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The Impact of Population Aging on Japan in a Multi-sector Dynamic General Equilibrium Model

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The Impact of Population Aging on Japan in a Multi-sector Dynamic 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 pharmaceutial industry, the medical services, the social insurance and welare, and the long-term care insurance sectors are considered within the combined model of independently developed static and dynamic CGE models, and demand for these sectors are estimated to increase by 12.25 percent, 19.78 percent, 21.66 percent, and 18.76 percent from year 2020 in a graying Japan, 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 in year 2018 to 369.21 million in year 2034 to fulfil the increasing demand for long-term care insurance services.

Keywords: Aging, Japan, Long-term Care Insurance, 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 population aging on the Japanese economy with multi-production sectors and overlapping generations.

Since Ballard et al (1985) examined the impact of tax reforms on several production sectors within a static computable general equilibrium (static CGE) model, the static CGE model has been applied in several different research fields[1]. Auerbach and Kotlikoff (1982 and 1987) numerically investigated the 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 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 time. In reality, each household makes a simultaneous decision over consumption of different goods in each time as well as savings over time. The former decision can be considered 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 production sectors over time, this paper tries to integrate two independently developed computable general equilibrium models in order to overcome disadvantages of each model[2].

Preference over goods depends on age, and the future change in the demographic structure

[1]The GTAP model is considered as one of applied models to the internatinal 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.

[2]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.

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. Re-categorization of the original IO Table with 190 different production sectors to 15 production sectors was made consistent to 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 each time, 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 each time.

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 2020) are considered as much as possible to specify the future economy. EFPMLA (2020) 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), and İmrohoroğlu et al (2019)). 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. Compared to the demand in year 2020 with their highest value, or their peak value, demand for the pharmaceutical product, the medical services, the public hygiene services, the social insurance & welfare services, and the long-term care insurance services will increase by 12.25 %, 19.78 %, 18.93 %, 21.66 %, and 18.76 % from year 2020, respectively. The corresponding highest demand levels at their peak are 10,797.08 billion yen, 56,213.90 billion yen, 1,874.34 billion, 10,529.46 billion yen, and 10,727.07 billion yen, respectively. Second, while demand for the product of the pharmaceutical sector becomes highest in year 2040, demand for other 4 sectors becomes highest in year 2046. Third, an expansion of demand for these aging-related products induces more demand for labor in these sectors. In particular, while the combined labor force of both of the social insurance & welfare and the long-term care insurance services sectors is 431 million in year 2020, it will increase to 467.6 million in year 2034. Finally, based on the estimate of labor force of the long-term care insurance sector in year 2018 by the Ministry of Health, Labor and Welfare (MHLW; 2018), labor force of the long-term care insurance sector is estimated to increase to 369.21 million at its peak in year 2034. Since the estimate of labor force of the long-term care insurance sector in year 2018 by the MHLW (2018) is 334 million workers, it should increase by 10.5 % from year 2018 to year 2034 in order to sustain the long-term care insurance sector in a graying Japan. These numerical results indicate that labor mobility in the labor market should be smooth enough without friction to cope with an expansion of demand for products of aging-related sectors.

This paper is organized as follows. The next section introduces the model in detail. Section 3 explains assumptions about the future economy with the benchmark result, and Section 4 presents numerical results in detail. Section 5 concludes the paper.

2 The Model

2.1 Demographic Structure

An overlapping generations economy in discrete time with a model period of one year is considered. Households are homogenous within the same cohort, and the representative household in each cohort is considered. The representative household appears in the economy at age 20 as a decision maker. Although the household faces uncertainty regarding its death in each period, it dies with certainty at the end of its age of 99 if it is alive until age 99. It is assumed that there is no uncertainty regarding the size of the total population in each period. Denote the survival rate of cohort g by $P_{s,g}$, and it is defined by $P_{s,g} = \prod_{i=1}^{s} q_{i,g}$, where $q_{j+1,g}$ is the conditional survival rate of a j years old household which survives to $j+1$ years old of cohort g. $P_{s,g}$ is calculated based on the actual and projected population data.

Due to uncertainty of lifetime in each period, accidental/unintended bequests generated by death of all cohorts exist in each period, and such bequests are distributed to the surviving household in a particular age. Denote the pre-taxed amount of accidental/unintended bequests inherited in age s at time t by $bq_{s,t}$, and each cohort receives the net bequests denoted by $(1 - \tau_{q,t})\, bq_{s,t}$ once in its life, where $\tau_{q,t}$ is the inheritance tax rate at time t. No bequest motives are assumed so that the representative household of each cohort enters an economy with no assets. No liquidity constraint is imposed. The age-specific fertility and mortality rates are time variant, both of which are calculated based on the actual past data and the projection of year 2017 by the IPSS. This implies each cohort has different fertility and mortality rates over time, and $P_{s,g}$ differs among different cohorts.

2.2 The Representative Household

The representative household in each cohort is forward-looking, and future events affect decisions made today. The representative household faces lifetime uncertainty in each period, but there is no other uncertainty such as an income shock through its lifetime[3].

In reality, each household makes a simultaneous decision over consumption of different goods in each time as well as savings over time. This paper considers such simultaneous decision making in the following nested model. At the first stage, the representative household maximizes its expected lifetime utility with respect to its consumption of a composite good and leisure time over time[4]. Then, at the second stage, the representative household divides its consumption of a composite good into different domestic consumption goods in order to maximize its utility defined over different domestic goods in each time.

First Stage[5]*:*

[3]If there is also uncertantiy in lifetime wage income, then precautionary savings motives exist. Thus, with the assumption of no income shocks, the magnitude of the impact of any policy change on savings, thus on the capital labor ratio, will be smaller. However, qualitative results should not be affected. On this aspect, see Kitao (2015a), and Kitao (2015b).

[4]This composite good can be interpretted as GDP minus exports plus the amount used for the intermediate production process in a national account.

[5]The dynamic part of this paper uses the basically similar model to Kato (2018).

At the first stage, the representative household is assumed to maximize its expected lifetime utility with respect to consumption of composite goods and leisure time. The household's expected lifetime utility of cohort g, denoted by $E[V_g]$, is given by

$$E[V_g] = \sum_{s=20}^{99} P_{s,g} (1+\delta)^{-(s-20)} \frac{u(c_{s,t}, l_{s,t})^{1-\rho}}{1-\rho}, \tag{1}$$

where ρ is a reciprocal of the elasticity of substitution between consumption at the different time. δ is the time preference. $c_{s,t}$ and $l_{s,t}$ are consumption of a composite good and leisure of a s years old household at time t, respectively. The definition of a composite good is given by:

$$c_{s,t} = c_{s,t}\left(X_{s,t}^1, X_{s,t}^2, \cdots, X_{s,t}^{15}\right),$$

where $X_{s,t}^i$ $(i = 1, 2, \cdots, 15)$ denotes 15 different final consumption goods produced in 15 different production sectors at time t. The list of 15 different final consumption goods is given in Table 1. Note that there is a relationship of $t = g + s$. The felicity function of u is given by:

$$u(c_{s,t}, l_{s,t}) = \left[c_{s,t}^{\frac{\xi-1}{\xi}} + \kappa l_{s,t}^{\frac{\xi-1}{\xi}}\right]^{\frac{\xi}{\xi-1}}, \tag{2}$$

where ξ denotes the elasticity of substitution between consumption and leisure, and κ denotes the weight parameter for leisure.

The budget constraint of the representative household is:

$$\begin{aligned} a_{s+1,t+1} = {} & [1 + (1-\tau_{r,t}) r_t] a_{s,t} + (1 - \tau_{w,t} - \tau_{p,t} - \tau_{e,s,t}) e_s (1 - l_{s,t}) w_t \\ & + (1-\tau_{w,t}) b_{s,t} + (1-\tau_{q,t}) bq_{s,t} - (1+\tau_{c,t}) c_{s,t} - IC_{s,t} - \theta_t LT_{s,t}, \end{aligned} \tag{3}$$

where $a_{s,t}$ is the amount of assets held by a s years old household at the beginning of time t. e_s is the measure of efficiency of labor of the household, and e_s is the efficiency measure. Labor efficiency is obtained from the data[6].

[6]Basic Survey of Wage Structure (BSWS) of year 2011 and Labor Force Survey (LFS) of year 2012 are

$\tau_{r,t}$, $\tau_{w,t}$, $\tau_{p,t}$,and $\tau_{c,t}$ are the interest income tax rate, the wage income tax rate, the public pension contribution rate, and the consumption tax rate, respectively. $\tau_{e,s,t}$ is the contribution rate to the long-term care insurance (LTCI), which is applied to the representative household while it is working in age s at time t[7]. After retirement, the representative household still has to contribute to the LTCI. The fixed amount of contributions is denoted by $IC_{s,t}$ in age s at time t. Note that an individual starts to contribute to the LTCI once she becomes age 40 in Japan. Between age 40 and 64, all individuals belong to the second group (age group between 40 and 64), and the amount of their contributions depends on their earnings. Their contribution rate is given by $\tau_{e,s,t}$. Once an individual becomes age 65, then she is transferred to the first group (age group of 65 and over), in which she still has to contribute to the LTCI, but the amount of contributions is fixed by $IC_{s,t}$. This paper takes into account such a realistic aspect of the LTCI, and the contribution rate for the second group (age group between 40 and 64) and the fixed amount of contributions for the first group (age group of 65 and over) are both calculated based on A Summary of the Long-term Care Insurance by the Ministry of Health, Labor and Welfare (MHLW; 2017). $LT_{s,t}$ is the total cost of obtaining services through the LTCI, and the θ_t is the co-payment rate at time t. $LT_{s,t}$ is calculated based on Survey of Long-term Care Benefit Expenditure (SLCBE) of year 2014, and $LT_{s,t}$ is assumed to be age-dependent, but time invariant. θ_t is assumed to be 0.1 to reflect the current rate.

$b_{s,t}$ is the amount of public pension benefits in age s at time t[8]. w_t and r_t are the wage rate per the efficiency unit and the interest rate, respectively. Public pension benefits are given by

$$b_t = \begin{Bmatrix} \epsilon_t \left(H_t + \overline{H}_t\right); & s \geq RH \\ 0; & s, < RH \end{Bmatrix}, \tag{4}$$

both used to specify the efficiency profile of each worker over time.

[7]Precisely speaking, although the retirement age is assumed to be fixed at age 65, the positive rate of $\tau_{e,s,t}$ is applied up to age 64, and it becomes zero when the representative household becomes age 65. When the household becomes age 65, it starts paying the fixed amount of contributions.

[8]For more detailed studies on the public pension benefits, see, for instance, Yamada (2011) and İmrohoroğlu et al (2016).

where RH is the retirement age of 65, and fixed through this paper. This implies that the representative household optimally chooses labor supply in intensive margin but not in extensive margin[9]. Public pension benefits are taxed to reflect reality. ϵ_t is the replacement rate[10]. $\overline{H}_t$ and H_t denote the fixed amount of basic pension benefits and earning related benefits, respectively, and H_t is given by:

$$H_t = \frac{1}{RH} \sum_{s=20}^{RH} w_t e_s \left(1 - l_{s,t}\right).$$

It is assumed that the representative household maximizes (1) with respect to $c_{s,t}$ and $l_{s,t}$ subject to (3), and the first order conditions yield the following optimal equations:

$$\begin{aligned} u'\left(c_{s,t}, l_{s,t}\right) u\left(c_{s,t}, l_{s,t}\right)^{-\rho} &= \frac{q_{s+1,g}\left[1 + \left(1 - \tau_{r,t+1}\right) r_{t+1}\right]}{1+\delta} \frac{1+\tau_{c,t}}{1+\tau_{c,t+1}} \\ &\times u'\left(c_{s+1,t+1}, l_{s+1,t+1}\right) u\left(c_{s+1,t+1}, l_{s+1,t+1}\right)^{-\rho}, \qquad (5) \\ l_{s,t} &= \left[\frac{\kappa\left(1+\tau_{c,t}\right)}{\left(1 - \tau_{w,t} - \tau_{p,t} - \tau_{e,s,t}\right) w_t e_s}\right]^{\xi} c_{s,t}, \qquad (6) \end{aligned}$$

where

$$u'\left(c_{s,t}, l_{s,t}\right) = \frac{\partial\left(c_{s,t}, l_{s,t}\right)}{\partial c_{s,t}}.$$

Once the initial consumption of a composite good is given, (5) determines the optimal consumption path over time. The initial consumption is given for the optimal consumption path to satisfy the lifetime budget constraint.

Second Stage[11]*:*

[9] Kitao (2015a), Kitao (2015b), and Kitao(2017) argue the case of both margins.

[10] There are several definitions of the replacement rate of the public pension scheme. See İmrohoroğlu et al (2016) in detail. This paper uses the Japanese official definition of the replacement rate, which is defined as the ratio of pension benefits, which a typical household of a 65 years old husband of category 2 and a wife only with the basic fixed amount of pension benefits receives, to average disposal earnings of category 2 male workres. The replacement rate based on this definition is currently just above 60 %.

[11] The static part of this model is close to Kato (2012).

At the second stage, the representative household divides its consumption of a composite good, which is optimally chosen by itself at the first stage, into 15 different final domestic consumption goods in order to maximize its utility in each time. Its utility is given by:

$$U_g\left(X_{s,t}^1, X_{s,t}^2, \cdots, X_{s,t}^{15}\right) = \sum_{i=1}^{15} \alpha(s)_i \ln X_{s,t}^i, \tag{7}$$

where $X_{s,t}^i$ denotes consumption of a final domestic consumption good i of a s years old household at time t. $\sum_{i=1}^{15} \alpha(s)_i = 1$ is assumed for all ages. In order to capture the impact of population aging on different production sectors, $\alpha(s)_i$ is assumed to depend on ages. i denotes each production sector. The parameter value of each $\alpha(s)_i$ is determined by using the social accounting matrix (SAM) made from the IO Table of year 2011[12].

