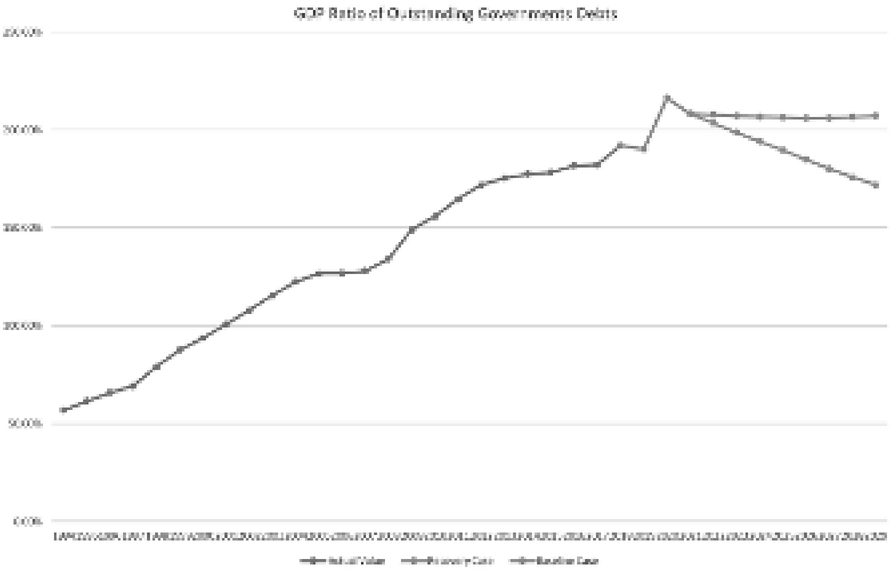


Figure 5-4

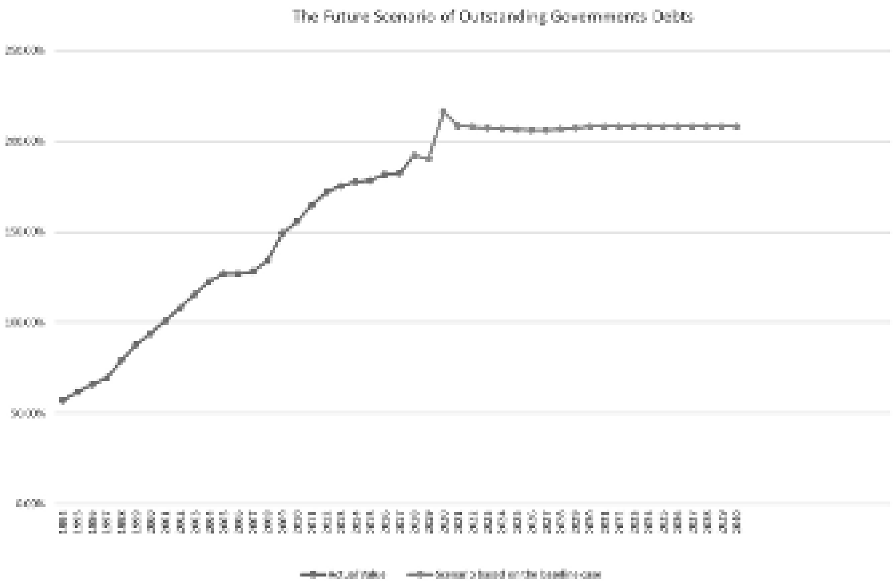


Figure 5-5

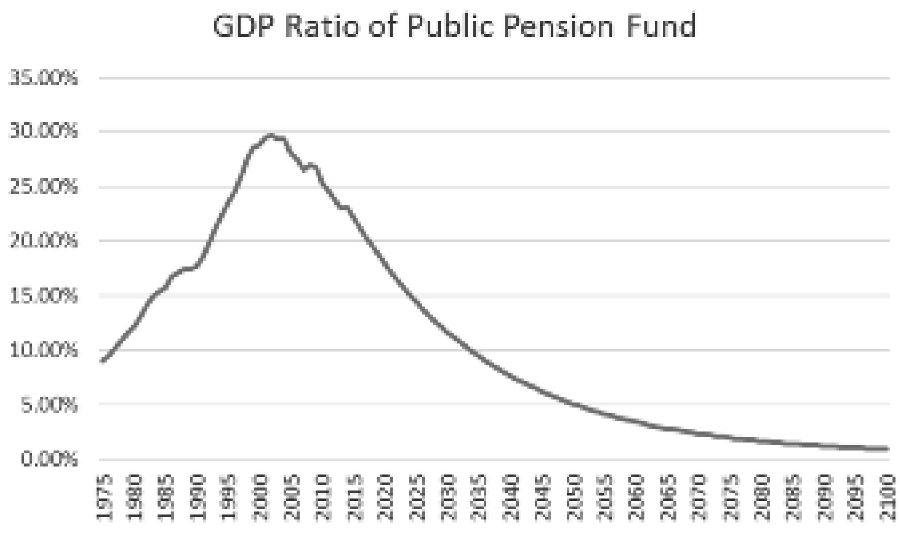


Table 1: The list of final domestic consumption goods

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Food	Housing	Fuel, Light & Wager Charge	Furniture & Household Utensils	Clothing & Footwear	Pharmaceutical	Medical Services	Public Hygene	Social Insurance & Welfare	Long-term Care Services	Transportation & Communication	Education	Recreatinal Services	Other Consumption Expenditure	Others

Table 2 (Static part of the model)

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\beta_{k,i}$	0.430839	0.720433	0.323142	0.242593	0.045946	0.684492	0.214598	0.093734	0.076498	0.170567	0.407861	0.140822	0.420927	0.404322	0.344764
$\beta_{L,i}$	0.569161	0.279567	0.676858	0.757407	0.954054	0.315508	0.785402	0.906266	0.923502	0.829433	0.592139	0.859178	0.579073	0.595678	0.655236

Table 3 (Static part of the model)

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ay_i	0.369496	0.606607	0.496285	0.334325	0.310126	0.363902	0.544265	0.664799	0.678783	0.74492	0.338765	0.752842	0.455604	0.598733	0.27843

Table 4: Tax Rates for Year 2011 (Static part of the model)

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$\tau_{i,t}^{p}$	0.046438	0.047129	0.043652	0.034653	0.028944	0.02623	0.016043	0.016572	0.004445	0.022561	0.049094	0.01273	0.040749	0.026369	0.018751
