FISCAL SUSTAINABILITY

IN THE LIGHT OF AGING TREND:

Finding the Patterns among Aged OECD Countries

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by

SANGWON LEE

Dr. Ronald Ratti, Dissertation Supervisor

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The undersigned, appointed by the Dean of the Graduate School, have examined the dissertation entitled

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IN THE LIGHT OF AGING TREND:

Finding the Patterns among Aged OECD Countries

Presented by Sangwon Lee,
a candidate for the degree of Doctor of Philosophy,
and hereby certify that, in their opinion, it is worthy of acceptance.

Professor Ronald Ratti

Professor Douglas J Miller

Professor X. Henry Wang

Professor Doh C Shin

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Sangwon Lee

Dr. Ronald Ratti, Dissertation Supervisor

ABSTRACT

This study is an investigation into the fiscal sustainability of countries in the light of the aging trend and finds that it runs downhill in the countries that are classified as high-level age and have experienced the trend of high-speed aging. This conclusion, and the others that follow, come from the empirical results of the 18 OECD countries, using the annual financial data from 1971~2005.

First, this study finds that the reaction of the primary surplus against increasing the debt−GDP ratio, as the indicator of the fiscal sustainability, is negative or changing from positive to negative in seven countries. Included in this group is Japan, the highest age and aging speed country in the world.

Second, it identifies the distinctive properties within groups that are classified by both the age level and the aging speed. In particular, high-age level countries with the high-speed aging trend show signs of financial difficulty with rapidly increasing debt-GDP ratios, whereas the relatively low-age level countries with slow-speed aging trend exhibit fiscal sustainability with decreasing debt-GDP ratios.

Third, it concludes that the U.S. has a chance to prepare for future fiscal difficulty, whereas Korea has a high probability that it will suffer from fiscal sustainability problems over the next two decades or more. The debt-GDP ratios for the main OECD countries are expected to double when compared to 2005 levels.

Chapter I.

Introduction and Motivation

Nowadays government financial affairs cannot but attract public attention in the light of their scale. For example, the general government total outlays ratio as a fraction of GDP (2005 Base) is 34.2% in Ireland, which has the smallest number in OECD, while in Sweden the ratio is 56.6%, the largest number. The mean of this ratio in OECD is 40.8%, and the mean in the EU area among OECD is 47.5%[1].

Moreover, the way governments handle their financial affairs (budget surpluses or deficits) sends important signals to the market. Having a balanced budget is an urgent issue facing financial authorities as well as the public.

The common framework of the fiscal structure is as follows: Total revenues are composed of tax revenue, which is the largest source, and non-tax revenue. Total expenditures include general government purchases, transfers, interest payments on the government debt, etc. If total revenue exceeds the total expenditures, we call it a surplus. If the revenues are equal to expenditures, this is a balanced budget, and otherwise, a deficit. When government chooses to deficit spend, then the revenue shortage has to be filled up by issuing government bonds.

The Government expenditure of each country is decided based on their history and current circumstances. For example, < Table 1−1 > shows the components of five countries' government expenditures.

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[1] Source: OECD Economic Outlook.

< Table 1−1 > Government Expenditure Component Ratio (2005 Base)

Country (ADR[1])	Public Service [2]	Social Affairs [3]	Education	Economic Affairs [4]
Korea (13.1%)	**27.1**	29.9	**17.0**	**26.0**
The U.S. (18.3%)	**30.5**	40.4	**17.0**	12.1
The UK (24.4%)	**22.5**	**56.1**	13.0	8.4
France (25%)	19.6	**60.1**	11.5	8.8
Germany (28.1%)	18.9	**62.7**	8.9	9.6

1) Aging Dependent Ratio(%) = {(+65 years old)/(15~64 years population)}x100

2) General public services + Defense + Public order and safety

3) Environment protection + Health + Social protection + Recreation

4) Economic affairs + Housing and community amenities

5) Unit: percentage (%) of general government total outlays

6) Source: UN Population Division/ OECD statistics portal(www.oecd.org/stastsporta/)

The public service expenditure (including defense) ratios are high in the U.S. and the UK due to Iraq War, and in Korea due to facing North Korea. The economic affairs ratio is high in Korea, which must spend more to expand SOC such as harbor facilities, high-speed railways etc, compared to other developed countries. One interesting point is that the education ratios are lower and social affairs (including medical care, health, etc.) ratios are higher in aged countries of Europe than those ratios in aging countries like the U.S. or Korea. Through this fact, we can assume that aging levels dictate the components of the government expenditures.

The Effects of Aging Society.

Potential risk factors in financial affairs vary from country to country. Among the potential risks, one factor is common to every country: the aging problem. Due to developments in medical fields, life expectancy is increasing in most countries, which is shown in < Table 1−2 >. In Japan, it is over 80, and the mean of OECD is 78. One can easily conclude this is an increasing trend. Timing may matter in the aging problem, but every society definitely has to face it.

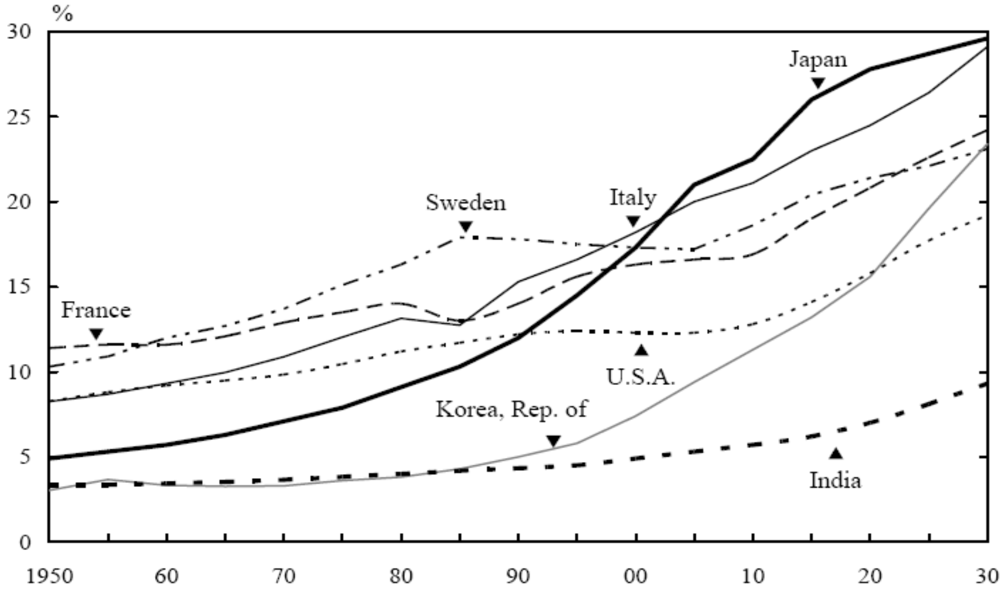
< Figure 1–1 > illustrates the trend of population transition. The proportion of people over 65-year-old population to total population is already over 20% in Japan and Italy. It forecasts that other European countries such as Sweden and France will pass over 20% in 2020. It also forecasts the U.S. and Korea will pass over or be close to 20% in 2030, despite their 2005 ratios being 12.3% and 9.4% respectively. In the trends of this ratio, the aging speed of Korea is astonishing. In the light of this aging speed, Korea’s ratio will catch up that of the oldest country, Japan, in the near future.

< Table 1 – 2 > Life Expectancy year (2005 base)

Japan	France	Germany	The UK	**OECD**	The U.S.	Korea
81.9	79.6	78.7	78.5	**78.0**	77.4	77.0

* Source : UN Population Division. (http://esa.un.org/unpp/)

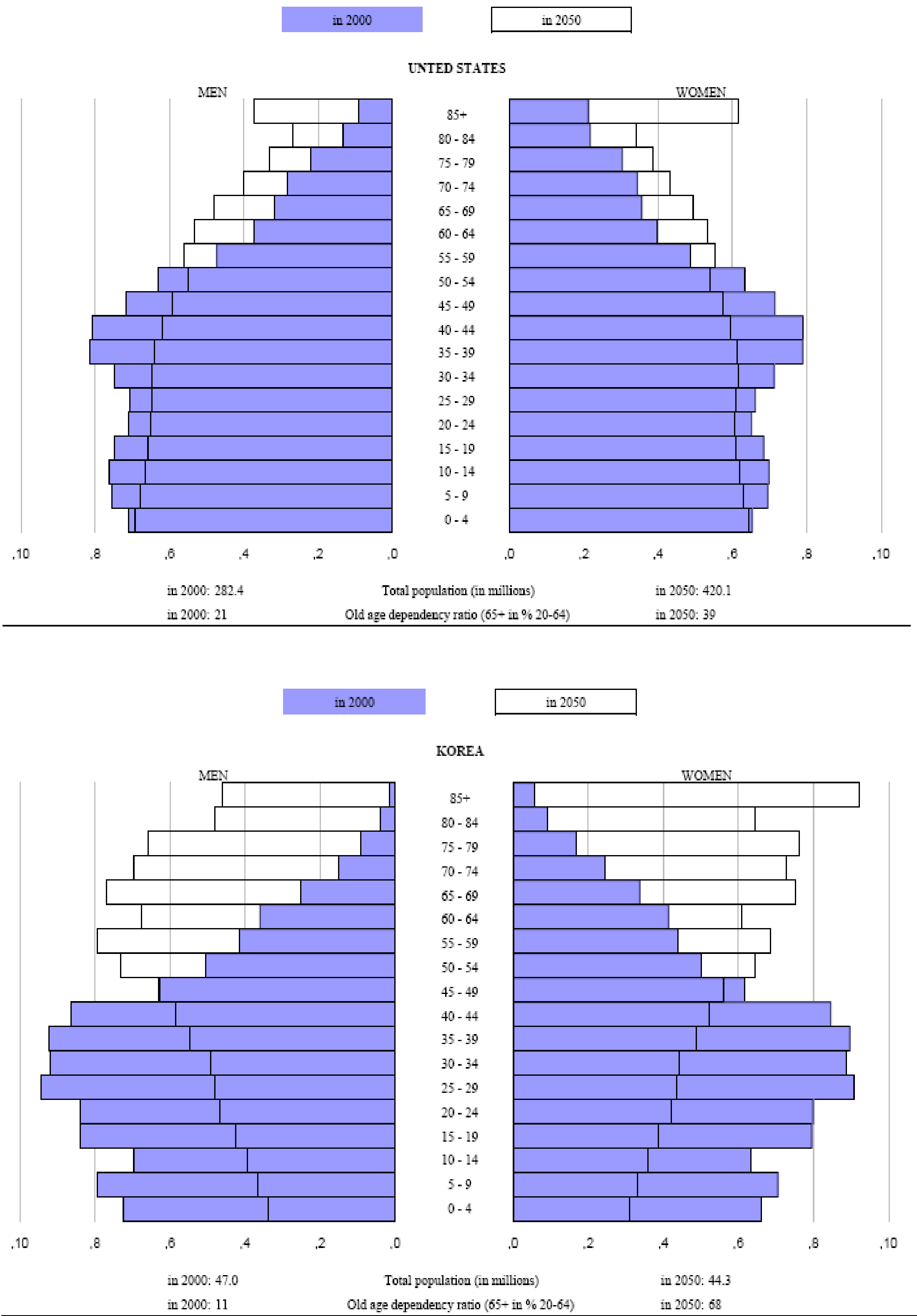
< Figure 1 – 1 > The Proportion of over 65 years Old Population to Total Population



* Source : Japanese Statistics Bureau. (www.stat.go.jp/engilsh/data/handbook/)

What are the effects of aging on a society? First, people over 65 years old are more likely to be retired, so they may receive pension payments or benefit from transfer payments to people in low-income brackets. Moreover, these people are highly probable to be big consumers of medical services. Consequently, in terms of government expenditure, the social affairs field expenditure should have to increase sharply. In terms of government revenue, the revenue cannot help decreasing because income, which is base of tax revenue, shrinks according to increasing retired people. While this is happening, however, the government’s revenue from income tax is decreasing due to more people retiring: A major issue since the income tax is such a large part of government revenue. We can illustrate the effect of a decreasing economically active population due to aging trend in the population pyramid shown in < Figure 1−2 >.

< Figure 1−2 > Population Pyramid in the U.S. and Korea



* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

** Source: OECD Demographic and Labor Force database. (www.oecd.org/els/social/indicators/SAG).

In the U.S., the total population is expected to increase from 282.4 million in 2000 to 420.1 million in 2050; an increase of 48.8% and the old age dependency ratio[2] will increase from 21% to 39%. In short, in 2000 it takes five workers to support one retired person, however in 2050, five people will have to support two retired people, indicating that personal burden will double.

Korea has the most dramatic population transition type among OECD countries. The total population will shrink by 5.7%, from 47 million in 2000 to 44.3 million in 2050, and the old age dependency ratio will rapidly increase from 11% to 68%. Using the same analogy as above, in 2000, ten people support one retired person, but in 2050, ten people will have to support seven retired people: the personal burden will be seven times larger.

Governments must prepare for the aging shock in advance by cutting superfluous expenditure and expanding their revenue bases. Logically there are five possible ways to achieve these goals:

(i) Reducing government expenditure in fields not affected by aging.

(ii) Increasing tax revenue by making tax rates higher.

(iii) Increasing non-tax revenue by selling government assets.

(iv) Imposing an inflation tax by increasing money supply.

(v) Issuing government bonds.

First, the reducing expenditure plans are limited in the sense of execution of power. If one tries to change the schedule of even a single item in the budget, he or she may face with organized resistance. Politicians, who have to consider the voters, have difficulty willingly making the government to reduce its spending.

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[2] This ratio is calculated by dividing over 65-year-old populations by 20 ~64-year-old populations. It is different from the Aged Dependency Ratio, and this concept is only used in the population pyramid.

The plans that increase tax rates have a serious side effect on the national economy through restraining the willingness to work. Raising tax rates causes falling national productivity, followed by decreasing the tax base and eventually diminishing government revenues. Furthermore, these methods stir up tax protests. We can further examine this through checking the level of people's tax burden. The ratio of the general government total tax and non-tax receipts to GDP in the < Table 1−3 > shows that the levels of people's burden are high in European countries. The mean of this ratio for OECD countries in the Euro area is 45.1%, which is around 7% higher than that of OECD, 38.5%. Only three countries have room to raise tax rates.

The selling of government assets may be an effective method in countries that have huge assets or are planning to privatize public enterprises. However, the privatization itself stirs up political protests, and the revenue from selling government assets only has a small, one time effect on the government's total revenues. The increasing money supply method also has limitations. Increasing money supply provokes inflation, which causes many side effects in an economy. It raises a question about the equity of burdens between actual property owners and financial property owners, creditors and debtors, etc. We have to consider the conservatism of the Central Bank, which has authority in stabilizing price levels.

< Table 1 – 3 > General Government Total Tax and Non-tax Receipts (2005 base)

France	Germany	The UK	**OECD**	The US	Korea	Japan
50.7%	43.6%	41.9%	**38.5%**	33.1%	31.9%	31.7%

* percentage of normal GDP

** Source : OECD Economic Outlook.

The last method is classified as the government's fiscal policy. Issuing government bonds is considered as the last resort for the financial authorities. This method is easily adopted in reality, even though it also raises many problems such as transferring burdens to next generations and distorting the financial market by absorbing the liquidity. As a result, government debt has been accumulated continuously.

According to < Table 1−4 >, the ratio of general government gross financial liabilities to GDP already passed over 100% in Japan and Italy; the mean of OECD is close to 80%. The level of this ratio is quite high considering the fact that this ratio is higher than that of the one-year government revenue to GDP ratio in almost all countries.

In addition to the problem of the government debt level, the accumulation speed of debt is another major issue. In < Table 1−5 >, we can see the importance of this speed. The liability ratios to GDP increase relatively gently in Germany and France. However, the ratios jump two or three times as much from the 1995 levels to those of 2005 in Japan and Korea. This problem is becoming a matter of great concern for many countries. Thus, discussions about the fiscal sustainability are focused on the accumulation process of government debt and whether this process is stationary or sustainable or not.

< Table 1 – 4 > General Government Gross Financial Liabilities (2005 base)

Japan	**OECD**	France	Germany	The US	The UK	Korea
177.3%	**77.6%**	75.4%	71.1%	62.4%	46.5%	24.7%

* percentage of normal GDP

** Source: OECD Economic Outlook.

< Table 1 – 5 > The Trend of General Government Gross Financial Liabilities

Country	1995	2000	2005	’05 – ‘95
The U.S.	70.7	55.2	61.8	Δ8.9
The UK	52.2	45.6	46.5	Δ5.7
Germany	55.7	60.4	71.1	+15.4
France	62.6	65.2	76.1	+13.9
Japan	**87.7**	137.1	**173.1**	**+85.4**
Korea	**5.5**	16.3	**24.9**	**+19.4**

* Percentage of normal GDP

** Source: OECD statistics portal (www.oecd.org/stastsporta/)

Distinctive features and Contribution of this Paper

Considering these difficult conditions in financial affairs, one may raise the following questions: (i) Are OECD countries fiscally sustainable? (ii) Is there a common trend or pattern in financial variables among the already aged countries? (iii) If so, can we apply this kind of pattern to low-level aging countries like the U.S. or Korea? Or what will be the future values of the debt-GDP ratio in major countries? This paper examines the government financial annual data of 18 OECD countries from 1971 to 2005 in relation to questions (i), (ii) and (iii). Relating to question (iii), this paper also uses the Global Insight data from 2008 to 2035.

First, we find that some countries have difficulty with fiscal sustainability. Many aged countries recently exhibit a negative relationship between primary surplus and debt−GDP ratio, while most low-level aging countries still have a positive relationship between these variables. This indicates that the aging variable plays an important role in predicting financial difficulty.

Second, we can find an identical trend between adjusted primary surplus and debt−GDP ratio using panel data of the aged OECD countries. This pattern is obvious in the groups that are high-age and fast-aging countries. This finding supports the conclusion that the aging variable is vital to national finance.

Relating to estimated future values, this paper evaluates two studies: one is using the panel data analysis results and another is using a debt accumulation equation. With the former process, we can roughly expect, using the reference group's information, that the U.S. is expected to be stable at the high−age levels while Korea has to prepare for a sharply increasing debt trend with positive primary surplus instead of current deficits. Moreover, if the huge deficits continue after 2006, both countries have a high probability to run into great financial trouble within one or two decades. With the latter process, we can predict that the main OECD countries' debt levels are increasing steadily until 2035, and most countries debt levels in 2035 will have more than doubled compared to that of 2005. In particular, the Japanese debt−GDP ratio may exceed 300% in 2035.

Through this study, we can know there is a little reserved power to prepare for the aging problem in the light of the government's supports due to the heavy debt levels. In the near future, most governments have to issue bonds or raise tax rates higher in order to make money for the counter movement against the aging problem. If the debt levels are already high enough, governments may suffer from issuing government bonds. Government bond prices will fall down and interest rates will skyrocket, causing chaos in the money market and eventually leading to decline in the whole economy. In this stage, the government bonds are no longer safety assets, even in the U.S.

Moreover, the aging issue will cause the distribution problem between generations. If the governments neglect to reduce their debt levels now, then future generations have to pay back these debts through raising tax rates in addition to the burden of supporting old generations. This means that the current generation enjoys a lot while the future generations bear twice burden in terms of taxation. Therefore, the governments should take control of debt levels to leave rooms for the next generations. These actions are painful for politicians who face the elections. Most voters do not want to raise their tax rates. Thus, a group of public service personnel, independent from political interest, should hold the nation's fiscal health.

Sample selection problem

The reason to select OECD countries to study is that the aging problem is serious in developed countries. 88.8% of the world population between age 15 to 64 years is living in developing countries and 11.2% is living in developed countries, whereas 61.1% of the world population over 65 years old is living in developing countries and 38.9% is living in developed countries in 2005. (Source: Korea National Statistical Office (KNSO)) This statistic shows that developed countries have higher aged dependency ratios than developing countries.

Among the top 20 countries with high GDP, China, Brazil, India and Russia are not belonging to OECD. (Source: KNSO) However, the former three countries have aged dependency ratios of less than 12%, which means that they do not have to worry about the aging problem yet. Only the ADR of Russia is 19%. However, in this study we set focus on the countries in which aged dependency ratio is over 20%. Thus, Russia is out of that criterion.

Among the top 20 countries in terms of high GDP per capita, only Qatar dose not belong to OECD. (Source: KNSO) However, its population is less than 1 million, so we can leave this country out of the study scope.

Here is the list of top 20 countries with the high aged dependency ratio in 2005: Japan, Italy, Germany, Greece, Belgium, Bulgaria, Portugal, France, Spain, Latvia, Estonia, Austria, Finland, the UK, Ukraine, Switzerland, Lithuania, Denmark, Hungary and Norway. (Source: KNSO) Fifteen countries of this list belong to OECD. The other five countries have small population. (Bulgaria: 7 millions, Latvia: 2 millions, Estonia: 1 million, Ukraine: 4 millions, Lithuania: 3 millions) It may not lead other results if we neglect these small countries.

Here is another list of top 10 countries in terms of population: China, India, the U.S., Indonesia, Brazil, Pakistan, Bangladesh, Nigeria, Russia, and Japan. (Source: KNSO) We already checked the status of China, India, Brazil and Russia. The other four countries, except the U.S. and Japan, have aged dependency ratios of less than 9%, which means that those are young countries.

Therefore, we can assume that choosing OECD countries to study the aging effect on the government budget do not cause any sample selection problem.

The paper is organized as follows. In Chapter II, the related theoretical literatures are reviewed. We will briefly check the three methods used to estimate fiscal sustainability. In Chapter III, the models used to analyze the above questions are presented, followed by the methodologies in the regression process and the estimation process. Chapter IV describes the data used: population, government debt, primary surplus, etc. The empirical test results are shown in Chapter V, and forecasting the future is examined in Chapter VI. Chapter VII concludes the paper.

Chapter II.

Related Literature Review

There are a number of papers and methods to test for government fiscal sustainability. Before summarizing the preceding papers related to testing fiscal sustainability, I briefly list the main three indicators that are used by many researchers. These are:

(i) Government's Intertemporal Budget Constraint
(Or Present Value Government Borrowing Constraint: PVBC)

(ii) Reaction Function,

(iii) Primary Gap / Tax Gap.

2.1. Method for Testing Fiscal Sustainability

Government's Intertemporal Budget Constraint (or PVBC)

Since Hamilton and Flavin (1986) presented the PVBC, the Government's Intertemporal Budget Constraint model (IBC) became a traditional way to test fiscal sustainability and was broadly used by Kremer (1988), Wilcox (1989), Trehan and Walsh (1991), Hakkio & Rush (1991), Corsetti and Roubini (1991) and Quintos (1995). The specific model expansion and definitions of each variable are slightly different to each paper, but the basic framework of the IBC model is the same.

To simplify the main concept of the IBC, government should follow the IBC for maintaining fiscal sustainability. Here is the government budget constraint in time t.

$$B_t = (1 + r)\, B_{t-1} + G_t - T_t = (1 + r)\, B_{t-1} - S_t \qquad (1)$$

where B is a measure of government debt, G is government spending excluding the interest payment on government debt,[3] T is government revenue, S is the primary surplus,[4] and r is the interest rate on the government debt. Equation (1) can be explained as government debt (B_{t+1}) will increase from the present level (Bt) when the government expenditure inclusive interest payment (G_t + rB_t) exceeds the government revenues (T_t).

Because equation (1) should hold for every period, solving this recursively forward in time leads to the government intertemporal budget constraint.

$$B_t = \sum_{j=1}^{\infty} \frac{1}{(1+r)^j} S_{t+j} + A_0 \quad \text{, where } \; A_0 = \lim_{n\to\infty} \frac{1}{(1+r)^n} B_{t+n} \qquad (2)$$

If A_0 goes to zero, then we can say that the present value of the stream of future primary surpluses is equal to the initial debt stock level. Thus, the government is under a fiscally stable condition. So many researchers test fiscal sustainability by focusing on whether A_0 goes to zero or not. There are many ways to test the null hypothesis (H_o: A_0= 0), and these tests result in controversial issues like assumptions on the interest rate (r_t) and cointegration problems between variables etc. We will further examine this in section 2.2.

---

[3] The actual government expenditure in time t (E_t) is $E_t = G_t + rB_t$, which is shown on the budget bill of that fiscal year.

[4] Usually, the government primary surplus (S_t) is defined as $S_t = T_t - G_t$

Reaction Function

As mentioned before, the IBC model is very controversial. As a result, different conclusions may be drawn according to the interpretation. To avoid this kind confusion, a relatively easy way to check fiscal sustainability is introduced. This method directly focuses on the relationship between primary surplus and government debt without the discounting process. Bohn (1995, 2005) and Uctum et al (2006) used this method. Suppose $S_{t+1} = (1+ r_{t+1})\ S_t$, then we can rewrite[5] the government budget constraint of equation (1) in GDP ratio form as:

$$b_{t+1} = x_{t+1}\ (b_t - s_t) \qquad (3)$$

where $b_t = B_t / Y_t$ is the ratio of debt to GDP, $s_t = S_t / Y_t$ is the ratio of the primary surplus to GDP, $x_{t+1} = (1+ r_{t+1})\ Y_t / Y_{t+1} \approx 1+ r_{t+1} - y_t$ is the ratio of the gross return on government debt to the gross growth rate of GDP. (Bohn, 1998)

The reaction function method has a simple logical intuition, that if the government reacts to increasing debt by preparing to increase the current surplus, then this implies that the government policy is sustainable. We can express this logic in equation (4):

$$s_t = \rho\ b_t + \alpha\ Z_t + \varepsilon_t = \rho\ b_t + \mu_t \qquad (4)$$

where Z is a set of other determinants of the primary surplus, ε is an error term, and $\mu_t = \alpha\ Z_t + \varepsilon_t$.

---

[5] Forwarding one period of equation (1) → $B_{t+1} = (1+r_{t+1})\ B_t - S_{t+1}$
Substituting $S_{t+1} = (1+r_{t+1})\ S_t$ → $B_{t+1} = (1+r_{t+1})\ (B_t - S_t)$
Dividing both side with Y_{t+1} → $B_{t+1}/Y_{t+1} = (1+r_{t+1})\ Y_t / Y_{t+1}\ (B_t / Y_t - S_t/ Y_t)$

We will examine the Z variable in section 2.2. If ρ is significantly greater than zero, we can get equation (5) by substituting equation (4) in equation (3).

$$b_{t+1} = x_{t+1} (1 - \rho) b_t + \xi_t \tag{5}$$

where $\xi_t = - x_{t+1} \mu_t$. We assume that this is stationary. Due to $\rho > 0$, $(1 - \rho) < 1$ so the debt-GDP ratio has a high probability to be mean reverting.

The reaction function test is focusing only on the coefficient of the debt-GDP ratio to the primary surplus-GDP ratio to check whether this coefficient is significantly greater than zero or not.

Primary Gap and Tax Gap

After Blanchard (1990) introduces the concepts of the primary gap indicator and the tax gap indicator, many papers are written using these indicators, such as those by Horne (1991), Chalk and Hemming (2000), Koo (2002) and Broda (2004). These indicators are relatively simple, do not need a complicated model, and only need some forecasting information related to government expenditure, the real interest rate and the real GDP growth rate. The primary gap indicator is:

$$d^* - d_t = (n_t - r_t) b_t - d_t \tag{6}$$

where d^* is the permanent primary deficit, $d_t = D_t / Y_t$ is the ratio of the current primary deficit to GDP, n is the real growth rate of GDP, r is the real interest rate, $b_t = B_t / Y_t$ is the ratio of debt to GDP.

In short, the primary gap is the difference between the current primary deficit and the permanent primary deficit. The latter is the necessary deficit level to stabilize the debt ratio. If the current primary deficit is greater than the permanent primary deficit, the primary gap indicator goes below zero. This means the current budget balance has a high probability of not stabilizing the debt ratio. With a negative value of the primary gap, we can conclude that the current fiscal policy is not sustainable.

As an alternative model, the tax gap indicator has a similar logical structure. The tax gap indicator is:

$$t_t - t^* = t_t + (n_t - r_t) b_t - g_t \qquad (7)$$

where t is the ratio of taxes to GDP, t^* is the permanent tax to GDP ratio necessary to stabilize the debt ratio, and g is the ratio of government noninterest spending to GDP. Similar to the primary gap indicator, the tax gap indicator is the difference between the current tax ratio and the constant debt tax ratio. If the current tax is lower than the permanent tax, the tax gap indicator is negative, which means there is a high probability of instability of the debt ratio with the current government tax schedule. With the primary gap having a negative value, we can conclude that the current fiscal policy is not sustainable.

2.2. Preceding Researches

We can pick main preceding researches related to testing fiscal sustainability. In < Table 2 – 1>, we summarize these papers and divide those into two groups: one consists of studies for the U.S. only, and the other, studies for other countries.

< Table 2 – 1 > Summary of the Main Preceding Researches

Author (year)	Data Set	Model	Main Finding
Hamilton & Flavin (1986)	U.S. 1960~84	IBC model / Stationarity test	Fiscal Policy is Stable
Kremer (1988)	U.S. 1960~84	〃	Non-stationarity on Debt
Wilcox (1989)	U.S. 1960~84	〃	Not sustainable
Trehan & Walsh (1991)	U.S. 1960~84	IBC model/ Cointegration test	Sustainable
Hakkio & Rush (1991)	U.S. 1950~88	〃	Not sustainable
Quintos (1995)	U.S. 1947~92	〃	Still Sustainable
Bohn(1998, 2005)	U.S. 1916~95 U.S. 1792~2003	Reaction Function	Sustainable
Buiter & Patel (1990)	India 1970~87	IBC model / Stationarity test	Non-stationarity on Debt
Corsetti & Roubini (1991)	OECD Countries 1960~89		Italy etc are Insolvent
Ihori et al (2006)	Japan 1957~99	〃	Non-stationarity on Debt
Huh et al (2005)	5 Asian Countries 1974~2002	IBC model/ Cointegration test	Only Indonesia is Stable
Uctum et al (2006)	18 Countries 1970~2002	Reaction Function	Japan has problem
Koo (2002)	Korea 1970~99	Primary gap/ Tax gap	Sustainable till 1996
Broda & Weinstine (2004)	Japan 2000~2100	Tax gap	Stable Simulation Result

2.2.1. Study of fiscal sustainability for the U.S.

There are three main methods in the literature to test the U.S. fiscal sustainability: stationarity test using IBC model, cointegration test and reaction function test. We will go over these papers one by one.

One of the most important papers in testing fiscal sustainability is Hamilton and Flavin (1986), a milestone in this research field. They introduce the PVBC model and test for the U.S. fiscal sustainability with empirical data from 1960 to 1984, and conclude the U.S. holds the PVBC.

As mentioned in section 2.1., the focus of this method is to test $A_0 = 0$.[6] To be brief, if the growth rate of debt does not exceed the interest rate and this pattern lasts for a long time, then the value of A_0 goes to zero. In reality, the testing time horizon is relatively short, only 25 years in Hamilton and Flavin's work, so they introduce an empirical model[7] to check for fiscal sustainability. Due to the assumption of a constant interest rate, if primary surplus (S_t) and debt (B_t) are both stationary, it is logical to conclude the PVBC is stable. Through the stationarity test[8] on S_t and B_t respectively, the authors conclude that the test statistics lead to a rejection of the non-stationary assumption of S_t and B_t. This result supports that the U.S. budget has been balanced in present-value terms during 1960 to 1984. The remarkable contributions of their paper are assuming the constant interest rate, government-spending variable excluding interest payments, and adding money seigniorage, capital gains on gold as sources of government revenue.

Kremer (1988) raises a technical question about the way Hamilton and Flavin (1986) test the stationarity of debt (B_t). He argues that they ignore the presence of significant first-order autocorrelation on debt. He uses the same data period, and compares the results, both using the modifying term to correct the effect of

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6 $A_0 = \lim_{n\to\infty} \frac{1}{(1+r)^n} B_{t+n}$

7 $B_t = A_0(1+r)^t + E_t \sum_{t=1}^{\infty} (1+r)^{-j} S_{t+j} + \eta_t$, where B_t and S_t are adjusted debt and surplus.

8 Dickey-Fuller Test for unit root. H_0 : Z_t is non-stationarity with unit root.
$Z_t - Z_{t-1} = \Psi_0 - \Psi_1 Z_{t-1} + \Psi_2(Z_{t-1} - Z_{t-2}) + e_{z,t}$. If one can reject H_0, then Z_t is stationary.

autocorrelation of debt and without it.[9] He finds that the test statistics[10] are not significant enough to include the modifying term whereas they are significant in Hamilton and Flavin's (1986) model. He concludes that "non-stationarity of the real U.S. federal debt cannot be rejected on post-war data", which is contrary to the result of Hamilton and Flavin (1986).

Wilcox (1989) also raises a question about the PVBC model of Hamilton and Flavin (1986) in a new way, by focusing on the assumption of the constant interest rate. He allows for stochastic real interest rates. To be unconstrained from the change of the real interest rate, he discounted the debt series with ex-post real rates and tested for stationarity in the discounted debt.[11] He uses the autocorrelation test that is raised by Kremer (1988).[12] Examining statistics from the empirical regression model, Wilcox cannot reject the non-stationarity assumption of the discounted debt. He concludes that the U.S. fiscal policy, especially after 1974, is not sustainable. The discounted debt changed its trend around 1974 and increase rapidly.

Another major contribution to the literature is the cointegration test. Trehan and Walsh (1991) agree with the non-stationarity assumption in the U.S. debt. However, this fact cannot guarantee that the PVBC does not hold if there exists cointegration between debt and primary balances.

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[9] $\Delta B_t = 79.63 - \underset{(0.17)}{0.48}\, B_{t-1} + \underset{(0.22)}{1.02}\, \Delta B_{t-1}$: Hamilton and Flavin (1986) regression model; ( ) → standard error

$\Delta B_t = 19.43 - \underset{(0.28)}{0.10}\, B_{t-1} + \underset{(0.22)}{0.98}\, \Delta B_{t-1} - \underset{(0.34)}{0.59}\, \Delta B_{t-2}$: Kremer (1988) regression model; ( ) → standard error

[10] Augmented Dickey-Fuller test statistics from the equation of end note 9.
$\hat{\psi}_1 / \hat{\sigma}_1$, where $\hat{\sigma}_1$ is OLS standard error for $\hat{\psi}_1$

[11] $\Delta B_t = \gamma_0 + \underset{(0.402)}{0.198}\, B_{t-1} + \underset{(0.479)}{0.171}\, \Delta B_{t-1} + e_t$ (time period : 1975~84); ( ) → standard error

[12] $\Delta B_t = \gamma_0 - \underset{(0.128)}{0.128}\, B_{t-1} + \underset{(0.235)}{0.525}\, \Delta B_{t-1} - \underset{(0.271)}{0.117}\, \Delta B_{t-2} + e_t$ (time period : 1963~84); ( ) → standard error

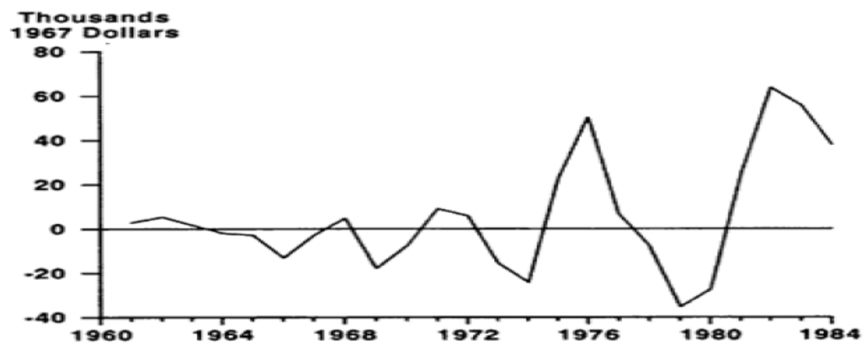
To check the cointegration property, we have to go back to the government budget constraint. We can rewrite equation (1) as:

$$B_t - B_{t-1} = r_t B_{t-1} + G_t - T_t = r_t B_{t-1} + D_t \qquad (8)$$

where D is the government primary deficit. There are two cases for the interest rate: (i) the constant interest rate such as Hamilton and Flavin (1986)'s model, (ii) the stochastic interest rate such as Wilcox (1989)'s model. In the first case, the stationarity linear combination of debt and primary surplus is a necessary and sufficient condition for holding of the IBC. In the second case, we can find an alternative condition using the relationship in equation (8). If the inclusion of the interest deficit ($r_t B_{t-1}+D_t$) is stationary, even though the interest rate (r_t) is stochastic and debt (B_t) is non-stationarity, then it supports the conclusion that IBC holds.