The representative household is assumed to maximize (7) with respect to its consumption of final domestic consumption goods, $X_{s,t}^1, X_{s,t}^2, \cdots$, and $X_{s,t}^{15}$, subject to its budget constraint such that:

$$\sum_{i=1}^{15} \left(1 + \tau_{c,t}^i\right) p_t^{Q_i} X_{s,t}^i = I_{s,t} - S_{s,t}, \tag{8}$$

where $p_t^{Q_i}$ denotes the price of good i at time t. $\tau_{c,t}^i$ denotes the final consumption tax rate on good i at time t. $I_{s,t}$, net income of age s at time t, is given by:

$$I_{s,t} = \left(1 - \tau_{w,t} - \tau_{p,t} - \tau_{e,s,t}\right) e_s \left(1 - l_{s,t}\right) w_t + \left(1 - \tau_{w,t}\right) b_{s,t} + \left(1 - \tau_{q,t}\right) bq_{s,t} - IC_{s,t} - \theta_t LT_{s,t}.$$

$S_{s,t}$ denotes the amount of savings, which is given by:

$$S_{s,t} = a_{s+1,t+1} - \left[1 + \left(1 - \tau_{r,t}\right) r_t\right] a_{s,t}.$$

Note that both $I_{s,t}$ and $S_{s,t}$ are determined at the first stage, and they are exogenously

[12] Since the actual SAM and the calculated parameter values of $\alpha(s)_i$ are both big data sets, they are provided upon request.

given at the second stage. (3) and (8) imply $\sum_{i=1}^{15} \left(1 + \tau_{c,t}^{i}\right) p_t^{Q_i} X_{s,t}^{i} = \left(1 + \tau_{c,t}\right) c_{s,t}$[13]. Since the optimal $c_{s,t}$ is determined at the first stage, $\left(1 + \tau_{c,t}\right) c_{s,t}$ is exogenously given at the second stage. Note that $\sum_{s=20}^{99} X_{s,t}^{i} = X_t^i$, and the price of X_t^i, $p_t^{Q_i}$, is measured in a time t composite good.

The representative household of each cohort is assumed to supply labor in 15 different production sectors. Denote labor supply in production sector i by $1 - l_{s,t}^{i}$, and $\sum_{i=1}^{15} \left(1 - l_{s,t}^{i}\right) = 1 - l_{s,t}$. Denote also the wage rate in production sector i at time t by w_t^i, and $\sum_{i=1}^{15} w_t^i \left(1 - l_{s,t}^{i}\right) = \left(1 - l_{s,t}\right) w_t$. Both w_t^i and $1 - l_{s,t}^{i}$ are calculated based on the actual social accounting matrix. Note that $l_{s,t}$ is optimally chosen at the first stage but each $l_{s,t}^{i}$ is calculated by using the actual social accounting matrix to make the model consistent to the actual data.

The representative household of each cohort is assumed to maximize (7) with respect to $X_{s,t}^{i}$ subject to (8) in each time, and the first order conditions yield the demand functions such that:

$$X_{s,t}^{i} = X_{s,t}^{i}\left(p_i, I_{s,t}, S_{s,t}; \alpha_i\right) = \frac{\alpha\left(s\right)_i \left(I_{s,t} - S_{s,t}\right)}{\left(1 + \tau_{c,t}^{i}\right) p_t^{Q_i}}, \; i = 1, 2, \cdots, 15. \qquad (9)$$

Note that $\alpha\left(s\right)_i$ can be calculated by using (9) and the actual social accounting matrix so that:

$$\alpha\left(s\right)_i = \frac{\left(1 + \tau_{c,t}^{i}\right) p_t^{Q_i} X_{s,t}^{i}}{I_{s,t} - S_{s,t}}, \; i = 1, 2, \cdots, 15,$$

where both the values of the denominator and the numerator can be obtained from the actual SAM.

2.3 The Firm

Following the conventional assumption of the static CGE model, the multiple decisions by each firm are described by the tree structure in the nested form, where each firm is assumed

[13] The value of $\tau_{c,t}$ is given by using $\tau_{c,t}^{i}$, which can be calculated from the actual SAM for all i.

to make a decision over several different items in each time. In the tree structure, the optimal behavior of each firm which makes a decision over different items is described as if the firm always makes a decision over two different items at different steps[14]. Each firm makes a decision over different items; the amount of exports of its own product, the amount of imported goods and intermediate goods used for its production, and the amount of labor and capital used in its production. This assumption simplifies a complicated decision over several items by each firm.

At step 1, a representative private firm in sector i ($i = 1, 2, \cdots, 15$) is assumed to use labor and capital to produce its first stage good such as a MVP (minimum viable product), Y_t^i at time t. Then, the firm is assumed to produce its good, Z_t^i, by using its own Y_t^i and $X_{i,j,t}$ at the second step. $X_{i,j,t}$ denotes a final domestic consumption good produced by firm j used by firm i for its production at time t. Thus, $X_{i,j,t}$ is the amount of a final domestic consumption good produced by firm j for the intermediate production process of firm i. At the third step, the firm is assumed to decompose its good, Z_t^i, into an exported good, E_t^i, and a good, D_t^i. This step is concerned about its optimal decision over the amount of its product to be exported. At the final step (the fourth step), the firm is assumed to produce its final domestic consumption good, Q_t^i, by using its good, D_t^i, and an imported good, M_t^i, at time t. This step corresponds to its optimal decision over how much it uses an imported good, M_t^i, and its own goods, D_t^i, to produce its final domestic consumption good, Q_t^i, which is consumed by the household and the government, and it is also used by the firm of sector i in its intermediate production process. The assumption of this tree structure in terms of different decisions can incorporate firm's complicated decisions over the amount of exports of its own product, the amount of imported goods and intermediate goods which the firm uses in its production process, and the amount of factor inputs into the model in a tractable way.

Note that all market clearing conditions are used to determine all prices endogenously

[14]For the detailed tree structure, see Kato (2012).

in their corresponding markets, and also that at each step the private firm is assumed to determine the amount of relevant variables in order to maximize its profit.

By the assumption of the above tree structure, all decision making processes can be simplified, and the optimal behavior about all different decisions can be incorporated as follows:

Step 1: The production of the first stage good

Each firm is assumed to produce its first stage good such as a MVP by using capital and labor. Each firm is assumed to maximize its profit given by:

$$\pi_t^i = p_t^{Yi} Y_t^i \left(K_t^i, L_t^i\right) - \delta_t^i K_t^i - w_t^i L_t^i, \tag{10}$$

where Y_t^i and p_t^{Yi} denote the first stage good produced by firm i and its price at time t, respectively. K_t^i and L_t^i denote capital and labor used by the firm in sector i in order to produce its first stage good at time t, respectively. K_t^i and L_t^i are both assumed to be sector i specific capital and labor, respectively. δ_t^i and w_t^i are the rental price of capital and the wage rate of labor in sector i at time t, respectively. The production technology is given by:

$$Y_t^i \left(K_t^i, L_t^i\right) = \Omega_t^i \left(K_t^i\right)^{\beta_{K,i}} \left(L_t^i\right)^{\beta_{L,i}}, \ i = 1, 2, \cdots, 15, \tag{11}$$

where $\beta_{K,i} + \beta_{L,i} = 1$ is assumed for all $i = 1, 2, \cdots, 15$. Both $\beta_{K,i}$ and $\beta_{L,i}$ are assumed to be time-invariant for all $i = 1, 2, \cdots, 15$. Ω_t^i expresses firm i's production technology at time t. Each firm is assumed to maximize (10) with respect to labor and capital subject to (11), and the first order conditions yield the demand functions such that:

$$K_t^i = K_t^i \left(p_t^{Yi}, \delta_t^i, w_t^i; \beta_{K,i}, \beta_{L,i}\right) = \frac{\beta_{K,i}}{\delta_t^i} p_t^{Yi} Y_t^i, \tag{12a}$$

$$L_t^i = L_t^i \left(p_t^{Yi}, \delta_t^i, w_t^i; \beta_{K,i}, \beta_{L,i}\right) = \frac{\beta_{L,i}}{w_t^i} p_t^{Yi} Y_t^i, \ i = 1, 2, \cdots, 15. \tag{12b}$$

Note that $\beta_{K,i}$ and $\beta_{L,i}$ can be calculated by using (12a), (12b), and the actual social accounting matrix so that:

$$\beta_{K,i} = \frac{\delta_t^i K_t^i}{p_t^{Y_i} Y_t^i},$$
$$\beta_{L,i} = \frac{w_t^i L_t^i}{p_t^{Y_i} Y_t^i}, \ i = 1, 2, \cdots, 15,$$

where $\delta_t^i K_t^i, w_t^i L_t^i$, and $p_t^{Y_i} Y_t^i$ can be obtained from the actual SAM of year 2011. The estimated values of $\beta_{K,i}$ and $\beta_{L,i}$ for year 2011 are given in Table 2.

Step 2: The production of Z_t^i

Each firm is assumed to produce its good, Z_t^i at time t, by using intermediate goods and its own good, Y_t^i, which production has been described at step 1. The optimal behavior of each firm in terms of production of its good, Z_t^i, can be described such that:

$$\underset{Y_i, X_{i,j}}{Max} \ \pi_t^i = p_t^{Z_i} Z_t^i - \left(p_t^{Y_i} Y_t^i - \sum_j^{15} p_{j,t}^X X_{i,j,t} \right),$$
$$st \quad Z_t^i = \min \left(\frac{X_{i,j,t}}{ax_{i,j}}, \frac{Y_t^i}{ay_i} \right), \ i = 1, 2, \cdots, 15,$$

where $X_{i,j,t}$ and $p_{j,t}^X$ denote an intermediate good j used by firm i and its price at time t, respectively. $p_t^{Z_i}$ is the price of Z_t^i. $ax_{i,j}$ denotes the amount of intermediate good j used for producing one unit of a final domestic consumption good produced by firm i, and ay_i denotes the amount of its own good, Y_t^i, for producing one unit of its good, Z_t^i. Both $ax_{i,j}$ and ay_i are assumed to be time-invariant for all $i = 1, 2, \cdots, 15$. The estimated values of ay_i for year 2011 are given in Table 3[15]. Note that the production function at this step is assumed to be the Leontief type. Using $ax_{i,j}$ and ay_i, and assuming that the market is fully

[15] The estimated values of $ax_{i,j}$ are not presented in Table 3, since the number of the estimated values reaches 225. The estimated values are given upon request.

competitive, the zero-profit condition can be written by:

$$p_t^{Z_i} = p_t^{Y_i} ay_i + \sum_{j}^{15} p_{j,t}^{X} ax_{i,j}, \ i = 1, 2, \cdots, 15. \tag{13}$$

Step 3: Decomposition of Z_t^i into an exported good and a good used for production of its final domestic consumption good

The optimal decision made by the firm in sector i in terms of the amount of exports of its own good is described as the the decomposition of Z_t^i ($i = 1, 2, \cdots, 15$) into an exported good, E_t^i, and a good for producing its final domestic consumption good, D_t^i. Each firm is assumed to maximize its profit such that:

$$\pi_t^i = p_t^{e_i} E_t^i + p_t^{d_i} D_t^i - \left(1 + \tau_{i,t}^p - \tau_{i,t}^s\right) p_t^{Z_i} Z_t^i, \tag{14}$$

where $p_t^{e_i}$ and $p_t^{d_i}$ denote the price when the good is sold abroad, and the price when its good, D_t^i, is used for producing its final domestic consumption good, respectively. Note that $p_t^{e_i}$ is measured in the domestic currency. $\tau_{i,t}^p$ and $\tau_{i,t}^s$ are the tax rates of a production tax imposed on the production of Z_t^i and the subsidy rate at time t, respectively. The values of $\tau_{i,t}^p$ and $\tau_{i,t}^s$ are calculated by using the actual SAM, and the calculated values are given in Table 4 for year 2011. The decomposition is assumed to follow the Cobb-Douglas technology such that:

$$Z_t^i = \left(E_t^i\right)^{\kappa_i^e} \left(D_t^i\right)^{\kappa_i^d}, \ i = 1, 2, \cdots, 15, \tag{15}$$

where $\kappa_i^d + \kappa_i^e = 1$ ($i = 1, 2, \cdots, 15$) is assumed. Both κ_i^d and κ_i^e are assumed to be time-invariant for all $i = 1, 2, \cdots, 15$. Each firm is assumed to maximize (14) with respect to E_t^i and D_t^i subject to (15), and the first order conditions yield

$$E_t^i = E_t^i\left(p_t^{e_i}, p_t^{d_i}, p_t^{Z_i}; \tau_{i,t}^p, \tau_{i,t}^s, \kappa_i^d, \kappa_i^e\right) = \frac{\kappa_i^e\left(1+\tau_{i,t}^p - \tau_{i,t}^s\right) p_t^{Z_i} Z_t^i}{p_t^{e_i}}, \tag{16a}$$

$$D_t^i = D_t^i\left(p_t^{e_i}, p_t^{d_i}, p_t^{Z_i}; \tau_{i,t}^p, \tau_{i,t}^s, \kappa_i^d, \kappa_i^e\right) = \frac{\kappa_i^d\left(1+\tau_{i,t}^p - \tau_{i,t}^s\right) p_t^{Z_i} Z_t^i}{p_t^{d_i}}, \ i = 1, 2, \cdots, 15. \tag{16b}$$

Note that κ_i^e and κ_i^d can be calculated by using (16a), (16b) for year 2012, and the actual social accounting matrix so that:

$$\kappa_i^e = \frac{p_t^{e_i} E_t^i}{\left(1+\tau_{i,t}^p - \tau_{i,t}^s\right) p_t^{Z_i} Z_t^i},$$
$$\kappa_i^d = \frac{p_t^{d_i} D_t^i}{\left(1+\tau_{i,t}^p - \tau_{i,t}^s\right) p_t^{Z_i} Z_t^i}, \ i = 1, 2, \cdots, 15,$$

where $p_t^{e_i} E_t^i$, $p_t^{d_i} D_t^i$, $p_t^{Z_i} Z_t^i$, $\tau_{i,t}^s p_t^{Z_i} Z_t^i$, and $\tau_{i,t}^p p_t^{Z_i} Z_t^i$ can be obtained from the actual SAM of year 2011. The estimated values of κ_i^e and κ_i^d are given in Table 5.