$\tau_{i,t}^{s}$	0.011303	0.00036	0.003873	1.77E-05	5.63E-05	1.13E-05	0.018181	5.01E-06	2.76E-05	0.003957	0.00212	0.001123	0.001082	0.004552	0.003998
$\tau_{i,t}^{m}$	0.122586	0.074455	0.02539	0.068295	0.122509	0.050353	0	0	0	0	0.037785	0	0.131171	0.043668	0.0562

Table 5 (Static part of the model)

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
κ_i^e	0.00745	0.00604	0.03106	0.07568	0.27945	0.04784	0.00001	0.00000	0.00000	0.00000	0.15906	0.00249	0.11281	0.09157	0.13882
κ_i^d	0.99255	0.99396	0.96894	0.92432	0.72055	0.95216	0.99999	1.00000	1.00000	1.00000	0.84094	0.99751	0.88719	0.90843	0.86118

Table 6 (Static part of the model)

i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
γ_i^m	0.09568	0.16252	0.03202	0.12154	0.55974	0.20841	0.00008	0.00000	0.00000	0.00000	0.07789	0.00392	0.14706	0.05048	0.05919
γ_i^d	0.90432	0.83748	0.96798	0.87846	0.44026	0.79159	0.99992	1.00000	1.00000	1.00000	0.92211	0.99608	0.85294	0.94952	0.94081

Table 7 (Dynamic part of the model)

Parameter	Description	Value/Source
P_s	Survival rate	IPSS(2017)
δ	Subjective discount factor	0.0286 / Kitao (2015a)
ρ	Risk aversion	3.0 / Kitao (2015a)
ξ	Relative preference	0.15
κ	Weight parameter for leisure	0.00001
$\tau_{r,t}$	Interest income tax rate	35.57 %/ Hansen and İmrohoroğlu (2016)
$\tau_{w,t}$	Wage income tax rate *	33.24 %/ Hansen and İmrohoroğlu (2016)
$\tau_{a,t}$	Inheritance tax rate	35 .00 %
α	Labor income share	0.6217/ Hansen and İmrohoroğlu (2016)
φ	Depreciation rate	8.421 %/ Hansen and İmrohoroğlu (2016)

