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Ageing and its Macroeconomic Implications in Japan

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Ageing and its Marcoeconomic Implications in Japan*

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Abstract

This paper conducts several simulations to illustrate economic growth and consumption behavior of Japanese economy where ageing and decline of population are progressing rapidly. Special attention is paid to an increase in medical expenditures and a decline of the ratio of labor forces to total population. Simulation results suggest the ongoing ageing does not have significant effects on macroeonomy compared with those of the technological progress, which shows a sharp contrast with the results of the existing literature.

1 Introduction

Changes in population and its generational composition in Japan have induced considerable anxiety about the future of Japanese economy that is ageing quite rapidly. According to the official forecasts by Institute of Population and Social Security Research(IPSS), the Japanese population will shrink to the half of the current size in 100 years. Since demographic changes affect the number of labor forces and saving, the changes might also have significant effects on macroeconomy. According to the forecasts, the labor-population ratio will decrease in near future due to the ongoing ageing. So far, a number of papers have been written to investigate the marcoeconomic effects of ageing in Japan. Yashiro,

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Koshio et al. (1997)[1], Miyajima and Ohsawa et al (1996) are such examples. Most of them predict that the ageing has significant negative effects on the consumption and GDP in Japan. Their analyses are, however, not based on the "standard" neoclassical economic growth model, rather adopt a very large macroeconometric model.

One of a few papers that use the standard growth model is Cutler, Poterba, Sheiner, and Summers (1990). Using a Ramsey style economic growth model, they illustrate future predicted changes in US and other OECD's economic growth rates and consumptions. Cutler et al. (1990) predict that consumption per capita in Japan will drop by 13 % between 2000-2050. With the same model under different parameter values, Suzuki (2001) predicts 6-11% decrease in consumption per capita in 50 years. Although their methodologies are quite rigid, some cautions are necessary when we interpret their forecasts.[2] Both Cutler et al. (1990) and Suzuki (2001) compare two equilibrium paths of consumption. The first equilibrium is defined as a case where the population and its generational composition are fixed the current level and capital levels are at its steady state value. The second equilibrium is defined as a case where the population will change as is predicted by the government and the initial capital level is at the steady state level defined in the first equilibrium. One interpretation of their setting is as follows. Until some specific date, the economy had been at the steady state level without any changes in population. One day, the agent of the economy realized that future population and the demographic composition would change. The agent had a perfect foresight at that time, and adjusted his/her consumption and investment behaviors to maximize the welfare of the economy. Although their approach is easy to conduct, the assumption that the people didn't know the future ageing in Japan is questionable since the estimates of future demographic changes have been published by IPSS for a long time.

This paper does not assume that initially the agent are ignorant

[1] Yashiro, Koshio et al. (1997) point out that the current level of the government debts is not sustainable under the predicted demographic changes mostly due to an increase in social welfare expenditures. Their results are, however, derived from a very large and complicated macroeconometric model that is similar to Cowles Commission approach. In other words, their models are not based on microeconomic behavior of agents and intertemporal optimizations.

[2] Matsuura, Watanabe, and Uemura (1998) takes slightly different approach. Based on the optimal growth model, they derived the Euler equation and the resource constraint. Then, they fitted the two equations and obtained the parameter values, and used those equations to get the future path of consumption and capital given the future estimates of population and labor forces. In other words, they did not solve the optimal path because they did not use the terminal condition or so called the "tarnsversality condition".

of future ageing. Rather, the paper hypothesizes that initially, the economy is on the transition path that converges to the steady state in the long run obtained by the public forecasts of future population. The current capital level is set by the actual value taken from *Private Capital Stock Statistics* in Japan. The results of the simulation in this paper are different from previous studies. The ageing does not have significant effects on consumption per capita in the long run even if assuming no technological growth. This departure from the existing literature comes from the difference in the treatment of the initial level of capital.

2 Forecasts of Ageing in Japan

Figure 1 shows the estimates of the future total population in Japan by IPSS. The total population will reach its peak in 2008, after that, the Japanese population will steadily shrink. Although this might seem to have significant effects on macroeconomy in Japan, as long as technology is linear homogenous without public goods nor externality, as is assumed in neoclassical economics, the level of population itself does not affect consumption per capita in the long run. What matters for the consumption per capita in the standard growth model is changes in the ratio of labor force to total population. Figure 2 shows the labor participation rate in Japan for each age group in January 2001.[3] The participation ratios of both male and females drop rapidly after they reach 60 years old, which might reflect "an age-limit system" widely adopted by firms in Japan. If the shapes of the participation ratios will not change in the future, together with the population forecasts by IPSS, we can calculate the future labor force ratio that is reported in Figure 3. The figure shows the labor force ratio will decline approximately 10 points in 50 years.

Recently, in addition to the decline of labor forces, surge in medical expenditures due to ageing has been analyzed deeply.[4] Figure 4 illustrates the medical expenditures per capita in Japan.[5] The curve shows huge increase in medical expenditures as age increases. If this correspondence between age group and medical expenses, using the population forecasts by IPSS, we can calculate the future expected medical expenditures. Figure 5 and Figure 6 show the future medical expenses per capita and the total medical expenditures, respectively. Whether this increase has significant effects on future consumption but medical

[3] The data is taken from "Labor Force Survey" published in March, 2001 by Statistics Bereau & Statistics Center in Japan.

[4] For detailed analyses of the expenses, see Tokita, Chino, and Kitaki (2000).

[5] The data is taken from the report of the statistics made by Ministry of Health & Welfare (1998).

expenditures per capita depends on the future GDP. In the following analyses, I include this forecasts of medical expenditures in the macroeconomic model, which enables us to see the effects of the medical expenditures on the future consumption.