Step 4: The Production of its final domestic consumption good

Denote the final domestic consumption good produced in sector i by Q_t^i ($i = 1, 2, \cdots, 15$) at time t. This final domestic consumption good is consumed by the representative household. The final domestic consumption good is assumed to be produced by using its good, D_t^i, and an imported good, M_t^i. This step corresponds to the optimal decision making behavior of each firm in terms of the amount of imported goods which are used in its production process. The production technology at this final step is given by the following Cobb-Douglas function:

$$Q_t^i = \left(M_t^i\right)^{\gamma_i^m} \left(D_t^i\right)^{\gamma_i^d}, \ i = 1, 2, \cdots, 15, \tag{17}$$

where $\gamma_i^m + \gamma_i^d = 1$ ($i = 1, 2, \cdots, 15$) is assumed. Both γ_i^m and γ_i^d are assumed to be time-invariant for all $i = 1, 2, \cdots, 15$. Each firm is assumed to maximize its profit with respect to

M_t^i and D_t^i subject to (17). Its profit is given by:

$$\pi_t^i = p_t^{Q_i} Q_t^i - \left(1 + \tau_{i,t}^m\right) p_t^{m_i} M_t^i - p_t^{d_i} D_t^i, \; i = 1, 2, \cdots, 15,$$

where $p_t^{Q_i}$ and $\tau_{i,t}^m$ denote the price of its final consumption goods, Q_t^i, and the import tariff rate, respectively. The import tariff rate is calculated by using the actual SAM, and it is given in Table 4. Then, the first order conditions yield

$$M_t^i = M_t^i \left(p_t^{m_i}, p_t^{d_i}, p_t^{Q_i}; \tau_{i,t}^m, \gamma_i^m, \gamma_i^d\right) = \frac{\gamma_i^m p_t^{Q_i} Q_t^i}{\left(1 + \tau_{i,t}^m\right) p_t^{m_i}}, \tag{18a}$$

$$D_t^i = D_t^i \left(p_t^{m_i}, p_t^{d_i}, p_t^{Q_i}; \tau_{i,t}^m, \gamma_i^m, \gamma_i^d\right) = \frac{\gamma_i^d p_t^{Q_i} Q_t^i}{p_t^{d_i}}, \; i = 1, 2, \cdots, 15. \tag{18b}$$

Note that γ_i^m and γ_i^d can be calculated by using (18a), (18b), and the actual SAM of year 2011 so that:

$$\gamma_i^m = \frac{\left(1 + \tau_{i,t}^m\right) p_t^{m_i} M_t^i}{p_t^{Q_i} Q_t^i},$$
$$\gamma_i^d = \frac{p_t^{d_i} D_t^i}{p_t^{Q_i} Q_t^i}, \; i = 1, 2, \cdots, 15,$$

where $p_t^{m_i} M_t^i$, $p_t^{d_i} D_t^i$, $p_t^{Q_i} Q_t^i$ and $\tau_{i,t}^m p_t^{m_i} M_t^i$ can be obtained from the actual SAM. The estimated values of γ_i^m and γ_i^d are given in Table 6.

2.4 The Government

Since the purpose of this paper is to explore the impact of population aging, three separate accounts of the government sector are explicitly considered; the general account, the public pension account, and the long-term care insurance account. The government issues government bonds, and accumulates the public pension fund. Each account is separately considered as follows.

2.4.1 General Account

The budget constraint of the general account is such that:

$$DB_t - DB_{t-1} = AG_t + r_t DB_{t-1} + PP_t + EE_t - R_t, \tag{19}$$

where DB_t denotes the amount of outstanding government debts at time t. AG_t is the total government expenditure. PP_t is the amount of transfers from the general account to the public pension account at time t. EE_t is the amount of transfers from the general account to the long-term care insurance account at time t. R_t is the total tax revenue, which is given by:

$$R_t = \tau_{w,t}\left(w_t L_t + AB_t\right) + \tau_{r,t} r_t AS_t + \tau_{c,t} AC_t + \tau_{q,t} BQ_t + TP_t + TM_t - SB_t, \tag{20}$$

The total labor income at time $t, w_t L_t$, is given by:

$$w_t L_t = \sum_{s=20}^{RH} e_s \sum_{i=1}^{15} w_t^i \left(1 - l_{s,t}^i\right) POP_{s,t} = \sum_{s=20}^{RH} e_s w_t \left(1 - l_{s,t}\right) POP_{s,t}, \tag{21}$$

where $POP_{s,t}$ denotes the total population of age s at time t.

The aggregated values of pension benefits (AB_t), private savings (AS_t), consumption of a composite good (AC_t), and bequests(BQ_t) are given as follows:

$$AB_t = \sum_{s=RH}^{99} b_{s,t} POP_{s,t},$$
$$AS_t = \sum_{s=20}^{99} a_{s,t} POP_{s,t},$$
$$AC_t = \sum_{s=20}^{99} c_{s,t} POP_{s,t},$$
$$BQ_t = \sum_{s=20}^{99} bq_{s,t} POP_{s,t}.$$

The government imposes a production tax and an import tax on 15 production sectors, and also subsidies these production sectors. The total production tax revenue (TP_t), the total import tax revenue(TM_t), and the total subsidies(SB_t) to 15 production sectors are given by:

$$TP_t = \sum_{i=1}^{15} \tau_{i,t}^{p} p_t^{Z_i} Z_t^i,$$
$$TM_t = \sum_{i=1}^{15} \tau_{i,t}^{m} p_t^{m_i} M_t^i,$$
$$SB_t = \sum_{i=1}^{15} \tau_{i,t}^{s} p_t^{Z_i} Z_t^i.$$

The total government expenditure(AG_t) is given by:

$$AG_t = \sum_{i=1}^{15} p_t^{Q_i} X_t^{g_i},$$

where $X_t^{g_i}$ denotes consumption of the final consumption good i by the government at time t[16].

2.4.2 Public Pension Account

On the public pension account, the budget constraint is such that:

$$F_t - F_{t-1} = r_t F_{t-1} + PP_t + CP_t - AB_t, \tag{22}$$

where F_t denotes the accumulated pension fund at time t. CP_t is the total amount of contributions collected at time t, which is given by:

$$CP_t = \tau_{p,t} \sum_{s=20}^{RH} w_t e_s \left(1 - l_{s,t}\right) POP_{s,t}.$$

[16] $p_t^{Z_i}$, $p_t^{m_i}$, and $p_t^{Q_i}$ are all measured in a composite good, c_t, at time t.

2.4.3 Long-term Care Insurance (LTCI) Account

The budget constraint of the long-term care insurance (LTCI) is given by:

$$TLT_t = FIC_t + TIC_t + OIC_t + EE_t, \tag{23}$$

where TLT_t is the total expenditure in the account at time t, and it is given by:

$$TLT_t = \sum_{s=RH-1}^{99} (1-\theta_t)\, LT_{s,t} POP_{s,t}. \tag{24}$$

EE_t is the amount of transfers from the general account to the long-term care insurance account at time t. $LT_{s,t}$ is the total cost through the LTCI, and the θ_t is the co-payment rate imposed on the representative household at time t. $POP_{s,t}$ denotes the total population of age s at time t.

FIC_t and TIC_t, are aggregated revenues contributed by each household at time t, which are such that:

$$FIC_t = \sum_{s=40}^{RH-1} \tau_{e,s,t} e_s \sum_{i=1}^{15} w_t^i \left(1 - l_{s,t}^i\right) POP_{s,t} = \sum_{s=40}^{RH-1} \tau_{e,s,t} e_s \left(1 - l_{s,t}\right) w_t POP_{s,t},$$

$$TIC_t = \sum_{s=RH}^{99} IC_{s,t} POP_{s,t}.$$

Note that FIC_t and TIC_t are the total contributions by the household which belongs to the first group between age 40 and 64, and to the second group between age 65 and over, respectively. To capture the realistic aspect, while FIC_t depends on wage income, TIC_t is the total amount of fixed contributions by the second group. The household has to pay a part of the total cost as a co-payment when it receives services through the long-term care insurance. The current co-payment rate, θ, is 10 %. OIC_t is the total amount the household pays by itself when it receives services through the long-term care insurance at time t, which is given by:

$$OIC_t = \sum_{s=RH-1}^{99} \theta_t LT_{s,t} POP_{s,t}.$$

In order to reflect reality, $\tau_{e,s,t}$ and $IC_{s,t}$ are both endogenously calculated to satisfy (6) in the following simulations.

2.5 Mobility of Factor Inputs among Different Production Sectors

The assumption on the degree of mobility of a factor input in the factor market is crucial to determine the equilibrium price of the factor input. It is assumed that sector specific factor inputs are used in each production sector so that factor inputs used among different production sectors are assumed to be different. This implies that labor and capital can be assumed to be immobile among different production sectors at least in the short run. However, through the training process of labor and different investment behavior over time, labor and capital become more mobile over time if the wage rate and the rental price are different among different production sectors. Factor inputs keep moving among different production sectors until the unique equilibrium prices are determined in the whole factor markets in the long run. Then, this paper considers two different assumptions; the short run, and the long run. In the short run, both labor and capital are completely immobile between different production sectors, so that different equilibrium prices of labor and capital are determined in factor markets of each production sector. On the other hand, in the long run, both labor and capital are completely mobile between different production sectors, so that the unique equilibrium prices of labor and capital are determined. Note that the paper only focuses on the domestic market so that equilibrium factor prices are determined in domestic factor markets under the assumption that economic environments of the world economy remain unchanged over time.

2.5.1 The Labor Market

The labor market equilibrium condition in each period for all i $(i = 1, 2, \cdots, 15)$ is given by:

$$\sum_{s=20}^{RH} e_s \left(1 - l_{s,t}^i\right) POP_{s,t} = L_t^i, \tag{25}$$

and the equilibrium wage rate is determined by (25). In the short term, labor is completely immobile and supply of labor in each production sector is completely fixed at a certain level, $\overline{l_{s,t}^i}$, and different values of w_t^i are determined by (25) for the fixed amount of $\sum_{s=20}^{RH} e_s \left(1 - l_{s,t}^i\right) = \sum_{s=20}^{RH} e_s \left(1 - \overline{l_{s,t}^i}\right)$ for all $i\,(i = 1, 2, \cdots, 15)$. In this case, it is assumed that $\sum_{i=1}^{15} \varphi_i w_t^i = w_t$ in (3), where φ_s is a weight parameter and $\sum_{i=1}^{15} \varphi_i = 1$[17].

In the long run, the household learns to equip itself with sector specific labor, and labor completely becomes mobile among different production sectors. Then the unique equilibrium wage rate, $w_t = w_t^i$ for all i, is determined to satisfy (25). Note that demand for labor by production sector, i, denoted by L_t^i, can be different among different production sectors due to different production technology described by (11). This implies that equilibrium labor supply in sector i can be different among different production sectors, and labor supply in each production sector keeps changing until the unique equilibrium wage rate is determined in all factor specific labor markets of 15 different production sectors.

2.5.2 The Capital Market

The capital market equilibrium condition in each period for all i $(i = 1, 2, \cdots, 15)$ is given by:

$$\sum_{s=20}^{99} K_{s,t}^i = K_t^i, \tag{26}$$

and the equilibrium rental price is determined by (26). In the short run, capital is completely immobile and supply of capital owned by the household of age s in each production sector is completely fixed at a certain level, $\overline{K_{s,t}^i}$, and different values of the rental price, δ_t^i, are

[17] The values of φ_i are calculated from the actual SAM.

determined by (26) for the fixed amount of $\sum_{s=20}^{99} K_{s,t}^{i} = \sum_{s=20}^{99} \overline{K_{s,t}^{i}}$ for all i ($i = 1, 2, \cdots, 15$). It is assumed that immobility of capital is caused by the adjustment cost denoted by ξ_t^i.

In the long run, the household changes its investment behavior if the rental prices of capital are different among different production sectors, and capital completely becomes mobile among different production sectors. Then the unique equilibrium rental price, $\delta_t = \delta_t^i$ for all i, is determined to satisfy (26). Note that demand for capital by production sector, i, denoted by K_t^i, can be different among different production sectors due to different production technology described by (11). This implies that equilibrium capital supply in sector i can be different among different production sectors, and capital supply in each production sector keeps changing until the unique equilibrium rental price is determined in all factor specific capital markets of 15 different production sectors.