Trehan and Walsh (1991) test the empirical model with the U.S. data from 1960 to 1984 and conclude that there is no evidence of a stationary linear combination between debt and the net-of-interest deficit, but the first difference of the stock of debt is stationary which implies that the deficit process is sustainable. Their conclusion is summarized in < Figure 2−1 >, which shows that the inclusive of the interest deficit fluctuated around mean zero during 1960 to 1984.

< Figure 2 − 1 > The Change in the Interest Inclusive Deficit of the U.S. (1960~84)



* Source: Trehan and Walsh (1991) paper

Hakkio and Rush (1991) use another regression equation to check the cointegration between the government revenue and government expenditure including interest payments.

$$R_t = a + b\,GG_t + \varepsilon_t \qquad (9)$$

where R is the government revenue, and GG is the government expenditure which includes: spending on goods and services, transfer payments and interest payments on the government debt. These are real terms and deflated by real GNP and population. Through empirical testing using the U.S. data from 1950 to 1988,[13] they try to find the answers to two questions: (i) Are government spending (GG) and revenue (R) cointegrated? (ii) Is $\hat{b} = 1$? In the results of their cointegration tests, they find that GG and R are cointegrated in 1950~88, but there is no cointegration in other periods. In the results of testing the value of b, b is significantly less than one in every period. To combine these results, the U.S. fiscal policy has not been sustainable since 1964, because of no cointegration between GG and R. During 1950 to 1988, the U.S. fiscal policy is not sustainable too due to $b < 1$ even though there exists cointegration between GG and R.[14]

Quintos (1995) argues that the cointegration itself is not a critical criterion, when examining the sustainability of the fiscal policy. Quintos's conclusion is that "the deficit process is still sustainable despite the failure of cointegration in the 80's." In the empirical test, Quintos uses a model similar to equation (9) like Hakkio and Rush (1991)'s model[15] using data from 1947 to 1992.

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[13] There are three testing periods: (1) 1950~88, (2) 1964~88, (3) 1976~88

[14] It means that the growth rate of government spending is higher than that of government revenue. The fiscal policy is not sustainable such that the government revenue never covers the government spending.

[15] R_t is real government revenue, G_t is real government expenditure including interest payments on the government debt and government debt is the market value of federal debt.

< Table 2 − 2 > Cointegration Test between Government Revenue and Expenditure

Regression Model : $R_t = a + b\ GG^*_t + \varepsilon_t$					
Hakkio & Rush (1991)			Quintos (1995)		
Data	Cointegration	b	Data	Cointegration	b
1950~88	O	$b < 1$	1947~92	O	$0 < b < 1$
■ 1964~88	X	$b < 1$	■ 1947~80	O	$b = 1$
■ 1976~88	X	$b < 1$	■ 1980~92	X	$0 < b < 1$

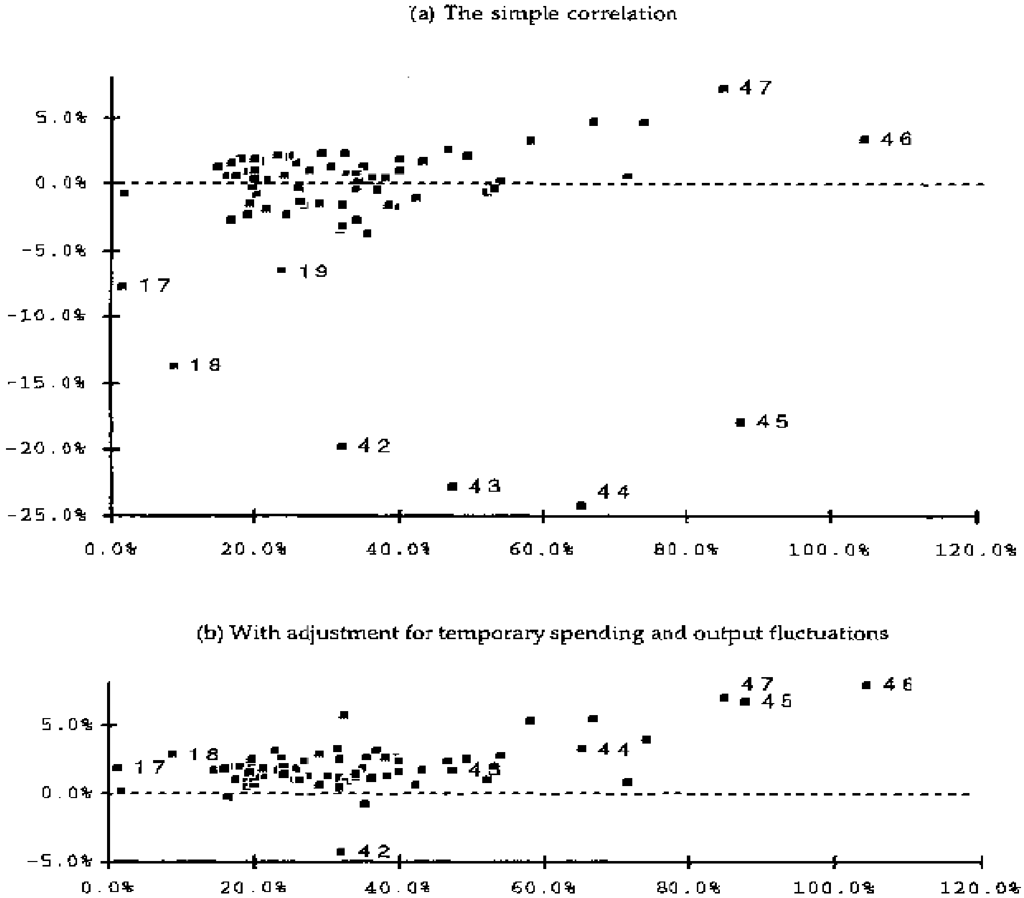
* Includes interest payments on the government debt.

Quintos introduces the break in the empirical regression model,[16] so the sub-periods are divided around 1980. The results of the cointegration test between government revenue and expenditure of Hakkio and Rush and Quintos are compared in < Table 2−2 >. Apparently, the results are similar to each other, but the conclusions are opposite. This is due to the property of cointegration. Quintos argues that cointegration is not a necessary condition for concluding a country's fiscal activity is sustainable, contrary to Hakkio and Rush's reasoning.

As we review the trend of testing the fiscal sustainability, the stationarity test and cointegration test have controversial results even in the same data period. Bohn (1998, 2005) introduced a relatively easy method: utilizing the reaction function method. He argues that the fiscal policy is sustainable if the primary surplus is an increasing function of the debt. We can easily assume this relationship between primary surplus and debt by examining the adjusting process graphically in < Figure 2−2 >.

[16] $R_t = a + b\,G_t + \delta\,(D_t\,G_t) + \varepsilon_t$, where $D_t = 1$ if $t \in T_1 = \{1, \ldots, m\}$
$D_t = 0$ if $t \in T_1 = \{m+1, \ldots, T\}$

< Figure 2 − 2 > Primary Surplus versus Debt of the U.S. (1916~95)



* Source: Bohn (1998)[17] paper

Bohn's reaction function model is:

$$s_t = \rho\, b_t + \alpha_0 + \beta_g\, GVAR_t + \beta_y\, YVAR_t + \varepsilon_t \qquad (10)$$

where s_t is the ratio of the primary surplus to GDP, b_t is the ratio of debt to GDP, GVAR is the temporary government spending indicator, YVAR is the business cycle indicator, and ε is an error term. The variables GVAR and YVAR are Z in equation (4). These variables are taken from Barro (1986)[18] and play an important role in Bohn's empirical tests. The tests omitting these determinants of the primary surplus produce inconsistent estimates due to serious bias (see < Figure 2-2 >).

[17] Adjusted primary surplus $\tilde{s}_t = s_t - (\alpha_0 + \beta g\, GVAR_t + \beta y\, YVAR_t)$

[18] From Barro's Tax-Smoothing Theory: $GVAR = (g_t - g_t^*) / Y_t$,
$YVAR = (1 - Y_t / Y_t^*) (g_t^* / Y_t)$

< Table 2 – 3 > Reaction Function Test Results of Bohn.

	Bohn (1998)	Bohn (2005)
Data Period	1916 ~ 1995	1792 ~ 2003
Coefficient value (ρ)	2.8 ~ 5.4%	6.9 ~ 12.1%
Coefficient value (β_g, β_y)	$\beta_g < 0$, $\beta_y < 0$	$\beta_g < 0$, $\beta_y > 0$

Bohn conducted the reaction function test twice. < Table 2−3 > summarizes the test's results. His main finding is that the primary surplus reacts in a significantly positive way to an increase of debt-GDP ratio in both tests. The coefficient of variable GVAR is different in each test but it is not a significant difference. He also checked for possible problems such as autocorrelation and seigniorage,[19] and concluded that these issues do not affect the main findings.

2.2.2. Study of fiscal sustainability for other countries

The papers that study the fiscal sustainability of other countries are organized in a similar fashion to those studying the U.S. fiscal sustainability: stationarity test using IBC model, cointegration test, reaction function test, and the primary gap and tax gap. We will go over these papers one by one.

Buiter and Patel (1990) test the Indian public debt solvency with the data from 1970 to 1987. Their analyzing method is somewhat close to the stationarity test of Wilcox (1989). Buiter and Pate's IBC model is

$$b_t = (1 + r_{t-1})\, b_{t-1} + \delta_t - \sigma_t \qquad (11)$$

where b is total public debt as a fraction of GDP, r is the real interest rate minus the GDP growth rate, δ is the augmented primary deficit as a fraction of GDP, and the

[19] In U.S., the seigniorage effect averages 0.16% of GDP during 1915~2003. (Bohn 2005)

last term $\sigma = (M_t - M_{t-1}) / P_tY_t$ is seigniorage.[20] They conduct an augmented Dickey-Fuller test with the empirical regression model on Indian discounted public debt.[21] They conclude that their empirical test statistics cannot reject the non-stationarity assumption with the discounted public debt. Thus, Indian government's recent fiscal and monetary policies cannot guarantee solvency.

Corsetti and Roubini (1991) apply a stationarity test similar to Wilcox (1989) and Buiter and Patel (1990). They use the data from 18 OECD countries spanning 1960 to 1989.[22] Their basic model is close to Buiter and Patel (1990) in equation (11). The difference is that they use the real values instead of the ratio to GDP.[23] They conduct solvency tests using the discounted debt (Wilcox's method), the debt-GDP ratio (Buiter and Patel's method) and the real inflation-adjusted and seigniorage-adjusted current balance of the general government. The main finding is that among the G7 countries, only Italy is considered insolvent, and four smaller OECD countries (Belgium, Greece, Ireland and the Netherlands) have problems with the fiscal sustainability. These countries show large increasing current real fiscal deficits and high debt to GDP ratios.

Several characteristics are remarkable in their paper: the definition of debt, the definition of government, and explicit use of the seigniorage term. First, they use net debt for most countries,[24] but these result in bias problems. Social security reserves play a positive role in making the government balance a surplus; however, these are

[20] Due to the last term, they name their test as a solvency test instead of the fiscal sustainability test.

[21] $D_t = a_0 + a_1 t + \beta D_{t-1} + \mu_t$ where D is discounted public debt. $H_0 : \beta = 1 \ \& \ a_1 = 0$.

[22] The U.S., Germany, Japan, France, The UK. Italy, Canada, Belgium, Australia, Austria, Denmark, Finland, Greece, Ireland,The Netherlands, Norway, Spain, Sweden.

[23] For example, $d_t = D_t / P_t$ in Corsetti and Roubini, whereas $d_t = D_t / Y_t$ in Buiter and Patel.

[24] Australia, Austria, Greece, Ireland, Netherlands.

actually future liabilities. Over a certain aging threshold, a social security system may lead to huge government deficits. Second, their definition of general government includes state and local government, which causes some problems. For example, as they mentioned in their paper, a large fiscal deficit in the U.S. federal government can be offset by the fiscal surpluses of state and local authorities.

Ihori et al (2006) apply the stationarity test on debt with Japanese data of 1957~ 1999, which is similar to the testing method of Hamilton and Flavin. Their model starts with the government budget constraint shown in equation (1). They divide it by GDP and get

$$b_{t+1} = (1 + r - n)\, b_t - s_t \tag{12}$$

where b_t is the stock of government debt at the beginning of period t as a fraction of GDP, s_t is the primary surplus at period t as a fraction of GDP, r is the fixed nominal interest rate, and n is the fixed nominal growth rate.

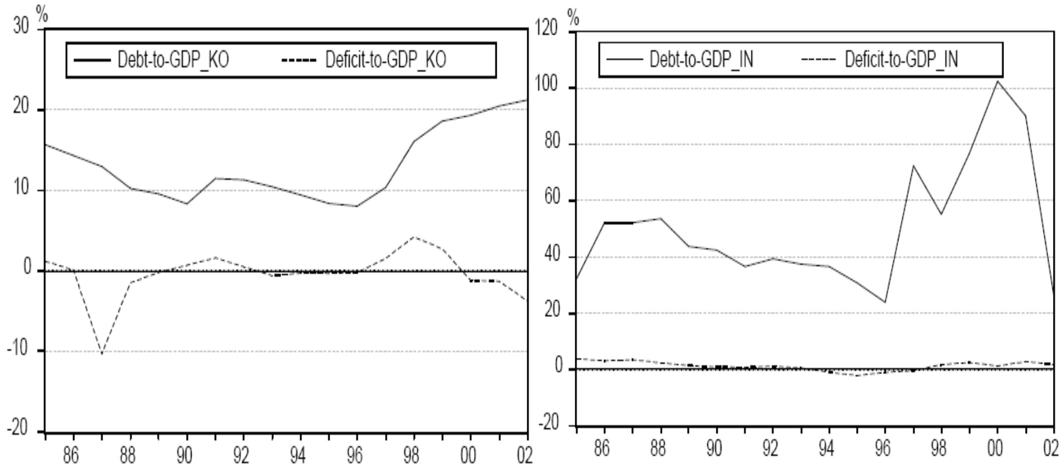
By recursive forward substitution like in equation (2), we get:

$$b_t = \sum_{j=0}^{\infty} \delta^j s_{t+j} + (1+r)^t A_1, \; where \quad A_1 = \lim_{j \to \infty} \delta^j b_{t+j}, \; \delta = \frac{1}{(1+r-n)} \tag{13}$$

Their null hypothesis is A_1 equal to zero, or, in other words, the debt-GDP ratio is stationary. In their empirical tests, the null hypothesis cannot be rejected during the period 1957~1997. However, if they stretch the testing periods from 1957~1998 or 1957~1999, then they can reject the stationarity of the debt-GDP ratio. This means that Japan starts to face the fiscal instability in the late 1990's. This finding supports the claim that "the actual deficit has exceeded the optimal level in the late 1990." Their paper has the same problem as the one by Hamilton and Flavin. They only focus on the stationarity of debt. Non-stationarity of debt itself cannot guarantee the fiscal instability. Furthermore, they use a fixed interest rate and growth rate: an unrealistic assumption.

< Figure 2 − 3 > The Trend of Government Debt and Deficit (1985~2002)

(a) Korea (b) Indonesia



* Source: Huh et al (2006) paper

Huh, et al (2006) use testing methods similar to Hamilton and Flavin and Trehan and Walsh, and they apply the method to 5 Asian countries' data from 1974 to 2002. These countries[25] have a common experience of a financial crisis in the late 1990's. In the process of overcoming this crisis, the government debt levels of these countries have risen sharply: a major of public concern. In the paper by Huh et al (2006), they conduct the stationarity test on the government deficit and debt separately. Their test results indicate that budget deficits are stationary in all countries. Considering the cointegration between deficit (or surplus) and debt, the stationarity of debt is a necessary condition for the fiscal sustainability. Using the ADF test on debt, only Indonesia is stationary.

Their finding is shown in < Figure 2−3 >. The trend of debt-GDP ratio is divergent after 1996 in Korea, whereas with Indonesia it converges to zero even though there is a huge fluctuation during the financial crisis period.

[25] Korea, Indonesia, Philippines, Thailand, Malaysia.

Uctum et al (2004) apply the reaction function test to 18 countries[26] using data from 1970 to 2002, examining whether governments respond to an increasing debt accumulation by generating a primary surplus or not. Their model is similar to Bohn's model in equation (10). The difference is that they use the primary balance series including seigniorage. They compare the unit root test approach to the reaction function approach and conclude that the latter has a more frequent mean reversion trend than the former, and they can get significant coefficients of debt variable against the primary surplus variable, with estimates varying from 0.03 to 0.65.

The main coefficient values classified by sign and magnitude are a changing trend from positive to negative in Japan, positive but shrinking in magnitude in France and Germany, positive and increasing in magnitude in the U.S. and Italy, strong positive in the UK, and positive but fluctuating in Korea. Their results are somewhat different from those of Corsetti and Roubini (1991), that of Huh et al (2005) using the stationarity test, and that of Koo (2002) using the primary gap and tax gap indicators.

One of the most remarkable characteristics is that they recognize the structural change in government fiscal policies and apply breaks in the regression model.[27] They find that "all countries except the UK have experienced at least one structural change." which is a more realistic interpretation.

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[26] The U.S. The UK, Canada, France, Germany, Italy, Japan, Korea, India, Indonesia, Malaysia, Thailand, Turkey, Costa Rica, Honduras, Mexico, Panama, Uruguay.

[27] I_i is the subperiod between break-dates t_{i-1} and t_i, and $1_{t\in Ii}$ is an indicator function such that $1_{t\in Ii}=1$ for $t_{i-1} < t < t_i$ and 0 otherwise.

$$S_t = \alpha_0 + \sum_{i=1}^{m+1} \rho_i B_{t-1} 1_{t\in Ii} + \alpha_G \widetilde{g}_t + \alpha_Y \widetilde{Y}_t + \varepsilon_t$$

Koo (2002) applies the primary gap and tax gap indicators to Korean data from 1970 to 1999. The main finding is that these indicators are worsening since 1997, corresponding to a sharp rising of the debt-GDP ratio, and finally he concludes, “The current primary deficit is too large and current taxes are too low to stabilize the debt ratio.” The weak point of his paper is the number of observations. Due to overcoming the financial crisis in 1997, the Korean government has had to put into practice an unprecedented unbalanced budget for many years, like the U.S. during World War I and World War II. However, it is difficult to draw conclusions about the fiscal instability with this short-term data.

Broda and Weinstein (2004) use the tax gap indicator to test Japanese fiscal sustainability over a 100-year horizon. Their definition of the debt variable, however, is the net debt, which is only half of the gross debt. Due to Japanese specification of structure in national assets and liabilities, they arrive at conclusions similar to those of Corsetti and Roubini (1991) mainly that “Japan’s future does not look any different than that of a typical OECD country.”

The remarkable characteristic is that they apply a simulation method in measuring future fiscal sustainability. The forecasting process is painful operation: we do not always know how the sign and magnitude of the interaction between variables change over time. For example, it is very difficult to forecast the population variable. However, it is even more difficult to get information on how this variable affects government revenue and expenditure, because a structural change in population directly affects the taxation base and other government revenues as well as government expenditure: such as medical care, transfers to lower income brackets, and pension system which are connecting to government expenditure.

Chapter III.

Model and Methodology

3.1. Model

3.1.1. Main Framework

Even though testing fiscal sustainability itself is important, it is more important to figure out the effect of aging by examining the relationship between the adjusted surplus and the debt along with the different aging levels, information that comes from the historical experiences of the already aged countries (the ADR is over 20% in 2005). If we find there is a significant relationship, we can estimate the future values of important variables in the low-age-level countries based on that relationship.

The financial authorities in almost every country, especially developed countries in OECD, try to maintain a balanced budget. If one country maintains a budget deficit for an extended time, it cannot sustain the side effects caused by the huge accumulation of government bonds. Creditors start to throw their government bonds into the market when they question the financial viability of repayment. The crash of bond prices causes skyrocketing interest rates, price levels, and a decline in the value of the national currency. These disasters in the monetary markets affect the real markets by decreasing investments and causing an economic slump, which leads to the reduction of government revenue. Finally, this country cannot help declaring default as it fails to issue additional government bonds. Thus, the scale of government bond issues must be held in check to avoid a vicious cycle caused by fiscal difficulty.

We reviewed the literature studying the limitation of sustainability in government finance in Chapter II. One methodology for testing the fiscal sustainability is focused on the relationship between government surplus and debt. If there is a positive reaction between government surpluses against increasing debt, this signal can support the fiscal sustainability. In addition to the sign, the magnitude of this reaction also has an important meaning. It is the core of this paper to find out the sign and the changes in the magnitude of the relationship between government surplus and debt along with the different aging levels with experiences of so-called "aged" OECD countries.

Every citizen has his or her own request for the government expenditure and government revenue structures. Most significant is that these requests are different with the change of aging levels in that society. The change of requests for the government expenditure along with different aging levels is shown in < Table 1−1 >. The percentage of education expenditure, the main beneficiary of which is youth, is 17% for both Korea and the U.S.; both of which also have a relative big proportion of young population. In the so-called "aged" countries, such as the UK, France and Germany, the percentages of education expenditure are 13%, 11.5% and 8.9%, respectively, which are declining in trend along with the progress grades of aging. The aged dependency ratios are 24.4% in the UK, 25% in France, and 28.1% in Germany. In contrast, the percentages of social affairs expenditure, in which the aged population is one of the main beneficiaries, are increasing along with increasing levels of aging. Thus, we can assume that the structure of government spending has been changed according to aging levels.

The results of the aging progress are illustrated in the historic trace of financial balances. Depending on the level of aging, the government should run a deficit or a balanced budget. Aging levels are different for each country. The aged dependency ratios are between 8.9% and 28.5% with a mean of 21.4% for OECD countries. We can find the relationship between surplus and debt along with aging levels using historical data of aged countries. Then we can roughly estimate the future values of the low-aging countries, Korea and the U.S. We can also estimate the future values of the debt-GDP ratio in the major countries using a debt accumulation function. The process of the main part is like this: (i) Finding out the trend between the debt and the primary surplus in OECD countries respectively by using the model of testing the fiscal sustainability in the time domain. (ii) Grouping the countries, after eliminating the effects of cyclical variables and converting the adjusted primary surplus and the debt variables from time domain to age index domain, and figuring out the trend between two variables along with aging levels in each selected group. (iii) Forecasting the future values of these variables of the low-aging-level countries using the information from (ii). However, there is a limitation to estimating the future values of the aged OECD countries with the panel data analysis results from (ii), because these do not contain any useful information relating to the futures of the aged countries after the ADR of 30%. Thus, we have to use another expected data set and methods to estimate the future fiscal conditions for these countries.

In order to conduct this process, we need at least three models: (1) the regression model to check the fiscal sustainability in the time domain, (2) the panel data analysis model to show the relationship among debt, adjusted primary surplus and age index (ADR), and (3) the debt dynamics model to estimate the future conditions for the main OECD countries.

3.1.2. Model Checking the Fiscal Sustainability

The General Idea of the model

According to the literature review in Chapter II, there are three general methods used to test for fiscal sustainability: (i) the stationarity test or cointegration test based on the IBC model, (ii) the reaction function model, (iii) the primary gap and tax gap indicators.

This paper's logical framework is based on the reaction function model. The main advantage of this model is that it is relatively easy to understand the relationship between the variables and without a complicated model, we need a relatively small number of variables.

The core of this model is that the fiscal sustainability is guaranteed by the characteristics of the mean-reverting debt-GDP ratio, which are inferred from the positive response of the primary surpluses to the debt-GDP ratio. In other words, if governments react to a rising debt trend by expanding the government's surplus, then this fact can be evidence of preparing for the future financial difficulty, which supports that the fiscal policy is sustainable. Thus, finding the relationship between the primary surpluses and the debt-GDP ratio is the key in the regression process.

The reaction function model used in this paper is inferred from the common elements[28] between the Bohn (1998, 2005) and the Uctum et al (2004) models.

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[28] In the light of variable definition, the main difference between two researches is on whether seigniorage is included or not. Bohn (2005) excludes the seigniorage due to trivial effect, averaging to 0.16% of GDP, where as Uctum et al (2006) explicitly includes the seigniorage.

The Reaction Function Model

The basic regression model to test the fiscal sustainability in accordance with the reaction function concept is

$$s_{ti} = \rho_{0i} d_{ti} + \alpha_{0i} + \beta_{gi} \tilde{g}_{ti} + \beta_{yi} \tilde{y}_{ti} + \varepsilon_{ti} \qquad (14)$$

where $s_t = S_t/Y_t$ is the ratio of the primary surplus to GDP, $d_t = D_t/Y_t$ is the ratio of (start-of-period) debt to GDP, $\tilde{g}$ is a measure of temporary government outlays, $\tilde{y}$ is a measure of temporary output, ε is a mean-zero error term, t represents time, and the index i represents countries. The primary surplus (s_t) is government revenue minus government expenditure excluding interest payments on government debt. Finally, (ρ, α, β_g, β_y) are regression coefficients.

$\tilde{g}$ is the temporary government spending indicator. We can get this by

$$\tilde{g}_t = \frac{(g_t - g_t^*)}{y_t} \qquad (15)$$

where g is the real current government spending, g^* is the real potential government spending, the difference ($g_t - g_t^*$) is called as the temporary real government spending, and y is the real GDP.

$\tilde{y}$ is the temporary output indicator. We can get this variable by

$$\tilde{y}_t = \left(1 - \frac{y_t}{y_t^*}\right) \times \left(\frac{g_t^*}{y_t}\right) \qquad (16)$$

where y is the real current GDP, and y^* is the real potential GDP. This is the business cycle indicator. The potential variables, y^* and g^*, can be derived by using the Hodric-Prescott filter. According to Brandner (1998), this filter is summarized by

$$Min\sum_{t=1}^{T}(y_t - y_t^*)^2 + \lambda\sum_{t=2}^{T-1}\left[(y_{t+1}^* - y_t^*) - (y_t^* - y_{t-1}^*)\right]^2 \quad (17)$$

where y is actual output, y^* is potential output, and λ is a lagrangian multiplier, which is a smoothing parameter, and we use λ=100 for yearly data. We can get g^* when substituting y variables in equation (17) with corresponding g variables.

Inquiry into the Variables Offsetting Cyclical Effect

The temporary government spending and the temporary output variables are called modifying terms which offset the cyclical fluctuation. In these variables, the difference between the current value and the potential value is important. According to Barro (1979), if government expenditure is larger than the normal level or the tax base is shrunk due to decreasing current national income compared to the normal income level, then this pressure supports the issuing of government debt. Thus, the cyclical fluctuation affects the relationship between government surplus and debt. Bohn (1998, 2005) also shows that the test results omitting these variables have insignificant values, a conclusion very different from the original results. Based on these facts, we proceed to remove the cyclical fluctuation from the relationship between government surplus and debt, which is helpful when applying the model to OECD countries.

Relating to the temporary government outlay indicator, Bohn (2005) uses the defense outlays as the proxy variable. The basis of his argument is summarized in < Figure 3−1 >. According to the U.S. historic data of 1792~2003, wars are the source of huge fluctuations in government deficits. The three huge deviations in the deficit from its trend correspond to the periods encompassing the Civil War, World

< Figure 3 − 1 > The U.S. Deficit in percent of GDP (1792~2003)

* Source : Bohn (2005) paper.

War I and World War II. Thus, he argues that defense outlays can be a very good proxy for the temporary government outlay indicator.

Contrary to his argument, there are broadly two problems in using the defense outlays as a proxy for the temporary government outlay indicator. First, the testing time span matters. The testing period in Bohn's paper (2005) is from 1792 to 2003, which is a longer period than that of this paper, 1980 to 2005. Furthermore, there are fewer wars during the time span of this study than the one conducted by Bohn. It is obvious that not all of OECD countries are involved in wars. This means that a number of OECD countries are more likely to show less fluctuation in the defense than that of the government expenditure.

Second, changes in other factors included in government expenditure are leading to further increases. For example, these factors include spending due to huge natural disasters, socio-political events, and increasing the scale of government offsetting to the market failure[29].

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[29] We can see these factors in real: Kobe earthquake in Japan 1995, Hurricane Katrina in the U.S. 2002, Typhoon Rusa in Korea 2002, skyrocketing in the world oil price in 1981, Reunification of German in 1990, Japanese depression during 1990's so called "losing 10 years", Freefalling value of the pound currency in the UK 1992, the financial crisis in Korea 1997, etc.

Owing to these reasons, this paper uses the whole government expenditure in calculating the temporary effect, which is similar to Barro (1986) and Uctum et al (2006).

Considering the Seigniorage Effect

Four papers in the literature review section discuss the seigniorage effect explicitly. First, Hamilton and Flavin (1986) introduce the money seigniorage as well as capital gains on gold stock. Before regressing primary surplus on government debt, they add the money seigniorage effect on the government surplus. Buiter (1990) and Corsetti (1991) put the seigniorage term in their budget constraint model. When Uctum et al (2006) close the chapter of defining the data; they say, "All primary balance series are inclusive of seigniorage."

Considering these various reports together, we can conclude that the basic idea of seigniorage is if government chooses to run deficit, then their financing methods are to issue bonds or to increase the money supply. The former is treated as the fiscal policy; the latter is counted as the monetary policy. There is an argument that if the seigniorage effect is included when testing the sustainability of government budgets, then it is a solvency test and not a fiscal sustainability test. Furthermore, the central banks are independent from the Administration. Their first objective is to stabilize the price level. In the point of view, that fiscal sustainability shows the evidence of government obvious actions facing financial difficulties, the seigniorage effect is just the side effect from an increasing price level, not an aiming result. Thus, we will not include the seigniorage term in the regression model to analyze the fiscal sustainability.

3.1.3. Model in the Panel Data Analysis

Here is the regression model in the panel data analysis.

$$\tilde{s}_{it} = \gamma_i d_{it} + \upsilon_{it} \qquad (18)$$

where $\tilde{s}$ is the ratio of the adjusted primary surplus to GDP, d is the ratio of (start-of-period) debt to GDP, υ is a mean-zero error term, and i is an index representing each of the already aged OECD countries. γ is a regression coefficient. We can get the adjusted primary surplus from equation (14).

We can eliminate the cyclical fluctuations by figuring out the adjusted primary surplus at each time. This process is shown in < Figure 2−2 >, which comes from Bohn's paper (1998). We can easily find the obvious positive relationship after filtering the fluctuations.

When conducting the panel data analysis, this paper also examines the explanatory power of the aging variable, the ADR. The main reason to conduct this analysis is that one can use these findings to compare one country's information with other countries'. At a certain specific year, all countries' aging levels are unique. For example, the U.S.'s aged dependency ratio is 18.9% in 1995. If one wants to compare the U.S. aging problem by using the experiences of Italy, the information for Italy in 1995 may be useless because Italy's aged dependency ratio is 24.3%. One should use the information from 1975 when Italy's aged dependency ratio is also 18.9%. Thus, checking the significance of the aging variable with adjusted surplus or debt is an important part of estimating the future values of the low-age countries.

3.1.4. Model of Debt Dynamics

In order to estimate the future debt−GDP ratios of the main OECD countries, we need the debt dynamic model such as:

$$d_t = d_{t-1} \big/ (1+n_t) - bb_t + sf_t \qquad (19)$$

where d_t is the debt−GDP ratio, n_t is nominal GDP growth rate, bb_t is budget balance as a fraction of GDP and sf_t is the actual value of stock−flow adjustments in each year.[30] The term of budget balance is different from the primary surplus in equation (14). The former includes the interest payment for the government debts, whereas the latter does not.

The interpretation of this equation is clear. If there is positive GDP growth in this economy and nothing to change and the government maintains a balanced budget, then the debt−GDP ratio will drop. If the government maintains a budget surplus and pays back government debt, then the debt−GDP ratio will also decrease. In order to drop that ratio, the value in the variable of sf_t is not significantly positive. In the light of this content, sf_t is a kind of error term. Thus, if we assume reasonable levels of the variable of sf_t for the main OECD countries with estimated values for budget balance and GDP growth rate, we can predict the debt dynamic path for each country.

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[30] "Nominal deficits do not coincide with changes in nominal debt. The difference, usually referred to as 'stock-flow adjustment', reflects differences in the definitions of the two indicators both with respect to the relevant transactions (the debt measure is gross of financial assets, whereas the deficit corresponds to a net flow of liabilities) and with respect to the valuation criteria adopted (e.g. nominal values versus accrual)." Balassone and Francese, (2004)

3.2. Methodology

3.2.1. Time Series Test with Structural Dummy Variables

Uctum et al (2006) introduce the method of applying the unknown multiple breaks in the government reaction function.[31] The idea of applying breaks in a regression model is splendid. However, there is a serious problem with their method. They only allow the coefficient of the debt variable to change along with the periods. If the real coefficient of the debt variable changes from a positive to a negative, then the intercept value may change together, which is not reflected in their model. To compensate this problem, we allow changes in both parameters using structural dummy variables.

With time series data or policy analysis, we usually want to address a structural change by adding the dummy variable. We call this dummy variable the structural dummy variable, which includes two-types of components: shift dummy and slope dummy. The former dummy is used to check the probability of an intercept change in the time series. The latter dummy is used to check the probability of the slope change in a model over time. If we ignore these structural dummy effects, our estimators tend to be either biased or inconsistent due to some neglected factors correlated with error terms.

---

[31] The OLS equation, with m(m=0,1,2,…), unknown break–points can be written as

$$s_t = \mu + \sum_{i=1}^{m+1} \alpha_i d_{t-1} 1_{t \in Ii} + \beta \tilde{g}_t + \gamma \tilde{y}_t + v_t ,$$

where I_i is the sub period between break-date t_{i-1} and t_i and $1_{t\in Ii}$ is an indicator function such that $1_{t\in Ii} = 1$ for $t_{i-1} < t \le t_i$ and 0 elsewhere. The parameters α_i (i=1,…,m+1) are estimated over the sub period I_i, while β, γ are defined over the full sample. (Uctum et al , 2006)

To further illustrate the meaning of the shift dummy variable, let's suppose the regression model is $Y_t = \beta_1 D_{1t} + \beta_2 D_{2t} + \beta_3 X_{1t} + \beta_4 X_{2t}$, estimated data period is 1975 ~ 2005, and there is a break in 1994. In this regression model, the dummy variable D_{1t} takes a value of 1 from 1975 to 1994, otherwise it takes a value of zero, and the dummy variable D_{2t} takes a value of 1 from 1994 to 2005, otherwise it takes a value of zero. If this period has significant values, then the intercept vales (β_1 and β_2) are different according to the period. It makes the values of Y_t during 1994~2005 higher (or lower) than those of the rest of the sample by ($\beta_2 - \beta_1$). It implies something happened in those years that shifted the regression line up or down.