3 The Model

This paper uses a very standard Ramsey-type optimal growth model. This model consists of identical consumers who live forever. The representative agent will change his/her labor supply, the number of consumers, and medical demands. The motions of those variables are assumed to be given. Although this assumption is quite restrictive, in order to focus on the effect of ageing to the macroeconomy, this is an easy way to begin. The representative agent maximizes the following utility function :

$$U=\sum_{t=0}^{\infty}\beta^{t}u\left(C_{t}\right). \tag{1}$$

The resource constraint is as follows : for all t

$$K_{t+1}=F\left(K_{t},L_{t};A_{t}\right)-N_{t}C_{t}+\left(1-\delta\right)K_{t}-M_{t}, \tag{2}$$

where C_t : Consumption per capita, K_t : Capital, N_t : Population, L_t : Labor Forces, M_t : Medical Expenditure, β : Discount Factor, A_t : Technological Index, δ : Depreciation Rate. The representative agent regards its population, labor forces, and medical expenditures as well as its technology as given. They have, however, perfect foresight of those variables. In other words, there are no uncertainties in the model.

The instantaneous utility function is assumed to be CRRA, that is,

$$u\left(C_{t}\right)=\frac{C_{t}^{1-\sigma}}{1-\sigma}, \tag{3}$$

where $\sigma>0$. The production function, $F\left(K_{t},L_{t};A_{t}\right)$ is Cobb-Douglas,

$$F\left(K_{t},L_{t};A_{t}\right)=A_{t}K_{t}^{\varphi}L_{t}^{1-\varphi}. \tag{4}$$

The technological index, A_t grows at constant rate, g, such as

$$A_{t}=e^{gt}A_{0}, \tag{5}$$

where $A_0>0$ is a positive constant.

The interpretation of the above model is as follows. In addition to the resource constraint (2), the representative agent has another constraint that restricts the labor participation ratio, L_t/N_t for all t. The agent chooses the optimal consumption and investment given the initial level of capital and future prospects of the technological changes, labor participation ratio, medical expenditures, and the total population.

The Euler equations are as follows:

$$u\left(C_t\right)' = \lambda_t N_t, \tag{6}$$

$$\lambda_t = \frac{\beta'}{\Phi}\left[\lambda_{t+1}\left(\frac{\varphi F_{t+1}}{k_{t+1}} + 1 - \delta\right)\right], \tag{7}$$

where $\Phi = (1+g)^{\frac{1}{-\varphi}}$, $\beta' = \beta\Phi^{1-\sigma}, K_t = \Phi^t k_t$. Φ is the long-run growth rate of the model.

4 Parameter Values

Parameter Values : (benchmark case)

$$\sigma = 3.72, \varphi = 0.275, g = 0, \beta = 0.98, \delta = 0.042$$

Unfortunately, except for the depreciation rate, δ ,[6] there are no wide agreements about the parameter values for Japanese macroeconomy. I take σ from Kitamura and Fujiki (1997).[7] Under Cobb-Douglas technology, $1-\varphi$ becomes the labor share in GDP. The average of the labor shares in Japan between 1994 and 1999 is 0.725, which implies $\varphi = 0.275$ so that I choose 0.275 for the benchmark case. The discount factor, β, is set at 0.98 for the benchmark case without particular reasons.[8] The assumption of zero technological growth, $g = 0$, is surely extreme. Probably, this value is the most difficult to estimate because the variable is not observable. A case with zero technological progress will represent the most pessimistic case. Later, several results of simulations with different parameter values will be shown.

[6] δ is taken from the Annual Report of Economic Survey in Japan (1997) which is used in many papers. Originally, δ is calculated from the Annual Report of Private Capital Stock.

[7] Kitamura and Fujiki (1997) use GMM and Consumption CAPM formula to estimate the rate of subjective discount rate and the relative rate of risk aversion.

[8] Later, I will show some cases with different discount factors.

5 Data

For GDP and Capital, I take them from SNA that is available through the web-page of Cabinet Office. Because the model abstracts from governmental activities and foreign trade, I define GDP as a sum of private consumption, investment, and inventory investment. For the same reason, I include only private capital stock for the simulation.[9] As is mentioned before, I use IPSS's forecasts of future population.[10] The labor forces are calculated from the labor participation rate that is shown in Figure 2 and the future predicted population. The medical expenditures are calculated as the future labor forces. Because the model does not contain the public sector, to be consistent with other macroeconomic variables, population, labor, and medical expenses are adjusted to cover only private sectors.[11]

6 Simulation Procedures

First, from the Euler equation (7) and the resource constraint (2), I calculated the steady state values of capital and consumption assuming that the total populations, the labor forces, and the medical expenditures will reach their steady state levels in year 2100.[12] Next, I solved the representative agent's maximization problem and linearized the system around the steady state. Third, using the data of capital and population etc. at 2000 and the future forecasts of N_t, L_t, and M_t, I obtained the transitional dynamics of the equilibrium where at the beginning time, the agent knows the economy will experience ageing and an increase in the medical expenditures. As an algorithm, I adopted the Linear-Quadratic methods explained in Burnside (1999).[13]

[9] Estimates of the public capital stock are available only up to year 1993 that is created by Cabinet Office in Japan. We do not have official estimates of the stock after 1994.

[10] Precisely, I use the medium estimates by IPSS.

[11] In 1999, about 8.3 % of labor forces are public officers for either central or local governments according to the National Personnel Authority. Therefore, I discounted the total population, the labor forces, and the medical expenditures by 8.3% assuming the ratio can be applied to those variables.

[12] This is assumed purely for practical reasons. Another possible way is to estimate the steady state levels of each variable by VAR or other time series methods. However, the series of the total population, the labor forces, and the medical expenditures are close to random walks, which gives us very unstable results of the steady state levels.