Table 8: The Distribution of the Cost of the Long Term Care Insurance

Year	Contributins by 1st group	Contributins by 2nd group	Tax
2000－2002	17%	33%	50%
2003－2005	18%	32%	50%
2006 - 2008	19%	31%	50%
2009 - 2011	20%	30%	50%
2012 - 2014	21%	29%	50%
2015 - 2017	22%	28%	50%
2018 - 2020	23%	27%	50%
2021 - 2023	23%	27%	50%
2024 - 2026	24%	26%	50%
2027 - 2029	24%	26%	50%
2030 - 2032	24%	26%	50%
2033 - 2035	25%	25%	50%
2036 - 2038	26%	24%	50%
2039 - 2041	27%	23%	50%
2042 - 2044	27%	23%	50%
2045 - 2047	28%	22%	50%
2048 - 2050	28%	22%	50%
2051 - 2053	28%	22%	50%
2054 - 2056	28%	22%	50%
2057 - 2059	28%	22%	50%
2060 - 2062	28%	22%	50%
2063 - 2065	29%	21%	50%
2066 - 2068	29%	21%	50%
2069 - 2071	29%	21%	50%

1st Group: Age 65 and Over
2nd Group: Age 40 – 64

Table 9-1: Actual and Model Values of Year 2011 (Unit: a million yen)

	i =	1	2	3	4	5	6	7	8
GDP	Actual	51,311,765.000	84,263,066.000	14,869,917.000	9,390,053.000	5,324,630.000	1,104,482.000	41,445,753.000	780,896.000
	Model	51,311,765.001	84,263,066.003	14,869,917.001	9,390,053.000	5,324,630.000	1,104,482.000	41,445,753.002	780,896.000
Value Added	Actual	33,355,633.000	106,109,375.000	41,282,598.000	13,643,503.000	5,759,641.000	4,587,009.000	23,239,086.000	952,821.000
	Model	33,355,633.001	106,109,375.017	41,282,598.000	13,643,503.000	5,759,641.001	4,587,009.000	23,239,086.000	952,821.000
Labor Income	Actual	13,665,229.000	21,039,644.000	24,355,051.000	6,892,128.000	1,329,720.000	813,524.000	18,321,142.000	842,514.000
	Model	13,665,229.000	21,039,644.000	24,355,051.000	6,892,128.000	1,329,720.000	813,524.000	18,321,142.000	842,514.000
Capital Income	Actual	10,344,184.000	54,218,210.000	11,627,451.000	2,207,508.000	64,038.000	1,764,933.000	5,005,951.000	87,140.000
	Model	10,344,184.000	54,218,210.000	11,627,451.000	2,207,508.000	64,038.000	1,764,933.000	5,005,951.000	87,140.000
Imports	Actual	6,291,913.000	23,313,420.000	2,356,211.000	3,370,947.000	3,773,737.000	1,735,393.000	3,620.000	0.000
	Model	6,291,913.001	23,313,420.016	2,356,211.000	3,370,947.000	3,773,737.001	1,735,393.000	3,620.000	0.000
Exports	Actual	501,339.000	783,995.000	2,341,640.000	2,131,308.000	1,292,170.000	347,894.000	234.000	0.000
	Model	501,339.000	783,995.000	2,341,640.000	2,131,308.000	1,292,170.000	347,894.000	234.000	0.000
Government	Actual	239,401.000	2,525,419.000	-672.000	789,704.000	504.000	0.000	33,159,023.000	416,088.000
Consumption	Model	239,401.000	2,525,419.000	-672.000	789,704.000	504.000	0.000	33,159,023.001	416,088.000
Investment	Actual	294,408.000	21,179,091.000	2,748,172.000	745,595.000	81,926.000	56,797.000	0.000	0.000
	Model	294,408.000	21,179,091.006	2,748,172.001	745,595.000	81,926.000	56,797.000	0.000	0.000