To further discuss the meaning of the slope dummy variable, now suppose the regression model is $Y_t = \beta_0 + \beta_1 X_{1t} D_{1t} + \beta_2 X_{1t} D_{2t} + \beta_3 X_{2t}$, with the same estimated data period and the same break of 1994. As in the previous explanation, the dummy variable D_{1t} takes a value of 1 before 1994, D_{2t} takes 1 after 2005, otherwise these take a value of zero. We can easily check the effects when this period has significant values. The coefficients of X_{1t} are β_1 and β_2. This implies that β_1 and β_2 are different from each other when the break is significant enough.

This paper applies this method to OLS tests using the reaction function:

$$s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t \qquad (20)$$

where $D_{ti} = 1$ for $t_{i-1} < t \leq t_i$, and 0 elsewhere, n is the number of the break−points (n=0 means that there is no break during the observed period), and (α_i , ρ_i) are coefficients of the dummy variables. Due to the shift dummy in the intercept part, we can avoid the weaknesses of the other model, which only recognizes the change of slope without allowing for the change of the intercept point.

In order to find out the periods of the structural changes, we use Chow's breakpoint test such as the Uctum's (2006) paper. The null hypothesis of this test is that there is no break throughout the whole period and the test statistic is:

$$F = \frac{(\bar{u}'\bar{u} - (u_1'u_1 + u_2'u_2))/k}{(u_1'u_1 + u_2'u_2)/(T-2k)} \tag{21}$$

where $\bar{u}'\bar{u}$: restricted sum of squared residuals, $u_i'u_i$: sum of squared residuals from subsample i, T: total number of observations, k: number of parameters in equation. If this test statistic is high enough to reject the null hypothesis, then we can assume that there are subsample periods which have significant differences in the estimated equations.

3.2.2. Panel Data Analysis

We often have problems with the unobserved effect with OECD countries' panel data, which is commonly known as the fixed effect. If we neglect this fixed effect, our estimators are not efficient when the composite error terms are serially correlated. After checking for the existence of the fixed effect, this paper uses the unobserved components model by including dummy variables for each of the cross-sectional units.

$$\tilde{s}_{it} = \gamma_i d_{it} + \sum_{j=1}^{N} C_j D_{ij} + \upsilon_{it} \tag{22}$$

where D_{ij} = 1 if i = j, D_{ij} = 0 otherwise, the coefficients on these dummy variables are the unobserved effects, i represents each country, and N is total number of countries.

The unobserved effect may also exit for a specific historical time. For example, during World War II, almost every country had financial difficulties, more recently the "9.11" effects influenced most OECD countries. Thus, the unobserved effect on time should be controlled. We call the unobserved effects of time and cross-sectional units a two way fixed effect. This paper will check for this kind of fixed effect and account for it when regressing each panel data set.[32] As the adjusted surplus includes the smoothing terms to allow for cyclical fluctuations, the panel data model can account for this in the time effects; whereas the OLS model can control this problem with the structural dummy variables. However, we should still check for autocorrelation in the panel data.

In order to check for the autoregression problem in the panel data analysis, we apply the Generalized Method of Moments (GMM) estimation of dynamic panel data models discussed below.[33]

If equation (18) is influenced by dynamic effects, that is, the lagged dependent variables have explanatory power, then we can write the panel data models as:

$$\tilde{s}_{i,t} = \gamma_i d_{i,t} + \beta_{lag} \cdot \tilde{s}_{i,t-1} + \varepsilon_{i,t} \qquad (23)$$

where $\tilde{s}_{i,t-1}$ are the lagged dependent variables, β_{lag} are the coefficients. To fix the problem that the lagged dependent variable is correlated with the disturbance, we apply the Instrumental Variable (IV)[34] method.

---

[32] We usually conduct the test for the group effects with an F test. Under the null hypothesis of equality, the efficient estimator is pooled least squares. The F ratio used for this test is $F(n-1, nT-n-K) = \dfrac{(R^2_{Pooled} - R^2_{LSDV})/(n-1)}{(1-R^2_{LSDV})/(nT-n-K)}$, where *LSDV* indicates the dummy variable model and *Pooled* indicates the pooled model. (Greene (2004), p289)

[33] This is a summary of GMM method in the textbook of Greene (2004).

[34] In the panel analysis, only one lagged variable is seriously correlated with the error term, so we use an IV formed as the two period lagged variable and the independent variable.

Finally, we conduct the panel analysis using the GMM method. The main advantage of this method is that it provides a basis to check whether certain lagged values of the dependent variables have effects on the present dependent variable or not. We will show the results of this method in section 5.2.

Due to the properties of annual data, fewer observations are used in this paper and the distributions of values in the main variables are quite scattered, sometimes having huge variations. In order to conduct tests with such limited information, we utilize a data smoothing process. This paper uses kernel density estimation, which is a non-parametric method, to smooth the data. There are three common choices in the kernel functions: Gaussian, Epanechnikov and Biweight or quadric functions. The functions and the smoothing process are outlined below.

The first step is to decide the bandwidth, "h". The bandwidth divides the X domain into "n" bins. Thus, "n x h" represents the total range in X domain, which contains the observed values. The second step is to find the average value in the interval $x_{i-h/2} < x_i \leq x_{i+h/2}$ by using the kernel function. The last step is to find $f(x_i)$, which represents the Y value with the highest probability in period of $x_{i-h/2} < x_i \leq x_{i+h/2}$.

Utilizing this method, we can find a smoothing trend in the relationship between important variables. However, there is a limitation in interpretation. The kernel curve just shows the rough trend in two variables with the current distribution pattern. The line does not indicate the likelihood of this happening. For example, the kernel curve may be the same whether the observations are close or scattered far from each other. Thus, this paper uses the information from the kernel process as a reference.

3.2.3. Methods for Estimating Debt Dynamics

This paper uses two methods for estimating debt dynamics: a deterministic method and a stochastic simulation method. The former can predict just one point value for the future value at a certain time, whereas the latter can estimate intervals in which the future estimated values could fall. If we have the estimated time series for the variables of budget balance and GDP growth rate and assume the value of the sf_t term in equation (19) for debt dynamics, then we can get the estimated deterministic debt series. The Global Insight Database provides the estimated values of budget balance and GDP growth rate, so we have the only remaining problem to assume the value of the sf_t term. The OECD database has the historical trends of this variable for main countries that are shown in < Table 3−1 >. We can predict future values for this variable with this information. However, the deterministic method has a problem in that it is almost impossible to be coincident of the estimated debt levels with the actual future values. The stochastic simulation method starts with this point of view. It is more realistic to estimate the future values as certain debt level ranges.

< Table 3 – 1 > The Trend of Stock−Flow Adjustments for Main Countries

(unit : %, fraction of GDP)

Country	1996	1998	2001	2003	2005	10−year Average
Japan	14.4	16.5	13.2	13.4	**17.7**	**15.6**
Italy	**20.0**	10.4	7.8	4.7	10.1	**8.0**
Germany	7.3	5.4	3.7	**7.8**	6.9	**5.3**
France	9.4	7.1	2.5	**10.2**	7.2	**6.5**
The UK	7.0	3.4	**−3.6**	6.0	**7.9**	**3.1**
The U.S.	5.2	**−0.1**	2.1	**10.8**	7.8	**4.1**
Korea	−2.4	**3.9**	**−2.5**	2.3	−0.1	**−0.4**

The process of this method is: (i) Estimate the best model to explain the trend of d_t. (ii) Assume the residuals follow the normal distribution. (iii) Simulate random variability of the error term. (iv) Forecast probabilistic debt levels.

Equation (19) can be written such as:

$$d_t = f(\frac{1}{(1+n_t)} d_{t-1}, bb_t, c) + e_t \tag{24}$$

where $f(\bullet)$ is the OLS regression function, *c* is a constant and *e* is an error term (e ~ N(0, σ_d)). Compared to equation (19), the stock-flow adjustment term is divided into *c* and e_t. If we have information for $f(\bullet)$, n_t, $bb_{t,}$ and e_t, then we can find the future values of the debt−GDP ratio. First, each country has its own trend in debt dynamics, so we can estimate a reasonable regression model for each country using its historical data. Second, estimated values for bb_t and n_t are provided by the Global Insight database. Third, we can generate 500 possible values for e_t at each corresponding time based on the assumption that e_t has a normal distribution. The reason to simulate the values for e_t is that we do not know exact future values of e_t. Finally, we can get probabilistic forecasted d_t that also has its own distribution at each corresponding estimated year.

Now we can show these results as prediction possibility using a prediction interval. If we use the standard error of the prediction error, a 100(1−α) % prediction interval can be estimated for the forecasted value of debt in time t:

$$PI_{U,L} = d_t \pm t_{n-k,\alpha/2} \cdot S\sqrt{1+h_t} \tag{25}$$

where PI_U is an upper bound of the prediction interval, PI_L is a lower bound of the prediction interval, S is the estimate for σ_d and h is a prediction matrix.

Chapter IV.

Data Description

4.1. Data Summary

This paper uses annual data from 1970 to 2006 to study 16 OECD countries, which are in higher aging levels[35], as well as the U.S. and Korea. The sources of the main variables and domain information are summarized in < Table 4−1 >. All the historical data information comes from OECD, UN, and IFS databases. Relating to estimated future values for 2010~2035, the essential estimated data information comes from the Global Insight and the OECD database.

< Table 4 – 1 > The Main Variables and Data Sources.

<table>
<tr><th>Variables / Domain information</th><th>Period</th><th>Source</th></tr>
<tr><td>➢ Population Pyramid</td><td>2000 / 2050</td><td>OECD</td></tr>
<tr><td>➢ Aged Dependency Ratio</td><td>1970 ~ 2035</td><td>UN</td></tr>
<tr><td rowspan="2">➢ Debt – GDP Ratio
➢ Primary Surplus − GDP ratio
➢ Real Government Outlays
➢ Real GDP</td><td>1970 ~ 1991*</td><td>International Financial Statistics</td></tr>
<tr><td>1990* ~ 2006</td><td>OECD</td></tr>
<tr><td rowspan="2">➢ Finance Balance
➢ GDP Growth Rate</td><td>1990 ~ 2005</td><td>OECD</td></tr>
<tr><td>2010 ~ 2035</td><td>Global Insight</td></tr>
</table>

* 1991 data in IFS and 1990 data in OECD is only used to calculate HP filter of GDP and government outlays.

35 Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the UK,

4.2. Population

The population data has two sources. The population pyramids, which show the characteristics of each country, are based on the OECD database. The other data, such as the age dependency ratio and birth rates etc. come from the UN database.

4.2.1. Population Pyramid

The population pyramids in Figures 4−1 to 4−7 show population by age group and gender in 2000 and 2050 as a percentage of total population of each group, based on OECD Demographic and Labor Force database. We can separate countries into two groups: those with decreasing or increasing total populations. < Table 4−2> summarizes the population transition of seven OECD countries.

< Table 4 − 2 > The Total Population and Dependency Ratio in main countries.

Country	2000		2050(E)	
	Total Population (million)	Dependency Ratio (%)	Total Population (million)	Dependency Ratio (%)
Japan	126.9	28	100.6	72
Italy	56.9	29	52.5	71
Korea	47.0	11	44.3	68
Germany	82.2	26	75.3	54
France	58.9	28	64.0	58
The UK	58.9	27	69.2	47
The U.S.	282.4	21	420.1	39

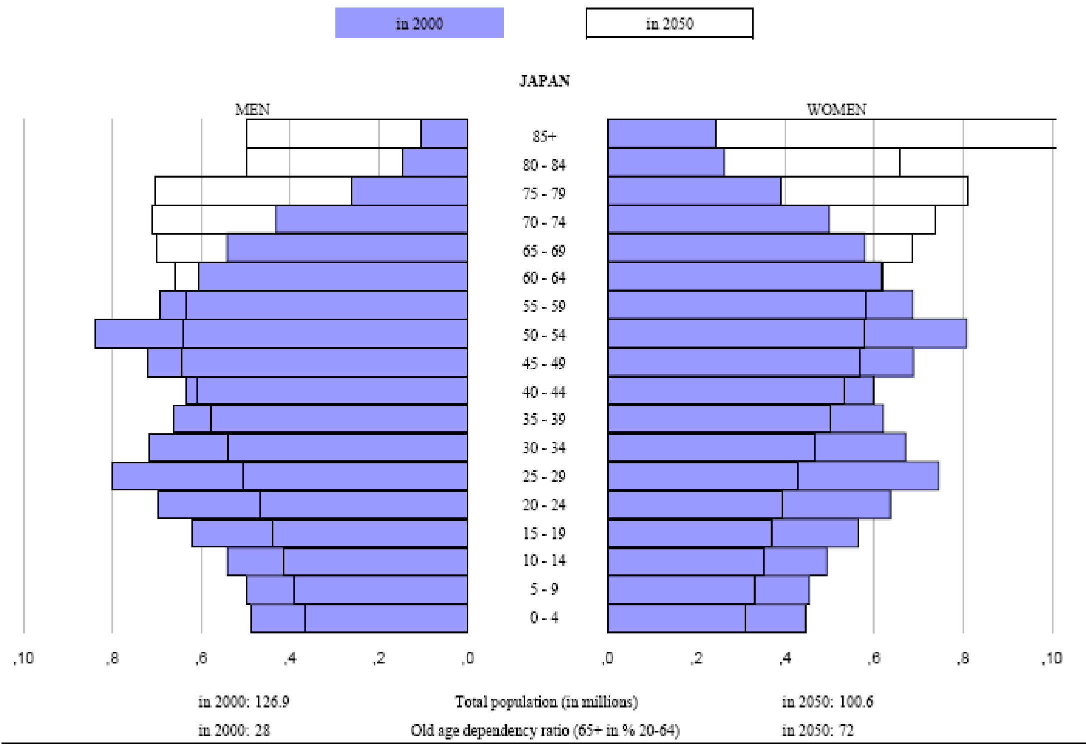
* Dependency Ratio = (+65 population) / (20~64 population) x 100

Population Transition in Japan

Actually, Japan could already be classified as a super-aged society in 2006.[36] The characteristics of the Japanese population pyramid are two baby boom periods and decreasing birth rates.

The so−called "crowd generation" was born right after World War II, and the "crowd generation Junior" was born during 1970~75. In 2050, when these generations retire, the dependency ratio is expected to pass over 70%. The pyramid also predicts a sharp decrease in birth rates for 50 years, which causes the total population to decrease by more than 20%.

< Figure 4 − 1 > Population Pyramid in Japan



* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

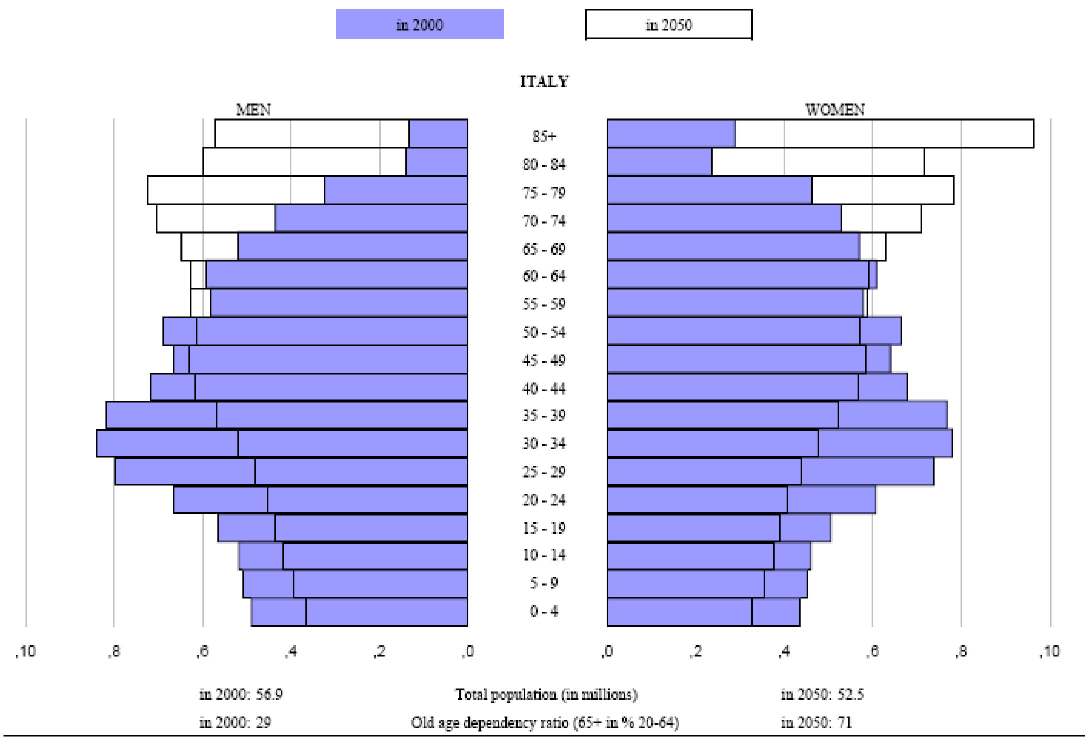
[36] The society has over 20% in the ratio of +65 year old population to total population.

Population Transition in Italy

Italy is another country classified as a super-aged society after 2006. It has similar characteristics to Japan; with only a different baby boom period.

The main bands are crowding in ages 25 to 39 years old based on 2000 data. In 2050, when these groups retire, the dependency ratio is expected to pass over 70%, which is close to the number for Japan. The pyramid also predicts a sharp decrease in birth rates for 50 years and the decrease in total population by 7.7%, which is less than Japan. This is because the main groups in population are relatively younger than the crowd generations in Japan.

< Figure 4 − 2 > Population Pyramid in Italy

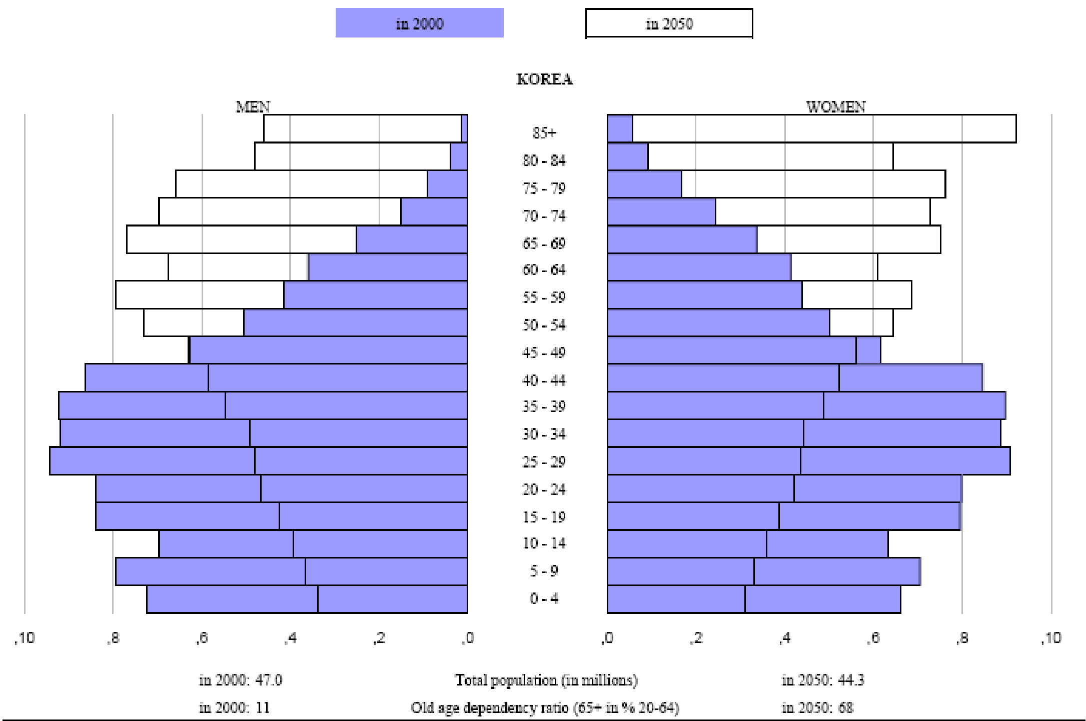


* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

Population Transition in Korea

Korea has two typical problems due to the aging process. One is the serious disparity among age groups and the other is an alarming decrease in birth rates. The large age group brackets consist of people born after the Korean War (1950~53), but then there was a sharp decreasing in birth rates[37] due to the birth control policies the 1970's resulting in a low delivery trend which will be expected to last for the next 50 years. After the members of this group retire, the dependency ratio will be close to 70%, and the total population will decrease from 47 million to 44.3 million, a decrease of 5.7%.

< Figure 4 − 3 > Population Pyramid in Korea



* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

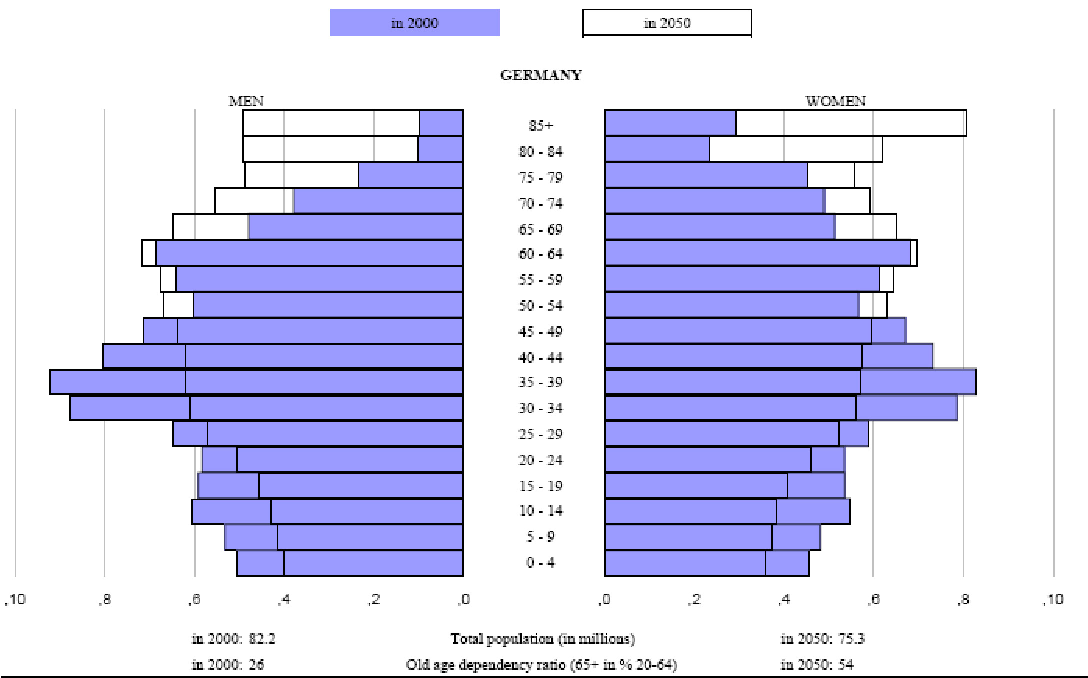
[37] The birth rates are 45.7 in 1960, 36.1 in 1970, 23.6 in 1980, 16.9 in 1990, 13.5 in 2000, and 10.4 in 2005. (unit: births per 1,000 population)

__Population Transition in Germany__

Germany also belongs to the class of countries that have decreasing total populations. The population pyramid type is similar to Japanese with a kind of camel shape, and it shows somewhat irregular fluctuation between age groups. The proportion of the age group who were born during 1945~50 is low due to the aftershock of losing the war, but the sudden decrease in the age group born in 1970~75 is hard to explain.

The total population is expected to drop from 82.2 million to 75.3 million (8.4%) by 2050, but the dependency ratio is expected to rise to 54%, only 1.1 times as much as that of 2000. This multiple number is the lowest one among the decreasing total population countries: Japan (1.6 times), Italy (1.5 times), and Korea (5.2 times).

< Figure 4 − 4 > Population Pyramid in Germany



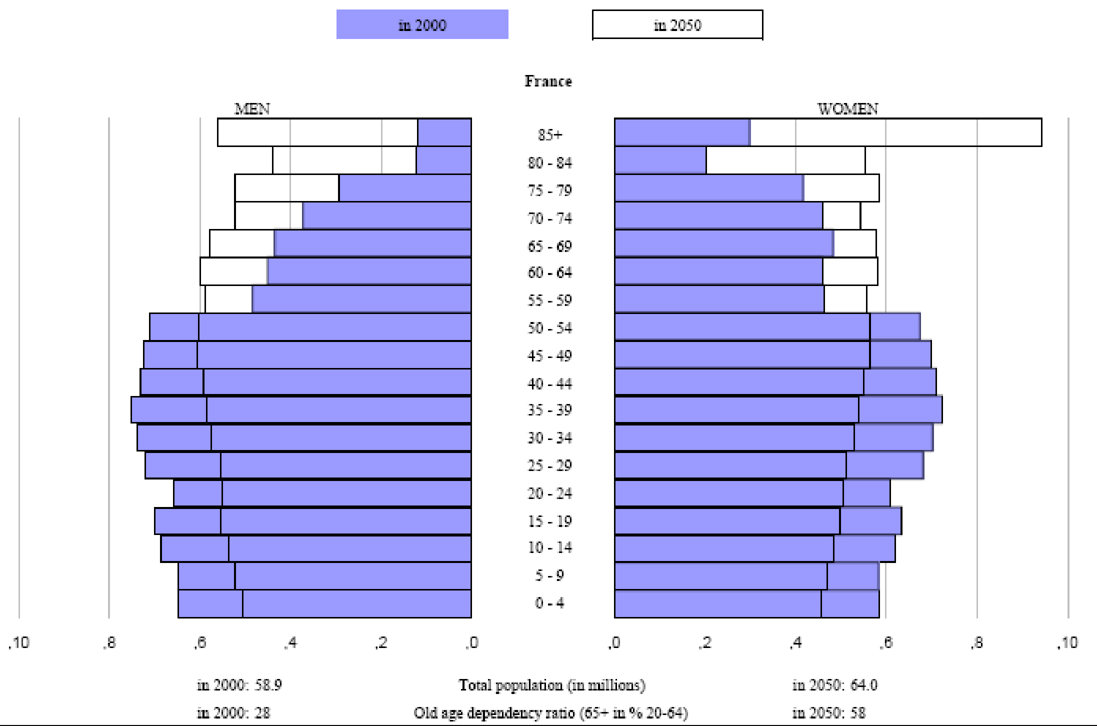
* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

Population Transition in France

France has an increasing total population. The total population is expected to increase from 58.9 million to 64 million (by 8.7%) during the next 50 years. The main reasons for this increase are that France maintains high birth rates and positive net migration rates.

The baby boom period starts after World War II. This generation was born after 1945, and they are younger than 54 in the pyramid of < Figure 4–5 >. The age dependency ratio will sharply increase when these generations start to pass over 65, which is around 2010. Finally, this ratio will reach 58% in 2050, which is just 1.1 times as higher than that of 2000.

< Figure 4 – 5 > Population Pyramid in France



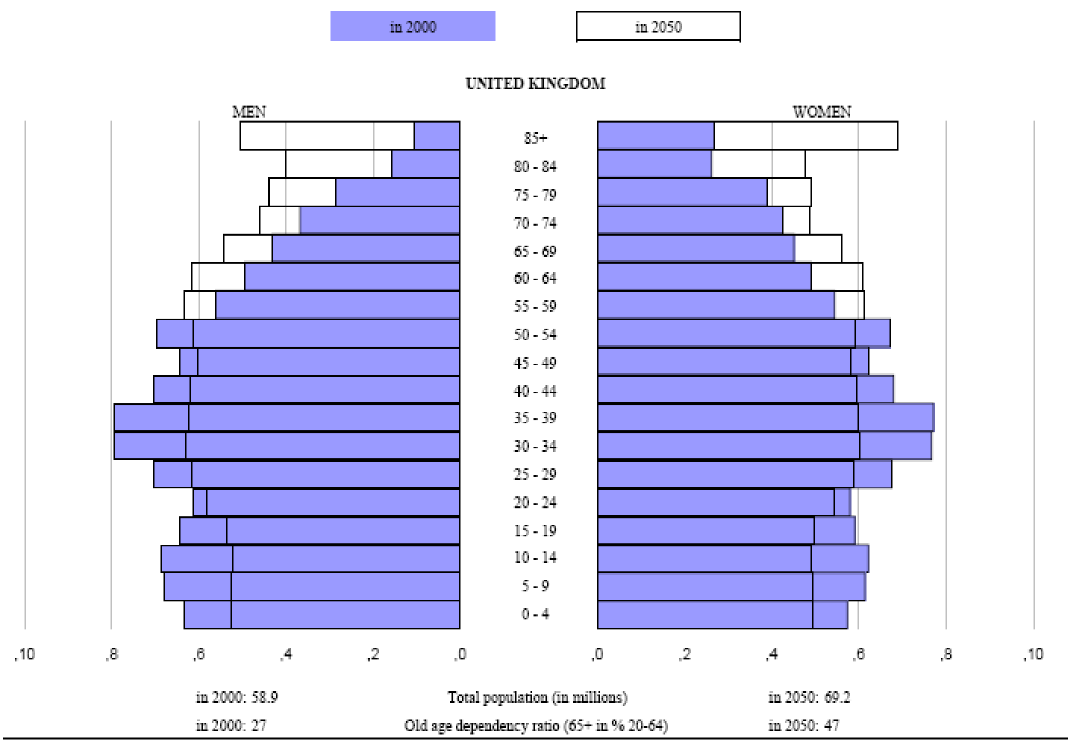
* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

Population Transition in the UK

The total population is also expected to increase in the UK. The increase will be no less than 17.5% over 50 years. The background of this large increase is similar to France.

As with other developed countries, except Germany, there is a small baby boom peak after 1945, but a larger one starts from the generations who were born during 1960~1970. The pyramid has a bit more fluctuation compared to France, but the aging trend is relatively stable. We can check it with the aged dependency ratio, which is 47% in 2050, only 0.7 times as high as that of 2000.

< Figure 4 − 6 > Population Pyramid in the UK



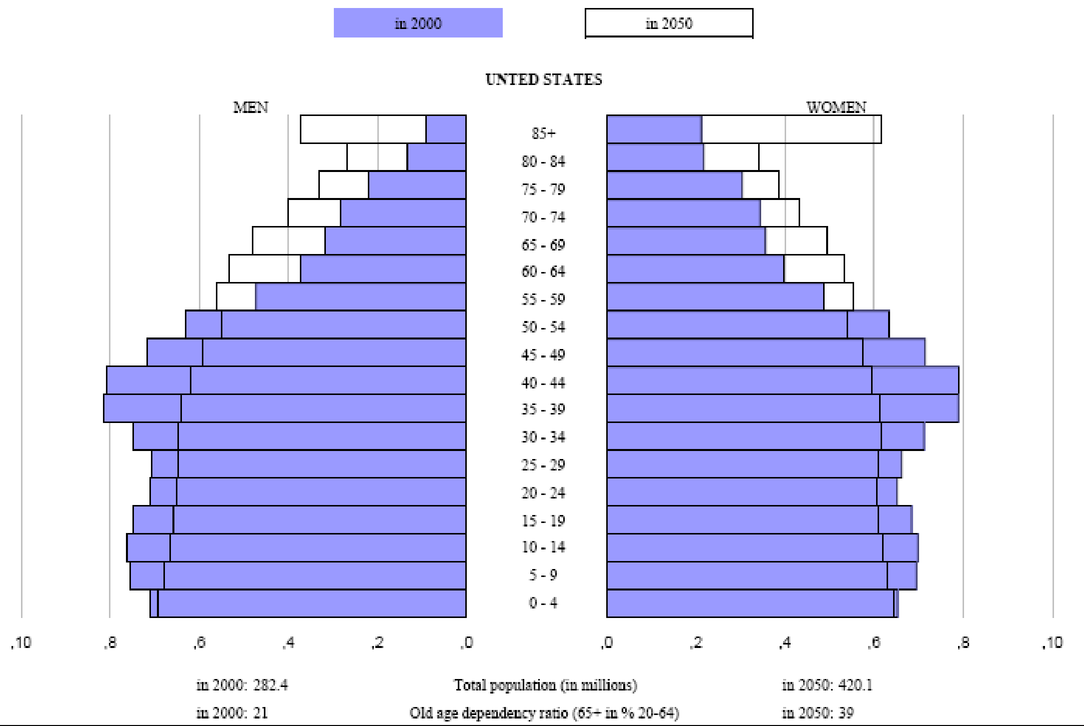
* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

Population Transition in the U.S.

The U.S. is expected to have a surprisingly high population growth rate. The total population will be 420.1 million in 2050, which is an increase of 48.8% over 50 years. This is mainly due to the increasing birth rate and positive net migration rate.

As < Figure 4−7 > shows, the proportions of people under 20 years old are increasing through 2050. Due to this trend, the U.S. is expected to have a stable population structure in 2050. Even though the baby boomer generation, which was born between 1946~65, starts to retire in 2010, the aged dependency ratio will increase only to 39%; roughly half of the 2050 values of Japan and Italy.

< Figure 4 − 7 > Population Pyramid in the U.S.



* population by age group, gender, in 2000 and 2050 in percentage of total population in each group.

Aging Speed in Main Countries

As we see in < Table 4–2 >, the aging speed and levels are different for each country due to the differences in their population structures. For example, in 2000 Korea has an aged dependency ratio of 11%, the lowest value in this study, but is expected to have the third highest value by 2050.

There are special sub-categories[38] that go along with the levels of the aging process. < Table 4–3 > shows when the country reached or will reach a certain aging level and how long it takes to get to that level. The time it took to go from 7% aged to 20% aged ratio was in general around 80 years, and this supports the fact that every society will pass over 20% of aged ratio by no later than 2040. We can get the idea that no country can avoid the aging problems, even though the arrival time is not known with certainty.

< Table 4 – 3 > The Increasing Speed of the Aged Ratio*

	Reached year			Duration (year)	
	7%	14%	20%	7 → 14%	14 → 20%
France	1864	**1979**	2018	**115**	39
Italy	1927	1988	**2006**	**61**	**18**
The UK	1930	**1975**	2025	**45**	50
Germany	1932	**1972**	2009	**40**	37
The U.S.	**1942**	2015	2036	73	21
Japan	1970	1994	**2006**	**24**	**12**
Korea	**2000**	2018	2026	18	8

* = (over 65 years old population) / (total population) x 100

** Source: Korea National Statistical Office. (www.kosis.kr)

[38] If the ratio of over 65 years old population to total population is higher than 7%, 14%, or 20%, we call that society as "Aging Society", "Aged Society" or "Super-Aged Society, respectively.

4.2.2. Age Dependency Ratio

Aged Dependency Ratio data is based on the UN Population Division database. This ratio represents the burden of economic activity placed on those between the ages of 15 ~ 64 needed to support the older population (over 65). Here is the relationship between dependency ratios in equation (20).

$$\underset{\left(\frac{0\sim 14Population+over65}{15\sim 64Population}\right)}{\text{Dependency Ratio}} = \underset{\left(\frac{0\sim 14Population}{15\sim 64Population}\right)}{\text{Youth Dependency Ratio}} + \underset{\left(\frac{over65Population}{15\sim 64Population}\right)}{\text{Aged Dependency Ratio}} \quad (20)$$

Aged Dependency Ratio is used as "Age Index" in equation (16) of section 3.1.3. The Dependency Ratio does not represent the financial pressure since this ratio also contains the Youth Dependency Ratio. The young population (age 0 ~14) is the source of the future tax base; an increase in the number of youth is a positive signal in terms of long-term national finance.