[13] Since the total population, the labor forces, and the medical expenditures do not follow simple time series such as AR1 as is often assumed in the real business cycle literature, I treated all the variables such as the total population in year 2002, 2003,..., as different predetermined variables, which ends up with a very large matrix

7 Results

Figure 7 shows the transitional dynamics of (1) consumption per capita (million yen), (2) private capital stock (trillion yen), (3) total medical costs (trillion yen), (4) GDP per capita (million yen), (5) total consumption (billion persons), (6) GDP (trillion yen), (7) capital return, (8) ratio of medical costs to GDP, and (9) gross investments (trillion yen). Although GDP will begin to decrease within 10 years, consumption per capita will continue to grow for 30 years. The reason for the differences is as follows. In the model, at the initial period, the consumer knows that the economy is going to experience ageing in near future. In order to have smooth consumption path, the consumer accumulates capital to keep future output level at some certain level. We can observe the accumulation in the sub-figure (9) that shows high level of investment in near future. As a result, the movement of GDP per capita becomes quite stable that can be seen in sub-figure (4) whose fluctuations are only about 3 %. Sub-figure (7) shows the movement of capital return, which exhebits constant decline of the return. That implies the relative shortages of the current capital stock level compared to the current labor force level. Although the statistics of capital stock might contain serious measurement errors, as long as the figure shows, the shortage of the capital stock seems robust. Several other simulation results are reported in the next section.

8 Other cases

Figure 8 and 9 show the cases with different capital shares, $\phi = 0.25, 0.3$, respectively. The other parameters are unchanged. As the capital share increases, the importance of a decrease in the labor forces weakens. Therefore, with $\phi = 0.3$, the consumption per capita will not decrease as much as in the base case or a case with $\phi = 0.25$. Figure 10 and 11 illustrate the cases with different convavities in the utility function, $\sigma = 0.1, 10$, respectively. With very small σ, such as 0.1, the representative consumer does not smooth consumption. Therefore, the consumption per capita exhibits strong volatility when the labor forces and the medical expenditures do not move smoothly. On the other hand, with strong concavity in the utility function, the consumption per capita is quite smooth compared with other cases.

Figure 12 and 13 show the cases with different discount factors, $\beta = 0.99, 0.97$, respectively. With small discount factor, or equivalently, with

that contains 303 state variables.

large subjective discount rate, the consumption per capita will be smaller in 2100 than that in 2001. That is because the steady state level of capital is a decreasing function of the discount factor as the standard Euler equation predicts. Therefore, with $\beta = 0.97$, the capital stock will converge to the smaller levels than in other cases. Finally, Figure 14 illustrates the case with 1% TFP growth. Although the assumption of 1% rate of technological progress is quite modest, the effects on the consumption per capita are significant. Figure 14 suggests the effects of ageing on the consumption per capita is not as large as the effects of a "small" technological progress such as 1%.

9 Concluding Remarks

The simulation results above, particularly Figure 14 with a small technological progress, implies the ageing itself is not a serious issue for Japan in the standard growth model. Several cautions are, however, necessary to interpret the result. First, the adoption of the standard growth model implies the existence of the complete market where all the resources are utilized efficiently. The sub-figure of the capital return in Figure 7 predicts 9% of the rate of return for capital in year 2001, which is significantly higher than the actual level. This might imply that the current private capital is not utilized efficiently, so that the agent does not have incentive to add capital as the model predicted. This leads us to investigate the possibilities of capital hoarding. Second, the model does not contain non-convex aspects of the economy such as public goods and externalities. If such a non-convexity has significant effects on the macroeconomy, a decrease in the total population itself might have large negative effects on the welfare and the consumption. The considerations of those issues are beyond the scope of this paper. The model presented here should be interpreted as a benchmark on which several considerations must be added. However, such a simple model is useful to clarify the complicated interactions of many economic variables.