	i =	9	10	11	12	13	14	15
GDP	Actual	7,847,093.000	8,238,273.000	65,941,196.000	23,766,675.000	56,274,356.000	151,581,036.000	37,924,142.000
	Model	7,847,093.000	8,238,273.000	65,941,196.001	23,766,675.001	56,274,356.006	151,581,036.002	37,924,142.005
Value Added	Actual	5,337,562.000	6,175,231.000	60,028,697.000	26,462,315.000	57,627,965.000	149,495,613.000	26,006,284.000
	Model	5,337,562.000	6,175,231.000	60,028,697.002	26,462,315.000	57,627,964.997	149,495,613.005	26,006,284.000
Labor Income	Actual	4,897,379.000	4,997,142.000	26,171,066.000	22,274,987.000	23,236,498.000	79,591,099.000	13,627,196.000
	Model	4,897,379.000	4,997,142.000	26,171,066.000	22,274,987.000	23,236,498.000	79,591,099.000	13,627,196.000
Capital Income	Actual	405,674.000	1,027,626.000	18,026,421.000	3,650,952.000	16,890,584.000	54,023,212.000	7,170,178.000
	Model	405,674.000	1,027,626.000	18,026,421.000	3,650,952.000	16,890,584.000	54,023,212.000	7,170,178.000
Imports	Actual	0.000	0.000	9,349,371.000	136,686.000	12,382,949.000	10,551,695.000	3,888,429.000
	Model	0.000	0.000	9,349,371.002	136,686.000	12,382,948.998	10,551,695.005	3,888,429.000
Exports	Actual	0.000	0.000	21,726,227.000	86,619.000	10,329,662.000	20,881,621.000	10,521,871.000
	Model	0.000	0.000	21,726,227.000	86,619.000	10,329,662.000	20,881,621.000	10,521,871.000
Government	Actual	5,819,952.000	7,643,350.000	205,911.000	18,224,475.000	2,290,558.000	39,953,798.000	14,194,133.000
Consumption	Model	5,819,952.000	7,643,350.000	205,911.000	18,224,475.001	2,290,558.000	39,953,798.002	14,194,133.001
Investment	Actual	0.000	0.000	5,910,820.000	0.000	15,564,667.000	13,736,884.000	13,208,138.000
	Model	0.000	0.000	5,910,820.002	0.000	15,564,667.005	13,736,884.004	13,208,138.004

Table 9-2: Key Parameter Values of Year 2018 for the Dynamic Part of the Model

Variables	Actual	Model
GDP ratio of outstanding government bonds	192.00%	192.00%
GDP ratio of public pension fund	19.47%	19.47%
GDP ratio of government expenditures	37.33%	37.33%
Primary balance	-1.90%	-1.90%
GDP growth rate (real)	0.30%	0.30%
National burden ratio	48.40%	49.00%
Replacement Rate of the Public Pension*	62.90%	62.83%
Contribution rate of the public pension in year 2017 **	18.30%	18.29%
Wage income tax rate	33.24%	33.78%

Sources for the actual values: Ministry of Finance, Cabinet Office, and Ministry of Internal Affairs and Communications

*) The replacement rate is of the Kousei-Nenkin

**) The contribution rate is of the Kousei-Nenkin.

Figure 6-1: Demand for medical services

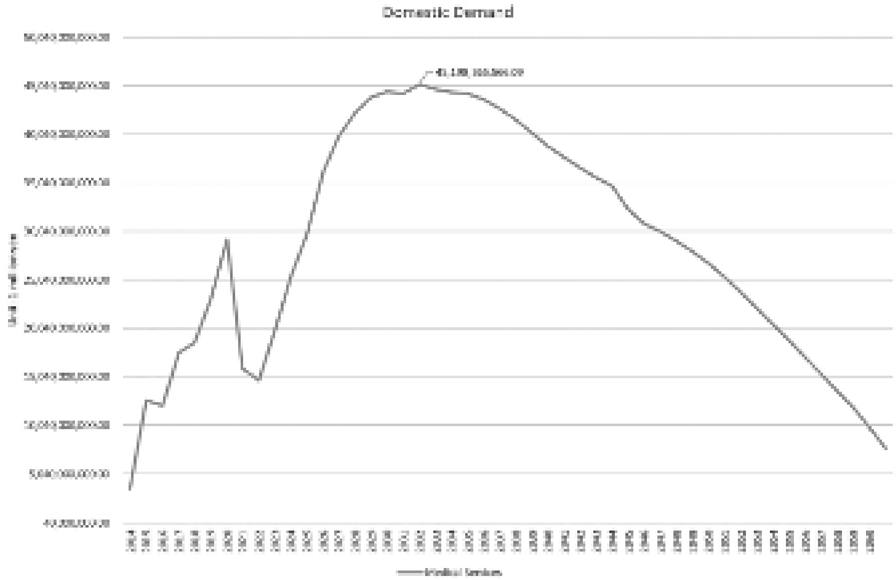


Figure 6-2:
Demand for social insurance & welfare services and long-term care insurance services