2.6 Competitive Equilibrium

For a given sequence of all demographic parameters, $\{POP_t, P_{t-g}\}_{t=0}^{\infty}$, given sequences of all government policies, $\left\{DB_t, F_t, \tau_{w,t}, \tau_{r,t}, \tau_{c,t}, \tau_{q,t}, \tau_{p,t}, \tau_{e,s,t}, \tau_{e,RH-1,t}, \theta_t, b_t, IC_{s,t}, \epsilon_t, \overline{H}_t\right\}_{t=0}^{\infty}$ and $\left\{\tau_{i,t}^{p}, \tau_{i,t}^{m}, \tau_{i,t}^{s}; i = 1, 2, \cdots, 15\right\}_{t=0}^{\infty}$, and a given sequence of elderly care services, $\{LT_{s,t}\}_{t=0}^{\infty}$, the perfect foresight competitive equilibrium is defined as the sequences of $\{r_t, w_t\}_{t=0}^{\infty}$, $\{\delta_t^i, w_t^i; i = 1, 2, \cdots, 15\}_{t=0}^{\infty}$, and $\left\{p_t^{Q_i}; i = 1, 2, \cdots, 15\right\}_{t=0}^{\infty}$, which satisfy the following conditions:

1. The optimal conditions for the representative household, (5) and (6), are satisfied for all generations in each period with the non-ponzi condition.

2. The optimal condition for the representative household, (9), is satisfied for all generations in each period.

3. The optimal conditions for the firm, (12a), (12b), (13), (16a), (16b), (18a), and (18b), are satisfied in each period.

4. Three budget constraints for the government, (19), (22), and (23), are satisfied in each period.

5. The market equilibrium condition for the final domestic consumption good is satisfied in each period for each i $(i = 1, 2, \cdots, 15)$ such that:

$$Q_t^i = \sum_{s=20}^{99} X_{s,t}^i + X_t^{g_i} + \sum_{j=1}^{15} X_{i,j,t} + X_t^{s_i},$$

where $X_t^{s_i}$ denotes the amount of investments by sector i at time t. Note that $X_t^{s_i} = \frac{\delta_t^i}{P_t^{Q_i}} \left(K_{t+1}^i - (1 - \varphi_t) K_t^i \right)$, where φ_t is the depreciation rate at time t and it is assumed to be the same among all production sectors[18],[19]. Note that this paper only considers the domestic consumption good market[20].

6. The labor market equilibrium condition, (25), is satisfied in each period for all i $(i = 1, 2, \cdots, 15)$.

7. The capital market equilibrium condition, (26), is satisfied in each period for all i $(i = 1, 2, \cdots, 15)$.

8. The asset market equilibrium condition is satisfied in each period such that:

$$AS_t + F_t + S_t^f = K_t + DB_t,$$

where $K_t = \sum_{i=1}^{15} \sum_{s=20}^{99} \delta_t^i K_{s,t}^i$, and S^f denotes the total amount of savings by the foreign sector, or the deficits in the current account. S^f is given by:

$$S^f = \sum_{i=1}^{15} p_t^{m_i} M_t^i - \sum_{i=1}^{15} p_t^{e_i} E_t^i.$$

Since $p_t^{e_i}$ and $p_t^{m_i}$ are both measured in the domestic composite good, they are also expressed

[18]Since the amount of investments by the production sector in the actual Input-Output Table is not negligibly low for some sectors, the amount of investments is included in this equilbrium condition.

[19]$X_t^{s_i}$ and K_{t+1}^i are assumed to be different goods.

[20]This implies that the value of contributions by sector i to the Gross Domestic Product (GDP) is given by:
$p_t^{Q_i} Q_t^i + p_t^{e_i} E_t^i - \sum_j^{15} p_t^{Qi} X_{i,j,t}$.

such that:

$$p_t^{e_i} = \varepsilon_t p_t^{w,e_i},$$
$$p_t^{m_i} = \varepsilon_t p_t^{w,m_i}, \; i = 1, 2, \cdots, 15,$$

where ε_t denotes the exchange rate, and p_t^{w,e_i} and p_t^{w,m_i} are world prices of the exported good produced in sector i and imported goods used in sector i, respectively. The world prices are assumed to be exogenously given, and this implies that the exchange rate is endogenously determined within the model.

9. The efficient market condition is satisfied in each period for all i ($i = 1, 2, \cdots, 15$). In the short run, the efficient market condition is given by:

$$r_t = \delta_t^i - \varphi_t - \xi_t^i.$$

In the long run, the efficient market condition is given by:

$$r_t = \delta_t - \varphi_t,$$

where δ_t is the equilibrium rental price determined by (26) in the long run.

10. The sequence of the consumption tax rate, $\{\tau_{c,t}\}$, is endogenously determined to satisfy (19) from year 2021.

11. The sequence of the contribution rate of the public pension scheme, $\{\tau_{p,t}\}$, is endogenously determined to satisfy (22) until year 2017.

12. The sequence of the replacement rate of the public pension scheme, $\{\epsilon_t\}$, is endogenously determined to satisfy (22) from year 2018.

13. The sequence of the revenue instruments of the LTCI, $\{\tau_{e,s,t}, \tau_{e,RH-1,t}, IC_{s,t}\}$, is endogenously determined to satisfy (23) in each period.

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 2020) 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 (2020) 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[21]. 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[22]. 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[23]. The demographic structure before year 1920 is assumed to have the same distribution

[21]The populaiton 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.

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

[23]The data of age 85 and over from year 1920 to 1946 was calculated based on the actual survival rate of

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 2.

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 in (1) and (2) 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 (Ω_t). Note that in EFPMLA (2020) the future economic growth rates are given as targeted values. This paper exogenously gives the value of Ω_t 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 (2020). Figure 2 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 (2020), 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 Ω_t is exogenously given, in order for the model value of endogenously calculated economic growth rate of GDP to become

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.

close to the value assumed in EFPMLA (2020). The exogenously calculated value of Ω_t is shown in Figure 3. 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[24] of several key variables such as the future primary balance and economic growth as targeted figures[25].

In EFPMLA (2020), there are two assumptions on the future economic environment up to year 2029; a recovery case and a baseline case. Figure 4-1 to 4-3 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 (2020).

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 (2020) 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 5-1.

The consumption tax rate is assumed to be endogenously calculated from year 2021 in

[24] 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)).

[25] 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.

order to satisfy (19)[26]. 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 (19)[27]. 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 is 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 5-2 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.

A half of the total amount of basic pension benefits is transferred annually from the general account in reality, which is P_t in (19) and (22). This paper incorporates this fact[28].

The contribution rate ($\tau_{p,t}$) and the replacement rate (ϵ_t) are used as policy instruments in order to satisfy (22). 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 (22). From year 2018 the contribution rate is exogenously given at 18.3%, and the replacement rate is endogenously

[26]As pointed by Kitao (2015a), the wage income tax is more distortinary 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.

[27]The exogenously given values of the consumption tax rate in all simuations 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.

[28]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%.

calculated to satisfy (22)[29]. From year 2018 the replacement rate becomes a new policy instrument to satisfy (22).

The MHLW reported that the replacement rate in year 2009 was 62.3 %[30], 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 amount 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 (E_t). 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 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

[29] 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%.

[30] Note that this is the offical 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).

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 ($\tau_{e,s,t}$) for the second group and the fixed amount of contributions ($IC_{s,t}$) for the first group to satisfy (6), 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[31]. 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 3, in order to realize the assumption of the baseline case in EFPMLA (2020).

[31] The data set of consumption of the household contains 1215 obsersations of each of the actual and model values, and it can be provided upon request.

4 Impact of Population Aging

4.1 On Demand

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; the pharmaceutical products, medical services, public hygiene, social insurance & welfare, and long-term care insurance services. This paper particularly pays more attention to the impact on these 5 production sectors. Figure 6-1 and 6-2 show the impact of population aging on demand for these 5 production sectors[32]. Demand for the medical services sector is much higher than other 4 sectors, and it is shown separately in Figure 6-1. Indeed, demand for all 5 sectors is expected to increase due to population aging. Compared to the demand level in year 2020, demand for the medical services, the pharmaceutical, the social insurance & welfare, and the long-term care insurance services sectors will increase to their peak levels by 19.78 %, 12.25 %, 21.66 %, and 18.76 %, respectively. The corresponding highest demand levels at their peak are 56,213.90 billion yen, 10,797.08 billion yen, 10,529.46 billion yen, and 10,727.07 billion yen, respectively.

While demand for these 5 sectors will all increase, their peaks will come in a different time. While the peak of demand for the pharmaceutical sector will come in year 2040, the peaks of other 4 sectors will come in year 2046[33]. Note that demand for all 5 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 for these 5 sectors[34] in the future.

[32]Since the economic size of the public hygiene sector is much smaller than other 4 sectors, it is not shown in both figures.

[33]Demand for products of the public hygiene sector will increase by 18.93 % from its level of year 2020 at its peak in year 2046.

[34]While the per capita GDP is forecasted to increase due to the srong assumption in EFPMLA (2020), 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.

4.2 On Labor Income

Since demand for these 5 sectors will increase in a graying Japan, more labor inputs are needed to cope with higher demand. Figure 7-1 and 7-2 show the total labor income of the 4 sectors. Since the pharmaceutical sector is less labor intensive than others, its labor income is much smaller. Note also that both of the social insurance & welfare sector and the long-term care insurance services sector are more labor intensive.

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 the goods of these sectors could not be fulfilled. This implies that stable economic growth of a graying Japan depends on the extent how much 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 labor force of the pharmaceutical sector is much smaller than other sectors, and it is separately shown in Figure 8-2. Note also that the experiment was conducted based on the actual data of Labor Force Survey unyil 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 467.6 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. Figure 8-3 shows the future labor force of the long-term care insurance sector based on the estimate of year 2018 by MHLW (2018). Then, in year 2034, the labor force needed in the long-term care insurance sector is estimated to be 369.21 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. In particular, 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. Compared to the demand in year 2020 with their highest value, demand for these 5 sectors will increase by 12.25 %, 19.78 %, 18.93 %, 21.66 %, and 18.76 % from year 2020, respectively. The increase in demand also induces higher demand for labor in these sectors, and the combined labor force of both of the social insurance & welfare and the long-term care insurance services sectors will increase to 467.6 million in year 2034. 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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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

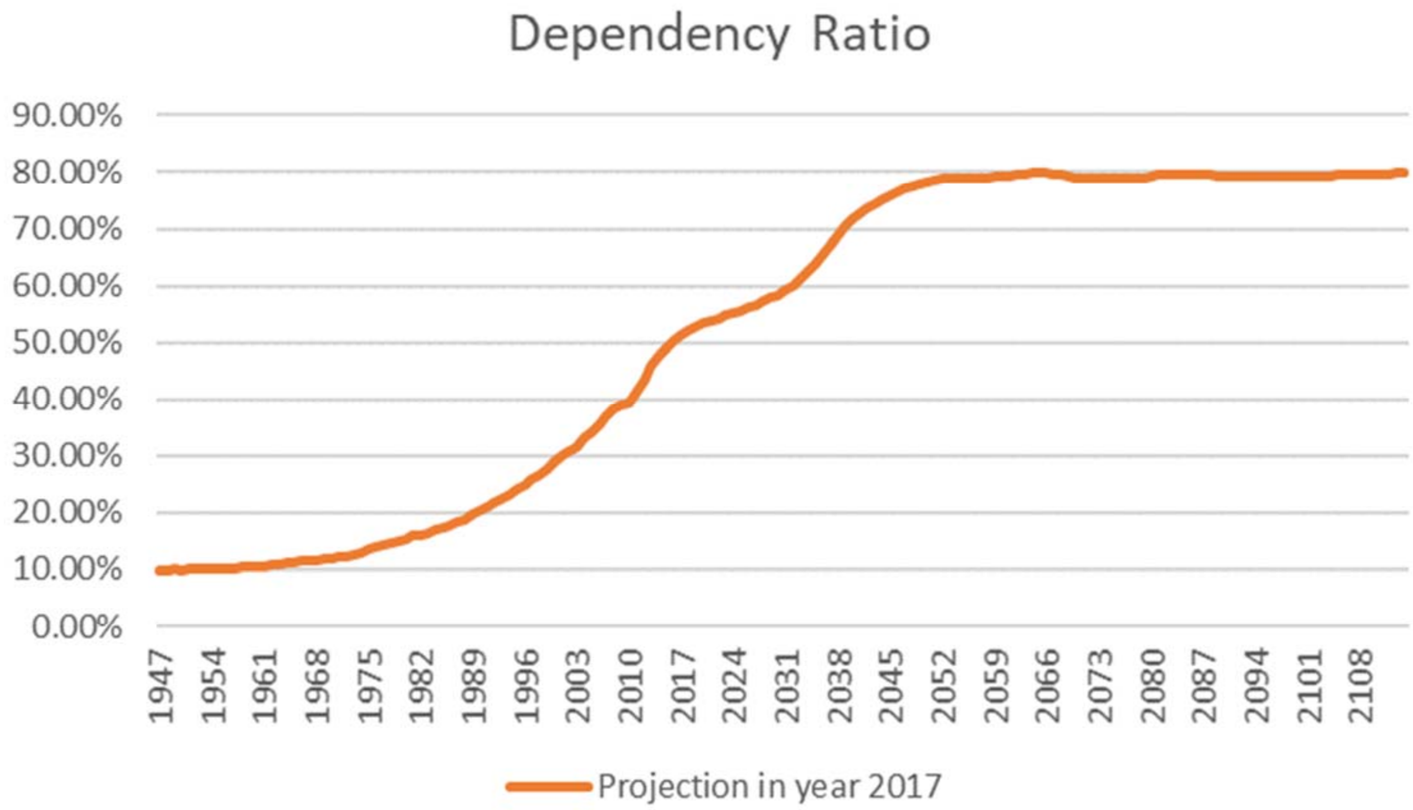
Table 6 (Static part of the model)

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)

Figure 1



Dependency Ratio
90.00%
80.00%
70.00%
60.00%
50.00%
40.00%
30.00%
20.00%
10.00%
0.00%
1947
1954
1961
1968
1975
1982
1989
1996
2003
2010
2017
2024
2031
2038
2045
2052
2059
2066
2073
2080
2087
2094
2101
2108
Projection in year 2017