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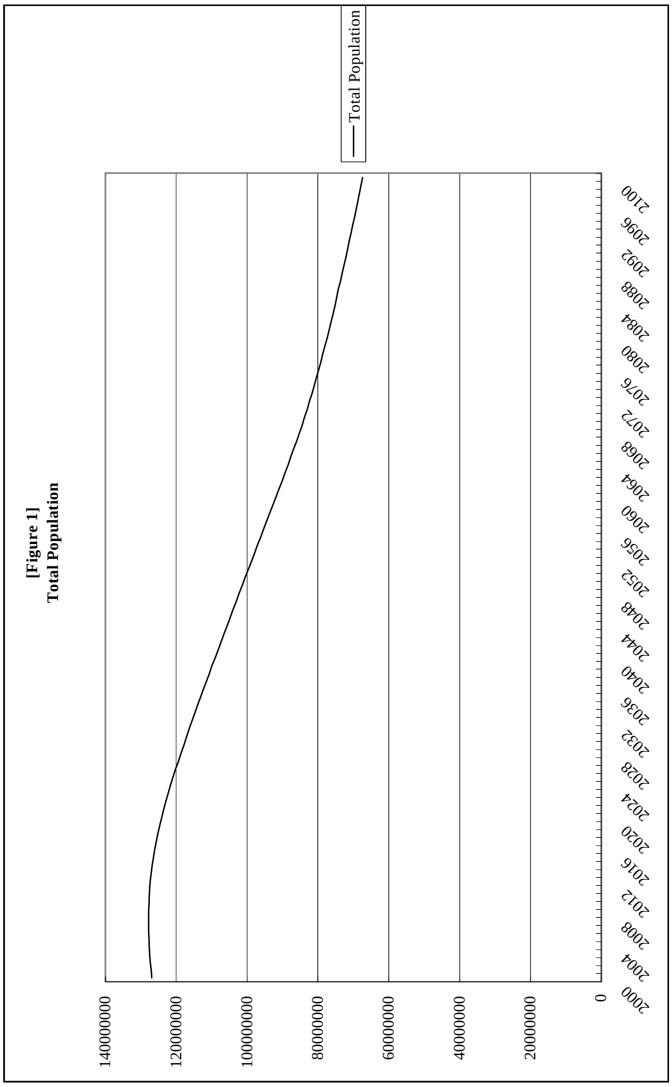
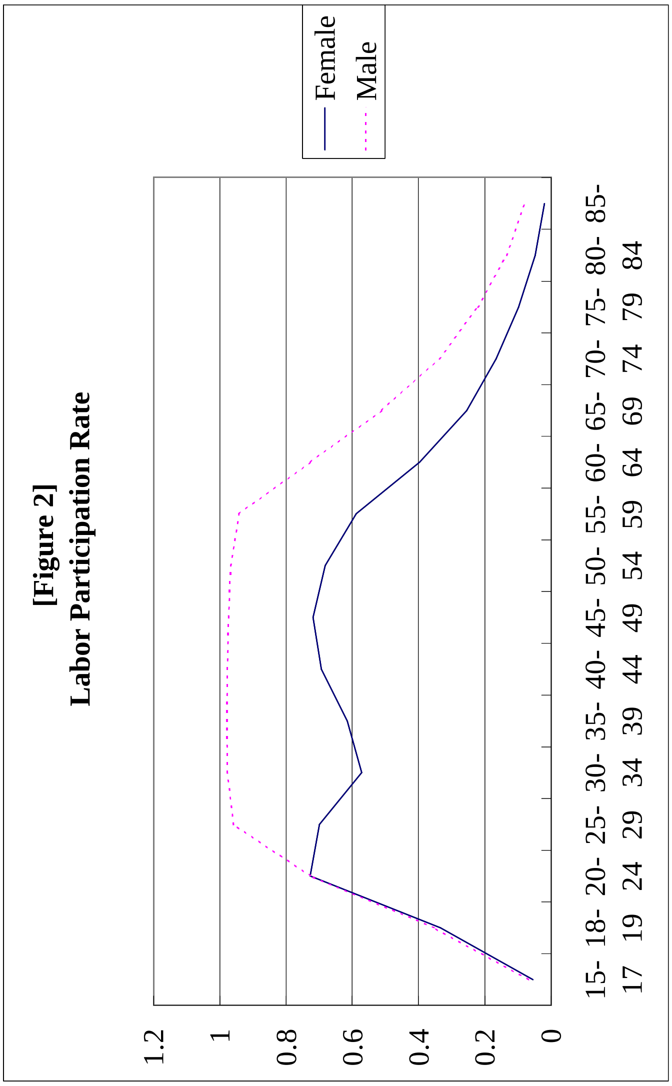
Figure 1:



[Figure 1]
Total Population
Total Population
140000000
120000000
100000000
80000000
60000000
40000000
20000000
0
2000
2004
2008
2012
2016
2020
2024
2028
2032
2036
2040
2044
2048
2052
2056
2060
2064
2068
2072
2076
2080
2084
2088
2092
2096
2100

Figure 2:



[Figure 2]
Labor Participation Rate
Female
Male
0
0.2
0.4
0.6
0.8
1
1.2
15-17
18-19
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84
85-

Figure 3:

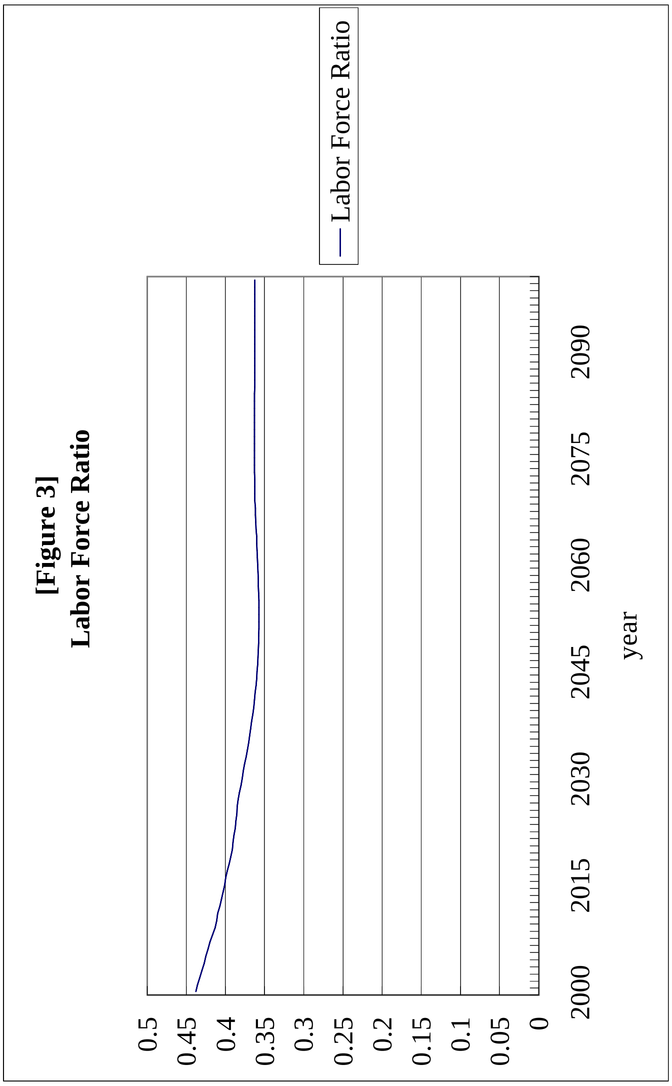

[Figure 3]
Labor Force Ratio
Labor Force Ratio
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2000
2015
2030
2045
2060
2075
2090
year

Figure 4:

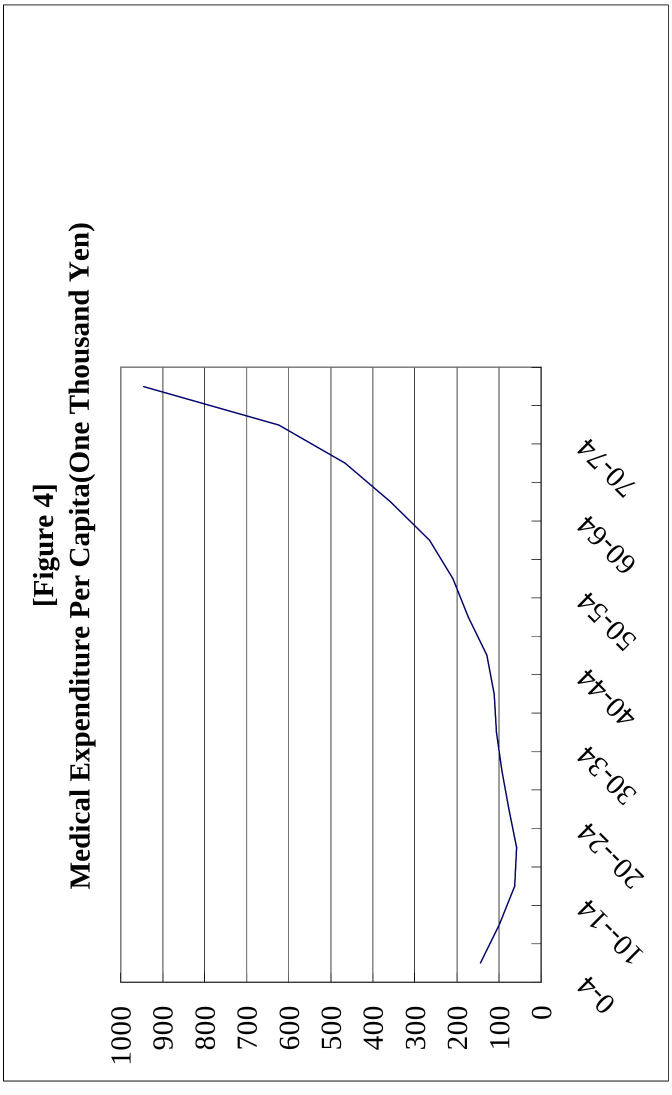
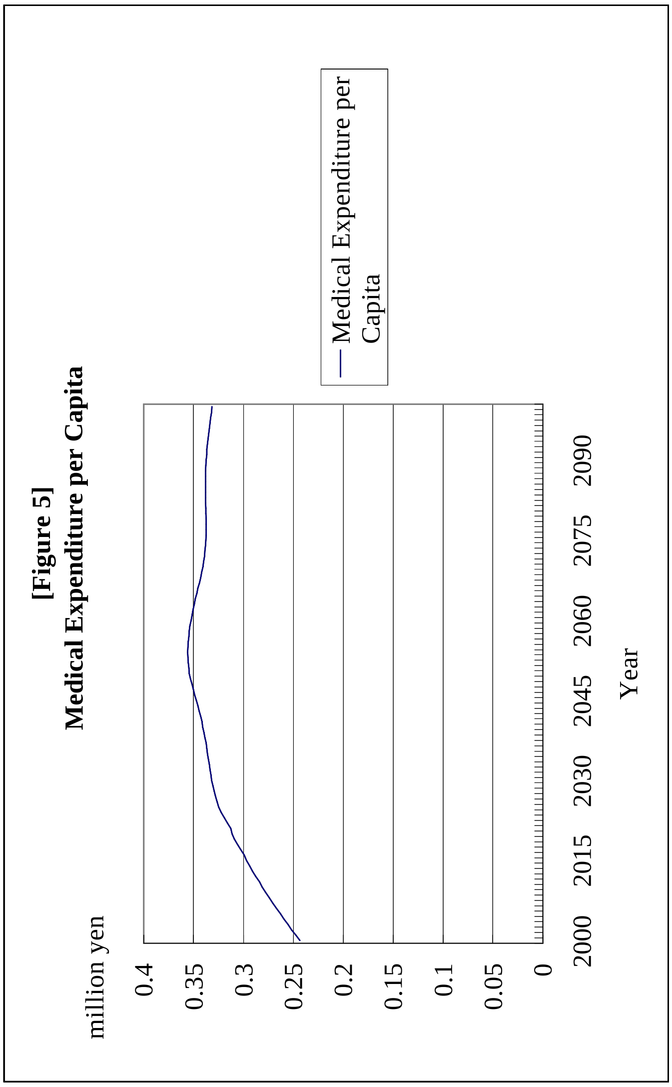

[Figure 4]
Medical Expenditure Per Capita(One Thousand Yen)
1000
900
800
700
600
500
400
300
200
100
0
0-4
10--14
20--24
30-34
40-44
50-54
60-64
70-74

Figure 5:



[Figure 5]
Medical Expenditure per Capita
million yen
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2000
2015
2030
2045
2060
2075
2090
Year
Medical Expenditure per Capita

Figure 6:

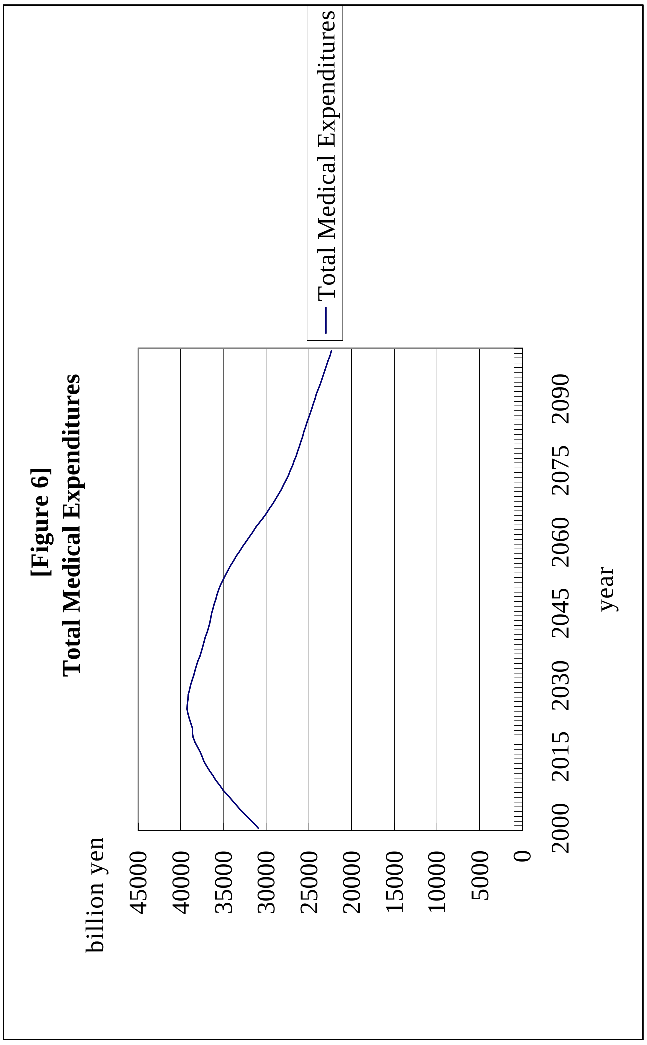

[Figure 6]
Total Medical Expenditures
billion yen
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
2000
2015
2030
2045
2060
2075
2090
year
Total Medical Expenditures