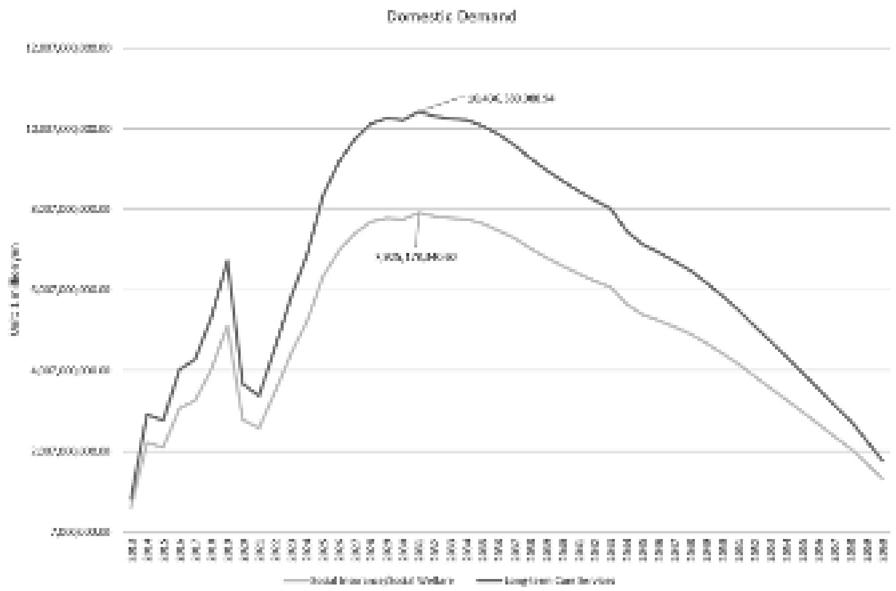


Figure 6-3: Demand for public hygiene services

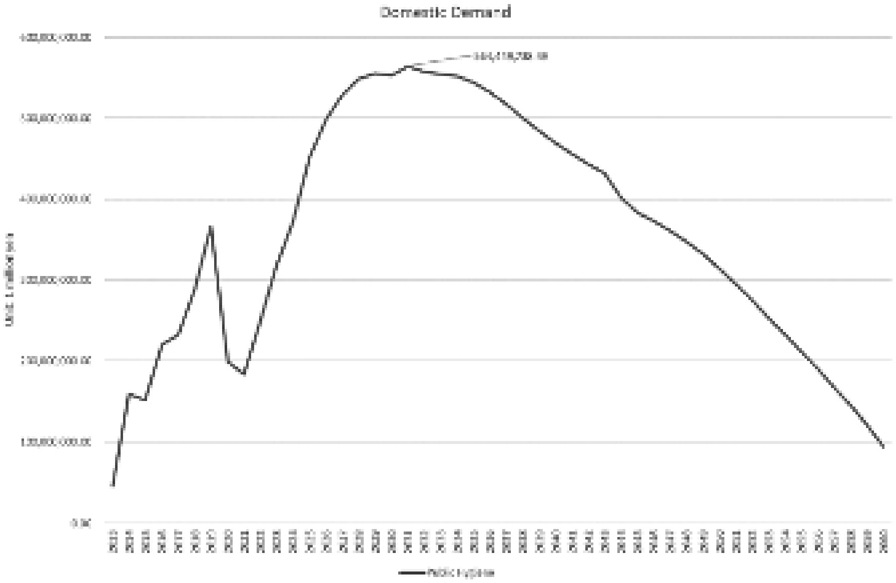


Figure 6-4: Demand for pharmaceutical industry services

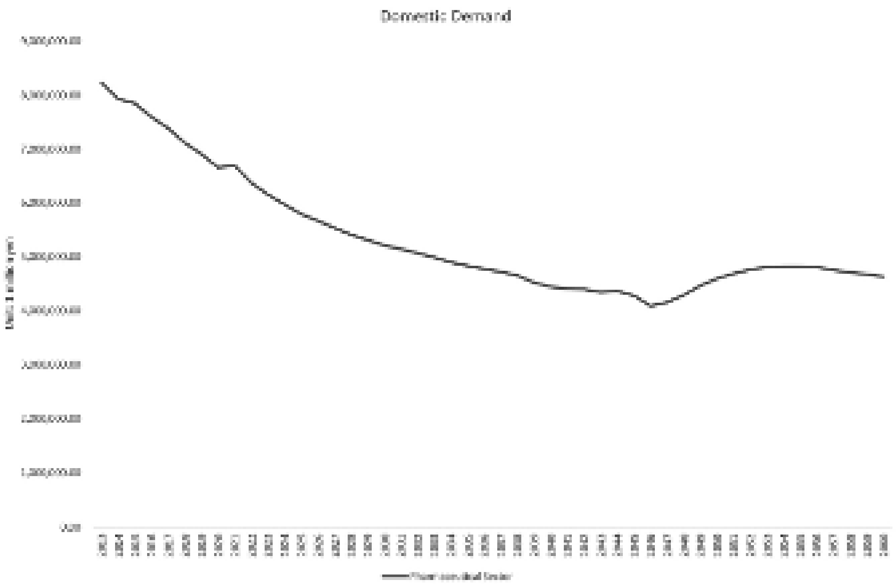