Figure 2

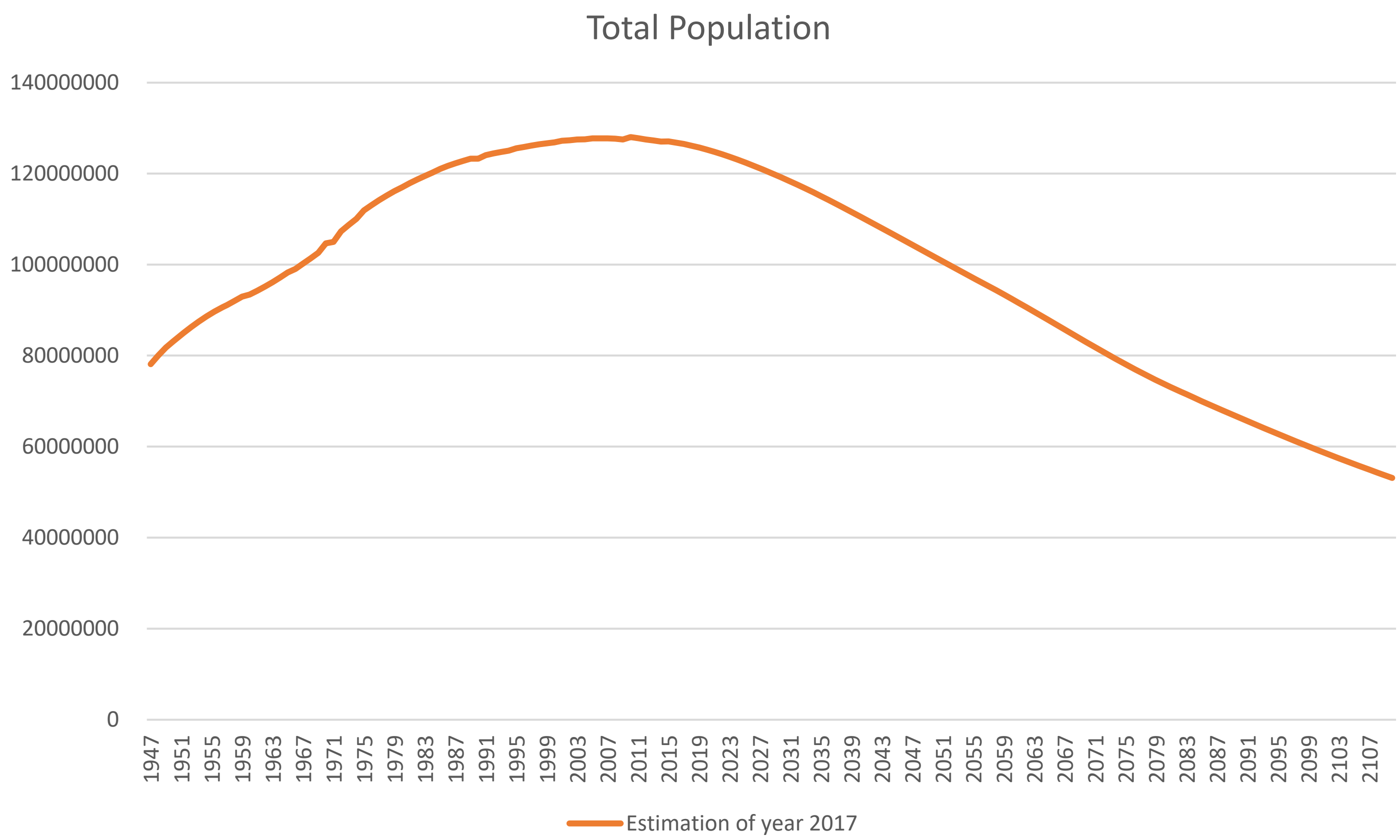
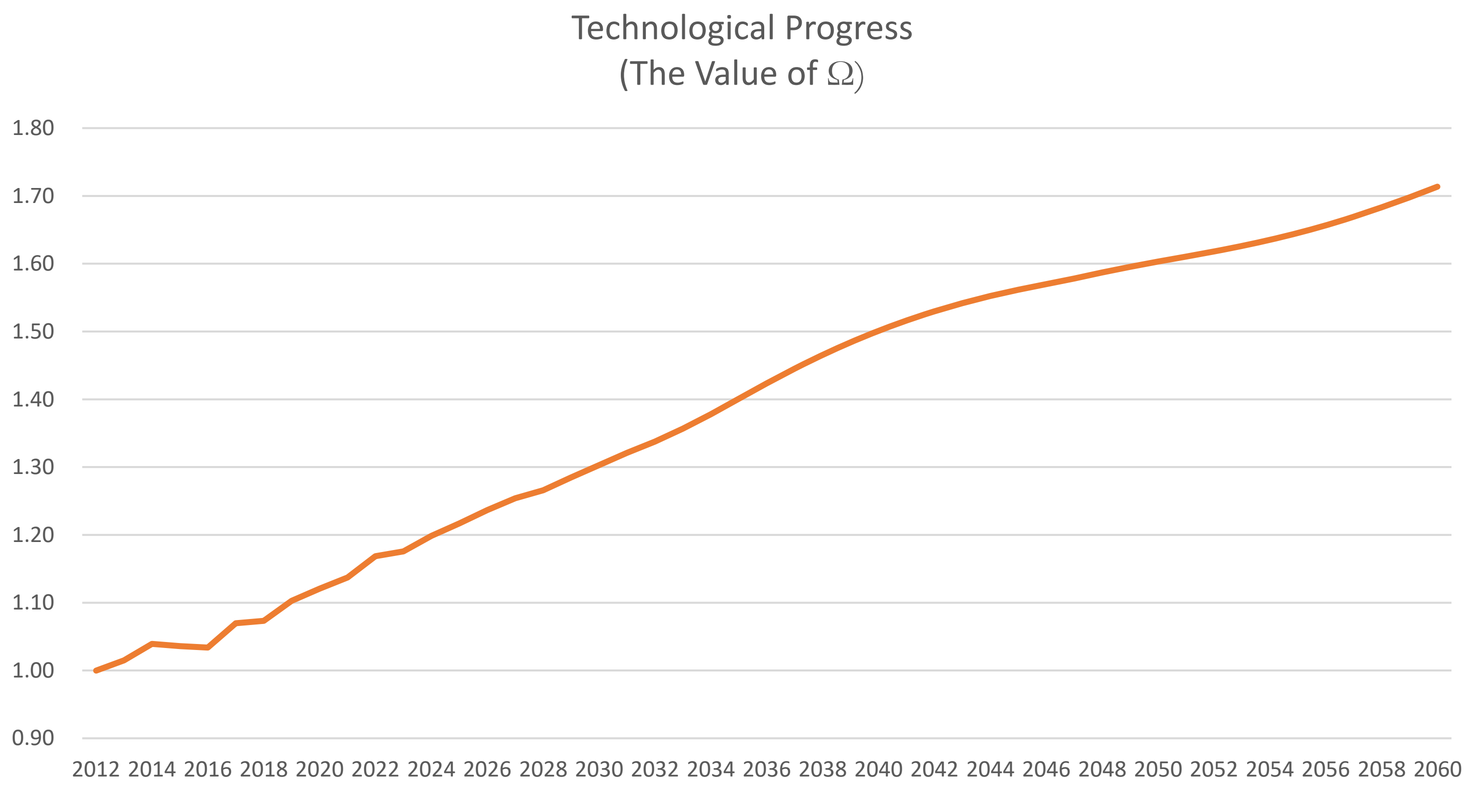

Total Population
140000000
120000000
100000000
80000000
60000000
40000000
20000000
0
1947
1951
1955
1959
1963
1967
1971
1975
1979
1983
1987
1991
1995
1999
2003
2007
2011
2015
2019
2023
2027
2031
2035
2039
2043
2047
2051
2055
2059
2063
2067
2071
2075
2079
2083
2087
2091
2095
2099
2103
2107
Estimation of year 2017

Figure 3



Technological Progress
(The Value of Ω)
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050 2052 2054 2056 2058 2060

Figure 4-1

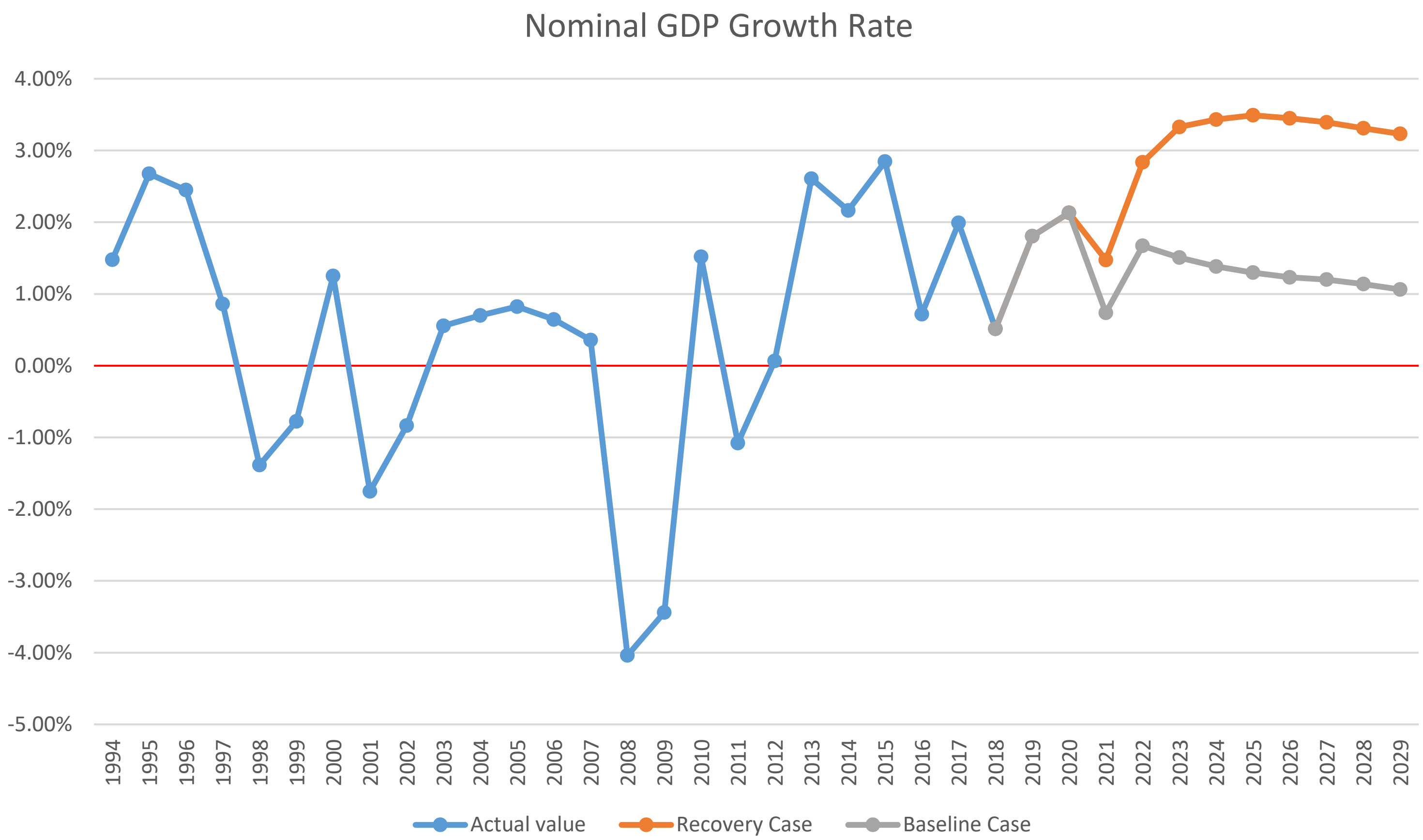

Nominal GDP Growth Rate
4.00%
3.00%
2.00%
1.00%
0.00%
-1.00%
-2.00%
-3.00%
-4.00%
-5.00%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
Actual value
Recovery Case
Baseline Case