Figure 7: Base Case

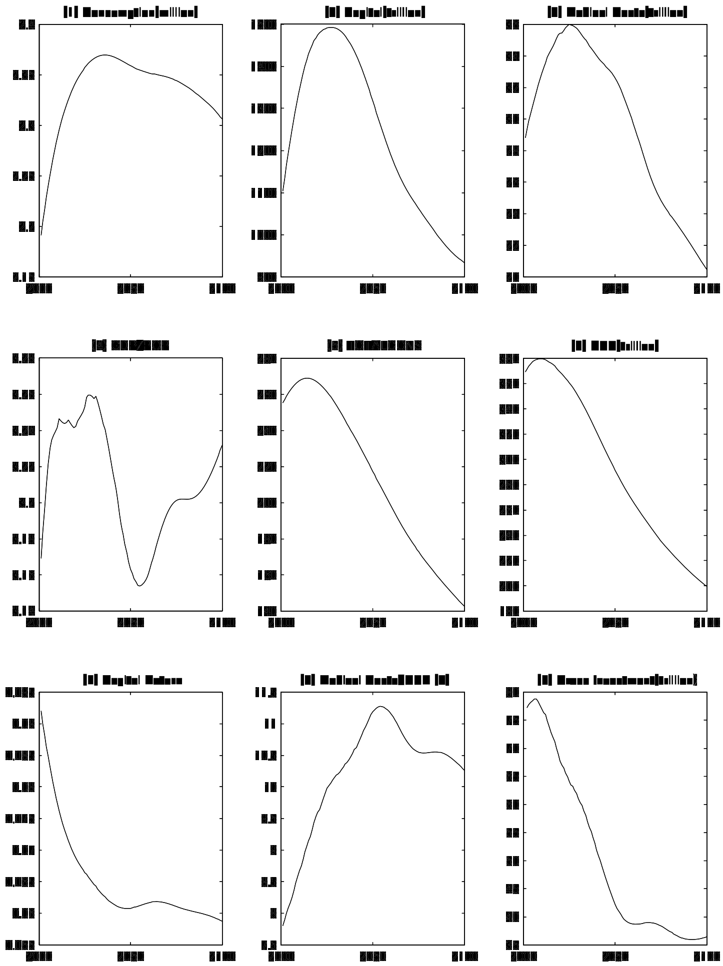


Figure 8: $\varphi = 0.25$

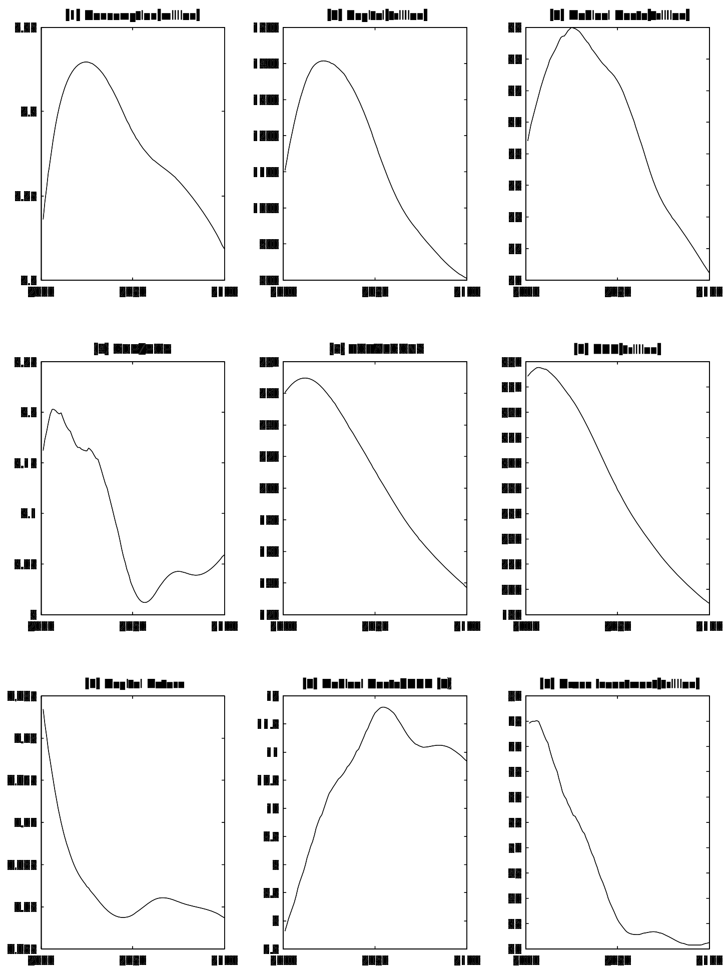


Figure 9: $\varphi = 0.3$

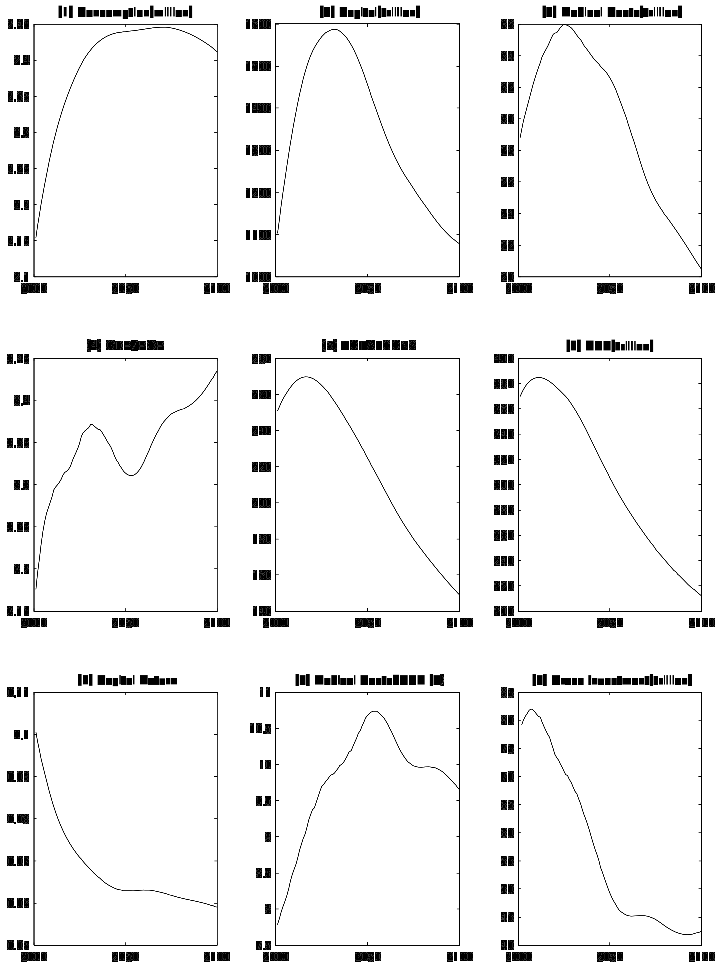


Figure 10: $\sigma = 0.1$