Figure 7-1: Total labor income in the medical services sector

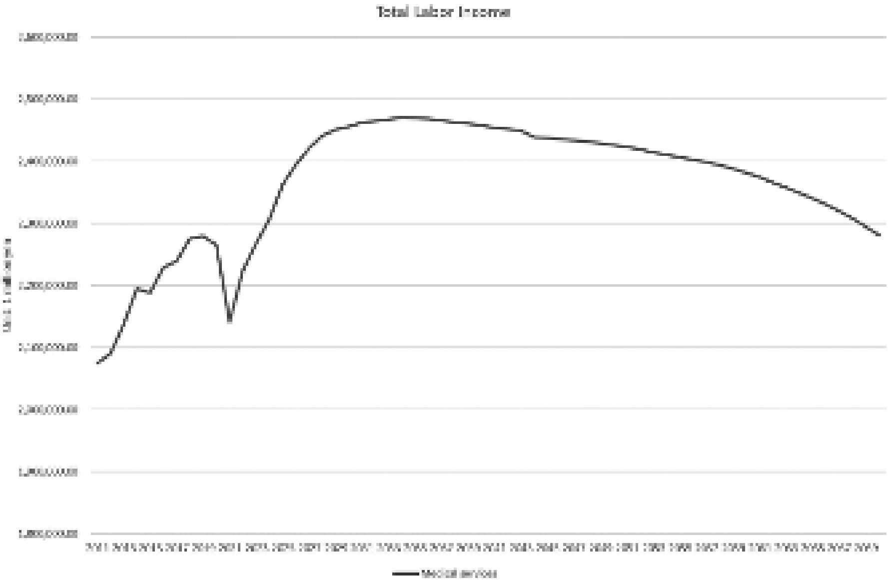


Figure 7-2:
Total Labor Income in social insurance & welfare services and long-term care insurance services