Figure 4-2

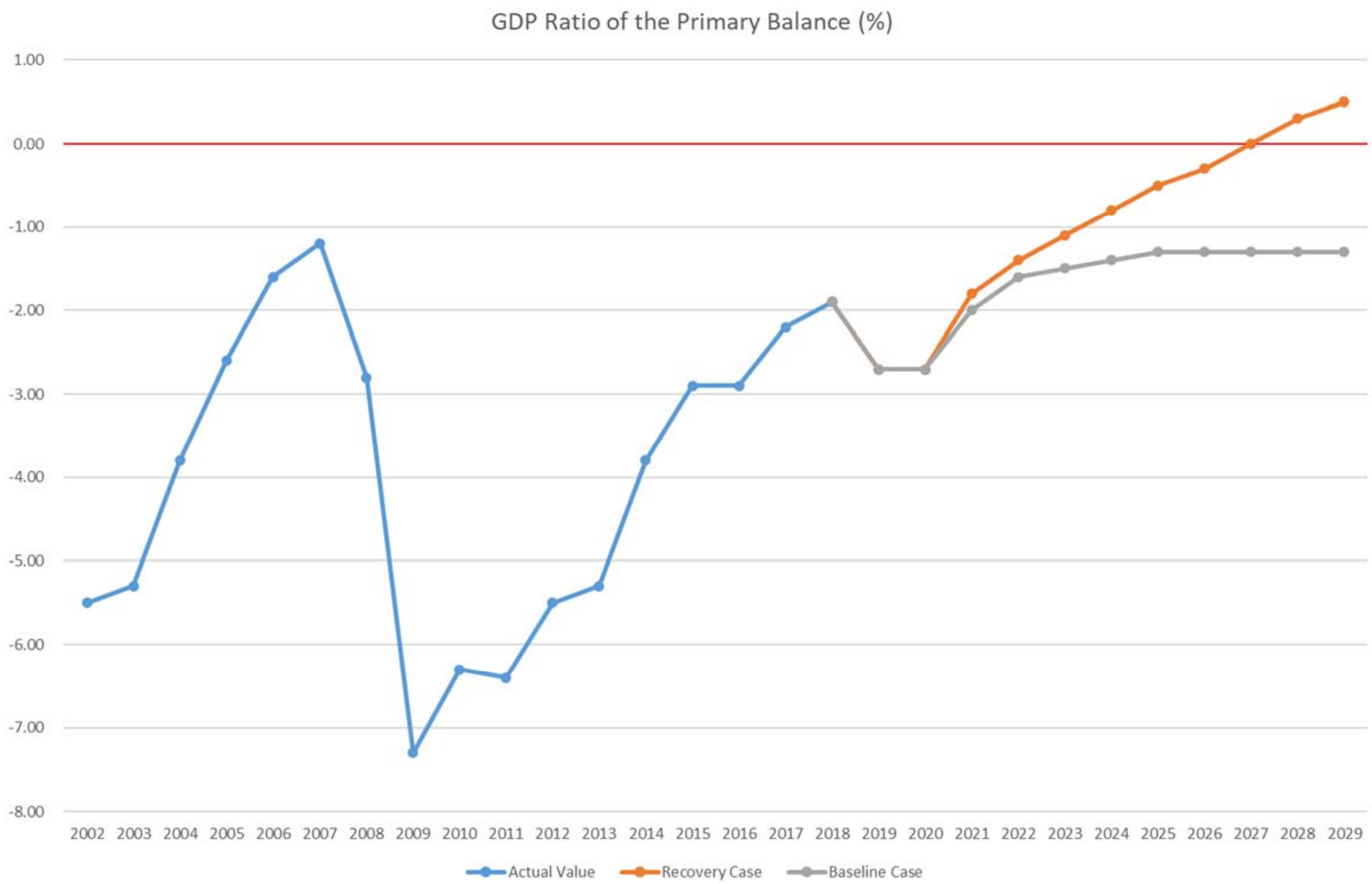

GDP Ratio of the Primary Balance (%)
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029
Actual Value
Recovery Case
Baseline Case

Figure 4-3

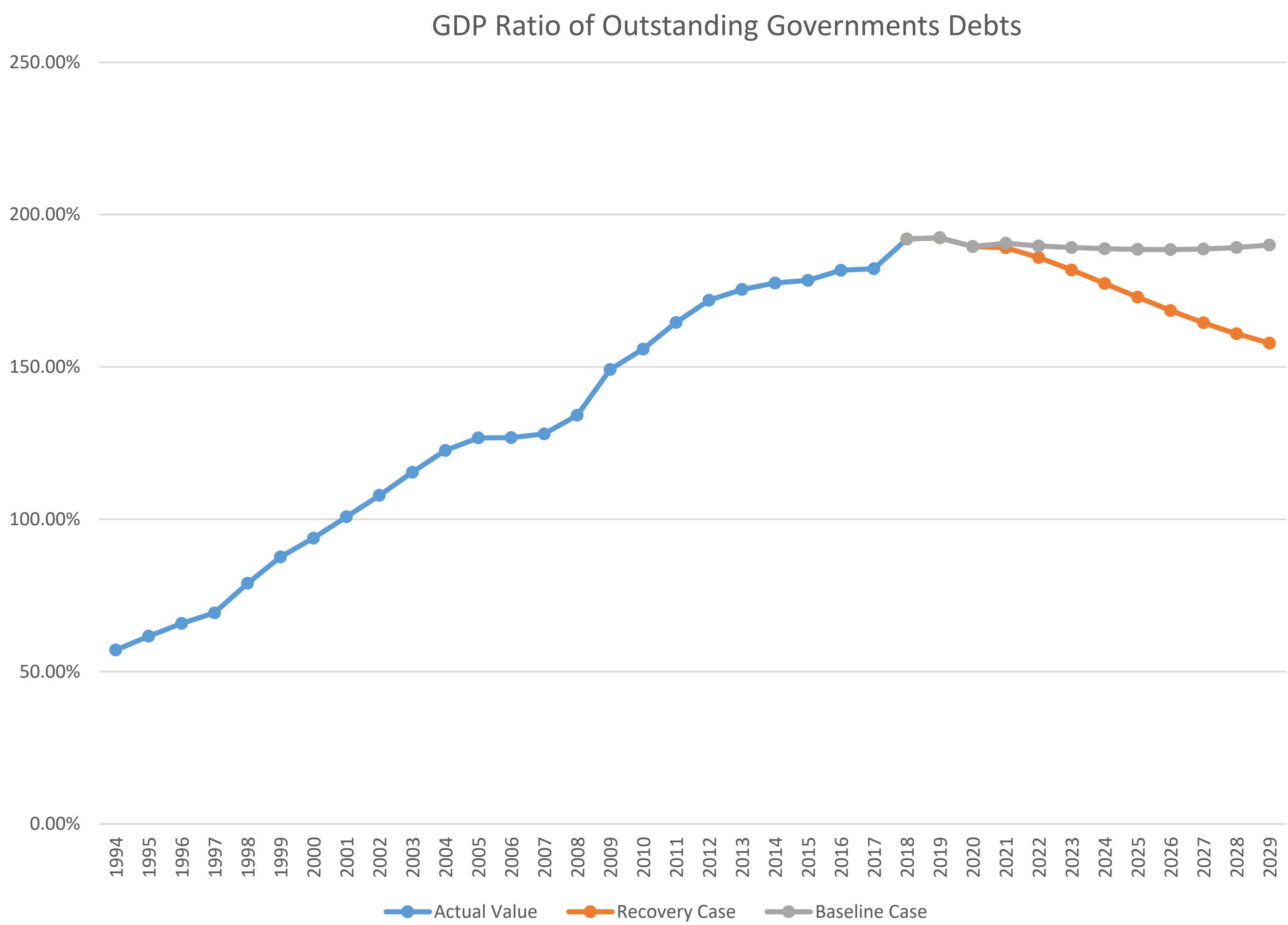
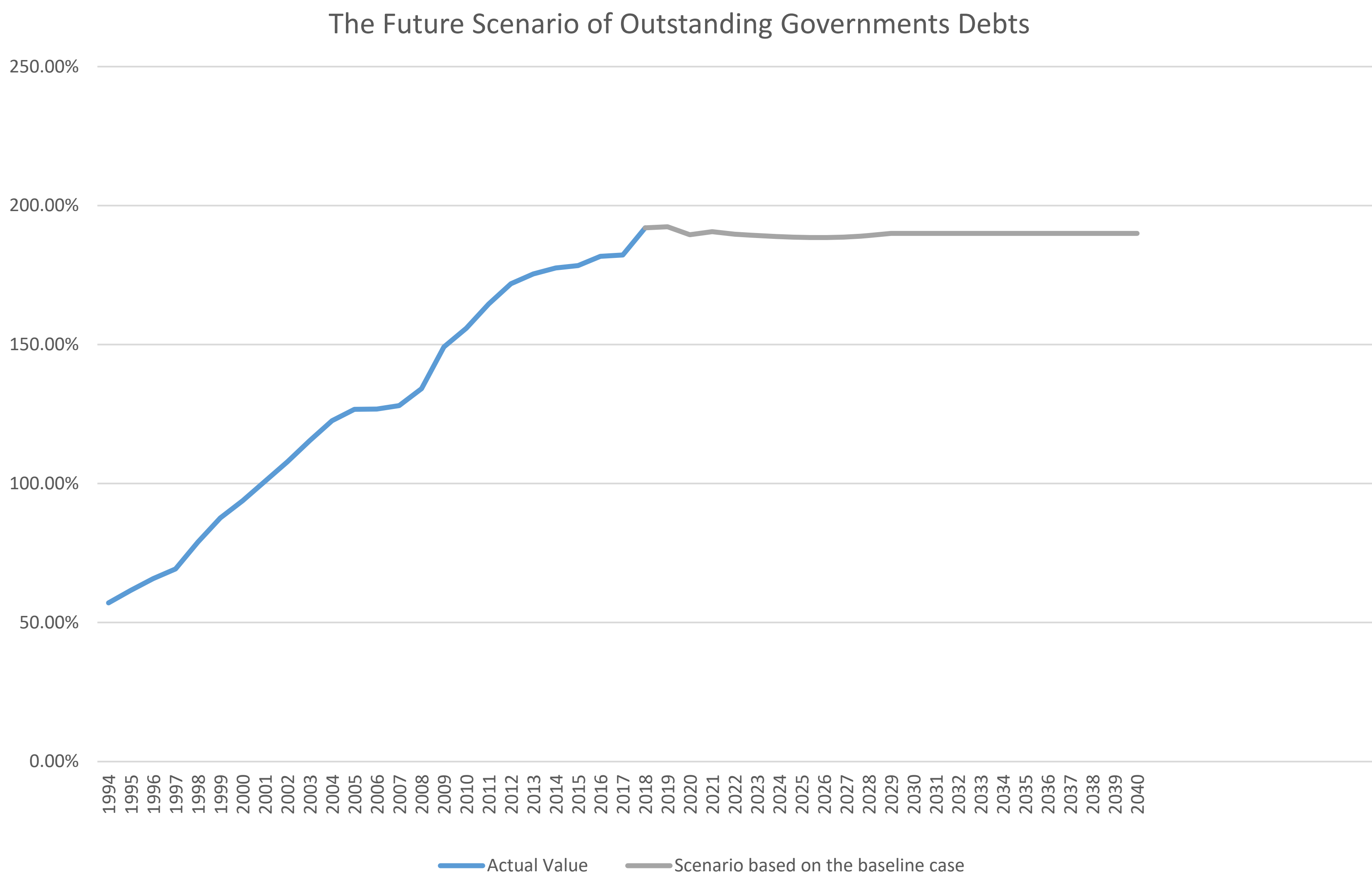

GDP Ratio of Outstanding Governments Debts
250.00%
200.00%
150.00%
100.00%
50.00%
0.00%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
Actual Value
Recovery Case
Baseline Case

Figure 5-1



The Future Scenario of Outstanding Governments Debts
250.00%
200.00%
150.00%
100.00%
50.00%
0.00%
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
Actual Value
Scenario based on the baseline case

Figure 5-2

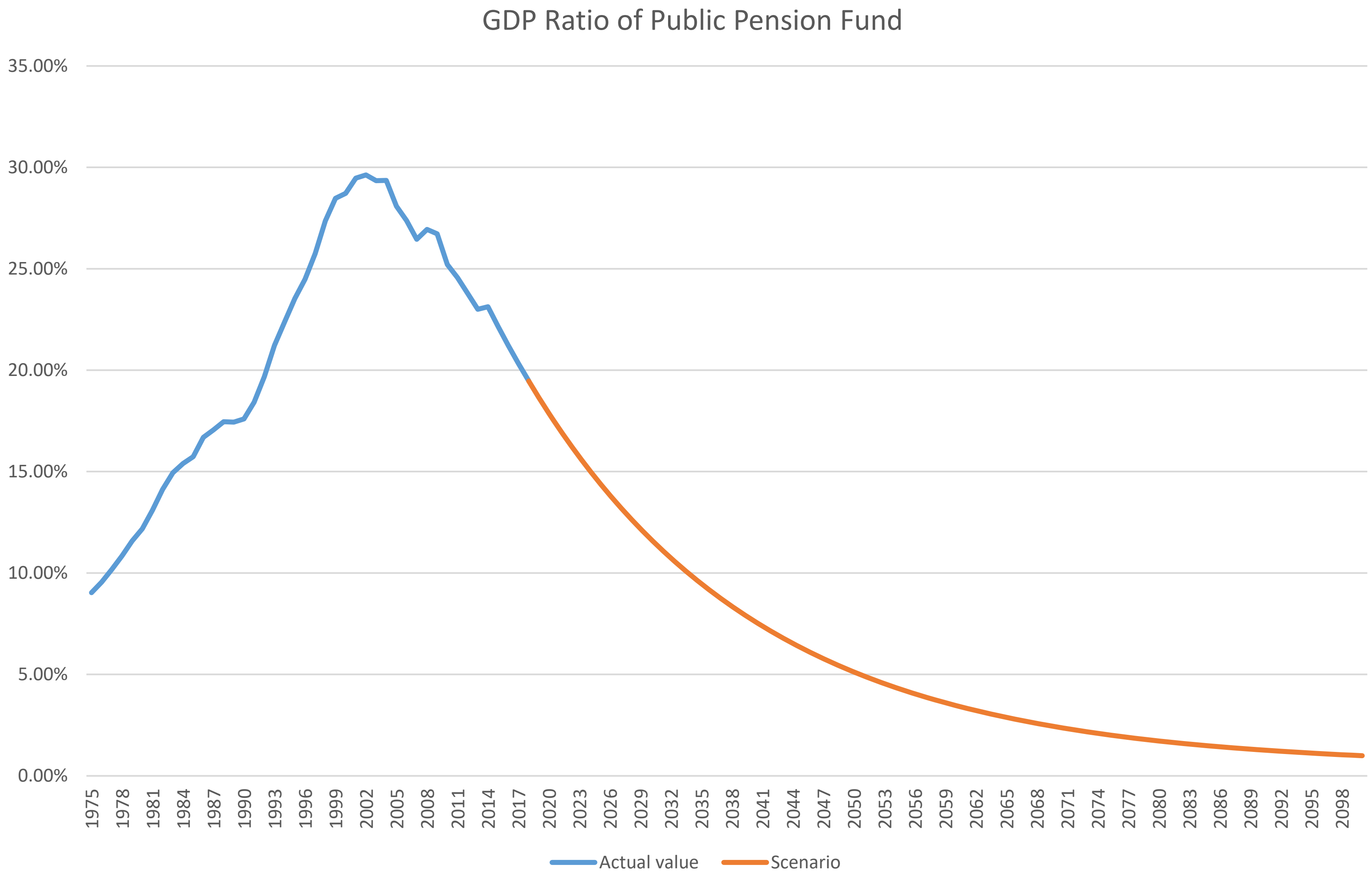

GDP Ratio of Public Pension Fund
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
1975 1978 1981 1984 1987 1990 1993 1996 1999 2002 2005 2008 2011 2014 2017 2020 2023 2026 2029 2032 2035 2038 2041 2044 2047 2050 2053 2056 2059 2062 2065 2068 2071 2074 2077 2080 2083 2086 2089 2092 2095 2098
Actual value
Scenario