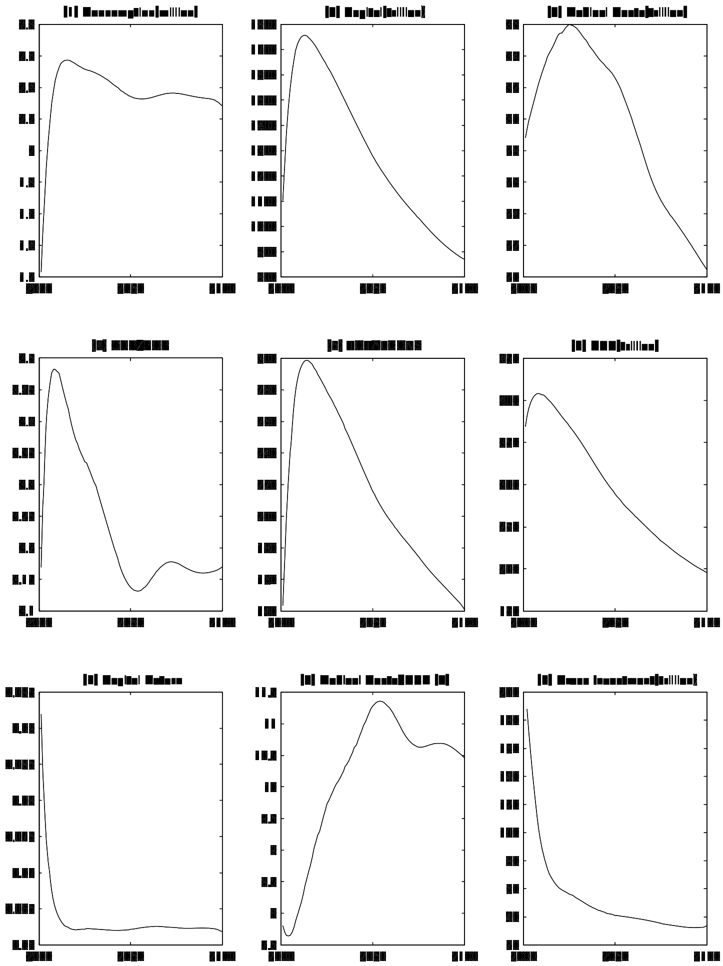


Figure 11: $\sigma = 10$

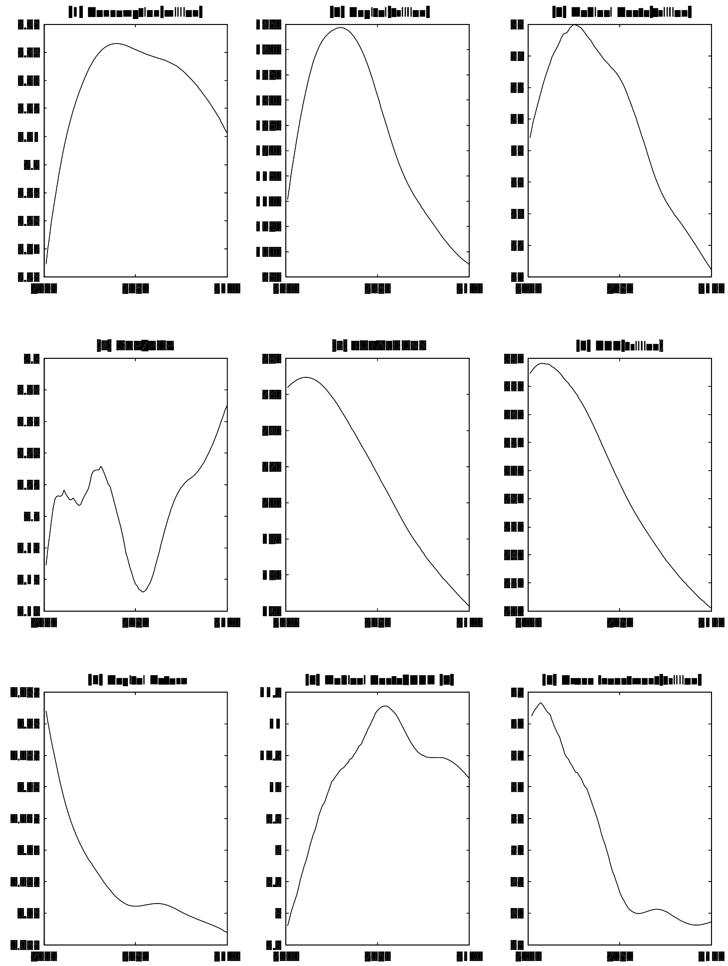


Figure 12: $\beta = 0.99$

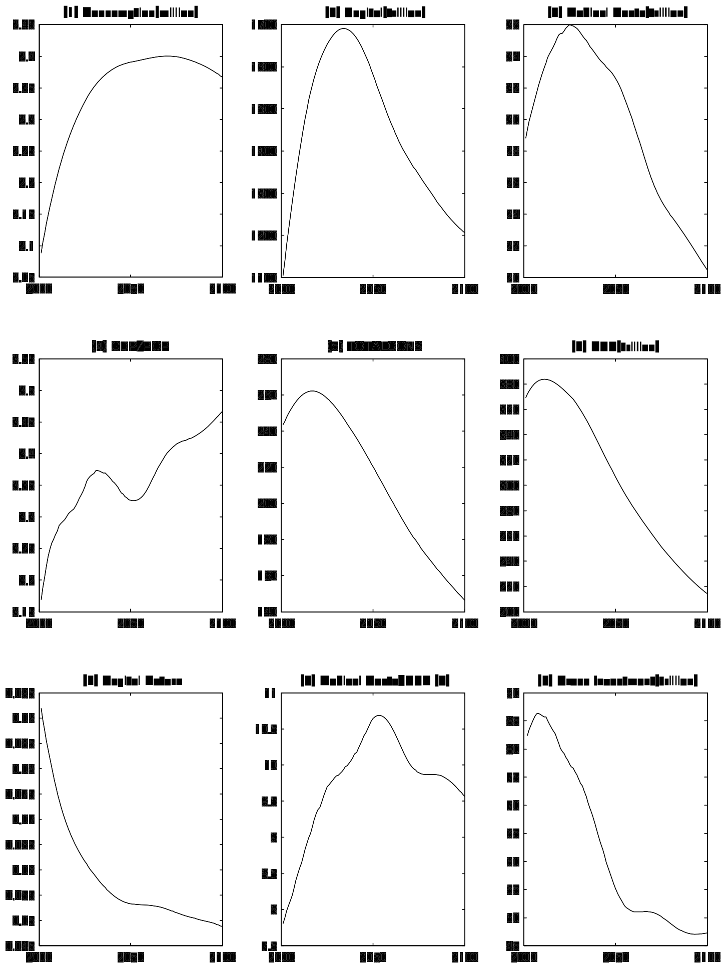


Figure 13: $\beta = 0.97$

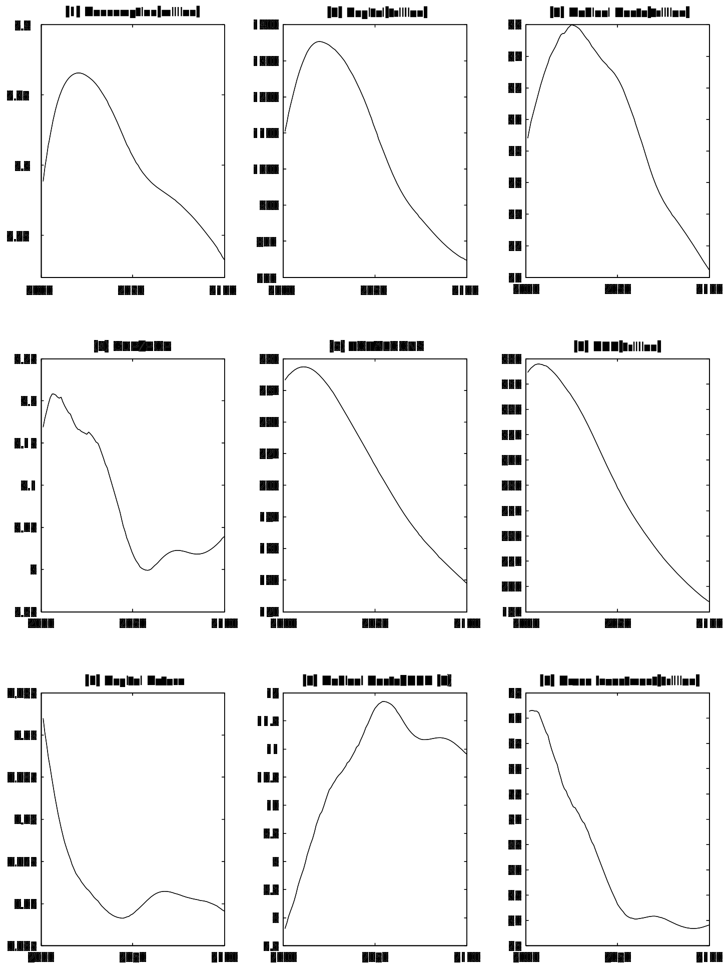


Figure 14: $g = 0.01$