In contrast, the aged population (age over 65) has a high probability of being out of the tax base. Most members in this age group are already retired and may have little or no earned income. Only some of them have the property tax liability; while the government expenditure for their welfare increases a lot due to expanding health care services, pension payments, transfer payments for the low-income bracket and many other factors. Thus, the government has to "red-ink" finance if one focuses on the revenue and expenditure of this age group. This implies the Aged Dependency Ratio is a good proxy to express the fiscal difficulty. In short, the financial authorities have to expect that with an increasing Aged Dependency Ratio (ADR) achieving a balanced budget is difficult due to expanding requests for government aid and shrinking government revenues.

We can consider the alternative aging index rather than the ADR: the Aged Child Ratio and Percent distribution of population aged 80 years and over.

We can calculate the Aged Child Ratio by dividing population aged between 0 and 14 by the population aged 65 years and over. If this ratio is high, then this country has become aged society. For example, the Aged Child Ratio of Japan in 2005 is 142.2, where as that of India is 15.1. Almost one third of OECD countries have Aged Child Ratios exceeding 100. However, this index cannot show the changing trend of the main tax based population. It is possible that the population aged between 15 and 64 years is decreasing with the same Aged Child Ratio. Thus, the ADR is better than the Aged Child Ratio in terms of representing the pressure of the fiscal difficulty.

Percent distribution of population aged 80 years and over may indicate the aging trend of one society. However, this index represents only some portion of the aged people and it fails to show the changing trend of the tax base. Thus, we can focus on the ADR as the aging index in this study.

< Table 4−4 > shows the trend of the ADR in the main OECD countries. Seven countries are divided into two groups: one group consists of high age societies and the other is aging societies based on the ADR of 2005. In 1975, Germany, France and the UK have high values of the ADR compared to other countries. Then, for a time France and the UK have a decreasing or steady ADR due to maintaining high birth rates or positive net migration rates. Nevertheless, the decreasing trend in Germany in 1985 is mainly due to a disproportional population distribution (see Figure 4−4 and Table 4−5). As a result, France and the UK succeed to get steady increases in the ADR, while Germany loses control of this ratio after 1995.

< Table 4 – 4 > Aged Dependency Ratio in Main Countries

	1975	1985	1995	2005	2025(E)	2035(E)
Japan	11.6	15.1	20.1	**29.8**	*49.8*	*58.5*
Italy	18.9	18.8	24.3	**29.8**	*40.4*	*51.0*
Germany	**23.3**	21.0	22.7	**28.1**	*40.2*	*49.7*
France	**21.5**	19.7	21.3	**25.0**	*35.3*	*40.8*
The UK	**22.4**	23.1	24.4	**24.4**	*32.4*	*37.3*
The U.S.	16.3	17.6	18.9	**18.3**	***27.8***	***32.0***
Korea	6.2	6.5	8.3	**13.1**	***29.1***	***44.0***

* Source : UN Population Division. (http://esa.un.org/unpp/)

Looking at estimated values for 2025, three countries are expected to surpass 40%, two countries, 30%, and finally the U.S. and Korea are expected to reach over 27% and 29%, respectively. The aging speed is the highest in Japan, followed by Korea. Japan has the highest aging speed during the 35 years. The change in the ADR from 1975 to 2005 is 18.2%, followed by 10.9% for Italy, and 4.8% for Germany. As we see in < Table 4−2 > based on OECD data sources, the above counties are expected to have decreasing total populations by 2050. This problem is also illustrated in < Table 4−5 >.

< Table 4−5 > shows the 5-year rate increase in the populations of Japan, Italy, and Germany. The increasing rates of total population in Japan describe a downward curve, which leads the decreasing forecasted values in total population over the next 50 years. The most interesting thing is that all three countries have a decreasing trend in the 0~14 age group, which accelerates the aging speed of a country. Furthermore, the economically active population (15~64 age group) starts to decrease in its relative scale.

< Table 4 – 5 > 5 year Increasing Rate in Each Population Group

Country	Year	Total Population	0 ~ 14 age Population	15 ~ 64 age Population	Over 65 age Population
Japan	1975	6.9	8.1	5.3	19.3
	1985	3.5	**Δ5.5**	4.6	17.9
	1995	1.6	**Δ11.9**	1.4	23.3
	2005	0.7	**Δ4.5**	**Δ2.0**	15.5
Italy	1975	3.0	1.6	1.7	13.9
	1985	0.3	**Δ11.9**	5.1	**Δ2.8**
	1995	1.0	**Δ4.8**	0.5	9.6
	2005	1.7	**Δ0.6**	**Δ0.2**	10.2
Germany	1975	0.6	**Δ6.7**	1.5	9.1
	1985	Δ0.8	**Δ14.1**	4.5	**Δ7.4**
	1995	2.8	3.8	1.8	6.3
	2005	0.4	**Δ7.7**	**Δ1.3**	15.4

* Source : UN Population Division. (http://esa.un.org/unpp/)

Actually, the peak of this group for Japan was in 1995, and in 2000 for Italy and Germany. Examining the historical data of these countries, the duration between the peaks of the 0~14 age group and the 15~64 age group do not exceed 30 years. In contrast, the other countries such as Finland, Portugal, Norway etc., which already reached the peak of the first age group, have not faced the peak of the second age group. This is because the decreasing birth rates of these countries are not as steep as those of Japan, Italy and Germany.

We can divide the 16 OECD counties into groups based on two criteria: aging level and aging speed. The threshold values of each criterion are respectively 24% of the ADR in 2005 and 6% of the difference between max ADR and min ADR during 1975~2005.

< Table 4−6 > shows the countries which belong to each of four groups following these criteria: for example, < Group I > indicates the countries with under 25% aging level and lower than 6% in aging speed. < Group IV > consists of the high age countries with high aging speed. We can assume that countries that belong to the same age group have a high probability to have common experience in their financial balances, thus they show a similar pattern in the relationship between certain variables. We can find important differences between < Group I > and < Group IV > in the panel data analysis section.

< Table 4 – 6 > Grouping 16 OECD Countries

Aging Speed

Aged Level	Slow (6%)	Fast
High (24%)	< Group III > Belgium (26.3 // +5.8%), Sweden (26.4 // +4.1%), France (25.0 // +5.3%)	< Group IV > Germany (28.1 // +7.1%), Greece (27.1 // +8.0%), Italy (29.8 // +11.0%), Japan (29.8 // +18.1%), Portugal (25.0 // +9.2%), Spain (24.5 // +7.4%)
Low	< Group I > Austria (23.8 // +3.0%), Denmark (22.9 // +2.0%), Netherland (21 // +4.1%), Norway (22.3 // +2.8%), Switzerland (22.7 // +3.4%), The UK (22.4 // +2.0%)	< Group II > Finland (23.9//+8.1%),

* (o // #%) : o = ADR percentage in 2005
# = Max ADR – Min ADR, during 1975 ~ 2005

** Source: UN Population Division. (http://esa.un.org/unpp/)

4.2.3. Trend of Life Expectancy, Death, and Birth, Net Migration

The important factors that affect the ADR are life expectancy, death rate, birth rate, and net migration rate. The first two factors are mainly related to the numerator of the ADR, and the latter two factors relate to the denominator. We can see the trend of the former two factors in some countries in < Table 4−7 >.

< Table 4 – 7 > Life Expectancy and Death Rate

(a) Life Expectancy at birth (years)

	1975	1985	1995	2005
Japan	73.3	76.9	79.5	**81.9**
Italy	72.1	74.5	77.3	**79.9**
Germany	71.0	73.8	76.2	78.7
France	72.4	74.7	77.5	**79.6**
The UK	72.0	74.0	76.4	78.5
The U.S.	71.5	74.1	75.3	**77.4**
Korea	**62.6**	67.1	72.2	**77.0**

(b) Death rate (Deaths per 1,000 population)

	1975	1985	1995	2005
Japan	**6.5**	6.1	7.0	**8.0**
Italy	9.8	9.7	9.7	9.9
Germany	12.3	12.1	11.2	10.3
France	10.7	10.1	9.2	9.2
The UK	11.8	11.8	11.3	10.2
The U.S.	9.2	8.9	8.9	**8.3**
Korea	8.3	6.5	5.6	**5.4**

* Source : UN Population Division. (http://esa.un.org/unpp/)

As we can expect, life expectancy has a positive relationship, and death rate has a negative relationship with the ADR except in Japan and Italy, which are already super-aged societies. In < Table 4−8 >, we see that birth rate is the main factor in determining the aging speed and the migration rate is a kind of complement due to the fact that those migrating are usually young people ready to work.

< Table 4 – 8 > Birth Rate and Net Migration Rate

(a) Birth rate (Births per 1,000 population)

	1975	1985	1995	2005
Japan	19.9	12.9	9.7	9.0
Italy	16.1	10.7	9.7	9.4
Germany	11.4	10.8	10.0	8.7
France	16.3	14.3	12.8	**12.8**
The UK	14.5	13.5	13.2	**11.6**
The U.S.	15.7	15.6	15.7	**14.1**
Korea	**29.0**	21.1	15.9	**10.4**

(b) Net Migration rate (Net Migration per 1,000 population)

	1975	1985	1995	2005
Japan	Δ0.1	0	0.4	0.4
Italy	Δ0.4	Δ0.5	2.0	**3.9**
Germany	**2.3**	Δ0.3	**6.7**	**2.4**
France	**1.9**	1.0	1.5	**2.4**
The UK	Δ0.7	Δ0.9	0.6	**3.2**
The U.S.	**2.8**	3.6	4.0	**4.4**
Korea	Δ0.8	Δ1.0	Δ0.5	Δ0.3

* Source : UN Population Division. (http://esa.un.org/unpp/)

4.3. Government Debt

4.3.1. Definition

There are two ways to express the government debt: gross financial liabilities or net financial liabilities. Net financial liabilities are calculated by subtracting financial assets from gross financial liabilities. Some papers [39] introduce net financial liabilities in analyses of debt sustainability. However, gross financial liabilities as a percentage of GDP is the most commonly used government debt ratio in financial sustainability tests.

For most countries, gross financial liabilities refer to the liabilities (short and long-term) of all the institutions in the general government sector. Gross financial liabilities exclude any liabilities guaranteed by the government, and when this liability is calculated, government bonds are valued at nominal values instead of at market value.

In OECD data, debts within and between different levels of government are consolidated for the general government sector. IFS data, however, focuses on debt levels of the central government liabilities. Therefore, one may assume that there is a break in the debt series at 1991. Nevertheless, we cannot find any break in the series of the relationship between primary surplus and debt through the OLS analysis section, even though the general government debt is usually higher than the central government debt.

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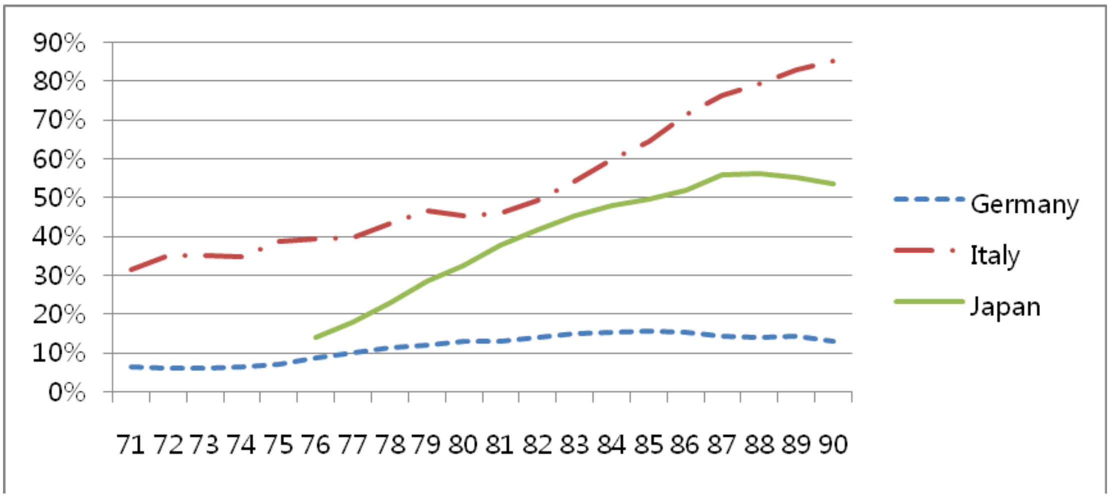
[39] Broda (2004) gives an example of Japan that the gross debt is 161% of GDP in 2002, but net debt is only 64%, thus he argues that gross debt number may overstate the fiscal problem. Chalk and Hemming (1999) has the same point of view.

4.3.2. Trend of the Ratio of Government Debt to GDP

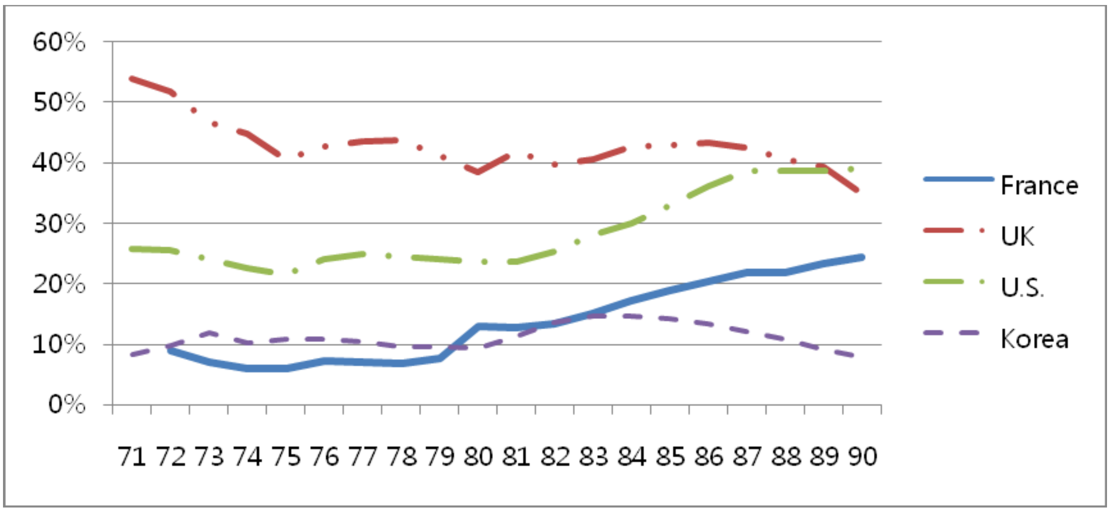
The main countries Japan and Italy have relatively high debt-GDP ratios during 1971 to 1990. Usually, the trend is increasing except in the UK, and Korea. Small OECD countries, like Belgium and the Netherlands, tend to have high ratios: close to 100% and over 50%, respectively.

< Figure 4 – 8 > Government Debt to GDP Ratio (1971~1990)

(a) Japan, Italy, Germany



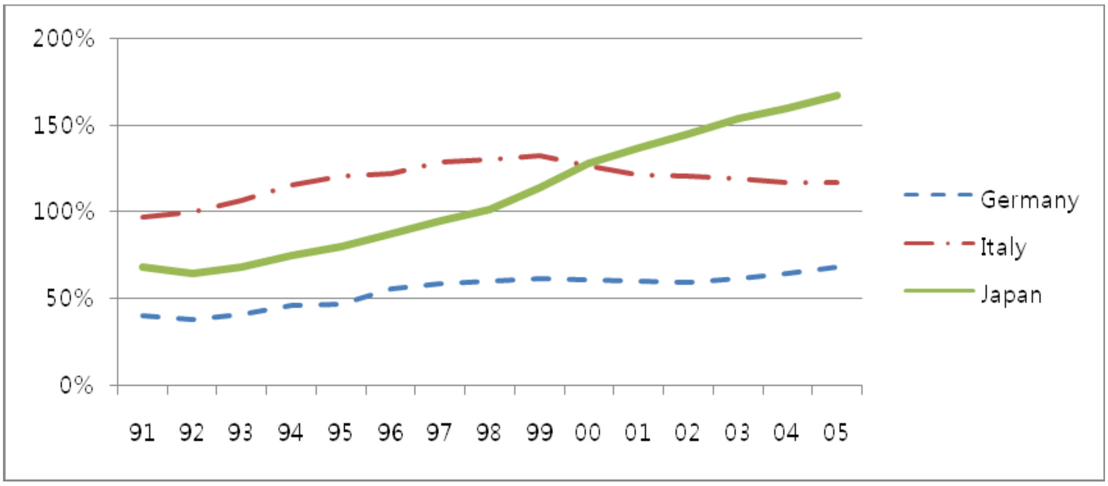
(b) France, The UK, The U.S., Korea



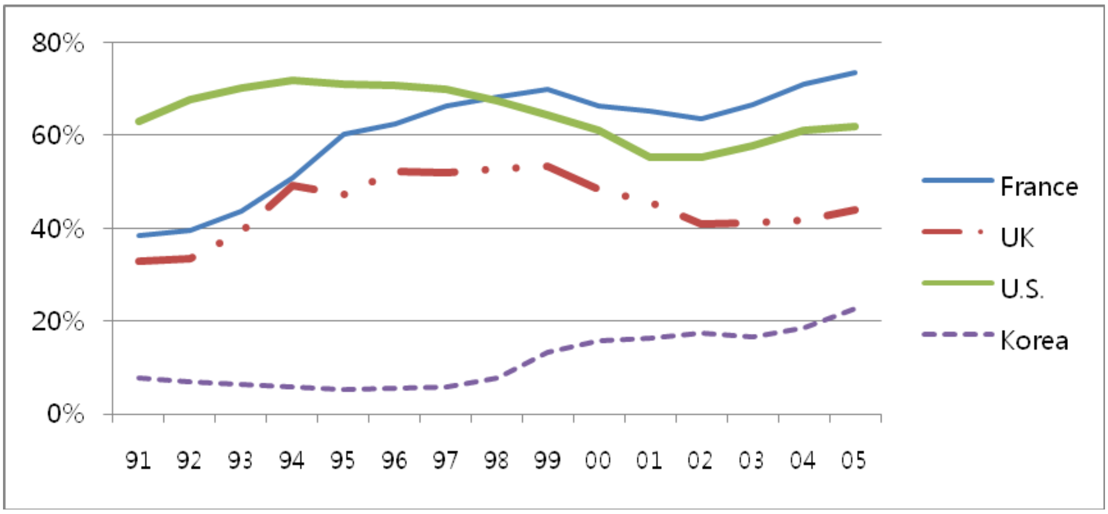
During 1991~2005, Germany shows a steady increase among the high-level aging countries. Italy's debt level is close to 120% and Japan's level has been skyrocketing since the late 1990's. Korea also has a sharply increasing trend but the debt level is still the lowest among OECD countries. The debt ratios of France, the UK, and the U.S. show decreasing trends for a while, however, this trend reverses after 2000.

< Figure 4 – 9 > Government Debt to GDP Ratio (1991~2005)

(a) Japan, Italy, Germany



(b) France, The UK, The U.S., Korea



4.4. Primary Surplus

4.4.1. Definition

The definition of the primary surplus is the total amount of government revenues minus total amount of government expenditures plus interest payments on the government bonds. If this number is positive, then it indicates surplus, if negative a deficit.

In this paper, there are two sources of this data: one is from IFS during 1971~1990 and the other is from OECD during 1991~2005. In the IFS database, total government revenues mean all transactions that increase the net worth of the government. For example, taxes, social contributions and other revenue are included. Total government expenditures mean all transactions that decrease the net worth of the government. These include purchases of goods and services, consumption of fixed capital, subsidies, social benefits, and interest payments, etc. There is no information about interest payments on government bonds, thus the proxy used is: the government's outstanding debt multiplied by government bond yield. Owing that the OECD database provides the government primary balances, we do not have to use a proxy for interest payments.

In the variables of primary surplus and debt, there are some missing values. This represents a problem with the data from Portugal and Greece, but with the data for Japan, Norway, France and Finland, this is only a minor issue.[40]

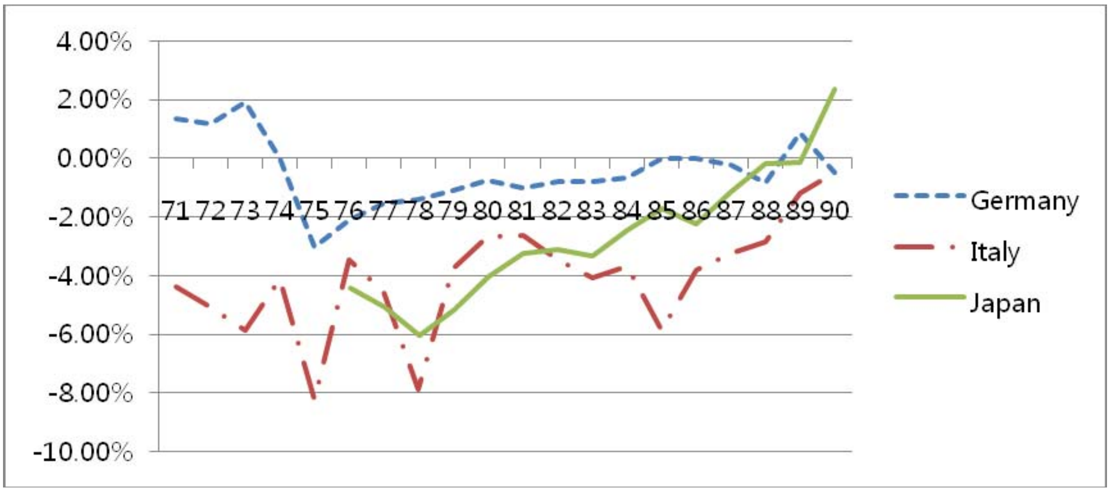
[40] Main Missing values : Greece (1971~1994), Portugal (1971~1990)

4.4.2. Trend of the Ratio of Primary Surplus to GDP

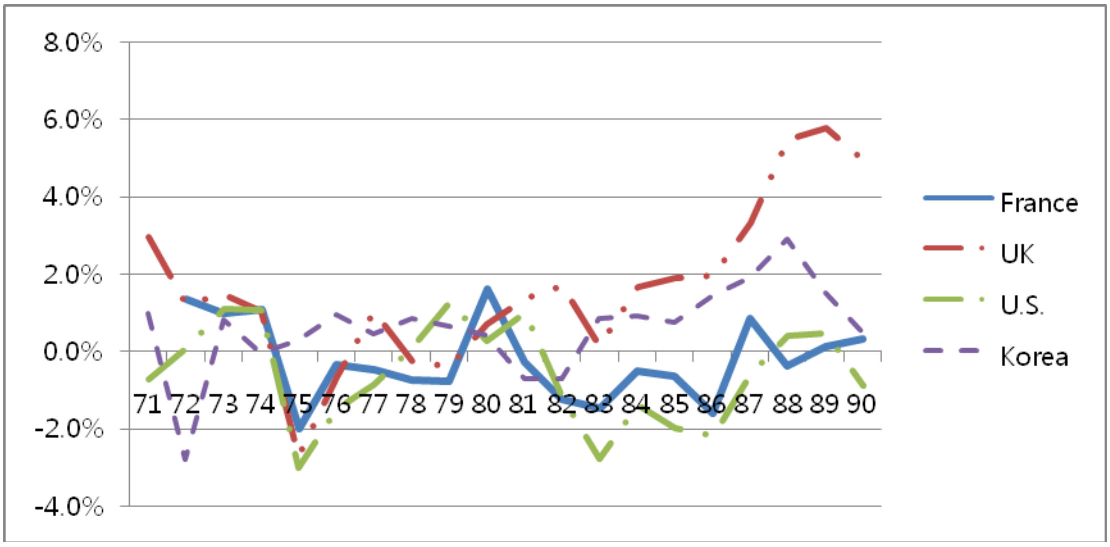
This ratio has a clearly increasing trend in Japan, Italy and the UK during 1971~1990. The other countries have fluctuations but the level is low or there is a tendency to converge to zero.

< Figure 4 – 10 > Primary Surplus to GDP Ratio (1971~1990)

(a) Japan, Italy, Germany



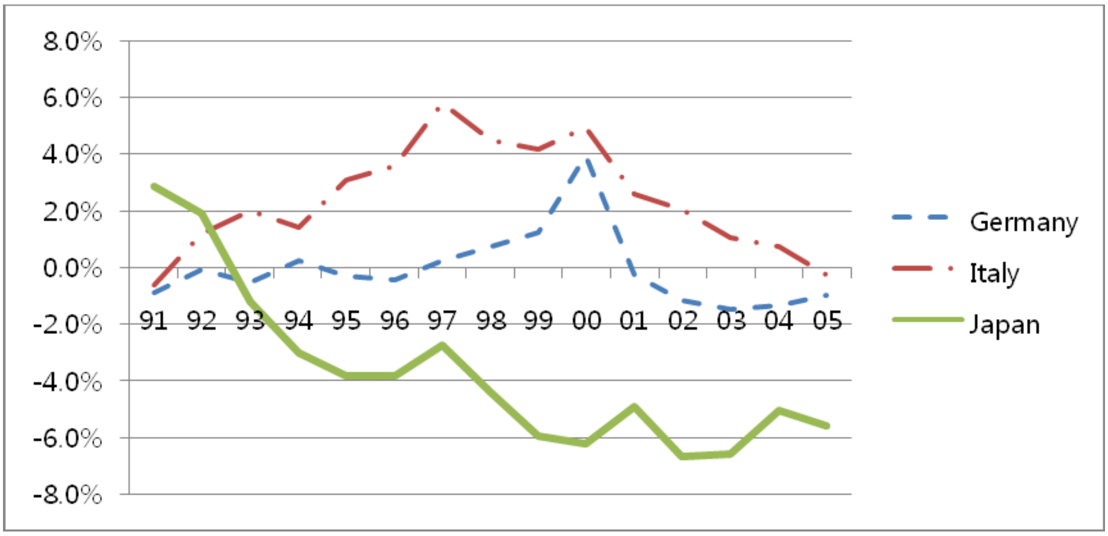
(b) France, The UK, The U.S., Korea



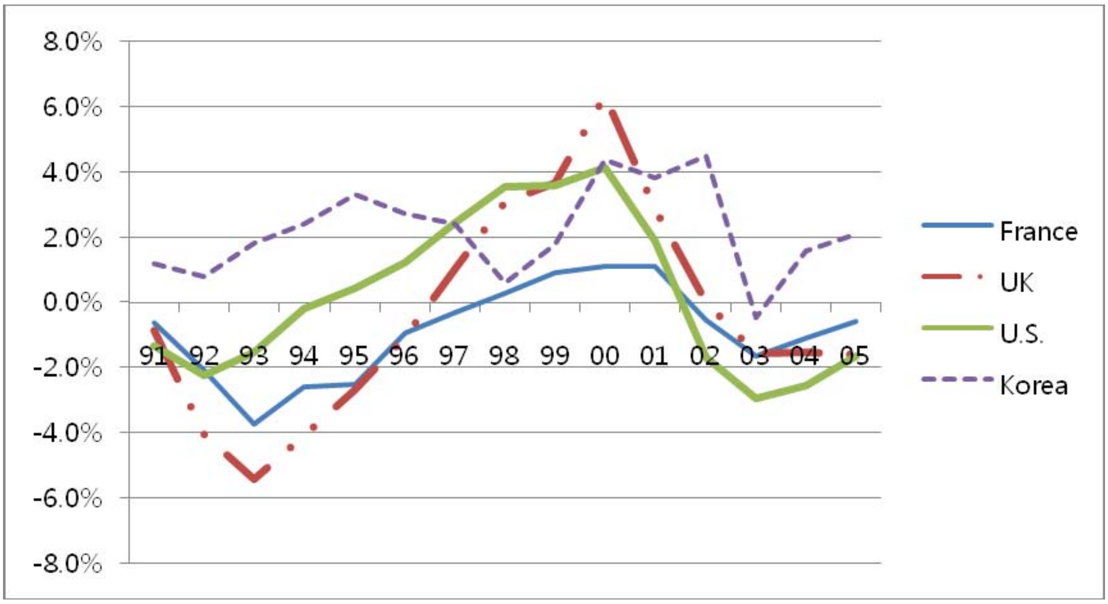
In contrast, the trend of primary surplus for Japan is clearly decreasing during 1991~2005. The other countries, except France, have high positive values in the late 1990's or early 2000's, followed by sharply decreasing values. France and Germany have relatively steady paths after 1991.

< Figure 4 – 11 > Primary Surplus to GDP Ratio (1991~2005)

(a) Japan, Italy, Germany



(b) France, The UK, The U.S., Korea



4.5. Fiscal Balance and GDP Growth Rate

4.5.1. Definition

To obtain the future values for the main variables that indicate fiscal conditions of that economy, we can use the Global Insight database that provides expected annual data for the government fiscal balance and nominal GDP up to 2035, and also use the OECD database for the same variables from 1990~2005 to find the debt trend of each country. If we have the future information about the fiscal balance and GDP growth rate, then we can estimate the future values for the debt variable by using the debt dynamic equation. The Global Insight data that is used in this paper is the one that was released in March 2007.

The fiscal balance indicates the difference between government total revenue and government total expenditure. If the latter is greater than the former, this case is called a deficit: the fiscal condition that the government spends more money than it gathers in. In this paper, this variable is a percentage of nominal GDP. The positive value of the fiscal balance is different from the concept of the primary surplus: the former contains every government expenditure, whereas the latter excludes the government spending related to the interest payments for government debt.

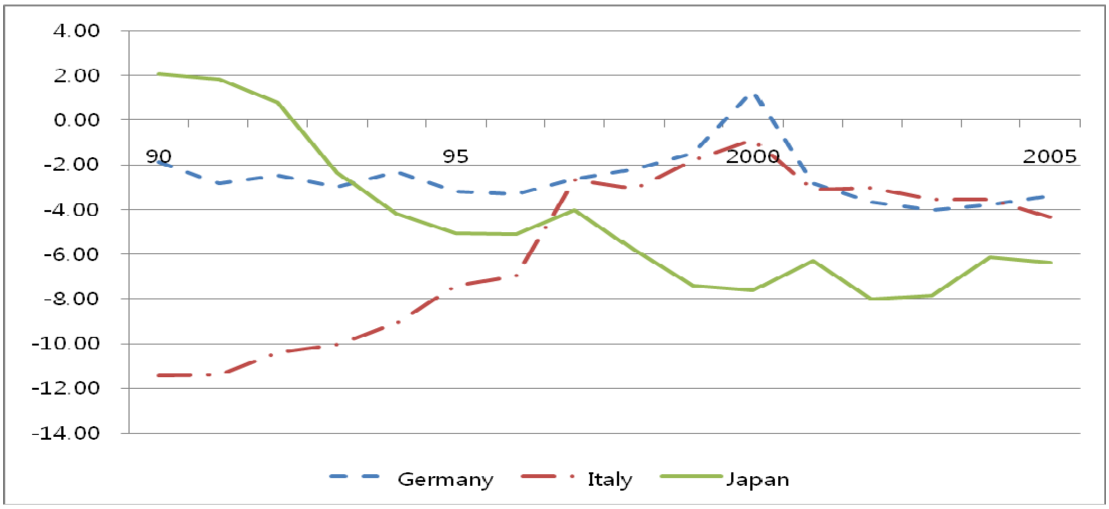
The Global Insight database has the estimated nominal GDP levels from 2009 ~ 2035. We can calculate the GDP growth rate using this information. As a percentage, it is the number calculated as the difference between previous year nominal GDP and current year nominal GDP divided by the previous nominal GDP level.

4.4.2. Trend of Fiscal Balance

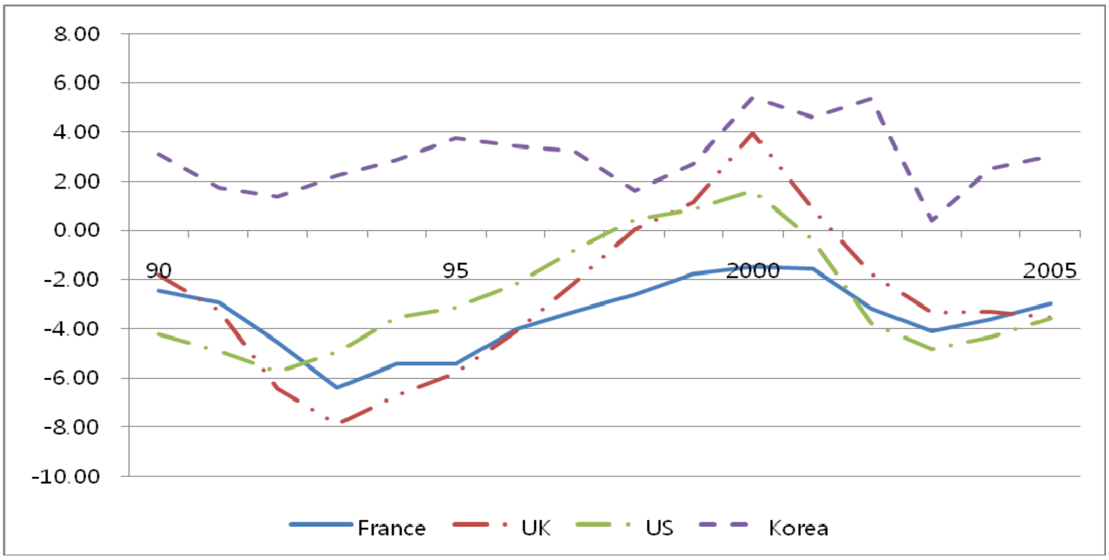
According to the OECD database, Japanese fiscal balance is decreasing from the early '90's, whereas Italy has an increasing trend in the 1990's. The UK, the U.S. and France have similar up and down trends in this variable, and the Korean fiscal balance has been positive for the whole period.

< Figure 4 – 12 > Historical Data of Fiscal Balance (1990~2005)

(a) Japan, Italy, Germany



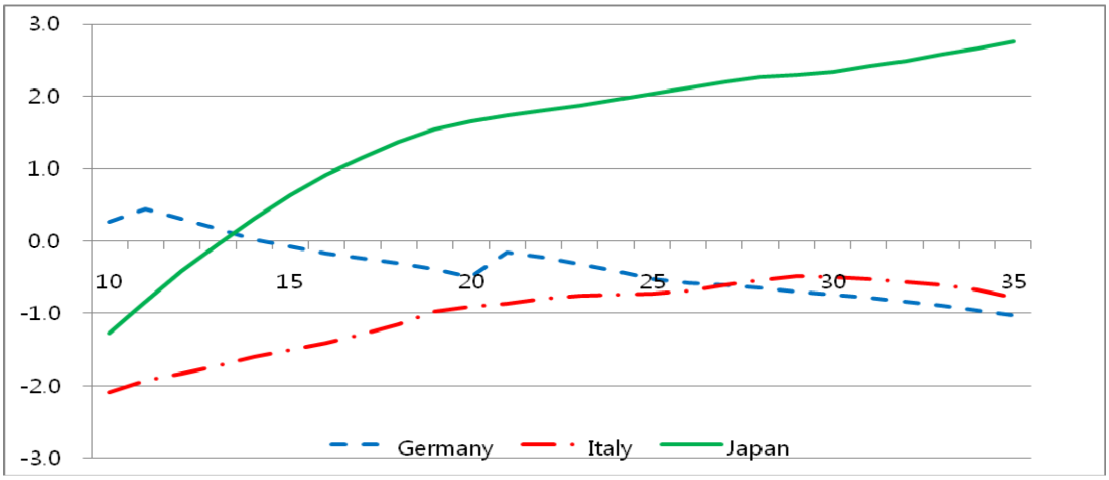
(b) France, The UK, The U.S., Korea



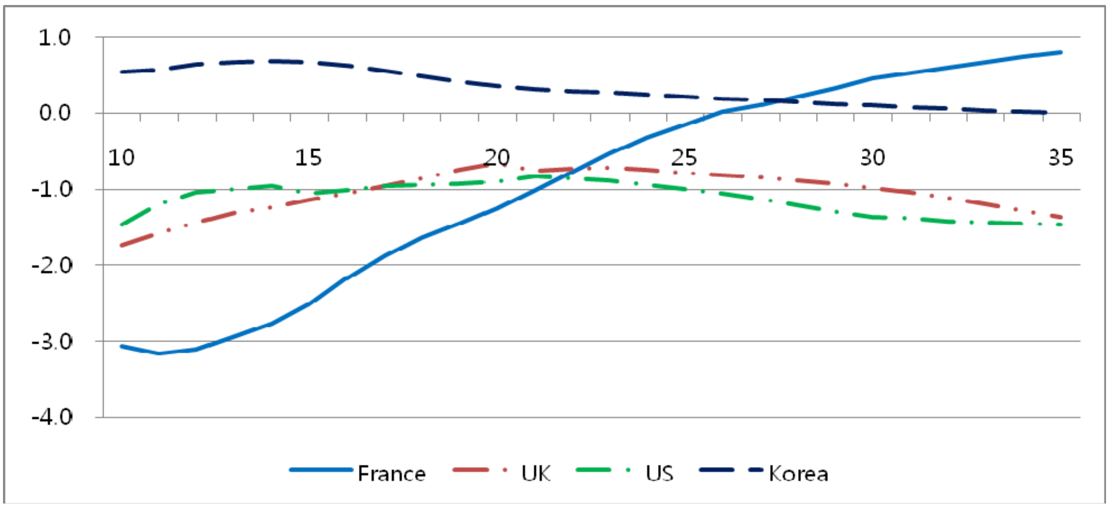
According to the Global Insight database, the fiscal balance of Japan starts from a negative value in 2010, then changes to positive and has strong positive values compared to the other main OECD countries. France has a similar pattern to Japan, while Korea is expected to have a small positive fiscal balance until 2035. Germany starts from positive and changes to negative. Italy, the UK, and the U.S. are expected to have negative fiscal balances during the entire estimated period.