Table 8:
The Planned Distribution of the Remaining Cost of the Long-term Care Insurance by the MHLW

Year	Contributins by		Tax
	1st group	2nd group	
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

Remaining Cost = Total Cost (100%) minus Co-payments (10%)

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

	i =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	0.000	0.000	9,349,371.000	136,686.000	12,382,949.000	10,551,695.000	3,888,429.000
	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	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	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	0.000	0.000	21,726,227.000	86,619.000	10,329,662.000	20,881,621.000	10,521,871.000
	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	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	239,401.000	2,525,419.000	-672.000	789,704.000	504.000	0.000	33,159,023.000	416,088.000	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	239,401.000	2,525,419.000	-672.000	789,704.000	504.000	0.000	33,159,023.001	416,088.000	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	294,408.000	21,179,091.000	2,748,172.000	745,595.000	81,926.000	56,797.000	0.000	0.000	0.000	0.000	5,910,820.000	0.000	15,564,667.000	13,736,884.000	13,208,138.000
	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	0.000	0.000	5,910,820.002	0.000	15,564,667.005	13,736,884.004	13,208,138.004

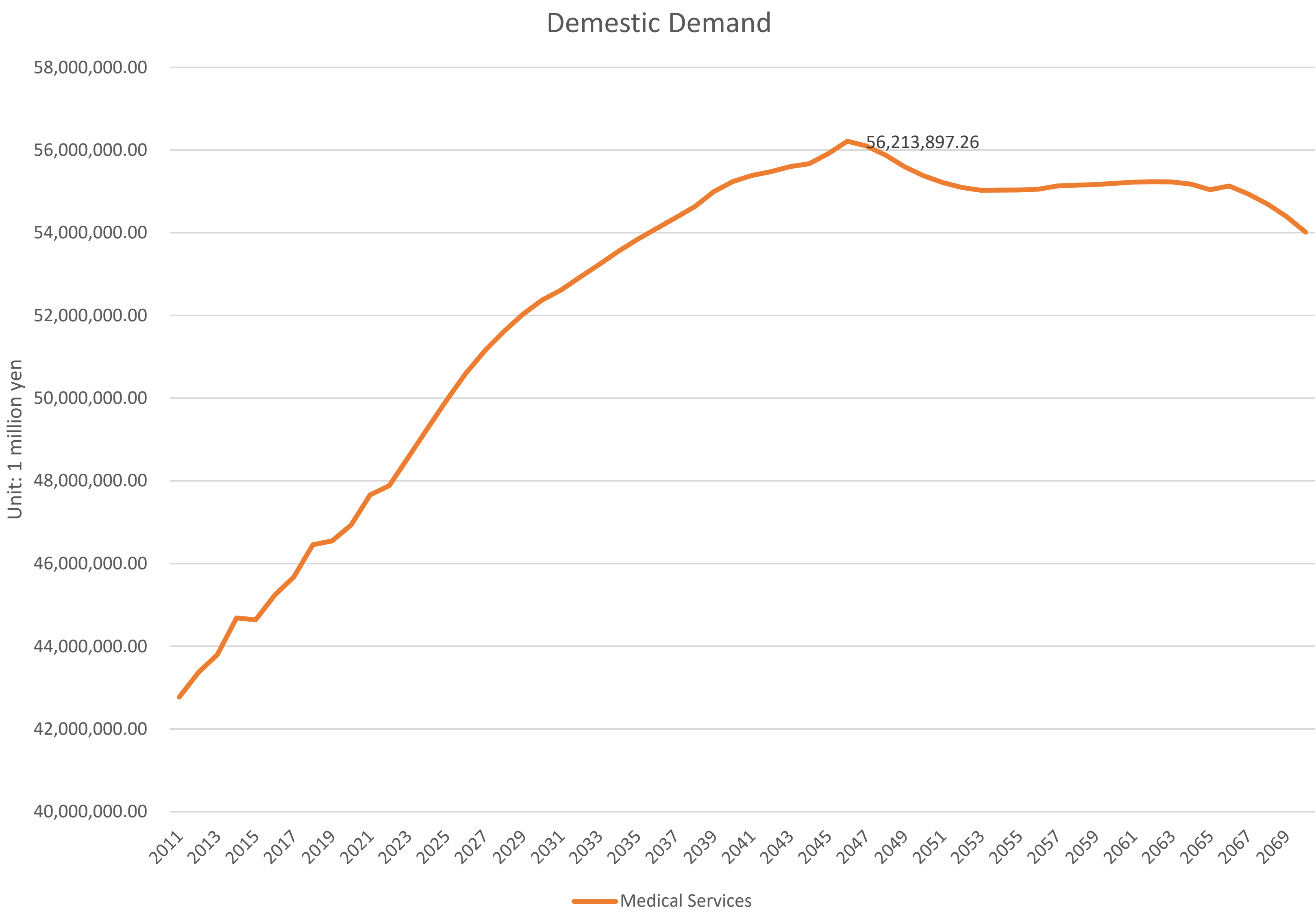
Table 9-2: Key Parameter Values of Year 2018 for the Dynamic Part of the Model

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

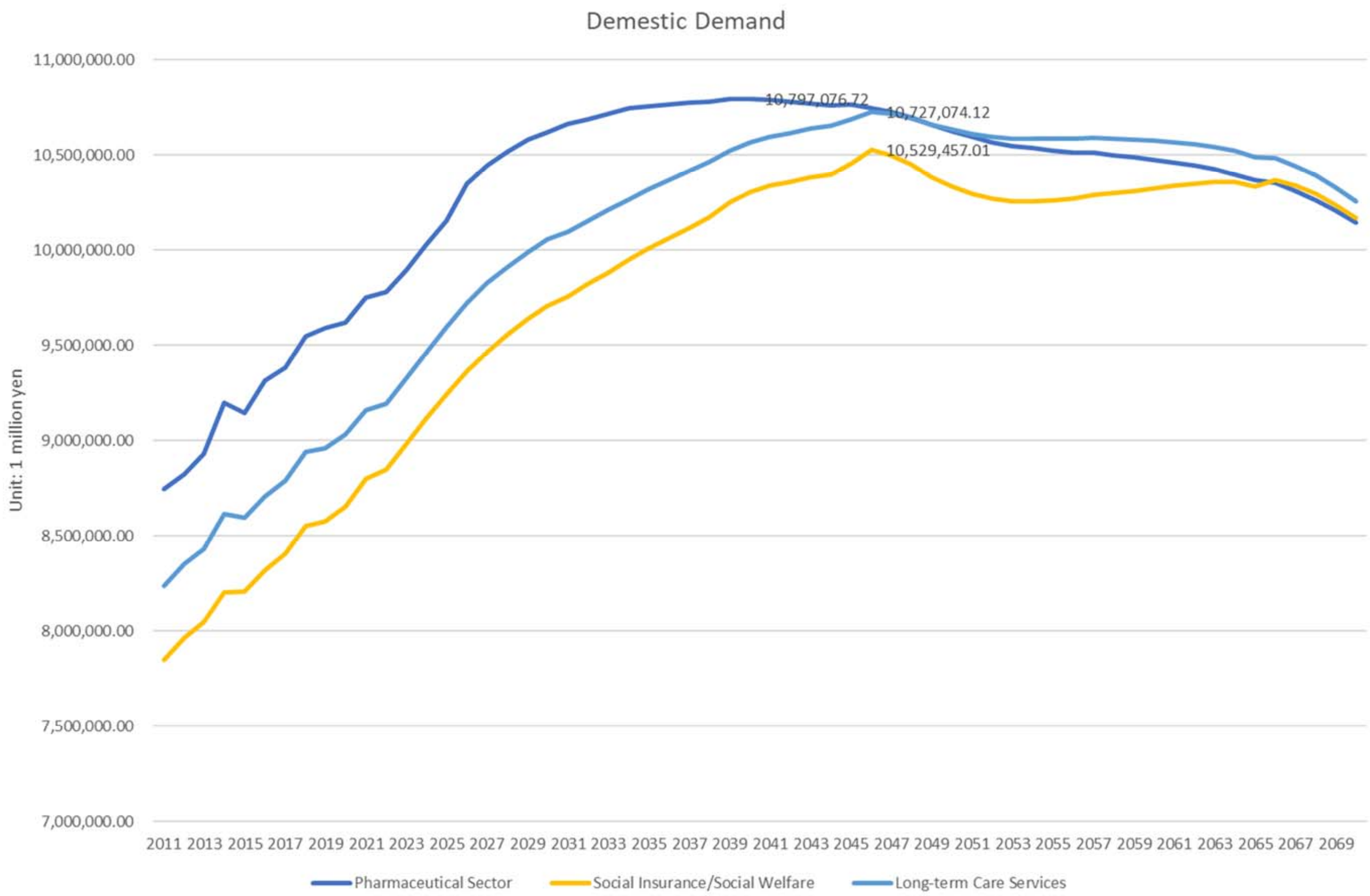
*) The replacement rate is of the Kousei-Nenkin
**) The contribution rate is of the Kousei-Nenkin.

Figure 6-1



Demestic Demand
58,000,000.00
56,000,000.00
54,000,000.00
52,000,000.00
50,000,000.00
48,000,000.00
46,000,000.00
44,000,000.00
42,000,000.00
40,000,000.00
Unit: 1 million yen
56,213,897.26
2011
2013
2015
2017
2019
2021
2023
2025
2027
2029
2031
2033
2035
2037
2039
2041
2043
2045
2047
2049
2051
2053
2055
2057
2059
2061
2063
2065
2067
2069
Medical Services

Figure 6-2

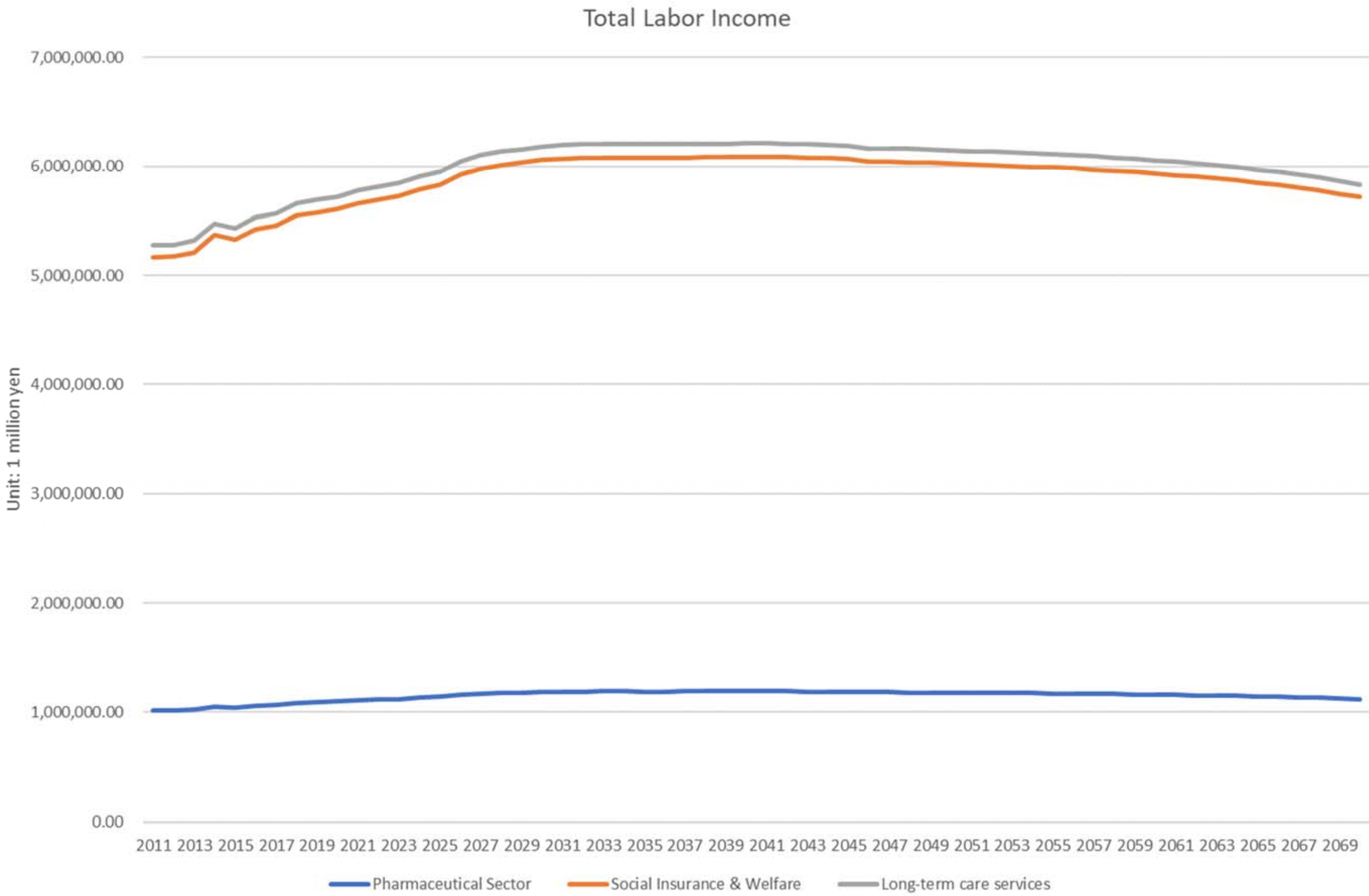


Demestic Demand
11,000,000.00
10,500,000.00
10,000,000.00
9,500,000.00
9,000,000.00
8,500,000.00
8,000,000.00
7,500,000.00
7,000,000.00
Unit: 1 million yen
10,797,076.72
10,727,074.12
10,529,457.01
2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055 2057 2059 2061 2063 2065 2067 2069
Pharmaceutical Sector
Social Insurance/Social Welfare
Long-term Care Services