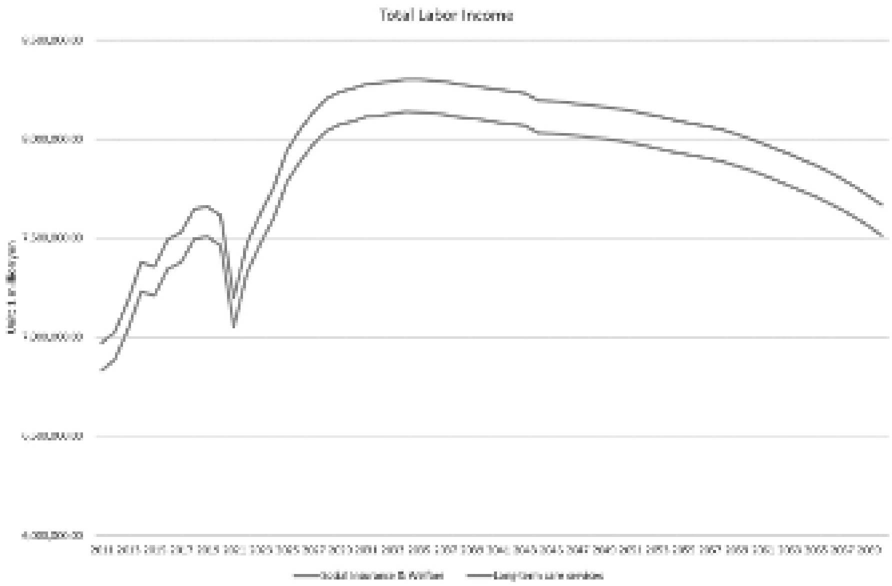


Figure 7-3: Total Labor Income in Public Hygiene services

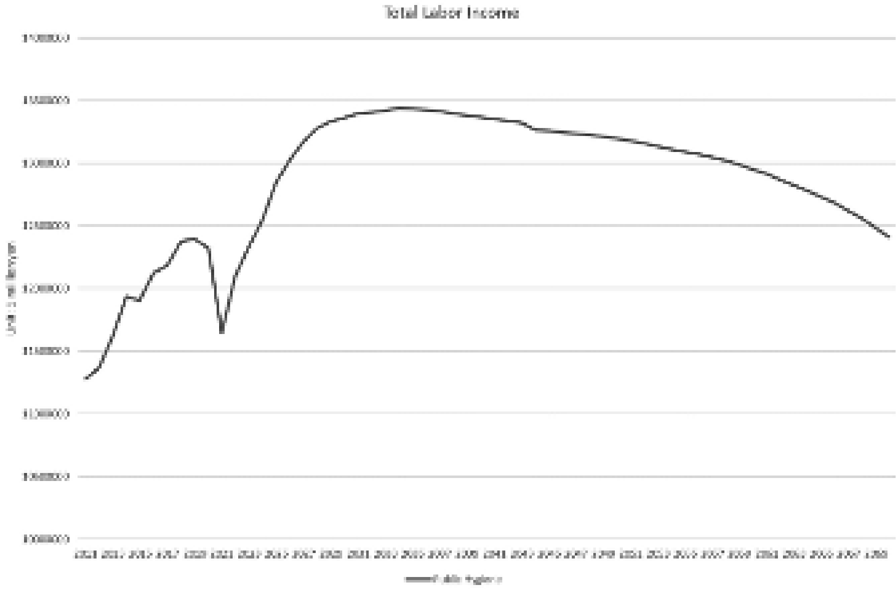


Figure 8-1

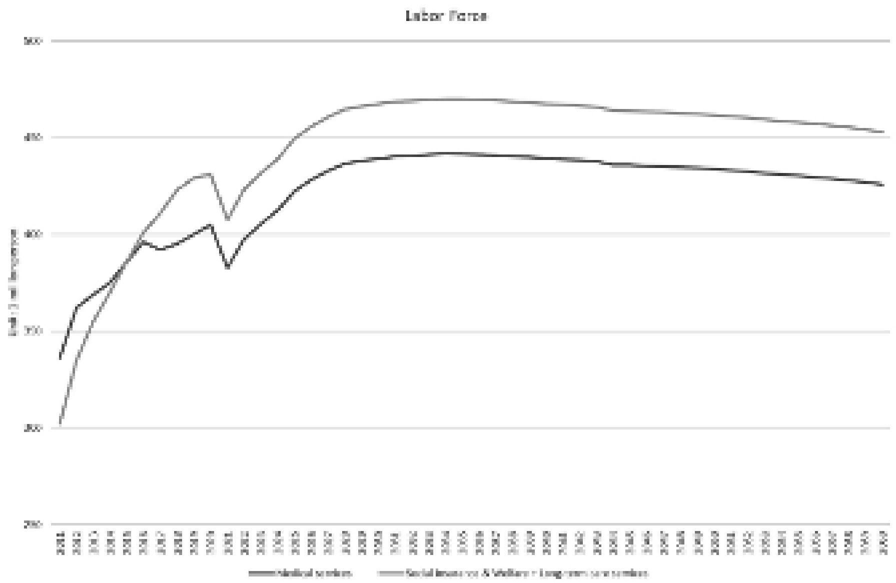


Figure 8-2