< Figure 4 – 13 > Estimated Fiscal Balance (2010~2035)

(a) Japan, Italy, Germany



(b) France, The UK, The U.S., Korea

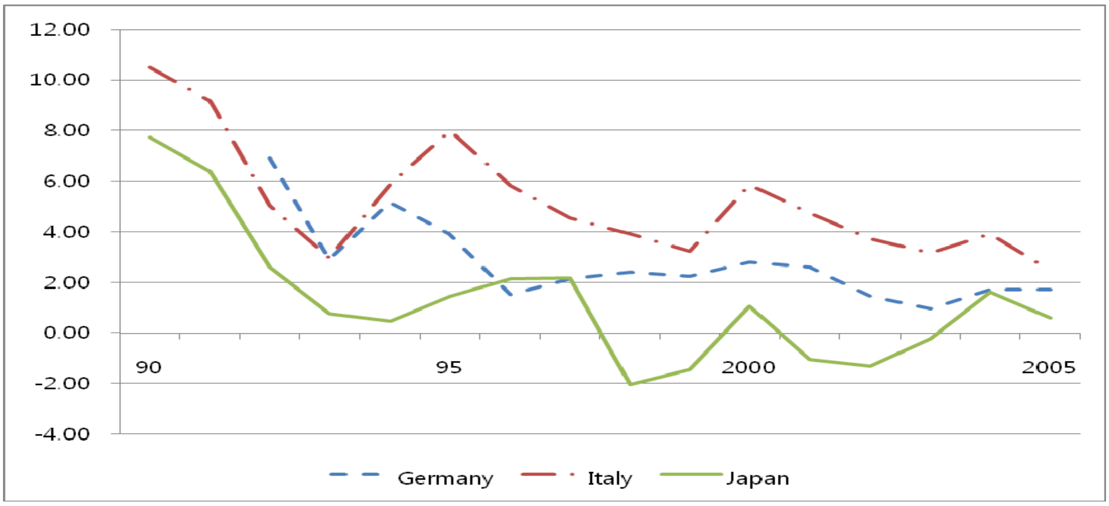


4.4.3. Trend of GDP Growth Rate

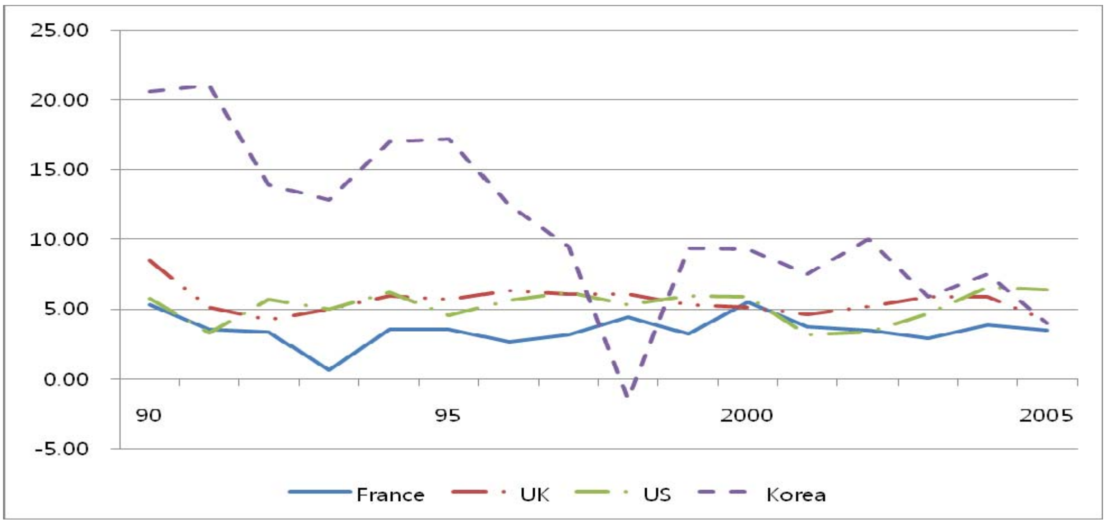
According to the OECD database, the Japanese GDP growth rate is decreasing since the early '90's and is sometimes negative, whereas Italy has fluctuating but positive growth rates. The UK, the U.S. and France have comparatively steady trends, and the Korea's growth rate was negative during the '97 financial crisis.

< Figure 4 – 14 > Historical Data of GDP Growth Rate (1990~2005)

(a) Japan, Italy, Germany



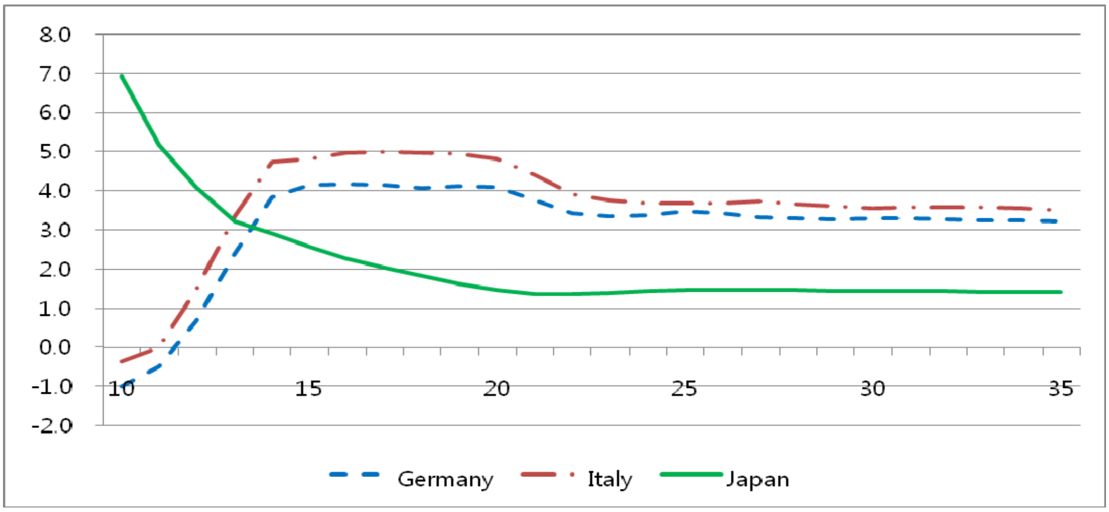
(b) France, The UK, The U.S., Korea



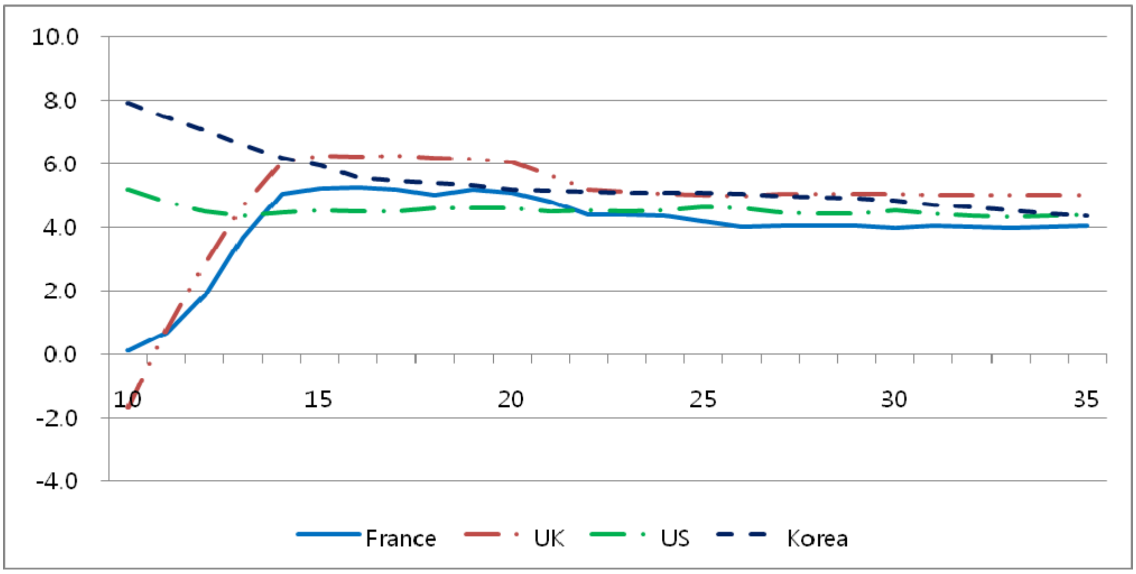
According to the Global Insight database, the estimated GDP growth rate for Japan starts at a high value in 2010, then steadily falls to around 1~2% by 2035. Korea and the U.S. have similar patterns but they are expected to have a steady growth rate around 4 ~ 6% for 30 years. Germany, Italy, France and the UK are expected to have low growth rates in 2010, then increase around 3 ~ 6% from 2015 to 2035.

< Figure 4 – 15 > Estimated GDP Growth Rate (2010~2035)

(a) Japan, Italy, Germany



(b) France, The UK, The U.S., Korea



Chapter V.

Empirical Results

5.1. The OLS Analysis

5.1.1. Summary of the OLS Analysis Results

This paper conducts an OLS analysis based on the annual data of 18 OECD countries using the reaction function that contains structural dummy variables. Some countries do not show any breaks during the whole period studied, but most countries have one or more breaks. Those breaks affect the slope and intercept in the reaction function, but sometimes only affect one of them. The OLS test results for the main countries[41] are shown in section 5.1.2.

The 18 OECD countries are divided into three sub-group tables based on the categories in the section 4.2.2. < Table 4−6 >: Group I, Group IV and the other countries. Group I represents the aged countries with the property of low-level, slow-aging speed. Group IV consists of the countries with high-level, fast-aging speed.

< Table 5−1 > shows the OLS test results of countries belonging to Group I. We can divide the results into three categories: a strong positive reaction, fluctuation in signs, and no significant reaction, the third group consisting of only Denmark. The first and second categories are explained below.

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[41] Japan, Italy, Germany, France, THE UK, U.S. and Korea

< Table 5 – 1 > OLS Test Results for Countries in Group I

The Regression Model : $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$							
Country	Coefficient					Adj-R^2	*DW*
	ρ			β_g	β_y		
Austria (SD^*)	**0.08**** (0.007)	**0.01**** (0.002)		−0.99** (0.14)	−0.71** (0.15)	0.88	2.22
➢ Period ➢ ADR(%) ➢ ΔADR	‘76~96 24.0→ 22.5 1.5↓	~05 → 23.8 1.3↑					
Netherlands (SD^*)	0.003 (0.020)	**0.05**** (0.015)		−0.45 (0.34)	−1.23 (0.29)	0.83	1.20
➢ Period ➢ ADR(%) ➢ ΔADR	‘76~85 16.9→ 17.6 0.7↑	~05 → 21.0 3.4↑					
Switzerland (SD^*)	**0.07**** (0.016)			−1.17** (0.16)	−1.11** (0.62)	0.73	2.31
➢ Period ➢ ADR(%) ➢ ΔADR	‘71~05 17.5→ 22.7 5.2↑						
Norway (SD^*)	−0.03 (0.06)	**0.18**** (0.044)		−0.98** (0.14)	−0.71* (0.31)	0.85	1.29
➢ Period ➢ ADR(%) ➢ ΔADR	‘72~79 20.8→ 22.5 **1.7↑**	~05 → 22.3 2.9↑↓					
The UK (SD^*)	**0.50**** (0.17)	**−0.55**** (0.17)	**0.43*** (0.18)	−0.32 (0.26)	−1.22 (0.30)	0.75	1.38
➢ Period ➢ ADR(%) ➢ ΔADR	‘71~79 20.1→ 22.8 2.9↑	~90 → 24.1 **1.3↑**	~05 → 24.4 0.3↑				
Denmark (SD^*)	0.01 (0.01)			−1.75** (0.38)	−1.08** (0.18)	0.88	1.44
➢ Period ➢ ADR(%) ➢ ΔADR	‘76~05 21.1→ 22.9 1.8↑						

* : 95% confidence, **: 99% confidence.

Austria, the Netherlands and Switzerland belong to the first category. These countries also have strong positive magnitude in the coefficient for the debt variable, which is greater than 0.05, and only Austria's recent trend is a slightly lower positive value. The values of the coefficient of the debt variable for the three countries have more than 99% confidence. The coefficients of the cyclical government expenditure variable are negative in these countries, and the coefficients of fluctuation in GDP are negative. The adjusted R^2 statistic is more than 0.7 and the Durbin−Watson statistics indicate that there are no significant autocorrelations. In terms of an aging trend, these countries are lower than 24% in the ADR. For example, the ADR of Austria in 1976 was 24%, decreased to 22.5% in 1996, and then increased to 23.8% in 2005. The ADR for the Netherlands ends at 21.0% in 2005, and that of Switzerland marks 22.7% in 2005.

Norway and the UK belong to the second category of Group I. Norway shows a negative reaction sign during 1972~79, then the sign changes to a strong positive value. The negative value is not significant at a 95% confidence level, whereas the positive value is significant with more than 99% confidence. If we consider the significance of the signs, Norway should belong to the first category. However, the UK has negative reaction sign from 1980~90, and this value is significant with a 99% confidence level. This fluctuation may be due to failing to adjust the cyclical outlays. The UK was involved in the Falklands War against Argentina in 1982, so defense expenditures placed a huge burden on fiscal affairs, which may explain the negative sign during 1980~1990 in the UK. The adjusted R^2 is more than 0.75 and the Durbin−Watson statistics indicate that there are no significant autocorrelations. The ADR of Norway was 22.3% in 2005, and that of the UK was 24.4% in 2005.

To summarize, those six countries in Group I show overall positive reactions if we focus on the significant results and exclude the particular period for the UK mentioned above. Furthermore, the magnitudes of these positive reactions are so strong, with more than 5% except in Denmark. The ADR for these countries are under 25%. Thus, we can conclude that the aging factor is not a big burden to the economy until around the ADR = 24%.

< Table 5−2 > shows the OLS test results of countries that belong to Group IV. We can divide the results into three categories: a change from positive to negative reaction, a change from negative to positive reaction (a group consist of only Portugal), and no significant reaction (a group made up of only Greece). The results of Portugal and Greece may be due to a short data series; earlier data for these countries are not available in the OECD or IFS databases. We focus on the first category: the results of Germany, Japan, Italy and Spain.

The value of the coefficient for the debt variable for Germany fluctuates. Those for Japan, Italy and Spain change from positive to negative. The coefficients of the cyclical government expenditure variable and fluctuation in GDP are all negative. The adjusted R^2 statistics are more than 0.89 in Germany, Japan and Italy, and 0.85 in Spain, values bigger than those for the countries in Group I. In terms of an aging trend, these countries' ADRs are higher than 24% in 2005. This means that high-level ADR countries have a high probability of becoming fiscally unstable. One fact that is more interesting is that the aging speed, calculated by the changes of the ADR levels in corresponding time, is around or above 0.3% per year when the reaction shows the negative sign. For example, the coefficient of the debt variable for Germany after 2000 is −0.13 with a 99% confidence level and the ADR change from 2000 to 2005 is 4.9%, on about 0.8% per year.

< Table 5 – 2 > OLS Test Results for Countries in Group IV

The Regression Model : $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$

Country	Coefficient					Adj-R^2	*DW*
	ρ			β_g	β_y		
Germany (SD*)	**−0.39**** (0.03)	**0.04**** (0.03)	**−0.13**** (0.02)	−1.30** (0.14)	−1.26** (0.13)	0.89	2.22
➢ Period ➢ ADR(%) ➢ ΔADR	'72~79 22.0→ 23.5 1.5↑	~99 → 23.2 0.5↑	~05 → 28.1 **4.9↑**				
Japan (SD*)	0.04 (0.024)	**0.05**** (0.01)	**−0.13**** (0.01)	−1.08** (0.18)	−1.75** (0.38)	0.93	1.48
➢ Period ➢ ADR(%) ➢ ΔADR	'76~79 11.8→ 12.3 0.5↑	~93 → 18.3 **6.0↑**	~05 → 29.8 **11.5↑**				
Italy (SD*)	**0.06**** (0.015)	**0.03**** (0.01)	**−0.02**** (0.003)	−0.31 (0.22)	−0.35 (0.25)	0.89	1.66
➢ Period ➢ ADR(%) ➢ ΔADR	'71~89 17.1→ 20.2 3.1↑	~01 → 27.3 **7.1↑**	~05 → **29.8** **2.5↑**				
Spain (SD*)	**0.20**** (0.05)	**−0.19**** (0.02)	**−0.09**** (0.03)	−0.86** (0.09)	−0.35* (0.53)	0.85	1.97
➢ Period ➢ ADR(%) ➢ ΔADR	'70~74 15.8→ 16.2 0.4↑	~85 → 18.6 **2.4↑**	~05 → 24.5 **5.9↑**				
Portugal (SD*)	**−0.03*** (0.023)	**0.01**** (0.004)		−2.27** (0.20)	−1.72** (0.13)	0.92	2.78
➢ Period ➢ ADR(%) ➢ ΔADR	'91~00 20.4→ 23.8 **3.4↑**	~05 → 25.0 1.2↑					
Greece (SD*)	−0.09 (0.09)			−0.24 (0.57)	0.42 (0.68)	0.71	1.06
➢ Period ➢ ADR(%) ➢ ΔADR	'96~05 22.5→ 27.1 4.6↑						

* : 95% confidence, **: 99% confidence.

In other words, when there is a negative relationship between primary surplus and debt, these countries experienced an increase of over 0.3% per year in the ADR. This indicates that the high-speed aging country is apt to face financial difficulty. There are two exceptions: Japan during 1980~1993 and Italy during 1990~2001. In the former case, the aging stage is under 20% in the ADR level, so it is possible to have the positive reaction sign even though the aging speed is faster than 0.3% per year. In the letter case, Italy controls the level of government debt due to its high debt−GDP ratio (see section 5.1.2.). In any case, we can conclude that aging factor may lead a big burden on the economy after the ADR = 24% with fast aging speed.

< Table 5–3 > shows the OLS test results for the rest of the countries: countries belong to Group II, Group III and Korea, the U.S.

Finland belongs to Group II: as they have an ADR under 25% with fast aging speed. It also has a positive reaction sign in the coefficient of the debt variable, 0.05, and the coefficient of cyclical government expenditure variable is positive. This is different from the previous countries' results, however, it is not a significant value. The coefficient of fluctuation in GDP is significantly negative. The adjusted R^2 statistic is 0.83 and the Durbin−Watson statistics indicate that there is no significant autocorrelation. In terms of an aging trend, Finland is lower than 24% in the ADR. Its ADR starts at 14.2% in 1972, and increases to 23.9% in 2005, a difference between the starting and the ending points is 9.7%; annual increases close to 0.3%. We can conclude that the fiscal conditions are sustainable until an ADR of 24% for a country with an annual aging speed lower than 0.3% using the results for Finland.

< Table 5 – 3 > OLS Test Results for the Rest Countries

The Regression Model : $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$

Country	Coefficient					Adj-R^2	*DW*
	ρ			β_g	β_y		
Finland	**0.05****			0.01	−1.97**	0.83	2.05
(SD*)	(0.01)			(0.14)	(0.28)		
➢ Period	‘72~05						
➢ ADR(%)	14.2→ 23.9						
➢ ΔADR	9.6↑						
Belgium	**0.03***	**−0.04****	**0.13****	−1.13**	−0.69**	0.97	1.79
(SD*)	(0.011)	(0.01)	(0.01)	(0.12)	(0.15)		
➢ Period	‘73~96	~00	~05				
➢ ADR(%)	21.4→ 24.2	→ 25.8	→ 26.3				
➢ ΔADR	2.8↑	**1.6↑**	0.5↑				
Sweden.	**0.15****	**−0.07****	**−0.48****	−1.46**	−2.05**	0.85	1.83
(SD*)	(0.05)	(0.02)	(0.17)	(0.18)	(0.35)		
➢ Period	‘82~90	~93	~05				
➢ ADR(%)	25.6→ 27.7	→ 26.8	→ 26.4				
➢ ΔADR	2.1↑	**0.9↓**	**0.4↓**				
France	**0.04***	−0.02	**−0.01****	−0.25	−0.64**	0.73	2.34
(SD*)	(0.02)	(0.01)	(0.003)	(0.12)	(0.12)		
➢ Period	‘75~90	~00	~05				
➢ ADR(%)	21.5→ 21.5	→ 25	→25				
➢ ΔADR	1.8↓↑	3.5↑	-				
Korea	0.01	**−0.17****		−0.83**	−0.76**	0.88	1.44
(SD*)	(0.05)	(0.05)		(0.09)	(0.16)		
➢ Period	‘71~89	~05					
➢ ADR(%)	6.2→ 6.8	→ 13.1					
➢ ΔADR	0.6↑	**4.5↑**					
The U.S.	**0.04****	**−0.03****		−2.22**	−1.31**	0.82	1.43
(SD*)	(0.008)	(0.008)		(0.36)	(0.33)		
➢ Period	‘71~01	~05					
➢ ADR(%)	15.9→ 18.6	→ 18.3					
➢ ΔADR	2.7↑	0.3↓					

* : 95% confidence, **: 99% confidence.

Group III consists of the countries with over the ADR 25% and slow aging-speed. Belgium, Sweden and France belong to this group. Unlike the other groups, the results of Group III are mixed. The reaction sign for Belgium fluctuates. It shows a significant negative sign during 1997~2000, then turns to a strong positive sign. The coefficients of the cyclical government expenditure variable and fluctuation in GDP are significantly negative. the adjusted R^2 statistic is 0.97 and the Durbin−Watson statistics indicate that there is no significant autocorrelation. In terms of an aging trend, Belgium is categorized as a slow aging speed country; the difference between start and end points is 4.9%, for which the annual increase is around 0.15%. However, one interesting fact is that the annual aging speed is 0.4% in the ADR when Belgium has a negative reaction sign (−0.04) during 1997~2000. We can assume that fast aging speed, which is higher than 0.3% per year, may hamper fiscal sustainability. The reaction signs for Sweden and France are similar in that those signs start positive and become negative. However, in terms of the aging factor, it is difficult to find patterns. During the periods of negative reaction signs in Sweden, the ADR is decreased from 27.7% to 26.4%. In France, the period of significant negative reaction has no change in the ADR. Even though both countries' ADR levels are higher than 25% in those periods, the aging speed alone may not have explanatory power for the negative reactions.

Korea and the U.S. are not aged countries; both have the ADRs under 20%. However, these countries have negative reaction signs. This means that the aging factor may not be a main reason for fiscal instability for those countries.

By examining the OLS test results for 18 OECD countries, we can conclude that the aging factor is an important variable in deciding the sign on the debt variable in the reaction function. Thus, it is a decisive factor for fiscal sustainability.

5.1.2. The OLS Results of Main Countries

Japan

The Chow breakpoint test reveals the two breaks as shown in < Table 5−4 >. The null hypothesis is that there is no break in the series, which should be rejected because the test statistics are so high. For example, the F−statistic value for two breaks in 1980 and 1994 is 31.09. Thus, the P−value is close to zero. However, in those breaks, the changes in the coefficient of the debt variable are significant at each time, but the changes in the intercept are only significant in the break of 1994 as shown in < Table 5−4 >.

This table indicates the results of the OLS test analysis using the reaction function for the Japanese data. The most important finding is that the Japanese government fails to maintain stable debt levels after 1994. The coefficient of the debt variable after 1994 is −0.13 and the T-statistic is quite high. This means that the Japanese government has a high probability of facing fiscal difficulty in the near future. By examining < Figure 5−1 >, we find a strong negative trend in the relationship between debt and primary surplus.

< Table 5 − 4 > Chow Breakpoint Test Result for Japan

Breaks in 1980, 1994 (2 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 31.09	Prob. F(6,21)	= 0
Log Likelihood Ratio	= 68.73	Prob. Chi – Square (6)	= 0
Wald Statistic	= 186.6	Prob. Chi – Square (6)	= 0

< Table 5 − 5 > The OLS Test Results for Japan

Japan : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$

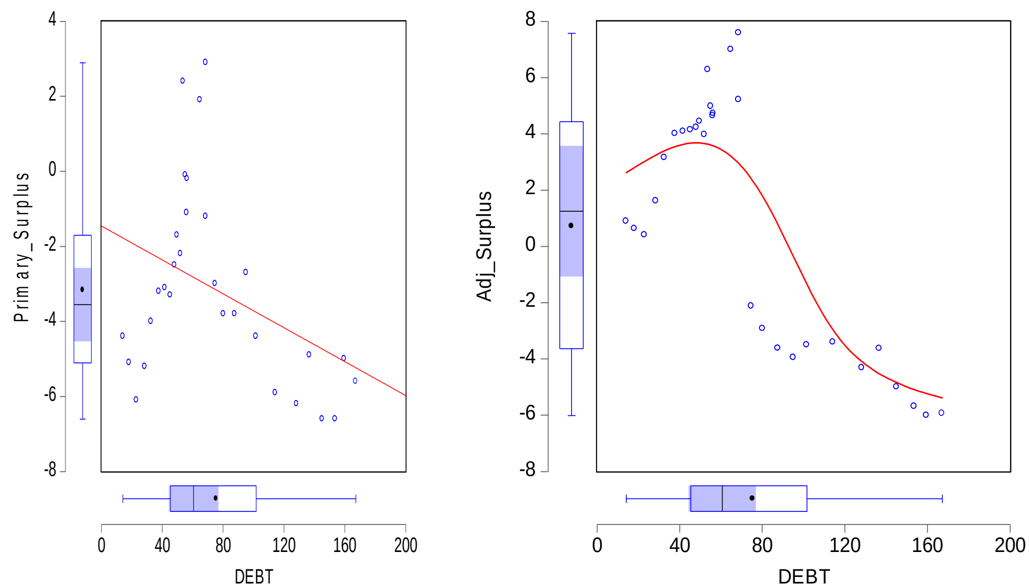
Period	Variable	Coefficient	T-statistics	Variable	Coefficient	T-statistics
’76 ~ ’79	ρ	0.04	(1.8)	α	**−6.33**** (‘76~’93)	(−12.3)
’80 ~ ’93		**0.05****	(3.9)			
’94 ~ ’05		**−0.13****	(−10.2)		**6.08****	(7.8)
’76 ~ ’05	β_g	**−1.08****	(−5.96)	β_y	**−1.75****	(−4.58)
	’76	’94	’05	R^2	Adj-R^2	*DW*
ADR(%)	11.8	18.7	29.8	0.95	0.93	1.48

* : 95% confidence, **: 99% confidence.

< Figure 5 – 1 > Primary Surplus versus Debt of Japan

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



Italy

The Chow breakpoint test results for Italy indicate that there are two breakpoints in 1990 and 2002, which is shown in < Table 5−6 >. Italy has the highest debt to GDP level of all OECD countries except Japan. However, the OLS test results using the reaction function tells us that this government was fiscally stable during 1971~2001. This is mainly due to Italy being a member of the EU. The EU requires each member country to fulfill, among other requirements, the fiscal convergence criteria of the Treaty of Maastricht (1992) and the Pact for Stability and Growth (1997).[42] Thus, Italy is presumed to conduct retrenchments in finance.

We can draw this conclusion since the average primary surplus during 1971~1991 is −3.9%, but from 1992~2004 is 2.8%, followed by negative values in 2005. After 2002, the sign of the debt variable changes to negative in < Table 5−7 >. This means that the fiscal information in Italy fails to reflect the changing of aging conditions during 1992~2001. This is the analysis used to form Group V, which excludes Italy from Group IV in the panel data analysis part.

< Table 5 − 6 > Chow Breakpoint Test Result for Italy

Breaks in 1990, 2002 (2 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 2.95	Prob. F(6,21)	= 0.01
Log Likelihood Ratio	= 24.66	Prob. Chi – Square (6)	= 0.001
Wald Statistic	= 23.61	Prob. Chi – Square (6)	= 0.002

[42] Peter Brandner, Leopold Diebalek, Helene Schuberth. “Structural budget deficits and sustainability of fiscal positions in the European Union.” Oesterreichische Nationalbank, Working Paper (1998)

< Table 5 − 7 > The OLS Test Results for Italy

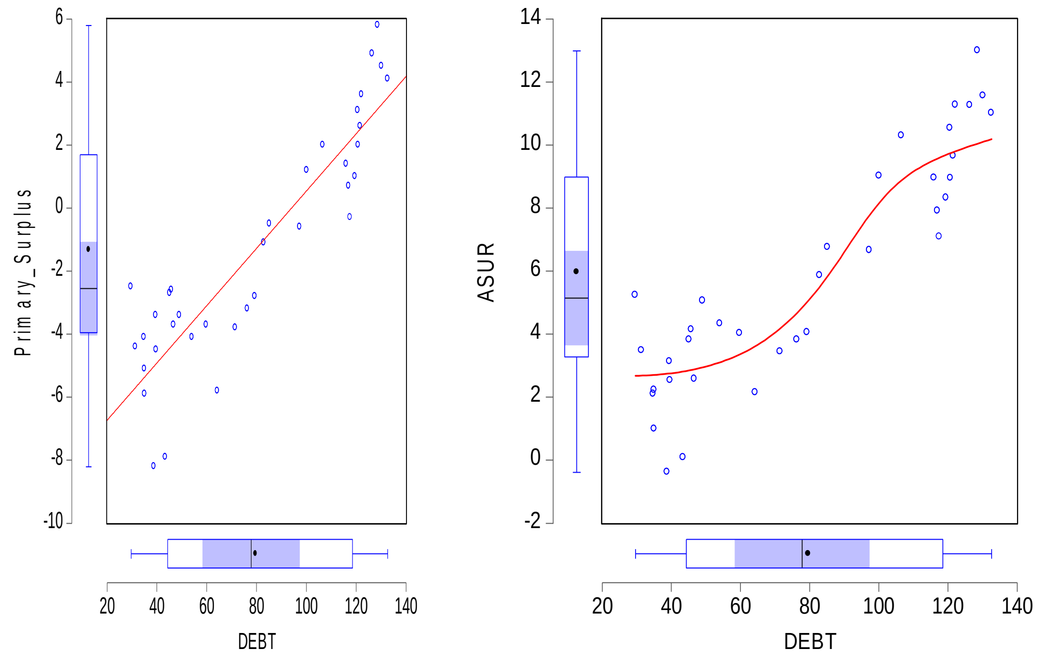
Italy : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$						
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
’71 ~ ’89	ρ	**0.06****	(3.82)			
’90 ~ ’01		**0.03****	(3.03)			
’02 ~ ’05		**−0.02****	(−5.12)	α	**−7.26**** (’71~’05)	(−7.96)
’71 ~ ’05	β_g	−0.31	(−1.43)	β_y	−0.35	(−1.36)
ADR(%)	’71 17.1	’02 27.5	’05 29.8	R^2 0.91	Adj-R^2 0.89	*DW* 1.66

* : 95% confidence, **: 99% confidence.

< Figure 5 – 2 > Primary Surplus versus Debt of Italy

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



Germany

< Table 5−8 > indicates that there are two breaks, one in 1980 and the other in 2000, in the data series of Germany. Germany also has a strong negative relationship between surplus and debt in two periods, ’72~’79 and after 2000, which are summarized in < Table 5−9 >. All coefficients and intercept points are significant with more than 99% confidence. In terms of the aging speed, we find one particularly interesting result. After 2000 among aged OECD countries, the aging speed of Germany is second. Japan is first with an increase of 4.4% in the ADR during 2000~2005, followed by Germany with a 4.1%, then Italy with a 2.8% increase. This aging factor may affect difficulties in fiscal affairs that result in the sign of the coefficients of the debt variable changing.

We further examine this trend in < Figure 5−3 >. In the simple correlation between primary surplus and debt, it seems that there is a positive relationship in graph (a). However, in the correlation between these variables, after adjustments in graph (b), we can find the decreasing trend in the surpluses when debt is increasing.

< Table 5 − 8 > Chow Breakpoint Test Result for Germany

Breaks in 1980, 2000 (2 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 10.72	Prob. F(6,21)	= 0
Log Likelihood Ratio	= 54.02	Prob. Chi – Square (6)	= 0
Wald Statistic	= 85.75	Prob. Chi – Square (6)	= 0

< Table 5 − 9 > The OLS Test Results for Germany

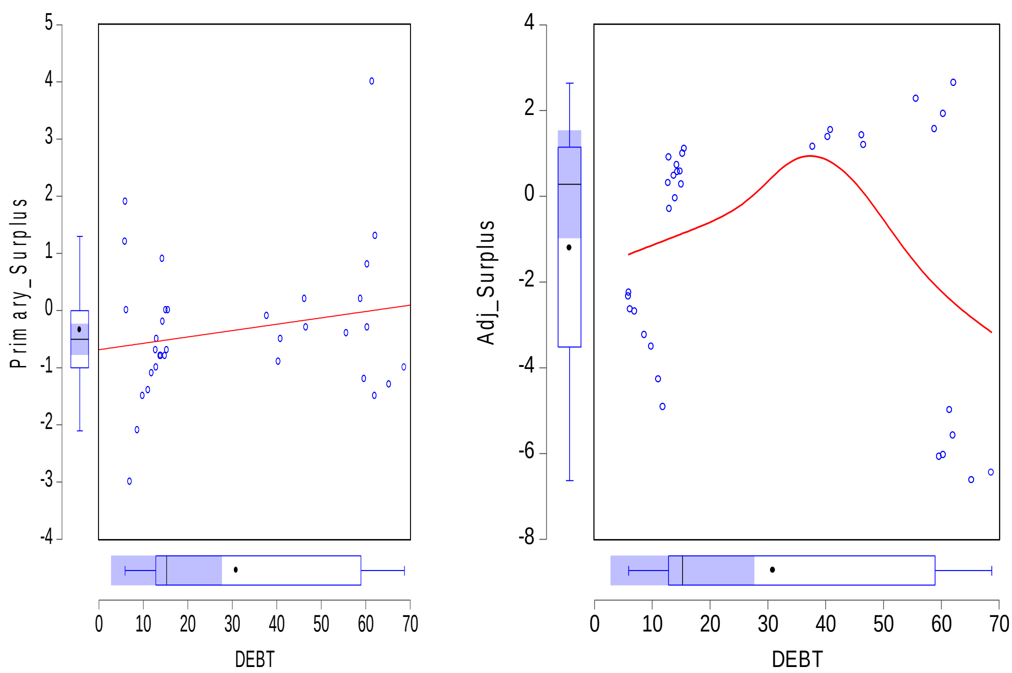
Germany : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$						
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
'72 ~ '79	ρ	**−0.39****	(−11.5)	α	**2.34****	(9.44)
'80 ~ '99		**0.42****	(12.6)		**−3.22****	(−10.5)
'00 ~ '05		**−0.13****	(−5.6)		**6.55****	(4.2)
'72 ~ '05	β_g	**−1.30****	(−9.4)	β_y	**−1.26****	(−9.6)
	'72	'00	'05	R^2	Adj-R^2	*DW*
ADR(%)	22.0	24.0	28.1	0.92	0.89	2.22

* : 95% confidence, **: 99% confidence.