Figure 7-1

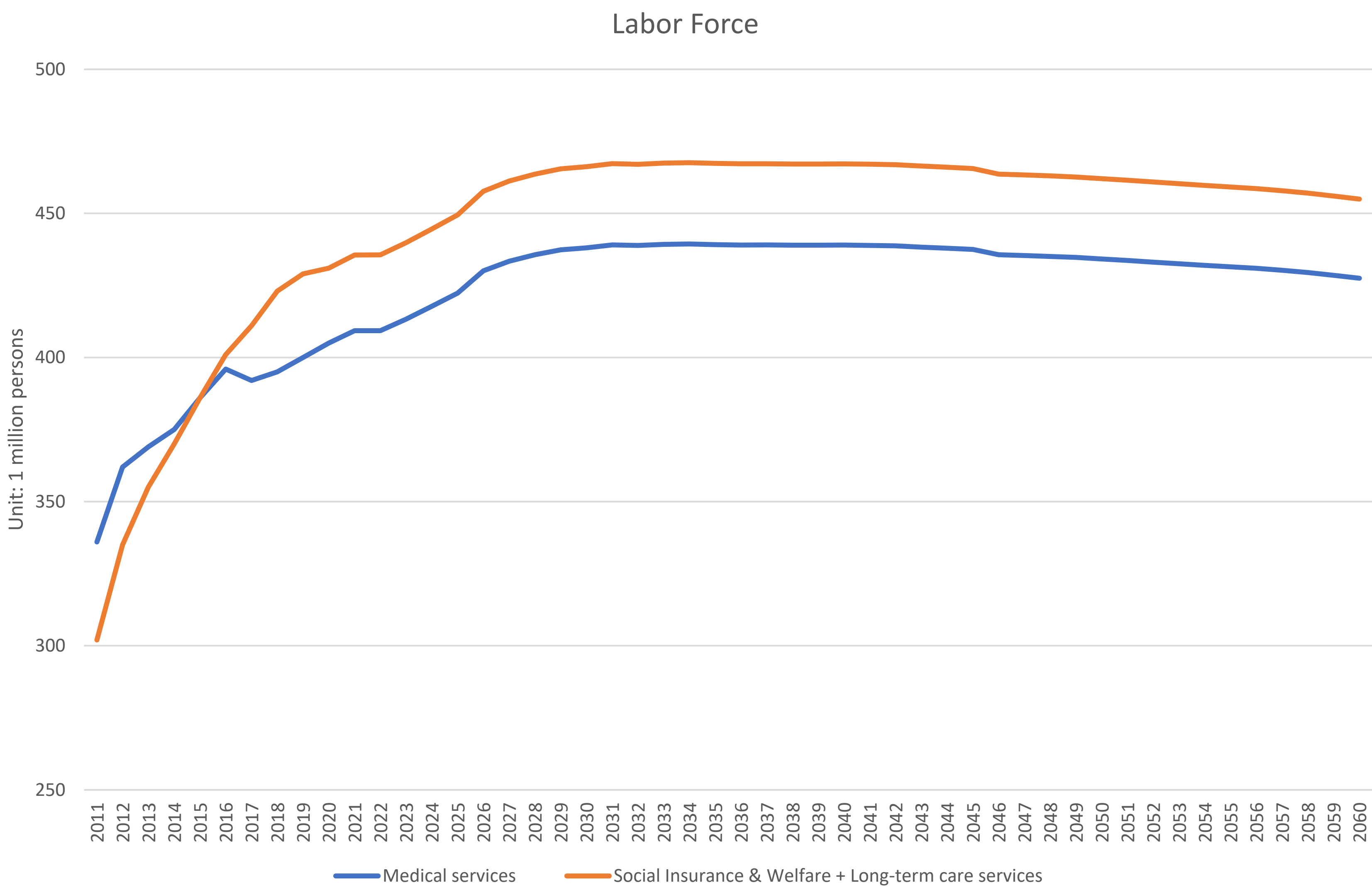
Total Labor Income
19,500,000.00
19,000,000.00
18,500,000.00
18,000,000.00
17,500,000.00
17,000,000.00
16,500,000.00
16,000,000.00
15,500,000.00
15,000,000.00
14,500,000.00
Unit: 1 million yen
2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055 2057 2059 2061 2063 2065 2067 2069
Medical services

Figure 7-2



Total Labor Income
7,000,000.00
6,000,000.00
5,000,000.00
4,000,000.00
3,000,000.00
2,000,000.00
1,000,000.00
0.00
Unit: 1 million yen
2011 2013 2015 2017 2019 2021 2023 2025 2027 2029 2031 2033 2035 2037 2039 2041 2043 2045 2047 2049 2051 2053 2055 2057 2059 2061 2063 2065 2067 2069
Pharmaceutical Sector
Social Insurance & Welfare
Long-term care services

Figure 8-1



Labor Force
500
450
400
350
300
250
Unit: 1 million persons
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
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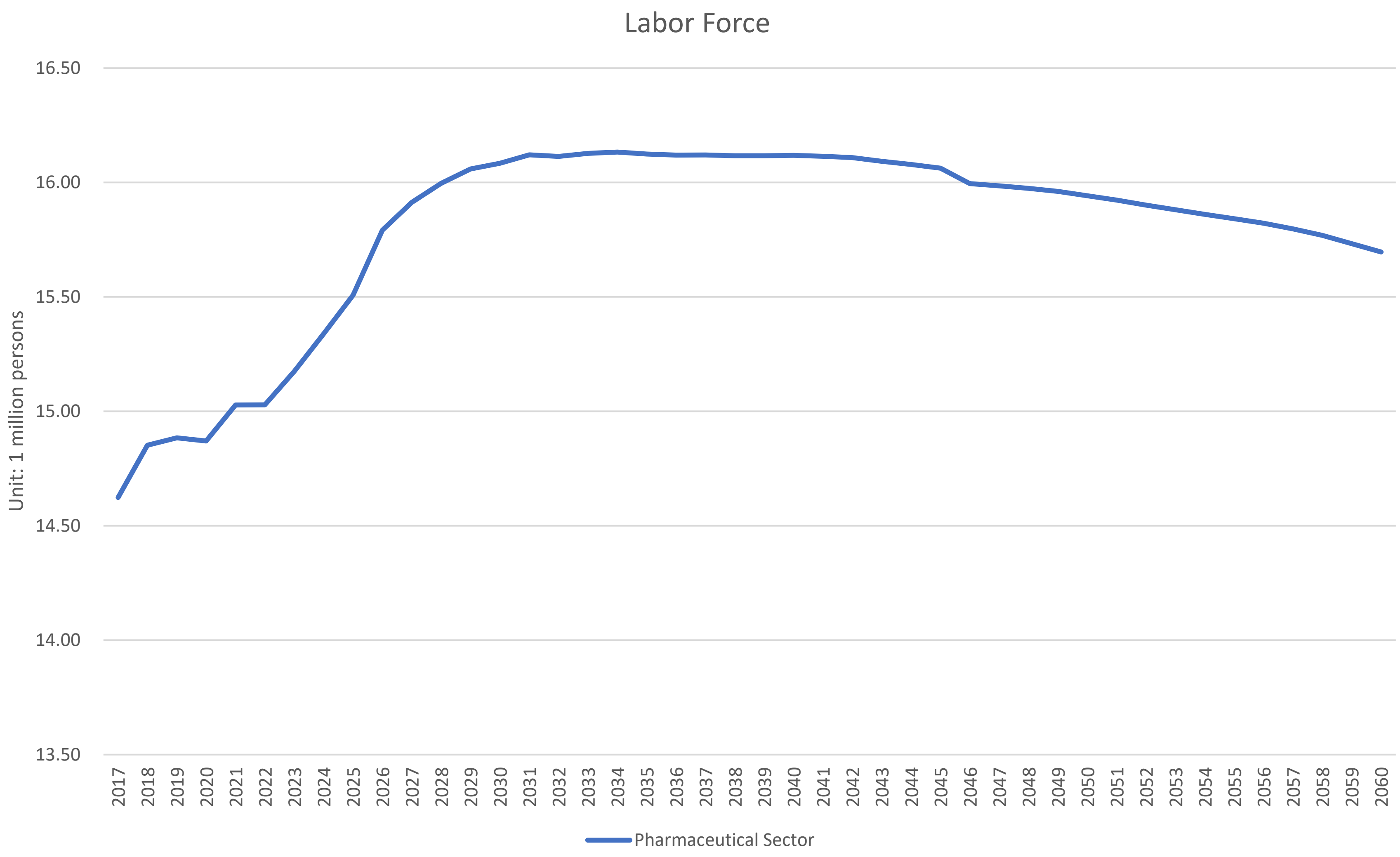
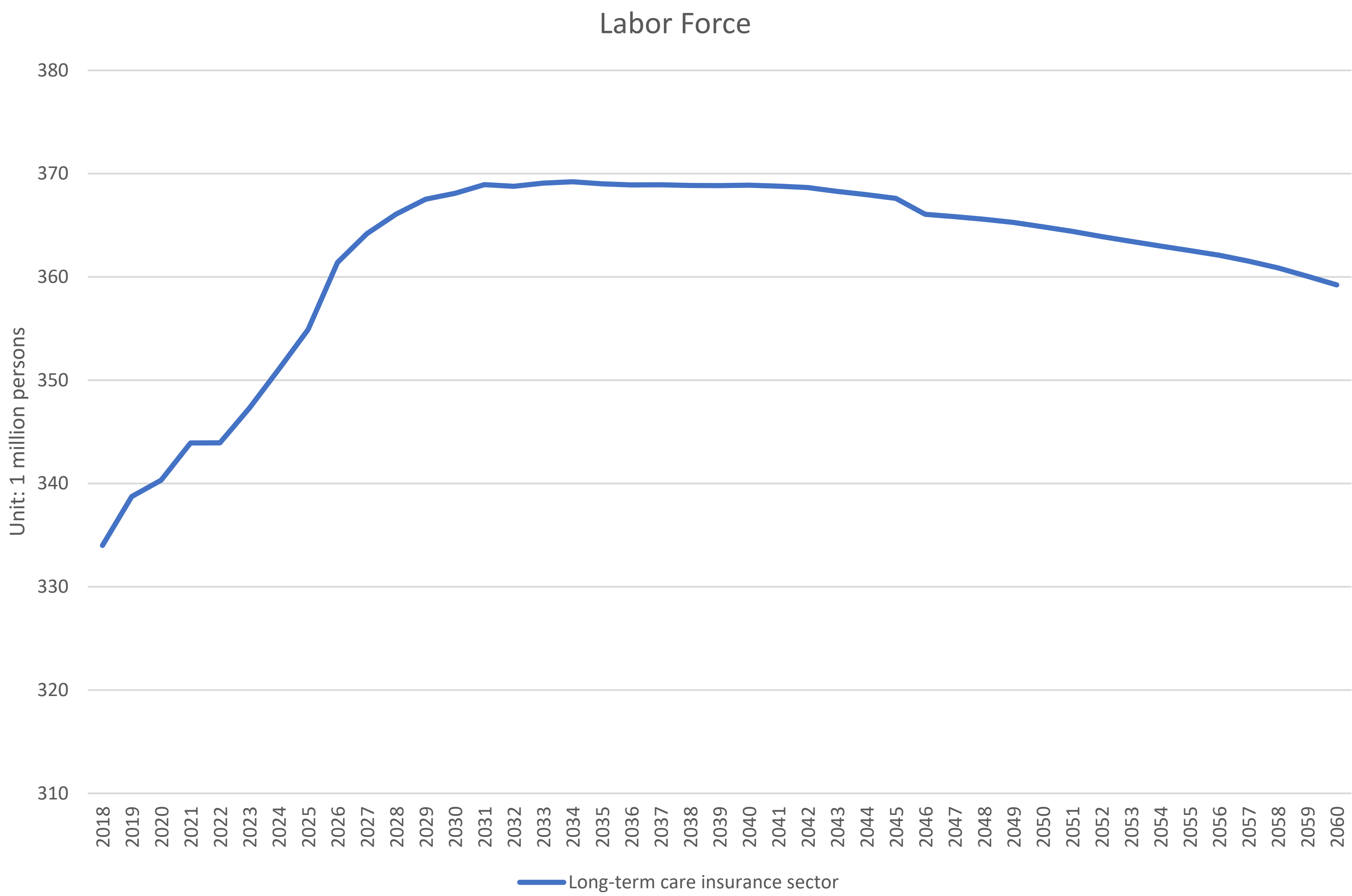
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
Medical services
Social Insurance & Welfare + Long-term care services

Figure 8-2



Labor Force
16.50
16.00
15.50
15.00
14.50
14.00
13.50
Unit: 1 million persons
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
Pharmaceutical Sector

Figure 8-3



Labor Force
Unit: 1 million persons
380
370
360
350
340
330
320
310
2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060
Long-term care insurance sector