< Figure 5 – 3 > Primary Surplus versus Debt of Germany

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



France

< Table 5−10 > indicates that there are two breaks, one in 1991 and the other in 2001, in France with more than 99% confidence. The coefficients of the debt variable have different signs and significance: they start with a significant positive value, then have a non-significant negative value, and finally, have a significant negative value, which is shown in < Table 5−11>. The test results also show that the breaks do not have significant values in the intercept. The coefficients of the cyclical government outlays and the fluctuation in GDP are both negative. The trend for the coefficient of debt in the reaction function is decreasing and positive.

France's ADR levels fluctuate over the period of this study. The ADR in 1975 is 21.5%, it goes down to 19.7% in 1985 and then steadily goes up to 25% in 2005. This may suggest that there are fiscal burdens as the aging levels are going up.

< Figure 5−4 > indicates the trend in the relationship between surplus and debt. We can more clearly illustrate this trend in the adjusted primary surplus versus debt with the kernel fit line.

< Table 5 − 10 > Chow Breakpoint Test Result for France

Breaks in 1991, 2001 (2 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 3.53	Prob. F(6,21)	= 0.009
Log Likelihood Ratio	= 28.07	Prob. Chi – Square (6)	= 0.0005
Wald Statistic	= 28.22	Prob. Chi – Square (6)	= 0.0004

< Table 5 − 11 > The OLS Test Results for France

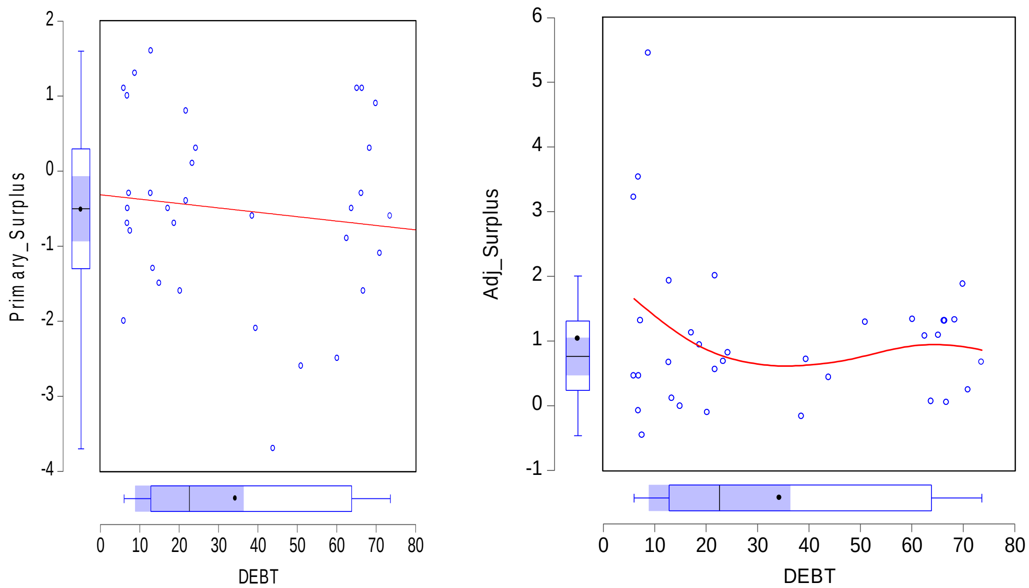
France : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$						
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
’75 ~ ’90		**0.04****	(2.54)			
’91 ~ ’00	ρ	−0.02	(−1.8)			
’01 ~ ’05		**−0.01****	(−4.67)	α	**−1.10**** (‘75~’05)	(−3.83)
’75 ~ ’05	β_g	−0.25	(−2.04)	β_y	**−0.64****	(−5.14)
	’75	’91	’05	R^2	Adj-R^2	*DW*
ADR(%)	21.5	21.5	25.0	0.78	0.73	2.34

* : 95% confidence, **: 99% confidence.

< Figure 5 – 4 > Primary Surplus versus Debt of France

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



The UK

We find that there are three breaks in the UK data by examining the results of the Chow break point test shown in < Table 5−12 >. The last break is only significance in the intercept, not in the coefficient of the debt variable. Every coefficient of the debt variable and intercept has a significant result with more than 95% confidence. These are summarized in < Table 5−13 >. The signs of coefficient for the debt variable fluctuate and end as a positive value.

There is another interesting aspect in the aging factor. The ADR of the UK in 1971 is 20.9%, 24.1% in 1991 and 24.4% in 2005. This indicates that the annual changes are different between the period before 1991 and after 1991. The average change of the ADR during 1971~1991 is around 0.16% per year. However, the average aging speed after 1991 is 0.02% per year in the light of the change value in the ADR. This means that the aging trend becomes slower after 1991.

< Figure 5−5 > shows the trend in the relationship between surplus and debt. Both graph (a) and (b) indicate that there is a positive relationship between these variables.

< Table 5 − 12 > Chow Breakpoint Test Result for the UK

Breaks in 1980, 1991, 1997 (3 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 14.94	Prob. F(6,21)	= 0
Log Likelihood Ratio	= 82.08	Prob. Chi – Square (6)	= 0
Wald Statistic	= 179.3	Prob. Chi – Square (6)	= 0

< Table 5 − 13 > The OLS Test Results for the UK

France : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$

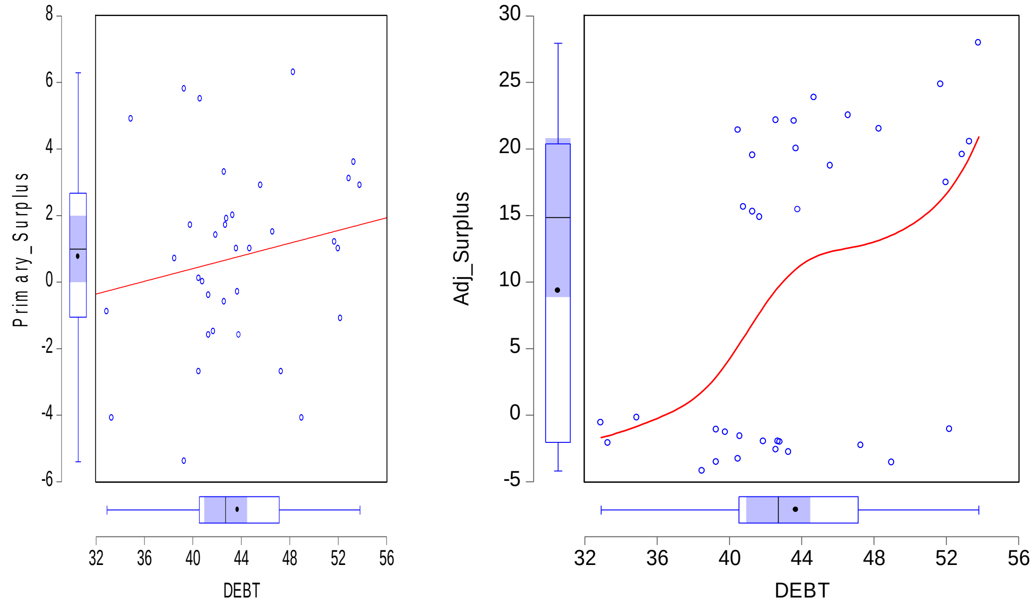
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
'71 ~ '79		**0.50****	(2.9)		**−21.8****	(−3.0)
'80 ~ '90	ρ	**−0.55****	(−3.3)	α	**26.7****	(3.7)
'91 ~ '96		**0.43*** ('91~'05)	(2.35)		**−4.24****	(−8.8)
'97 ~ '05					**−17.3***	(−2.14)
'71 ~ '05	β_g	−0.32	(−1.23)	β_y	**−1.22****	(−4.03)
	'71	'91	'05	R^2	Adj-R^2	DW
ADR(%)	20.9	24.1	24.4	0.81	0.75	1.38

* : 95% confidence, **: 99% confidence.

< Figure 5 – 5 > Primary Surplus versus Debt of the UK

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



The U.S.

The values of the Chow break point test statistics for the U.S. are a little bit different from that of the other countries, which is shown in < Table 5−14 >. With the F statistic, we cannot reject the null hypothesis with a 99% confidence level. This means there is no break in the U.S. data. However, the log likelihood ratio and Wald statistics still can reject the null hypothesis, so we conclude there is a break in 2002 in the U.S. The U.S. has one break in the coefficient of the debt variable and no break in the intercept, which is summarized in < Table 5−15 >. The coefficients of the cyclical government outlays and the fluctuation in GDP are both negative. The trend of the coefficient of debt in the reaction function shows a decreasing positive magnitude. This is mainly due to increasing government expenditure relating to the Iraq war and Hurricane Katrina damage.

The ADR levels for the U.S. fluctuate over the course of this study. The ADR in 1971 is 15.9%, it goes up to 18.8% in 1995, and then steadily goes down until 2005. < Figure 5−6 > shows the trend in the relationship between surplus and debt. We can see the trend in the adjusted primary surplus versus debt more clearly with the kernel fit line.

< Table 5 − 14 > Chow Breakpoint Test Result for the U.S.

Breaks in 2002 (1 time) vs. Null Hypothesis (No Break)			
F – Statistic	= 3.12	Prob. F(6,21)	= 0.03
Log Likelihood Ratio	= 13.26	Prob. Chi – Square (6)	= 0.01
Wald Statistic	= 12.47	Prob. Chi – Square (6)	= 0.01

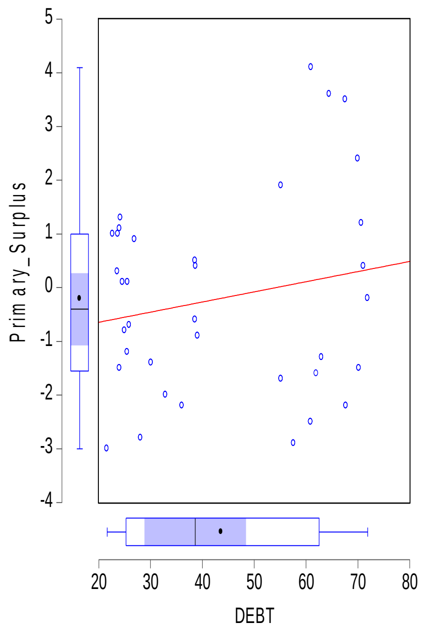
< Table 5 − 15 > The OLS Test Results for the U.S.

The U.S. : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$						
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
’71 ~ ’01	ρ	0.04**	(5.14)	α		
’02 ~ ’05		**−0.03****	(−4.20)		**−1.83**** (‘71~’05)	(−5.12)
’71 ~ ’05	β_g	−2.22**	(−6.08)	β_y	−1.31**	(−3.95)
	’71	’02	’05	R^2	Adj-R^2	*DW*
ADR(%)	15.9	18.6	18.3	0.85	0.82	1.43

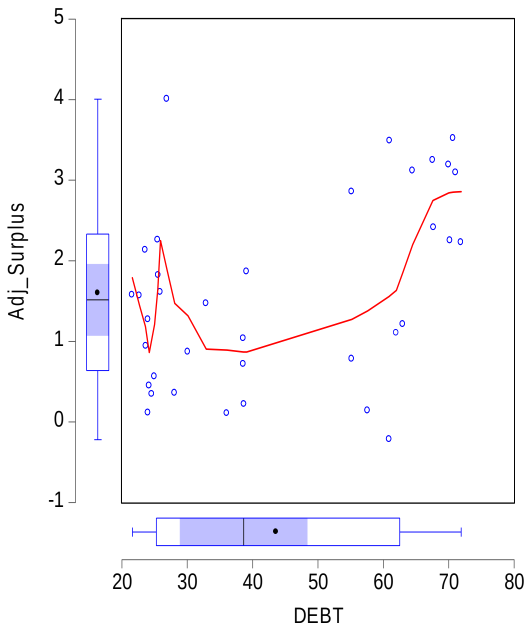
* : 95% confidence, **: 99% confidence.

< Figure 5 – 6 > Primary Surplus versus Debt of the U.S.

(a) The Simple Correlation with the regression line



(b) After adjustment for cyclical fluctuations with the kernel fit line



Korea

The Chow break point test for Korea shows that there are two breaks in 1990 and 2000, which is summarized in < Table 5−16 >. However, in those breaks, the changes in the intercept are significant at each time, but the changes in the coefficient of the debt variable are only significant in the break of 1990; shown in < Table 5−17 >. The coefficients of the cyclical government outlays and the fluctuation in GDP are both negative.

The aging speed in Korea is interesting. The ADR in 1976 is 6.2%, 7.2% in 1990, and 13.1% in 2005. The change after 1990 is 5.9%. Considering that the change after 1991 of the UK is 0.3%, the aging speed of Korea is 20 times faster than that of the UK.

The trend of the coefficient of debt in the reaction function changes from positive to negative, even though the Korea's ADR is much lower than in other aged OECD countries. It is mainly due to increasing government expenditure relating to the financial crisis of 1997. < Figure 5−7 > shows the trend in the relationship between surplus and debt. We can further see this trend in the adjusted primary surplus versus debt with the kernel fit line.

< Table 5 − 16 > Chow Breakpoint Test Result for Korea

Breaks in 1990, 2000 (2 times) vs. Null Hypothesis (No Break)			
F – Statistic	= 15.39	Prob. F(6,21)	= 0
Log Likelihood Ratio	= 61.78	Prob. Chi – Square (6)	= 0
Wald Statistic	= 123.2	Prob. Chi – Square (6)	= 0

< Table 5 − 17 > The OLS Test Results for Korea

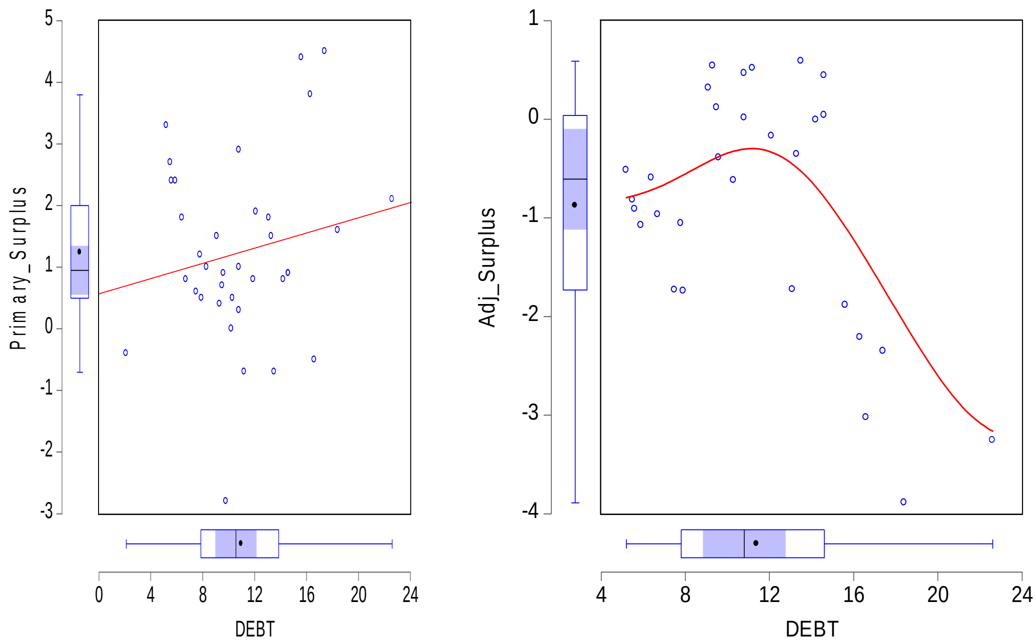
Korea : the model is $s_t = \sum_{i=1}^{n+1} \alpha_i D_{ti} + \sum_{i=1}^{n+1} \rho_i D_{ti} d_{ti} + \beta_g \tilde{g}_t + \beta_y \tilde{y}_t + \varepsilon_t$						
Period	Variable	Coefficient	T-statistics*	Variable	Coefficient	T-statistics*
'76 ~ '89	ρ	0.01	(0.17)	α	0.84	(1.26)
'90 ~ '99		**−0.17**** ('90~'05)	(−3.11)		2.16**	(3.29)
'00 ~ '05					2.20**	(4.87)
'76 ~ '05	β_g	−0.83**	(−9.19)	β_y	−0.76**	(−4.81)
	'76	'90	'05	R^2	Adj-R^2	*DW*
ADR(%)	6.2	7.2	13.1	0.91	0.88	1.44

* : 95% confidence, **: 99% confidence.

< Figure 5 – 7 > Primary Surplus versus Debt of Korea

(a) The Simple Correlation with the regression line

(b) After adjustment for cyclical fluctuations with the kernel fit line



5.1.3. Comparison with Previous Research

There are two main groups of previous papers using the reaction function: Bohn's papers and Uctum et al's paper. The former focuses only on the U.S. historical data and while the latter is expanded to other countries and includes the U.S. First, this paper differs in the data period from Bohn's papers. Due to longer periods, Bohn gets relatively strong positive coefficients for the debt variable, compared to this paper's result, which has a negative reaction sign after 2002. Another difference is the magnitude of the positive value. The reason that there are many coefficient values in Bohn's papers is that he divides the data into different periods and then conducted several tests. His regression line is just a straight line, different from the result of this paper. The regression line should have kinked when there are significant structural changes. This is one of the main findings of this paper. < Table 5−18 > summarizes the differences between papers.

Uctum et al expand the reaction function by using international data. Some of countries in their study are included in this paper. < Table 5−19 > shows the differences between this study and Uctum's. The reason that break points are different between the results is due to different data periods and the different ways of allowing for structural changes.

< Table 5 – 18 > Comparison with the Results of Bohn's Papers

	Bohn's Papers		This Paper	
	1998	2005		
Data Period	1916 ~ 95	1792 ~ 2003	1971 ~ 2005	
Coefficient of ρ	2.8 ~ 5.4%	6.9 ~ 12.1%	'71~'01 4.0%	'02~'05 **−3.0%**
Coefficients of β_g, β_y	$\beta_g < 0$, $\beta_y < 0$	$\beta_g < 0$, $\beta_y > 0$	$\beta_g < 0$, $\beta_y < 0$	

The main difference is that in this paper the coefficient of the debt variable shows many fluctuation and negative signs, whereas Uctum's paper fails to find any negative reaction in the main countries. Furthermore, the magnitudes are greater than −0.1 at 99% confidence in Japan, Germany and Korea. Even Italy, which controlled the government debt level, shows a significantly negative sign recently. These results are because this paper allows for the change in the intercept values, whereas Uctum's analysis does not. In addition, this paper includes the most recent year's information.

< Table 5 – 19 > Comparison with the Results of Uctum et al's Paper

Main country	Coefficient of ρ					
	Uctum et al (2006)			This Paper		
Japan	'71~'89 0.03 (5.4)	'93~'01 **−0.00** (−0.04)		'76~'79 0.04 (1.8)	'80~'93 0.05** (3.9)	'94~'05 **−0.13**** (−10.2)
Italy	'89~'91 0.08 (6.4)	'93~'94 0.11 (12.1)	'98~'01 0.13 (14.9)	'71~'89 0.06** (3.8)	'90~'01 0.03** (3.4)	'02~'05 **−0.02**** (4.0)
Germany	'71~'73 0.32 (10.0)	'75~'88 0.2 (12.2)	'90~'01 0.14 (14.1)	'72~'79 **−0.39**** (−11.5)	'80~'99 0.42** (12.6)	'00~'05 **−0.13**** (−5.6)
France	'72~'86 0.13 (5.1)	'90~'01 0.08 (6.0)		'75~'90 0.42** (2.5)	'91~'00 **−0.02** (−1.8)	'01~'05 **−0.01**** (−4.7)
The U.S.	'72~'95 0.03 (1.6)	'97~'02 0.08 (6.8)		'71~'01 0.04** (5.1)	'02~'05 **−0.03**** (−4.2)	
Korea	'71~'84 0.35 (3.0)	'86~'87 0.64 (4.6)	'91~'97 0.38 (2.2)	'76~'89 0.01 (0.2)	'90~'05 **−0.16**** (−3.11)	

1) (#) = T statistics
2) * : 95% confidence, **: 99% confidence.

5.2. The Panel Data Analysis

5.2.1. Summary of the Panel Data Analysis Results

Through the OLS tests for each aged OECD country, we find that the aging factor is important in the relationship between the fiscal variables. In this section, we try to analyze the properties of each group, which is classified by the aging criterion (see Table 4−6). This paper focuses on the panel data analysis of the four groups. The first group consists of 16 aged OECD countries. The second group consists of countries that are relatively less aged and have slow aging speeds among the countries of the first group. Six countries belong to this group and we call this "Group I". The third group is relatively high age countries with fast aging speed: a group of six countries that we call "Group IV". The last group is the same as the third group but excludes Italy because it fails to reflect aging properties in the fiscal variables: we call this "Group V". Korea and the U.S. are excluded in the panel data analysis due to their aging status. Both countries' ADRs are under 20%, thus they do not belong to the aged countries group.

There are three panel data analysis methods: Pooled regression, Fixed effect regression and GMM regression methods. Over all, the pooled regression test results have a lower R^2 statistic value compared to the results of the fixed effect regression due to the existence of significant periodical and cross-sectional fixed effects. The values of the R^2 and the Durbin−Watson statistics are still low in the fixed effect analysis, thus, we apply GMM method to increase those values. The main results are summarized in < Table 5–20 >.

The total population group (16 aged OECD countries) has a positive reaction sign in the relationship between the primary surplus and the debt variables. The fixed effect result is significantly positive with 95% confidence; however, the GMM result fails to find any significantly positive value. Both coefficients of the age variable against the primary surplus and that of the age variable against the debt indicate significant positive values in the fixed effect result, but no significant values in the GMM result.

The most interesting fact is that the coefficients' signs are opposite between Group I and Group V. In the relationship between the primary surplus and the debt variable, the fixed effect result is significantly positive in Group I, whereas the GMM result is significantly negative in Group V. Furthermore, Group V has negative signs in the coefficient of the age variable against the primary surplus, but positive signs in the coefficient of the age variable against the debt. The rest of the results are not significant.

< Table 5 – 20 > Summary of Fixed Effect and GMM Panel Data Analysis Results

	Coefficient of the Explanatory Variable		
	16 Countries	**Group I**	**Group V**
Surplus (Dep[1]) vs Debt (Exp[2])	**0.10**** [3] / 0.00 [4]	**0.17**** / 0.01	−0.02 / **−0.01****
Surplus (Dep) vs Age (Exp)	**0.36**** / −0.03	0.13 / −0.01	**−0.22**** / **−0.06***
Debt (Dep) vs Age (Exp)	**4.5**** / −0.1	−2.36 / −0.24	**5.2*** / 0.07

1) Dep : Dependent Variable, 2) Exp : Explanatory Variable, 3) Top of a diagonal : Fixed Effect result, 4) Bottom of a diagonal : GMM result, 5) * ⇒ 90% confidence, ** ⇒ 95% confidence

We conclude from the panel data analysis results that the aging factor burdens countries with the ADR greater than 25% and a fast-aging speed. The countries that have the ADR under 25% should have to prepare for the fiscal difficulty caused by the coming aging process. Followings are further examinations in the panel data analysis.

5.2.2. The Panel Data Analysis Results in Surplus and Debt

There are three analysis methods: pooled regression, fixed effect and GMM method. We apply these three panel data analysis methods together and compare the results. First, the pooled regression test results have a lower R^2 statistic value compared to the results of the fixed effect regression due to the existence of significant periodical and cross-sectional fixed effects. We can test the two way fixed effects by using the F statistic and Chi-square statistic. The test results are summarized in < Table 5−21> and we conclude there are cross-section / period fixed effects in all the groups.

< Table 5 − 21 > The Results of Redundant Fixed Effects Tests

	Effects Tests	Statistic	d.f.	Prob.
16 Countries	Cross-Section / Period F	7.29	(49,430)	0
	Cross-Section / Period Chi-square	291.0	49	0
Group I	Cross-Section / Period F	2.23	(39,153)	0
	Cross-Section / Period Chi-square	87.2	39	0
Group IV	Cross-Section / Period F	7.82	(39,115)	0
	Cross-Section / Period Chi-square	202.0	39	0
Group V	Cross-Section / Period F	2.05	(38,81)	0
	Cross-Section / Period Chi-square	81.4	38	0

< Table 5 – 22 > Panel Data Analysis Results in Surplus and Debt

	Analysis Method (Dependent variable: Primary Surplus)					
	Pooled Regression		**Fixed Effect**		**GMM Method**	
16 Countries	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−0.07 (0.49)	C	−3.60** (0.97)	C	−0.06
					Surplus $_{-1}$	**0.95**** (0.02)
	Debt	**0.03**** (0.01)	Debt	**0.10**** (0.02)	Debt	**0.00** (0.00)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.03	0.15	0.47	0.26	0.85	2.13
Group I	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	0.28 (0.73)	C	−4.12** (1.29)	C	−0.03
					Surplus $_{-1}$	**0.86**** (0.03)
	Debt	**0.06**** (0.02)	Debt	**0.17**** (0.03)	Debt	**0.01** (0.01)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.07	0.16	0.41	0.22	0.84	2.05
Group IV	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−2.36** (1.05)	C	−4.65** (1.68)	C	0.11
					Surplus $_{-1}$	**1.00**** (0.02)
	Debt	**0.05**** (0.01)	Debt	**0.08**** (0.03)	Debt	**−0.00** (0.00)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.06	0.05	0.74	0.13	0.96	2.15
Group V	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	0.19 (0.41)	C	−1.8** (0.8)	C	0.1
					Surplus $_{-1}$	**0.82**** (0.06)
	Debt	**−0.05**** (0.01)	Debt	**−0.02** (0.01)	Debt	**−0.01**** (0.00)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.38	0.28	0.68	0.40	0.98	1.84

1) (#) => Standard Deviations

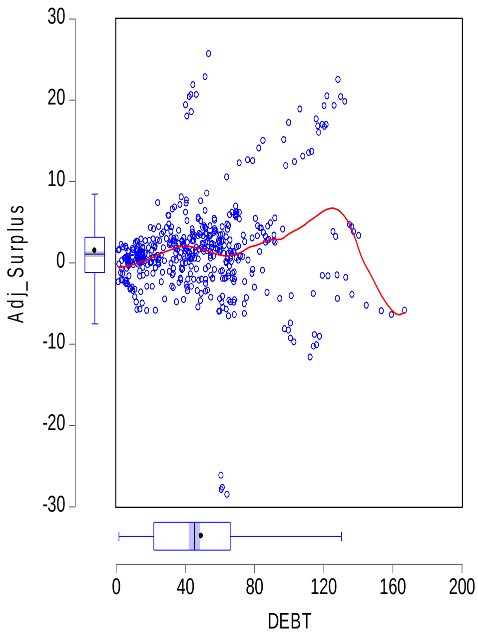
2) * ⇒ 90% confidence, ** ⇒ 95% confidence

< Table 5−22 > shows the panel data analysis results for the relationship between the primary surplus and the debt for four different groups. We already check the fixed effect tests, and now we focus on the results of the fixed effect and GMM methods. The *DW* statistics of the fixed effect regressions indicate that there are strong autocorrelations. Thus, we first include the lagged surplus variable as the explanatory variable and use a GMM estimator for this potential dynamic model due to the lagged dependant variable. As a result, the *DW* statistics for the GMM estimates rise to values near 2 because we have capture the dynamics in the relationship. In addition, the values of the R^2 statistics increase by the GMM methods. However, in Group I and Group V, the signs of the coefficient of the debt variable do not change compared to the results of the fixed effect regressions. Only the sign of Group IV changes from significantly positive to insignificantly negative. As mentioned before, the difference between Group VI and Group V is due to the exclusion of Italy. The control for the debt levels by the Italian government affects the sign of the coefficient of the debt variable in Group IV. Finally, the coefficient of the debt variable in the results of the fixed effect analysis is only negative in Group V. In the GMM methods, that coefficient has significantly negative value at 95% confidence.

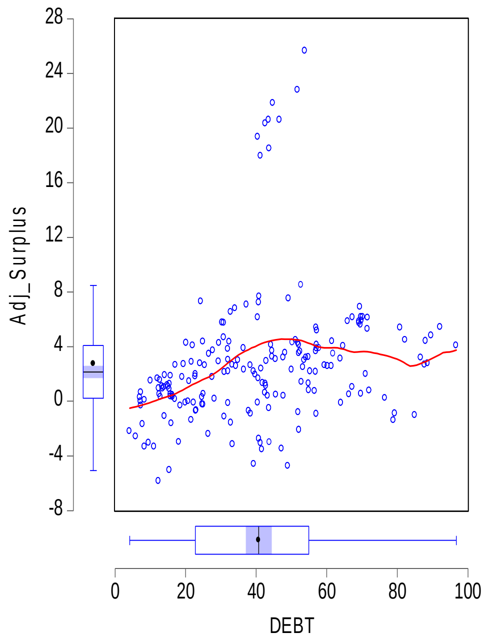
This fact supports the conclusion that the aging leads to worsening fiscal conditions. We illustrate this in < Figure 5−8 >. There are four graphs. We cannot easily find the trend in the group of 16 countries in graph (a). In addition, it is difficult to figure it out in the graph of Group IV, graph (c). However, we can see a steadily increasing trend in the graph of Group I, graph (b), and a clear decreasing trend in the graph of Group V, graph (d). We conclude that the OLS test results for Italy distort the group property of the high-age, fast-aging OECD countries.

< Figure 5 – 8 > Surplus versus Debt Distribution in Fixed Effect Analysis

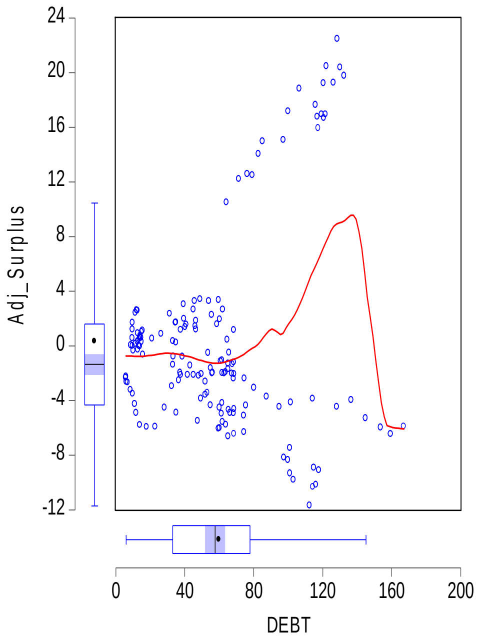
(a) 16 OECD countries



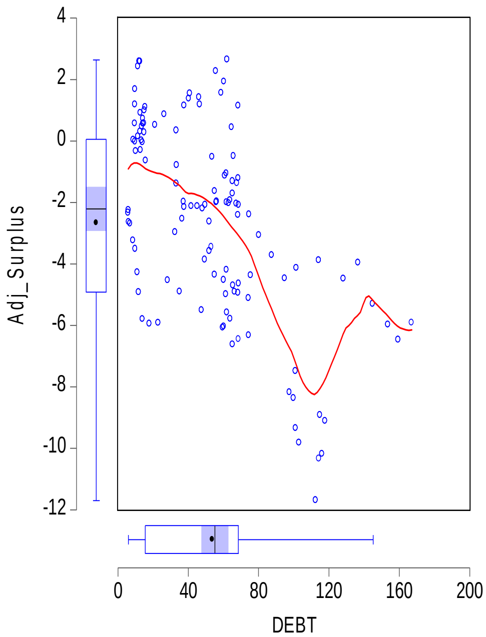
(b) Group I



(c) Group IV



(d) Group V



5.2.3. The Panel Data Analysis Results in Surplus and Age

In this section, we analyze the explanatory power of the aging factor. First, the relationship between adjusted surplus and the age index (ADR) is examined.

As in the previous section, we conduct the fixed effects tests and the results are summarized in < Table 5−23 >. We test the two way fixed effects by using the F statistic and Chi-square statistics. The test results of redundant fixed effects indicate that there are cross-section / period fixed effects in all the groups except Group I. The F test statistic of cross-section / period fixed effects rejects the null hypothesis, which there is no two way fixed effect, only with 90% confidence. However, the chi-square test statistic of cross-section / period rejects the null hypothesis with more than a 95% confidence level. Thus, we conclude that there are cross-section / period fixed effects in Group I.

< Table 5 − 23 > The Results of Redundant Fixed Effects Tests

	Effects Tests	Statistic	d.f.	Prob.
16 Countries	Cross-Section / Period F	6.46	(49,430)	0
	Cross-Section / Period Chi-square	265.4	49	0
Group I	Cross-Section / Period F	1.35	(39,153)	0.10
	Cross-Section / Period Chi-square	57.4	39	0.03
Group IV	Cross-Section / Period F	7.61	(39,115)	0
	Cross-Section / Period Chi-square	199.0	39	0
Group V	Cross-Section / Period F	3.87	(38,81)	0
	Cross-Section / Period Chi-square	125.2	38	0

< Table 5 – 24 > Panel Data Analysis Results in Surplus and Age

	Analysis Method (Dependent variable: Primary Surplus)					
	Pooled Regression		**Fixed Effect**		**GMM Method**	
16 Countries	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−1.81 (2.01)	C	−6.36** (3.1)	C	0.83
					Surplus $_{-1}$	**0.95**** (0.02)
	Age	**0.15** (0.09)	Age	**0.36**** (0.14)	Age	**−0.03** (0.04)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.01	0.15	0.43	0.24	0.85	2.14
Group I	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−0.39 (3.81)	C	−0.16 (9.27)	C	0.55
					Surplus $_{-1}$	**0.87**** (0.03)
	Age	**0.14** (0.17)	Age	**0.13** (0.42)	Age	**−0.01** (0.09)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.00	0.15	0.26	0.19	0.83	2.09
Group IV	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−4.57 (3.35)	C	−2.77 (3.22)	C	0.93
					Surplus $_{-1}$	**1.0**** (0.02)
	Age	**0.23** (0.15)	Age	**0.15** (0.15)	Age	**−0.04** (0.03)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.01	0.04	0.72	0.12	0.96	2.17
Group V	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	3.86** (1.55)	C	1.99 (2.5)	C	0.98
					Surplus $_{-1}$	**0.88**** (0.05)
	Age	**−0.31**** (0.07)	Age	**−0.22*** (0.12)	Age	**−0.06*** (0.04)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.13	0.19	0.69	0.41	0.83	2.07

1) (#) => Standard Deviations

2) * ⇒ 90% confidence, ** ⇒ 95% confidence

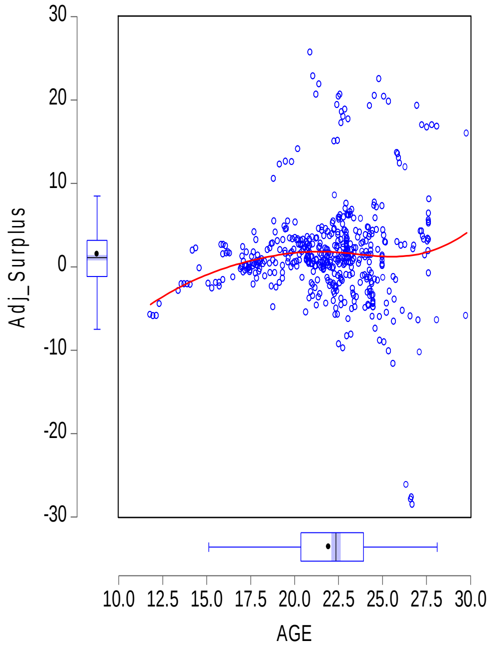
< Table 5−24 > shows the panel analysis results. As in the previous study mentioned above, we use three different panel analysis methods: pooled regression, fixed effect and GMM method.

According to the R^2 values in the panel OLS tests, the variables fail to have significant explanatory power due to the existence of the fixed effects. In the results of the fixed effect analysis, the R^2 values are comparably higher in Group IV and Group V. The most important finding is that the sign of the coefficient of the age variable is negative only in Group V with a 90% confidence level. This is mainly because Italy directly controls the government surplus for a while without reflecting the burden stemmed from the high-speed aging process. After controlling for the autocorrelation problem by including the lagged variable and using the GMM method, we can get higher values of the R^2 and the *DW* statistics. However, the coefficient signs for the age variable of Group I and Group IV change from positive to negative, and the negative magnitude of this variable falls in Group V, compared to the results of the other tests. Due to the low significance level of that coefficient for Group I, we can still argue that the high-level, high-speed aging countries have decreasing surplus as the aging level increases.

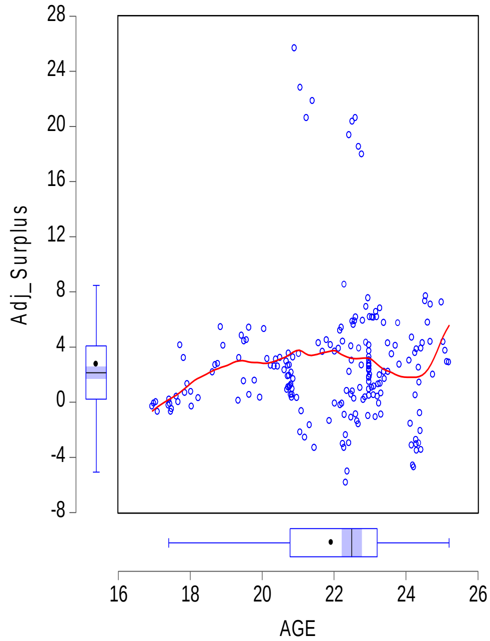
We can easily show the differences between the slopes of the aging variable and adjusted primary surplus in < Figure 5−9 >. Throughout the whole age period, the slope is mildly positive with a positive trend as shown in graph (b). However, the trend is mixed for Group IV as shown in graph (c). After excluding Italy, the trend changes to strongly negative as shown in graph (d). This means that the positive part in graph (c) is, in part, a result of including Italy

< Figure 5 – 9 > Surplus versus Age Distribution in Fixed Effect Analysis

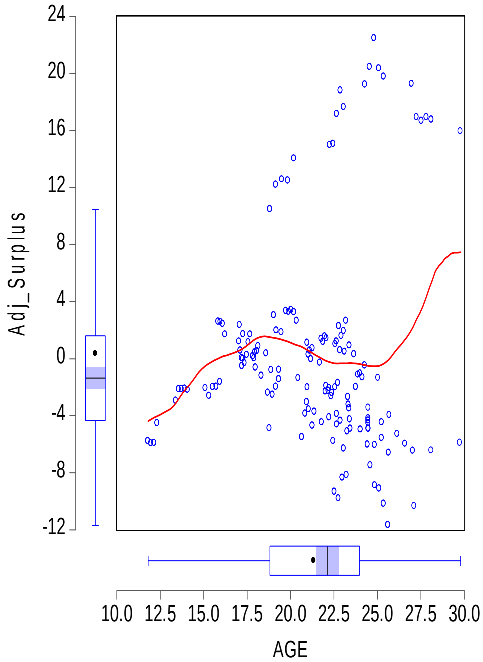
(a) 16 OECD countries



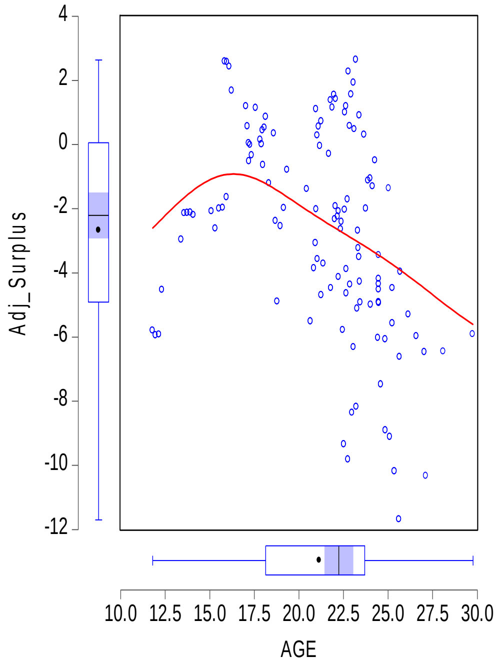
(b) Group I



(c) Group IV



(d) Group V



5.2.4. The Panel Data Analysis Results in Debt and Age

In this section, we analyze the relationship between debt and the age index (ADR). By the fixed effects tests in < Table 5−25 >, we know there are two way fixed effects. Thus, the pooled regression test results have low explanatory power compared to the fixed effect analysis.

< Table 5−26 > also shows the same style of panel analysis results as the previous study. According to the fixed effect results, the R^2 values are quite high, especially in Groups IV and V. The most interesting finding is the sign of the age variable in each group. It is positive in Groups IV and V, whereas the trend is negative in Group I. This finding means that the countries with slow-aging speed have enough energy to control the accumulating debt levels and the countries with fast-aging speed can only issue government bonds in order to counteract the burden stemming from the aging process. However, the coefficient's signs change from positive to negative in both Group IV and Group V due to the coefficient of the lagged debt variable, which is bigger than one. In terms of debt, the high-level, high-speed aging countries have a divergent debt trend, whereas debt can be controlled in the low-level, slow-aging countries.

< Table 5 − 25 > The Results of Redundant Fixed Effects Tests

	Effects Tests	Statistic	d.f.	Prob.
16 Countries	Cross-Section / Period F	51.1	(49,430)	0
	Cross-Section / Period Chi-square	923.9	49	0
Group I	Cross-Section / Period F	10.9	(39,153)	0
	Cross-Section / Period Chi-square	257.9	39	0
Group IV	Cross-Section / Period F	37.0	(39,115)	0
	Cross-Section / Period Chi-square	406.6	39	0
Group V	Cross-Section / Period F	30.1	(38,81)	0
	Cross-Section / Period Chi-square	328.8	38	0

< Table 5 – 26 > Panel Data Analysis Results in Debt and Age

	Analysis Method (Dependent variable: Debt)					
	Pooled Regression		**Fixed Effect**		**GMM Method**	
16 Countries	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−55.1** (9.9)	C	−49.4** (8.8)	C	4.29**
					$Debt_{-1}$	**0.99**** (0.01)
	Aget	**4.76**** (0.45)	Age	**4.5**** (0.4)	Age	**−0.10** (0.10)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.19	0.04	0.88	0.12	0.97	1.60
Group I	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	42.5** (16.9)	C	92.4** (32.3)	C	8.8*
					$Debt_{-1}$	**0.94**** (0.02)
	Age	**−0.08** (0.91)	Age	**−2.36** (1.5)	Age	**−0.24** (0.22)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.00	0.07	0.74	0.15	0.93	1.89
Group IV	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−73.0** (14.2)	C	−53.9** (12.0)	C	4.2
					$Debt_{-1}$	**1.01**** (0.02)
	Age	**6.23**** (0.7)	Age	**5.34**** (0.56)	Age	**−0.13** (0.18)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.37	0.03	0.95	0.14	0.98	1.70
Group V	Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
	Constant	−57.1** (16.2)	C	−56.1** (12.4)	C	0.24
					$Debt_{-1}$	**1.01**** (0.02)
	Age	**5.24**** (0.75)	Age	**5.2**** (0.6)	Age	**0.07** (0.13)
	R^2	*DW*	R^2	*DW*	R^2	*DW*
	0.29	0.03	0.95	0.16	0.98	1.84

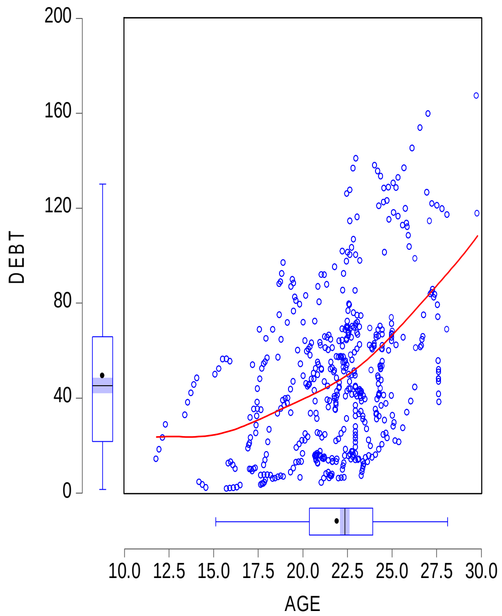
1) (#) => Standard Deviations

2) * ⇒ 90% confidence, ** ⇒ 95% confidence

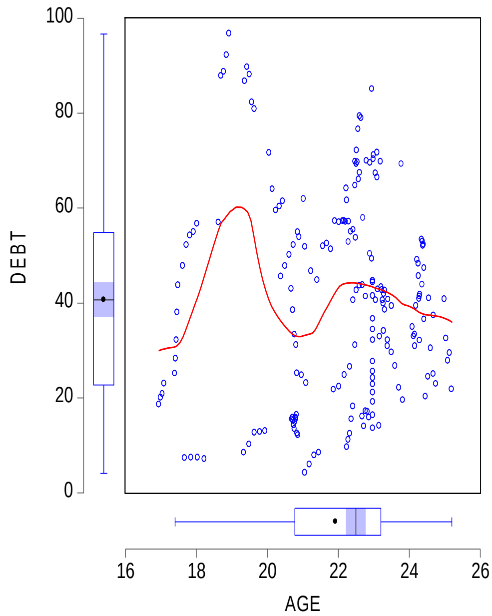
< Figure 5−10 > shows the results of the fixed-effect panel data analysis. The graphs (a), (c) and (d) show a positive relationship between debt and age index (ADR), whereas graph (b) shows a negative slope between these two variables.

< Figure 5 – 10 > Debt versus Age Distribution in Fixed Effect Analysis

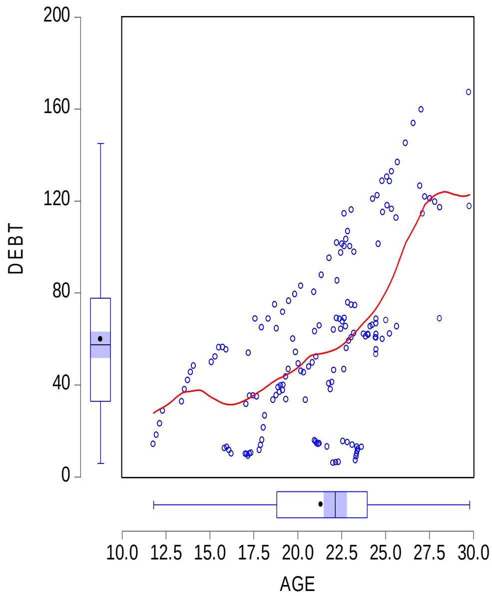
(a) 16 OECD countries



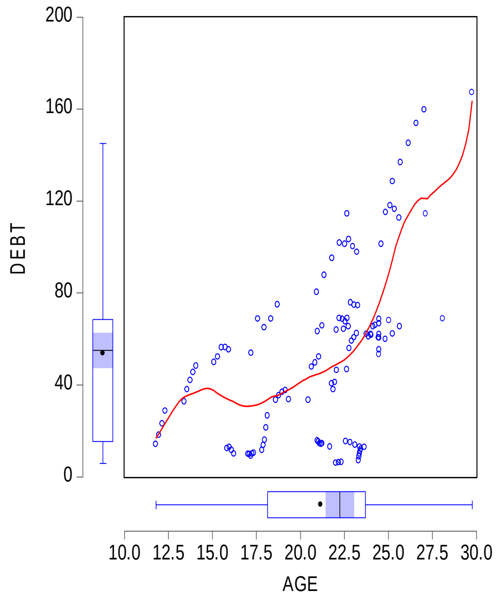
(b) Group I



(c) Group IV



(d) Group V



Chapter VI.

Future Debt Dynamics

We estimate the relationship between the debt variable and different aging levels in Chapter V. We can estimate the future fiscal conditions for the U.S. and Korea that have the ADRs under 20% in 2005 by using this information. However, that information only has explanatory power under 27~28% in the ADR. Thus, we apply the debt dynamic equation to estimate future values for the main OECD countries.

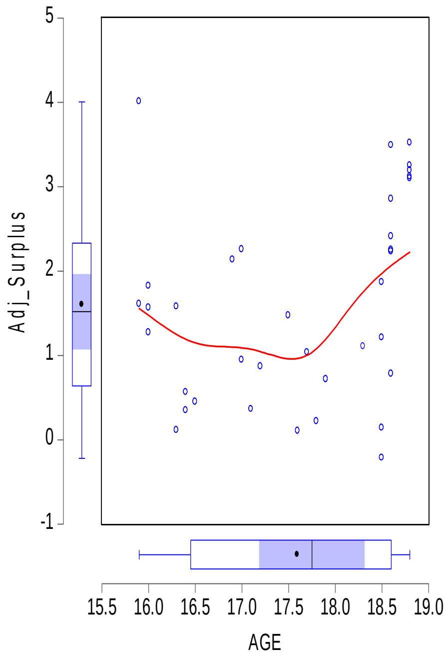
6.1. Expecting Futures with Panel data Analysis Results

We try to apply the prior findings in order to draw some conclusion as to the fiscal sustainability of the U.S. and Korea. First, we have to define the reference groups. The U.S. has an increase in the ADR of 2.1% during last 30 years, an average increase of 0.16% per year. The U.S. is expected to have an ADR of 21.7% in 2015, an average increase of 0.3% per year, and 27.8% in 2025, or an average increase of 0.55% per year. Thus, considering that Group I has an ADR value lower than 24% and the average aging speed lower than 0.3% per year, the reference group for the U.S. should be a mixture of Group I and Group V. During the next decade, the U.S. has a high probability of following the experience of Group I, and after the next decade, it is expected to follow the experience of Group V.

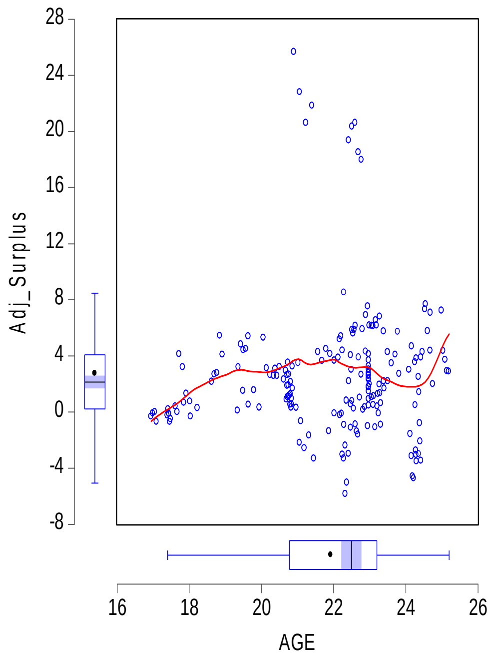
< Figure 6−1 > shows the trends for the U.S. and Group I. The U.S.'s adjusted surplus has a similar pattern compared to the corresponding aging levels of Group I. However, the debt levels are slightly higher than the trend of Group I.

< Figure 6 – 1 > Comparison the U.S. with Group I

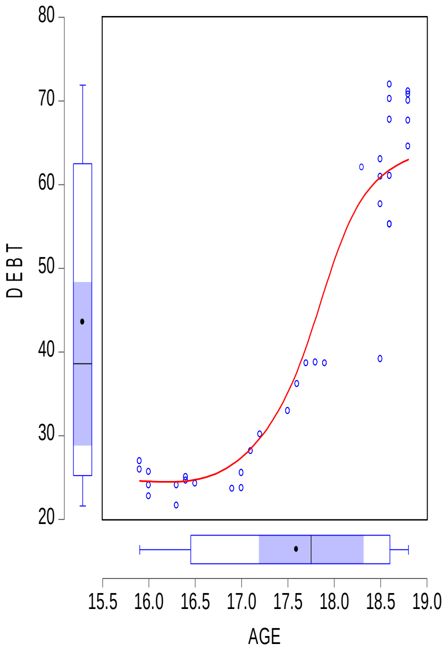
(a) Surplus vs. Age in the U.S.



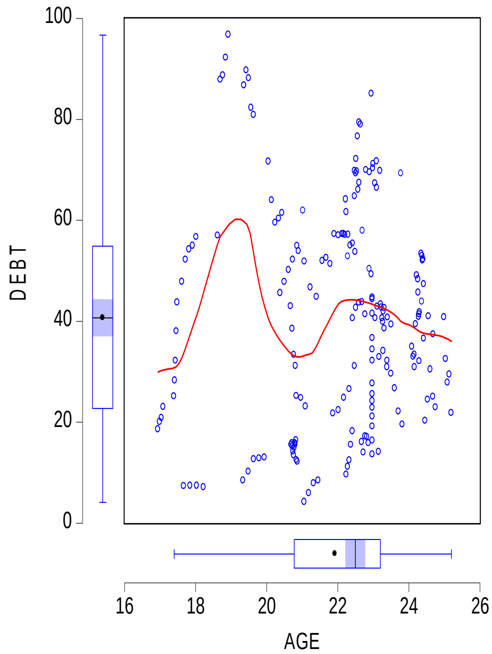
(b) Group I



(c) Debt vs. Age in the U.S.



(d) Group I



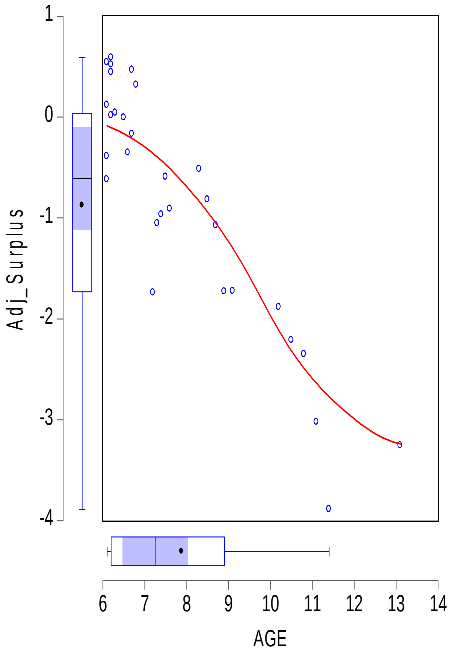
If one takes the scale of the U.S.'s GDP into account, we may conclude that the debt level should be controlled by maintaining fiscal sustainability, without considering the effect of the Iraq war, recent sub-prime mortgage problems, and other issues. Thus, we conclude that if the U.S. succeeds in maintaining stable debt-GDP ratio levels, the U.S. will be in a better position to prepare against the financial difficulty when aging speed and aging levels go higher after 2115.

Korea has an increase in the ADR of 7.0% during the last 30 years, or an average increase of 0.23% per year. However, Korea is expected to have an ADR of 18.8% in 2015, a 0.51% per year increase, and an ADR of 29.1% in 2025, a 0.94% yearly average increase. In terms of the aging speed, the aged countries, which experienced high-speed aging during 1995~2005, have average increasing rates per year such as 0.8%, 0.5% and 0.49%, respectively, for Japan, Germany and Italy. Considering this fact, the aging speed is remarkably fast in Korea. Thus, the reference group for Korea should be Group V. The reason Italy is excluded is that Italy fails to reflect the recent aging effects on the fiscal variables.

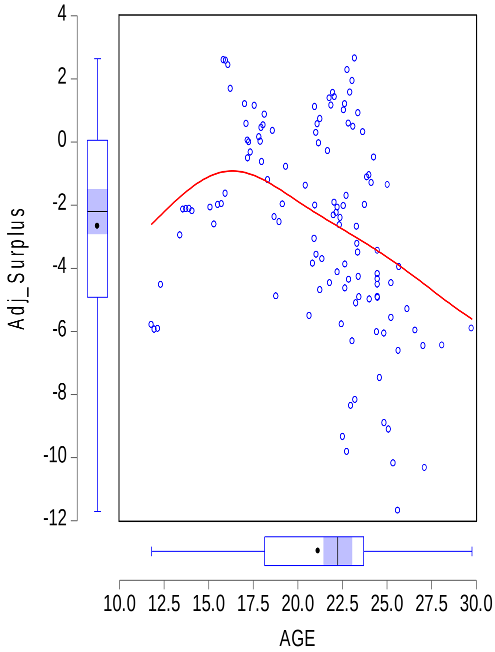
According to < Figure 6−2 >, Korea may face fiscal difficulty in one to two decades. Considering that the adjusted surplus ratio on the age domain has a positive relationship before the 15% level of the ADR and turns negative after 15%, the negative trend starts earlier than the corresponding aging levels of the reference group. Even though the absolute debt levels are still lower than other OECD countries, the debt accumulation speed is very steep compared to the speed of the reference group. Thus, we conclude that in the next 20 years, Korea has a high probability of incurring financial difficulties, which the high-speeded age countries have been faced with during the last one or two decades.

< Figure 6 – 2 > Comparison Korea with Group V

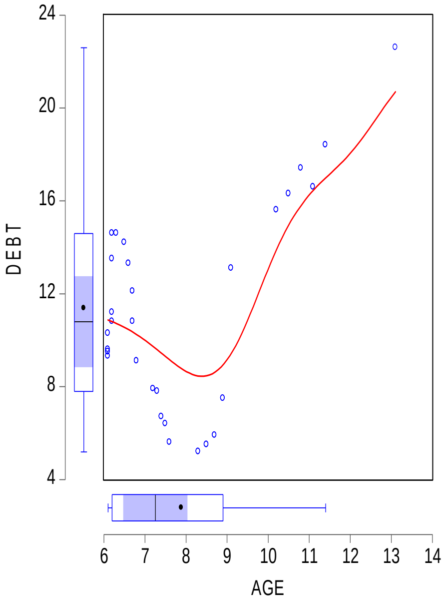
(a) Surplus vs. Age in Korea



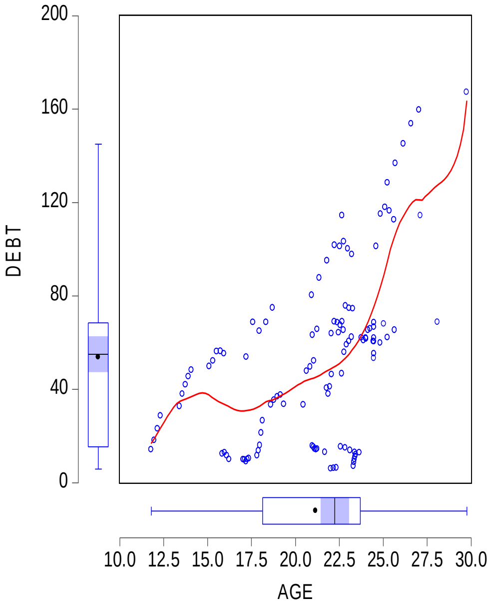
(b) Group V



(c) Debt vs. Age in Korea



(d) Group V



6.2. Estimating Future Debt Levels using Dynamic Equation

6.2.1. Estimating Future Debt Levels by Deterministic Method

As was said in section 3.2.3, this paper uses two methods to estimate debt dynamics: a deterministic method and a stochastic simulation method. In this section, we check the deterministic method by using the debt dynamic model from section 3.1.4. As in equation (19), if we know about the fiscal balance, GDP growth rate and the initial debt−GDP ratio, then we can estimate the debt dynamics. We have the information about these two variables from the Global Insight database and debt−GDP ratios of 2008, 2009 from the OECD database. It is only left to assume the stock−flow adjustment term, and there are many ways to assume this variable. We apply the following way.

As show in < Table 3−1 >, the main OECD countries have the trend of stock−flow adjustment variable. Among the main countries, the U.S. and Korea do not belong to the aged country group for which the ADR is over 20% in 2005. The mean of the remaining five main countries' 10−year average of stock−flow adjustments is 7.7%. Let us call this the aged effect in the adjustment term. Now, we assume the future value of this variable for each country as the mean of the aged effect and the 10−year average of the stock-flow adjustment of its own country. For example, Japan's 10−year average of the stock-flow adjustment is 15.6%, and thus the future assumed value for this term in Japan is (15.6% + 7.7%) / 2 = 11.7%, which is the highest one among the main countries. The Korea's 10−year average is −0.4%, and thus the future assumed value for Korea is (−0.4% + 7.7%) / 2 = 3.7%, which is the lowest one. We consider the future estimated values to be equal from 2010 to 2035.

The results from this deterministic method for the future debt levels are shown in < Table 6−1 >. This table also contains the aging information of each country that is supported by the UN database. The debt−GDP ratio in 2005 for each country is a real historical value, and the other ratios are estimated. For example, the Japanese debt−GDP ratio in 2005 is 167.1% and is a real historical number. Those in 2020 and 2035 are expected to be 237.7% and 319.9%, respectively. For Korea in 2005, it was 22.6%, while those in 2025 and 2035 are estimated as 48.5% and 60.1%, respectively.

< Table 6 − 1 > Expectation for Debt-GDP Ratio

(unit : %)

Country	Debt−GDP Ratio				
	< ADR: ~ 25%	25 ~ 30%	30 ~ 40%	40 ~ 50%	Over 50% >
Japan		('05) **167.1** < **ADR 29.9** >	('10) 179.6 < ADR 35.1 >	('20) 237.7 < ADR 47.3 >	('35) **319.9** < **ADR 58.5** >
Italy		('05) **117.5** < **ADR 29.9** >	('15) 155.8 < ADR 33.9 >	('25) 175.4 < ADR 40.4 >	('35) **195.9** < **ADR 51.0** >
Germany		('05) **68.7** < **ADR 28.1** >	('20) 111.2 < ADR 34.6 >	('35) **154.4** < **ADR 49.7** >	
France	('05) **73.6** < **ADR 25.0** >	('15) 119.5 < ADR 28.8 >	('25) 142.3 < ADR 35.3 >	('35) **152.0** < **ADR 40.8** >	
The UK	('05) **43.8** < **ADR 24.4** >	('15) 77.8 < ADR 27.4 >	('35) **110.1** < **ADR 37.3** >		
US	('05) **62.0** < **ADR 18.3** >	('25) 112.9 < **ADR 27.8** >	('35) **133.1** < **ADR 32.0** >		
Korea	('05) **22.6** < **ADR 13.1** >	('25) 48.5 < **ADR 29.1** >	('30) 54.2 < ADR 36.2 >	('35) **60.1** < **ADR 44.0** >	

Comparing the debt−GDP ratio in 2035 to 2005 values, in many countries this ratio doubles in value. The Japanese debt−GDP ratio is expected to increase from 167.1% in 2005 to 319.9%, and that of Italy is expected to change from 117.5% to 195.9%. While these countries' debt−GDP ratios are not expected to increase by twice as much as the level of 2005, both of their ratios are extremely high. Before reaching those debt levels, both governments will have to fix their fiscal problems. However, considering their aging processes, there are not many options to decrease the debt levels because the government's income will be restricted whereas government mandatory expenditure will increase rapidly. These countries are expected to have the ADRs over 50% in 2035, which means two people have to support one old person. One example to fix the problem is to extend the retirement age in the near future.

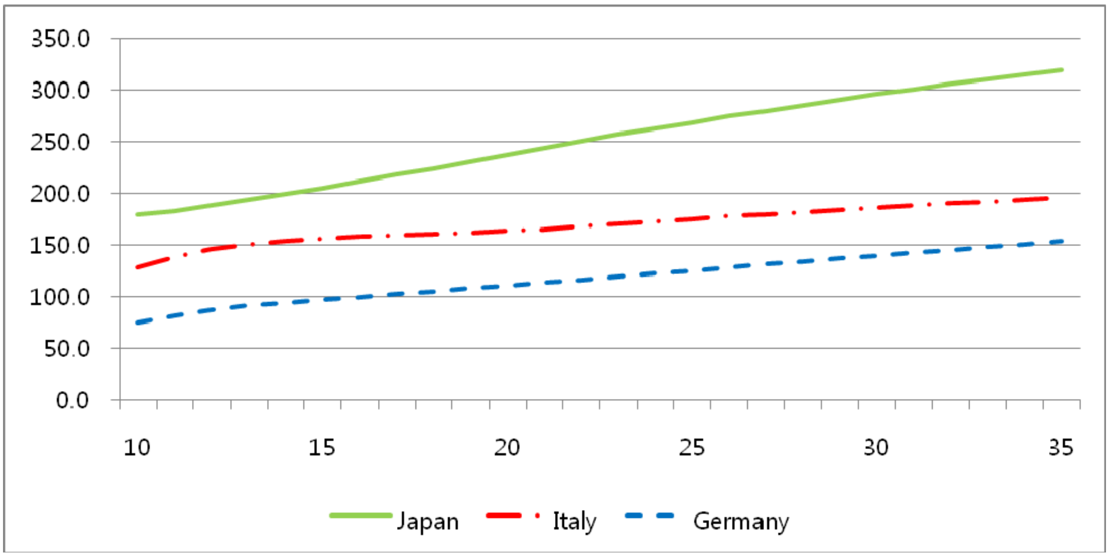
In terms of the expected aging levels in 2035, Germany, France and Korea will pass over 40% ADR. Germany is expected to reach almost 50% ADR, while France will just pass the 40% ADR line. Relating to the debt−GDP ratio, both countries are expected to pass over 150% in 2035, which are more than twice values of 2005.

One interesting expectation is related to the aging speed of Korea. Within 30 years, the Korean ADR is expected to increase from 13.1% to 44.0%, and the aging speed is accelerating during 2025~2035. The Korean ADR is estimated to surge by 14.9% in just 10 years, almost 1.5% per year. Considering that the annual aging speed of a fast−aging country is 0.3% per year in the panel data analyses, we can guess the speed. In the point of extreme aging speed, the expectation for the Korean debt−GDP ratio in 2035 seems to be underestimated even though its starting level of 2005 is only 22.6%.

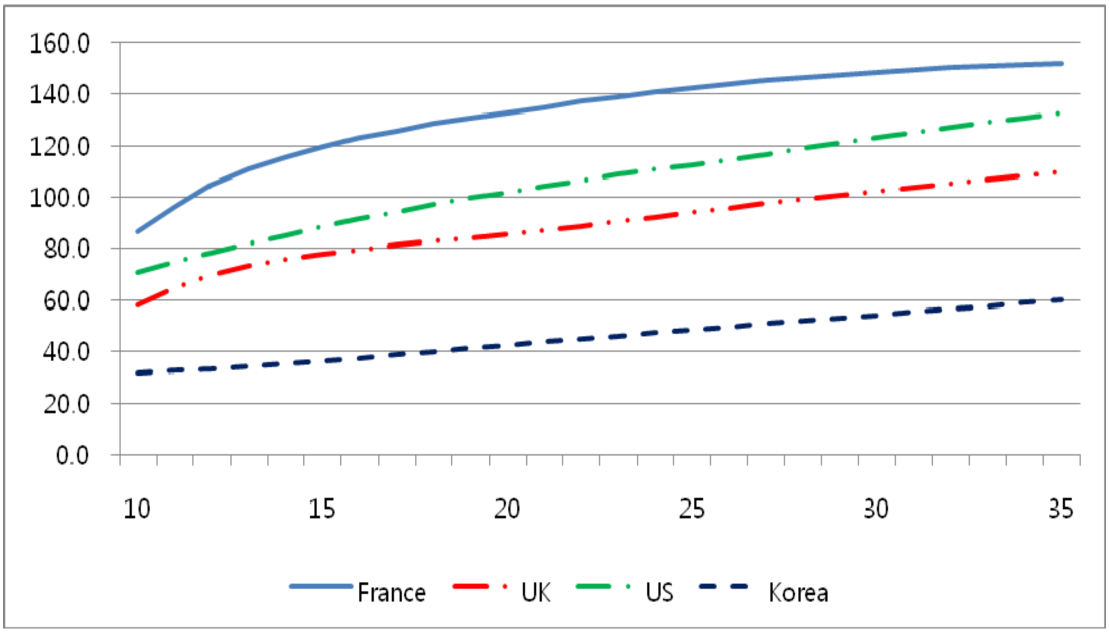
The UK and the U.S. are expected to stay at the ADR 37.3% and 32.0% in 2035, respectively, and have the debt−GDP ratios over 110%, which are more than twice as much as 2005 level. The trend of the estimated debt−GDP ratio values for the main OECD countries are shown in < Figure 6–3 >.

< Figure 6 – 3 > Estimated Values of Debt−GDP Ratio

(a) Japan, Italy, Germany



(b) France, The UK, The U.S., Korea



6.2.2. Estimating Future Debt Levels by Stochastic Method

Now we examine the stochastic simulation method in two debt-estimating methods. As seen in the previous section, the deterministic method has some weak points: it is difficult to represent future values, assuming the stock−flow adjustment term remains uniform for the entire estimating period is unrealistic, and there may be other determinant variables that have explanatory power for the future debt levels. The stochastic simulation method is used to adjust for these drawbacks. As summarized in section 3.2.3, the process of this method is: (i) estimate the best model to explain the trend of d_t using the debt dynamics of equation (19), (ii) assume the residuals follow the normal distribution, (iii) simulate random variability with 500 draws of the error term, and (iv) forecast the probabilistic debt levels with the 95% confidence.

The main differences between the deterministic method and the stochastic simulation method are: the application of equation (19), debt dynamics, and the assumptions about the error term. The former uses equation (19) directly to forecast the future debt levels assuming the stock−flow adjustment term as a weighted average for each country. The latter uses the determinant variables in equation (19) to regress the historical debt levels and find the feasible regression model for each country. The stock−flow adjustment term is divided by two in the stochastic simulation method: a constant term and an error term. After finding the OLS regression model, we then generate 500 possible errors for each year, form distributions of the values of dependent variable, and find the prediction intervals with a certain confidence level. Thus, the estimated debt levels are shown in a kind of a band shape for each country such as in < Figure 6−4 > of Japan.

In order to compare with the results to the deterministic method, the expected mean values for the debt–GDP ratio from the stochastic simulation method are summarized in < Table 6–2 >. Over all, the estimated debt–GDP values for France are similar using both methods. The stochastic method predicts higher debt–GDP ratios in 2035 for Japan, Germany and Korea, whereas the deterministic method estimates higher debt–GDP ratios in 2035 for Italy, the UK and the U.S.

< Table 6 – 2 > Expected Mean Value for Debt-GDP Ratio

(unit : %)

Country	Debt–GDP Ratio				
	< ADR: ~ 25%	25 ~ 30%	30 ~ 40%	40 ~ 50%	Over 50% >
Japan		('05) **167.1** < ADR 29.9 >	('10) 192.2 < ADR 35.1 >	('20) 279.9 < ADR 47.3 >	('35) **405.1** < ADR 58.5 >
Italy		('05) **117.5** < ADR 29.9 >	('15) 132.1 < ADR 33.9 >	('25) 147.4 < ADR 40.4 >	('35) **161.4** < ADR 51.0 >
Germany		('05) **68.7** < ADR 28.1 >	('20) 105.2 < ADR 34.6 >	('35) **179.3** < ADR 49.7 >	
France	('05) **73.6** < ADR 25.0 >	('15) 87.3 < ADR 28.8 >	('25) 123.2 < ADR 35.3 >	('35) **159.3** < ADR 40.8 >	
The UK	('05) **43.8** < ADR 24.4 >	('15) 56.9 < ADR 27.4 >	('35) **95.3** < ADR 37.3 >		
The US	('05) **62.0** < ADR 18.3 >	('25) 83.1 < ADR 27.8 >	('35) **107.9** < ADR 32.0 >		
Korea	('05) **22.6** < ADR 13.1 >	('25) 68.7 < ADR 29.1 >	('30) 81.2 < ADR 36.2 >	('35) **94.4** < ADR 44.0 >	

Japan

The first step in the stochastic simulation method is to estimate the OLS regression model in which the dependent variable is the debt−GDP ratio. The OLS regression results for Japan using the historical data from 1990~2005 is summarized in < Table 6−3 >. The explanatory variables are the previous period's debt−GDP ratio multiplied by $\frac{1}{(1+n_t)}$, where n_t is the GDP growth rate, the fiscal balance, and the trend term. A kind of fixed effect from the stock−flow adjustment term in equation (19) is included in the constant. In Japan, every explanatory variable except the fiscal balance has a significant value at 95% confidence levels. The high values in the constant and the coefficient of the trend term make the estimated results of the stochastic method greater than that of the deterministic method. These may imply that there are other omitted variables which increase government debt levels.

< Table 6 − 3 > The OLS Regression Results for Debt−GDP Ratio in Japan

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	19.43**	3.83	0.00
$debt_{-1}$[1)]	0.56**	0.09	0.00
Fiscal balance	−0.27	0.26	0.32
Trend	3.88**	0.67	0.00
R^2 :	0.997	*DW* :	2.317

1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

2) * : 90% confidence level, ** : 95% confidence level.

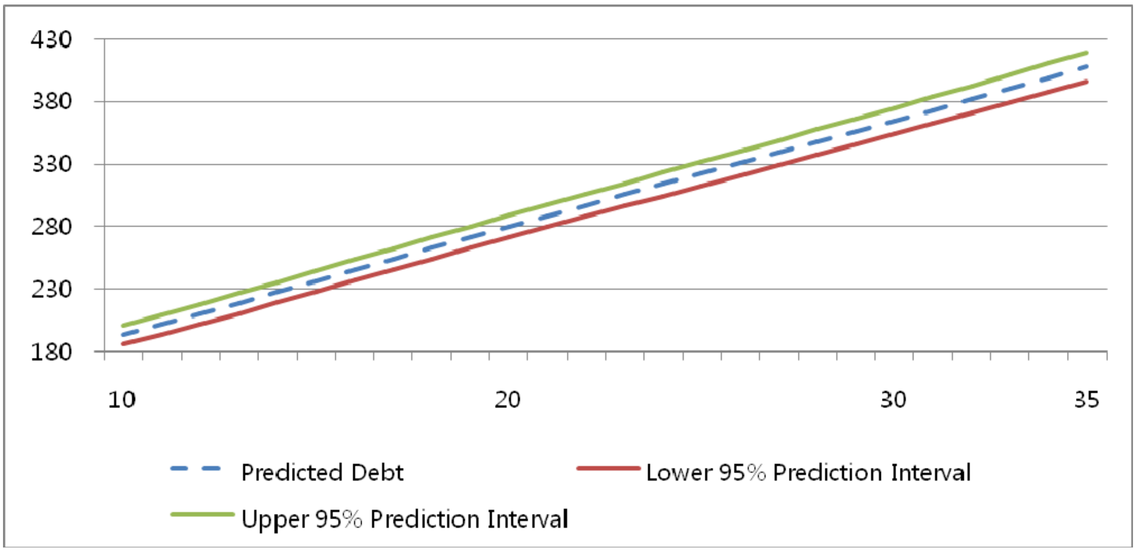
The results of estimating future debt−GDP ratios for Japan by the stochastic simulation method are shown in < Figure 6−4 >. With a 95% confidence level, the predicted debt−GDP ratio in 2035 is expected to be between 396.1% and 419.5%, with the mean of the predicted values, 405.1%, which is much higher than 319.9%, the result from the deterministic method.

If we try to find a similar estimated value between both estimating methods, we have to change the assumed value for the stock−flow adjustment term from 11.7% to 15.6%. The former assumed value, 11.7%, is the weighted average between 7.7% (the average of five high age countries' 10−year stock−flow adjustment values) and 15.6% (the Japanese 10−year average in this adjustment term). This means that the deterministic method using weighted average in the assumption for the stock−flow adjustment term may fail to reflect the debt trend in Japan because that assumption is lower. The reason to use the weighted average is to apply the aged effect using the properties in the adjustment term of other aged countries. Considering that Japan is the highest aged country with the fastest aging speed in the world, there is no other country to give information about the aged effect in Japan. Thus, it is reasonable to use the Japanese 10−year average in the adjustment term as the assumed value for estimating. If we use this assumption, we conclude that the debt−GDP ratio has a high probability to surge up to around 400% under the current fiscal policy and economic circumstance in Japan.

< Figure 6−4 > also shows the graph of expected values of debt−GDP ratio. The dotted line represents the mean value of the predicted debt−GDP ratios, and the straight lines represent the upper or lower bound of the predicted intervals with a 95% confidence.

< Figure 6 − 4 > Expected Values of Debt−GDP Ratio for Japan

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (29.9)	162.4	167.1	173.5
2010 (35.1)	185.4	192.2	201.1
2020 (47.3)	271.1	279.9	288.7
2035 (58.5)	396.1	405.1	419.5



Italy

The OLS regression results for the debt trend for Italy are shown in < Table 6−4 >. Compared to other countries' results, Italy has a positive coefficient in the fiscal balance term. The plus sign is not reasonable because the budget surplus can reduce the debt levels. However, this coefficient is not significant at 90% confidence, similar to the Japanese case. The interesting fact is that the value of the coefficient in the trend term. It is significant under 90% confidence and its value is the lowest among the main seven countries. The R^2 statistic is a little bit lower than that of

Japan, which leads to the bigger band width between the upper and lower predicted intervals.

The stochastic estimating results are summarized in < Figure 6−5 >. With a 95% confidence level, the predicted debt−GDP ratio in 2035 is expected to be between 146.3% and 176.6%, and the mean of the predicted values is 161.4%, which is much lower than 195.9%, the result from the deterministic method.

As in the process of explaining the results for Japan, if we try to derive a similar estimated value between both estimating methods, we have to change the assumed value for the stock−flow adjustment term from 7.9% to 6.0%. The assumed value, 7.9%, is the weighted average between 7.7% (the average of five high age countries' 10−year stock−flow adjustment values) and 8.0% (Italian 10−year average in this adjustment term). Italy is the highest age country in terms of the ADR level in 2005, with the ADR of 29.9%, the same as that of Japan. Thus, the stock−flow adjustment term should contain the properties of the other aged countries.

< Table 6 − 4 > The OLS Regression Results for Debt−GDP Ratio in Italy

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	44.91**	19.3	0.045
$debt_{-1}$	0.68**	0.15	0.001
Fiscal balance	0.71	0.53	0.21
Trend	0.44*	0.21	0.06
R^2 :	0.977	DW :	1.675

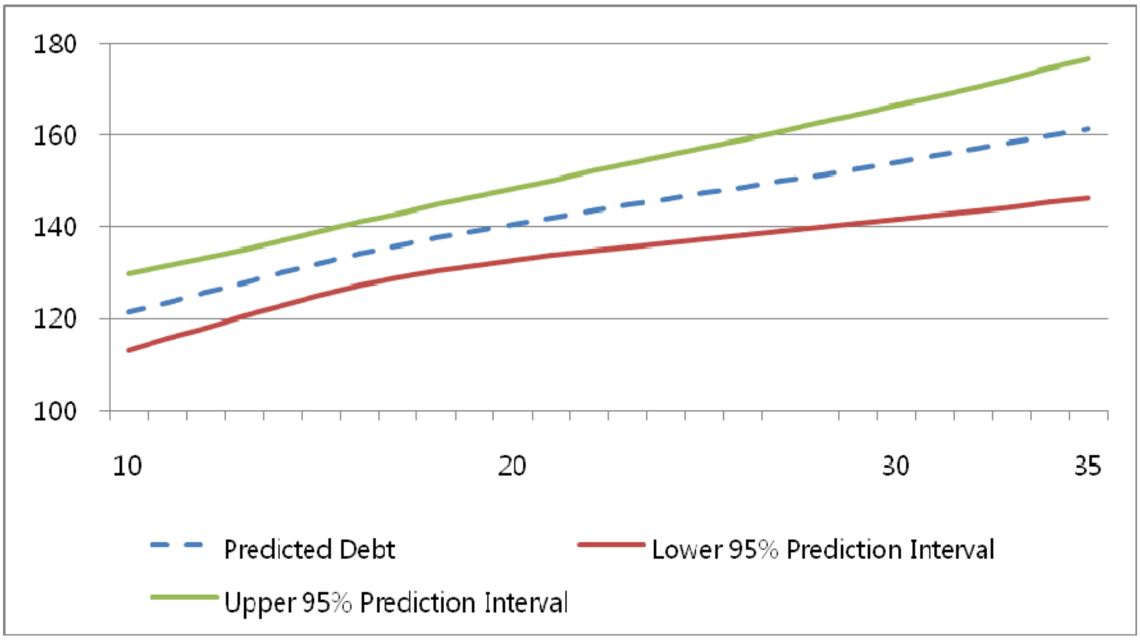
1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

2) * : 90% confidence level, ** : 95% confidence level.

The reason that the estimated debt levels are lower using the stochastic method may be due to artificial restrictions on debt levels by the Italian government. This also means that the Italy's recent fiscal data may fail to reflect the aged effect. We can support this reasoning by calculating the average stock−flow adjustment value during 1999~2003. This average is only 4.3%, whereas the 10−year average for Italy is 8.0%, and this fact supports the argument that the Italian government restricted its debt levels for a while, thus it is reasonable to exclude Italy when examining the aged effect in the panel data analysis.

< Figure 6 − 5 > Expected Values of Debt−GDP Ratio for Italy

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (29.9)	114.5	117.5	121.9
2015 (33.9)	125.1	132.1	139.0
2025 (40.4)	137.4	147.4	157.3
2035 (51.0)	146.3	161.4	176.6



< Figure 6−5 > shows the graph of expected values of debt−GDP ratio. Comparing this to the graph of Japan, the distance between the upper and lower bound of the predicted intervals is bigger than that of Japan.

Germany

The OLS regression results of the debt trend for Germany are shown in < Table 6−5 >. The coefficients of the main variables have significant values with a 95% confidence level. The coefficient of the fiscal balance is significantly negative; however, the absolute value exceeds one. Government debt may increase more than the increase of budget deficit. The coefficient's value of the trend term is the second highest among the seven main countries, following Japan. The R^2 statistic is 0.93 and is much lower than that of Japan and Italy. This property makes the band width between the upper and lower predicted intervals in 2035 reach around 80%.

< Table 6 – 5 > The OLS Regression Results for Debt−GDP Ratio in Germany

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	4.26	9.89	0.678
debt$_{-1}$	0.77**	0.19	0.004
Fiscal balance	−1.49**	0.64	0.048
Trend	1.25**	0.49	0.035
R^2 :	0.93	*DW* :	2.285

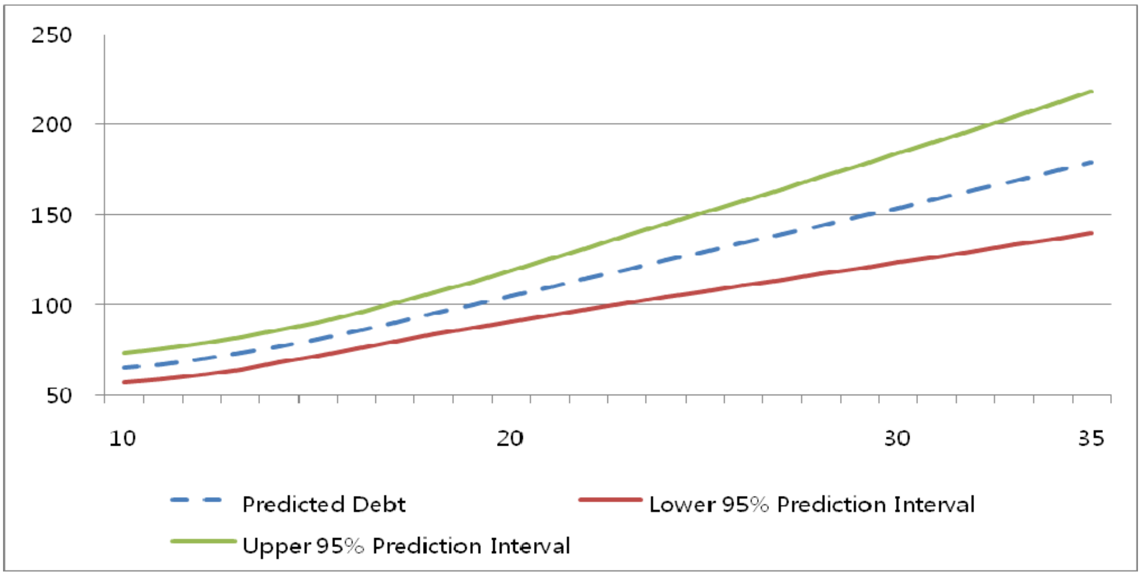
1) debt$_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

2) * : 90% confidence level, ** : 95% confidence level.

The stochastic estimating results are summarized in < Figure 6−6 >. With a 95% confidence level, the predicted debt−GDP ratio in 2035 is expected to be between 139.9% and 218.7%, and the mean of the predicted values is 179.3%, which is much lower than 154.4%, results from the deterministic method. The predicted intervals contain the deterministic estimated value. However, if we try to make a similar estimated value between the predicted mean value in the stochastic method and the deterministic estimate, we have to change the assumed value for the stock−flow adjustment term from 6.5% to 7.7%. Considering that the 10−year average of this value is 5.3% and the average of the main aged countries is 7.7%, it is proper to weight the aged effect more when estimating Germany debt levels.

< Figure 6 − 6 > Expected Values of Debt−GDP Ratio for Germany

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (28.1)	63.1	68.7	73.3
2020 (34.6)	91.1	105.2	119.3
2035 (49.7)	139.9	179.3	218.7



< Table 6 − 6 > The OLS Regression Results for Debt−GDP Ratio in France

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	9.83	12.4	0.459
$debt_{-1}$	0.78^{**}	0.19	0.007
Fiscal balance	−0.65	0.63	0.342
Trend	0.84	0.24	0.012
R^2 :	0.93	*DW* :	2.031

1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

2) * : 90% confidence level, ** : 95% confidence level.

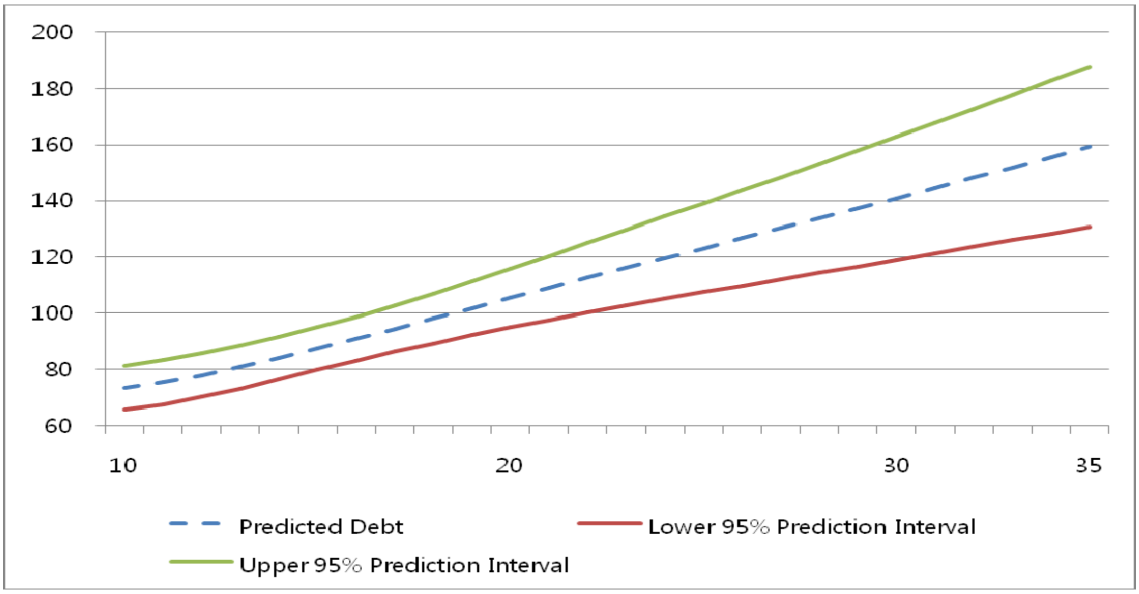
France

The OLS regression results for France are shown in < Table 6−6 >. Only the coefficient of the previous debt level term has a significantly positive value at 95% confidence. The R^2 statistic is 0.93, the same level as Germany.

The results of estimating the future debt−GDP ratios for France by the stochastic simulation method are shown in < Figure 6−7 >. At 95% confidence, the predicted debt−GDP ratio in 2035 is expected to be between 130.8% and 187.9%, and the mean of the predicted values is 159.3%, which is slightly higher than 152.0%, the result by the deterministic method. Considering that the estimated period is around 30 years, the results from both methods for France are quite similar to each other. This may be because that France is a high age country, so it already reflects the aged effect on the fiscal data.

< Figure 6 − 7 > Expected Values of Debt−GDP Ratio for France

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (25.0)	69.3	73.6	76.4
2015 (28.8)	79.7	87.3	94.9
2025 (35.3)	107.4	123.2	139.1
2035 (40.8)	130.8	159.3	187.9



The UK

The OLS regression results for the UK are summarized in < Table 6−7 >. The coefficient of the previous debt level term has a significantly positive value at 95% confidence, and the trend term is significant under 90% confidence. The R^2 statistic is 0.81, the lowest value among the main countries, which means that the historical fiscal data of the UK has lower explanatory power in estimating future debt levels than the other countries.

< Table 6 − 7 > The OLS Regression Results for Debt−GDP Ratio in the UK

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	13.5	11.6	0.268
$debt_{-1}$	0.71**	0.25	0.016
Fiscal balance	−0.13	0.48	0.793
Trend	0.58*	0.32	0.097
R^2 :	0.809	DW :	2.481

1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

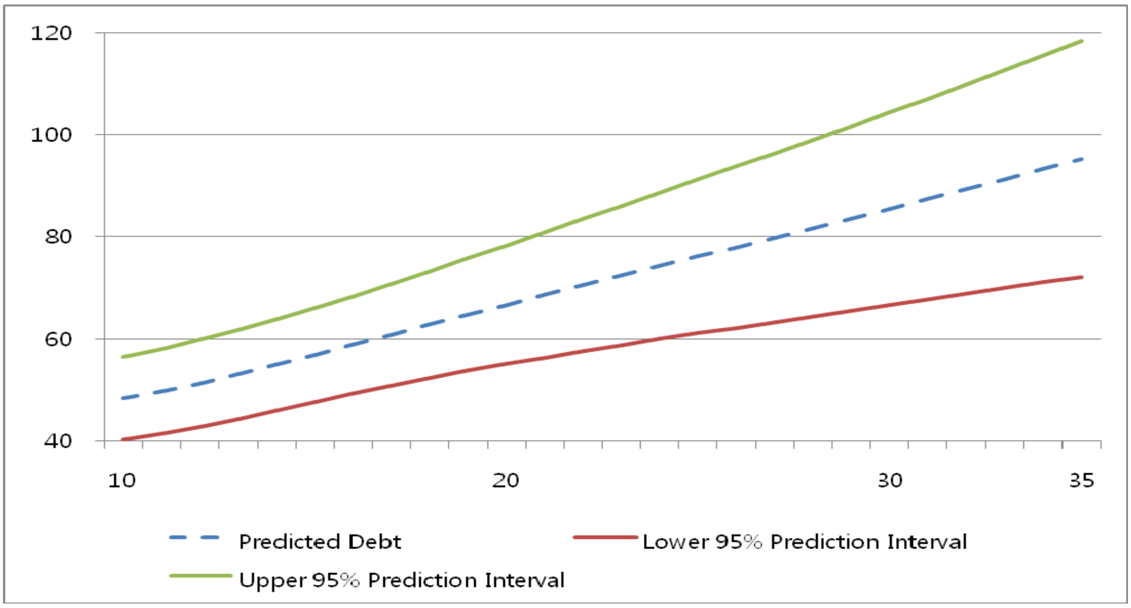
2) * : 90% confidence level, ** : 95% confidence level.

The results of estimating future debt−GDP ratios for the UK using the stochastic simulation method are shown in < Figure 6−8 >. At 95% confidence, the predicted debt−GDP ratio in 2035 is expected to be between 72.2% and 118.5%, and the mean of the predicted values is 95.3%, which is much lower than 110.1%, the results from the deterministic method.

Even though the predicted intervals contain the deterministic estimated value, if we try to make a similar estimated value between the predicted mean value in the stochastic method and the deterministic estimated one, we have to change the assumed value for the stock−flow adjustment term from 5.4% to 4.4%. The former assumed value, 5.4%, is the weighted average between 7.7% (the average of five high age countries' 10−year stock−flow adjustment values) and 3.1% (Japanese 10−year average in this adjustment term). The stochastic method is based on the historical debt trend, and the aged effect may not be reflected to a reasonable degree.

< Figure 6 − 8 > Expected Values of Debt−GDP Ratio for the UK

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (24.4)	36.7	43.8	49.6
2015 (27.4)	47.7	56.9	66.1
2035 (37.3)	72.2	95.3	118.5



The U.S.

The OLS regression results of the debt trend for the U.S. are shown in < Table 6−8 >. The coefficients of the main variables have no significant values with a 90% confidence levels. Even though the R^2 statistic is high at 0.987, the OLS regression has less meaningful results compared to other countries. The historical fiscal data of the U.S. has lower explanatory power in estimating future debt levels than the other countries, which leads to a wider band width between the upper and lower predicted intervals.

< Table 6 − 8 > The OLS Regression Results for Debt−GDP Ratio in the U.S.

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	23.8	10.3	0.26
$debt_{-1}$	0.29	0.20	0.39
Fiscal balance	−0.36	0.40	0.53
Trend	1.25	0.25	0.13
R^2 :	0.987	*DW* :	2.836

1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

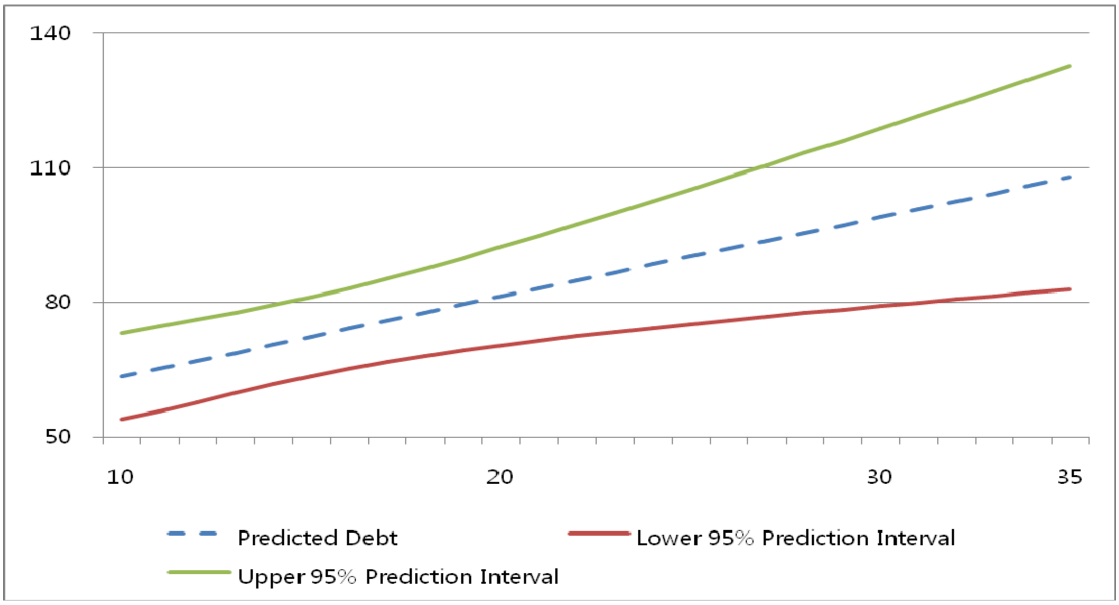
2) * : 90% confidence level, ** : 95% confidence level.

The stochastic estimating results are summarized in < Figure 6−9 >. With a 95% confidence level, the predicted debt−GDP ratio in 2035 is expected to be between 82.9% and 132.8%, and the mean of the predicted values is 107.9%, which is much lower than 133.1%, the results from the deterministic method. The predicted intervals fail to contain the deterministic estimated value.

However, if we try to make a similar estimated value between the predicted mean value in the stochastic method and the deterministic estimated one, we have to change the assumed value for the stock−flow adjustment term from 5.9% to 4.4%. The former assumed value, 5.9%, is the weighted average between 7.7% (the average of five high age countries' 10−year stock−flow adjustment values) and 4.1% (the U.S.'s 10−year average in this adjustment term). As with the explanation of the UK outcomes, the historical trend of the fiscal data of the U.S. may fail to reflect the aged effect fully.

< Figure 6 − 9 > Expected Values of Debt−GDP Ratio for the U.S.

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (18.3)	58.7	62.0	66.1
2025 (27.8)	75.1	90.1	105.2
2035 (32.0)	82.9	107.9	132.8



Korea

The OLS regression results of the debt trend for Korea are shown in < Table 6−9>. First, Korea has a positive coefficient in the fiscal balance term, which is similar to Italy. Even though this coefficient is not significant at 90% confidence, the reason this trend is included is that the Korean fiscal balances are all positive values, whereas there are increasing and decreasing debt levels during 1990~2005 according to the OECD database.

< Table 6 − 9 > The OLS Regression Results for Debt−GDP Ratio in Korea

	Dependent Variable : Debt−GDP ratio		
	Coefficient	s.d.	Prob(t)
Constant	−1.08	1.12	0.36
$debt_{-1}$	0.85^{**}	0.14	0.00
Fiscal balance	0.19	0.27	0.50
Trend	0.46^{**}	0.20	0.04
R^2 :	0.97	*DW* :	1.51

1) $debt_{-1}$ means $\frac{1}{(1+n_t)} \cdot d_t$ term in equation (19).

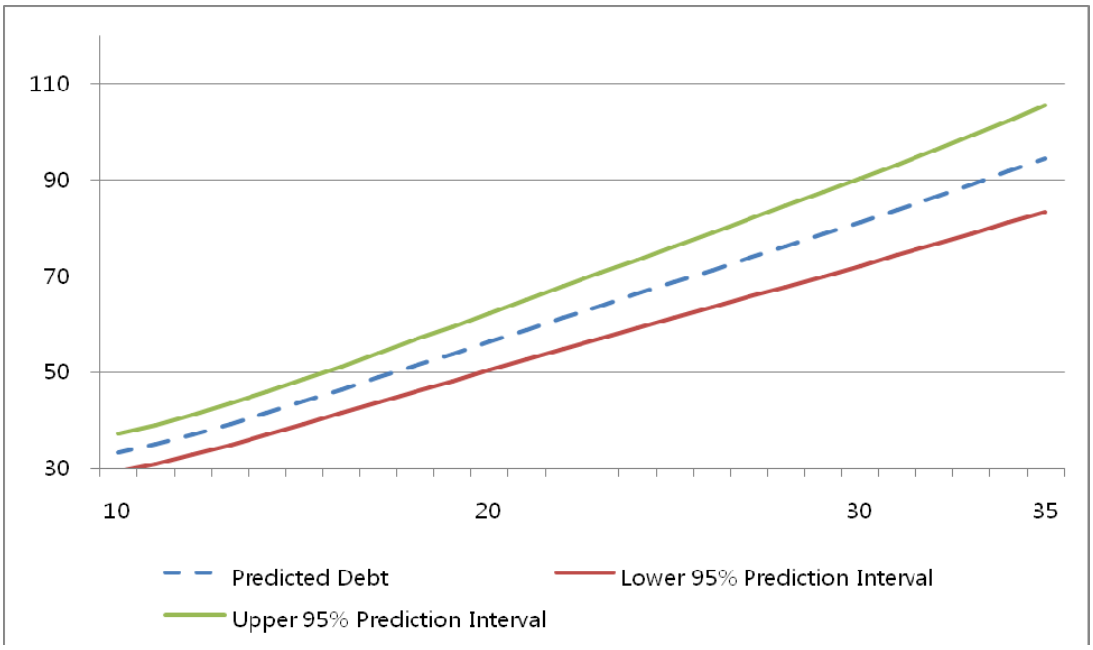
2) * : 90% confidence level, ** : 95% confidence level.

One interesting fact is that the value of the coefficient in the previous debt term is 0.85, which is significant at 95% confidence. This value is the highest among the main seven countries, followed by France (0.78) and Germany (0.77). This fact supports the argument that the budget incrementalism is present in Korea. In other words, if the debt level starts to increase, Korea has a high probability to get higher debt levels in the following periods.

The results of estimating future debt−GDP ratios for Korea using the stochastic simulation method are shown in < Figure 6−10 >. At 95% confidence, the predicted debt−GDP ratio in 2035 is expected to be between 83.4% and 105.4%, and the mean of the predicted values is 94.4%, which is much higher than 60.1%, the result by the deterministic method. If we try to calculate a similar estimated value between both estimating methods, we have to change the assumed value for the stock−flow adjustment term from 3.7% to 6.0%. The former assumed value, 3.7%, is the weighted average between 7.7% (the average of five high age countries' 10−year stock–flow adjustment values) and −0.4% (the Korean 10–year average in this adjustment term). This means that the recent Korean historical fiscal data shows a more upward increasing trend in the debt–GDP ratio than the deterministic method using the weighted average assumption for the aged effect. Considering that the Korean debt–GDP ratio in 2007 is 32.2%, it is expected to double by 2025 and triple by 2035. It is also estimated that the ADR will be 29.1% in 2025 and 44.0% in 2035. The increasing speed of the debt–GDP ratio is growing along with the aging process in Korea.

< Figure 6 − 10 > Expected Values of Debt–GDP Ratio for Korea

Year (ADR)	Expected Value (unit: %)		
	Lower 95% Prediction Interval	Predicted Debt	Upper 95% Prediction Interval
2005 (13.1)	18.1	22.6	24.8
2025 (29.1)	61.3	68.7	76.2
2030 (36.2)	72.1	81.2	90.3
2035 (44.0)	83.4	94.4	105.4



Chapter VI.

Conclusion

The main finding of this paper is that the fiscal sustainability in the light of the aging trend runs downhill in the countries that are in the high-level age status and have the characteristic of the high-speed aging trend. This conclusion comes from the empirical results of the 16 aged OECD countries, the U.S., and Korea using the annual financial data from 1971~2005. Furthermore, when we estimate the future debt levels in 2035, the debt−GDP ratio for the main OECD countries are expected to double when compared to 2005 levels.

First, through the OLS analysis, we find that the reaction of the primary surplus to an increase in the debt−GDP ratio, as the indicator of the fiscal sustainability, is negative or changing from positive to negative in the high−age level countries with fast aging speeds. Considering the recent aging trend in these countries, we can interpret the results as indicating that the aging problem is a decisive factor in deteriorating a country's fiscal sustainability.

Second, through the panel data analysis, we find the distinctive properties between identical groups, which are classified by both the aged level and the aging speed. The high−age level countries with the high−speed aging trend show difficulty in their financial affairs, with rapid increases in their debt-GDP ratios, whereas the relatively low−age level countries with the slow−speed aging trend maintain fiscal sustainability with decreasing debt-GDP ratios. These findings also support the conclusion that the aging problem largely leads to fiscal stability problems.

Third, by applying the properties found in the panel data analysis to the aging countries, we can conclude that the U.S., with a relatively slow aging trend, has a chance to prepare for fiscal difficulty if it succeeds in controlling the debt-GDP ratio. However, Korea, the lowest level aged country in 2005 among the investigated 18 OECD countries, has a high probability to suffer fiscal sustainability problems over the next two decades if it maintains its current fiscal position. When we apply the debt dynamics for the main OECD countries, we can estimate that the debt−GDP ratios increase sharply until 2035 in most countries. In 2035, Japan is expected to have more than 300%, and Italy, Germany and France, more than 150%.

We have to mention some limitations of this paper. There is the obvious limitation in forecasting the futures of countries with the information from different countries, which have the different social systems and different historical backgrounds. To get compatible exact values for the main variables, we should conduct a precise test using the simulation models. However, even after applying an accurate simulation method, the expectations are not guaranteed to be right at that point in the future. This means that the limitation of expectations cannot be overcome in any investigation. The focus of this paper is not on the exact expectations of future values, but on the rough estimations by using the experiences of other developed countries.

Another limitation is the data span. The investigated time-period is from 1971 to 2005; for some countries, an even shorter period. The short time-period causes problems in the adjustment of smoothing fluctuations of the government outlays and GDP, which reduces the explanatory power. However, the R^2 statistic of this study is not low, so it is not a major concern.

Some ideas in relation to future study:

First, the research scope should be reduced from generalities to particulars. This means that we should investigate the whole government revenue system, including the tax rates and taxing structures of each aged country according to the different aging levels. In terms of the government expenditure, we should study the individual divisions of the government support systems that are most affected by the aging problem, such as the pension system, medical insurance and social security system.

Second, we should consider counter−measure plans against the aging problem, which are not included in this fiscal analysis, such as the extension of the retirement age, the enforcing act, which puts companies under an obligation to employ aged people to a certain ratio, and so on. These policies indirectly place burdens of a financial system as the results of these policies dictate how a society deals with the aging problem.

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VITA

Sangwon Lee was born January 1, 1969, in South Korea. After attending schools in Seoul, he received the following degrees: a B.S. in Sociology in Seoul National University (1991), Master in Public Administration in Seoul National University (1999) and Ph.D. in Economics from University of Missouri-Columbia in the U.S. He took the Harry Gunnison Brown Graduate Student Teaching Award in March 2008. He is married to Yunsun Huh. Sangwon Lee and Yunsun Huh have a son and a daughter, Minsuk and Jinyoung. He passed higher examination for senior government official in 1994. He had abundant experience in public finance sector: procurement and budgeting field. He worked for Public Procurement Service. Since 1999, he has worked for Ministry of Planning and Budget, which was changed to Ministry of Strategy and Finance in 2008.