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AN EMPIRICAL EVALUATION OF FISCAL SUSTAINABILITY NEAR AND FAR*

JOONHYUK SONG**

This paper investigates both fiscal sustainability of the past and the effect of welfare spending on the future fiscal soundness. In theoretical angle, fiscal sustainability is defined by largely two conditions: No-Ponzi Game condition and debt ratio against GDP converge toward equilibrium. Empirical evidence suggests that Korea's finance has been maintained in a sustainable way in light of both conditions. Also, we find that near- and medium-term fiscal soundness will not be disturbed by social spending, induced by population ageing, due to huge reserves and surpluses produced by the national pension. However, as the pension surpluses draw to an end by 2047, debt-to-GDP ratio will reverse its course to an increasing trend, inflicting longer-term fiscal sustainability.

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Keywords: Fiscal Sustainability, Solvency Condition

I. INTRODUCTION

Sound finance is a prerequisite to sustaining macroeconomic stability. With a long-standing financial deficit and ever-increasing government

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** Research Fellow, Department of Macroeconomic and Financial Policies, Korea Development Institute, P.O Box 113, Cheongnyang, Seoul 130-012, Korea. Tel: +82-2-958-4101. Fax: +82-2-958-4088. E-mail: jhsong@kdi.re.kr

debt, the aggregate savings rate will decline. Such decline will be corrected by reduced investment and current account deficit, both of which will later serve to undermine a sustainable economic growth. Fortunately, Korea is regarded to have achieved sound finance by and large. Unlike other OECD nations whose economies have run a fiscal deficit consistently, the Korean economy, influenced by austerity policy to curb inflation since the 1980s, put its consolidated central government statistics into a surplus in 1987. Active participation of finance right after the financial crisis in 1997 turned the statistics to a deficit, but a balanced stance was recovered afterwards as shown in Figure 1.[1] Supported by such fiscal stance, Korea's national debt ratio was also relatively well-balanced, compared to other developed nations. As of 2007, Korea's debt-to-GDP ratio stands at 32.1% for general government's debt. Considering the average debt ratio of OECD nations in 2007 reached 75.4%, it is regarded highly stable.

However, there is no guarantee that such sound finance will persist in the future and many dormant problems are hanging to threaten the fiscal soundness. For one thing, the debt ratio is on a steep rise due to the increase in national bond that has been issued after the financial crisis for job creation and financial market stability. As Table 1 shows, the debt of central government against GDP stood at 8.2% in 1996, and reached 32.1% in 2007. Besides, there are many risks that could undermine the financial soundness in the future. Above all, potential growth rate of the Korean economy is currently on the decline, and it seems this will continue for a while. The high rise in its fiscal revenue that Korea had enjoyed once during its high growth period is probably no longer possible. According to Hahn et al. (2007), the real GDP growth of Korea will decline from 4.6% in the 2006-2010 periods to 2.7% in the 2021-2030 periods. Besides, it is impossible to exclude the possibility of a steep rise in expenditure in the future. One of the most serious risks is social welfare spending. Policymakers and academic researchers have warned in one voice that social welfare spending will be a major upcoming burden on the nation's public finances. In particular, public pension schemes will be the main obstacle to future fiscal soundness as they pay generous

[1] The time period is 1983-2007 as the OECD average figures can only be traced back to 1983.

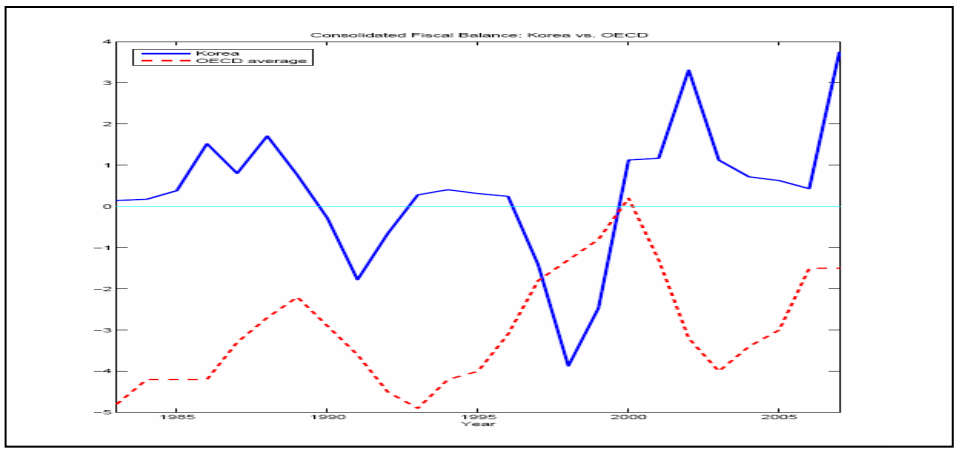
benefits relative to contributions. This problem becomes even more conspicuous in Korea as the speed of population ageing is remarkably high. According to the National Statistics Office, the aged population, 65 year olds and above, in Korea stood at 7 per cent of total population in 2000, but this population is projected to reach 15 per cent by 2019 and 20 per cent by 2025. The current trend of population ageing will raise expenditure demands for pension and medical expenses. It will be reasonable to recognize that the demand for welfare expenditure, which has begun to emerge these days, will persist over the coming years. Consideration of risk factors in the future requires us to conduct a consistent monitoring on fiscal soundness.

This paper aims to investigate public finances and evaluate the soundness of fiscal standing in various aspects. First, we attempt to evaluate whether the fiscal policies of the past have been managed in a way to achieve financial soundness. They are widely recognized to have been under stable management, but this study intends to provide a testable model for recognition and conduct more comprehensive evaluation. Second, we investigate the effect of welfare spending, induced by population ageing, on public debt-to-GDP ratio. Unarguably, population ageing is one of the most important risk factors in the long-run stability of fiscal standing. We find that the Korean fiscal position has been managed in a way to achieve fiscal soundness and stability. Also, near-and medium-term fiscal soundness will not be disrupted by welfare spending due to huge reserves and surpluses produced by the national pension. However, as those surpluses draw to an end by 2047, debt-to-GDP ratio will reverse its course to an increasing trend, inflicting longer-term fiscal soundness.

This paper is related to earlier works. Na (2006) argued that fiscal sustainability is rejected without the inclusion of structural breaks, but it holds when structural break dummies are included in the test. Na, Park and Park (2007) studied 3 different tests: Bohn's test, tax gap test, and International Government Debt Comparison Index, and reported that 3 tests consistently supported fiscal soundness of Korea. Park (2008) argued that the Korean government either pursued balanced budget for fiscal sustainability or made effort to improve fiscal balance when a

balanced budget was not possible. He also contended that the Korean government should increase tax revenues as a means to achieve fiscal soundness.

[Figure 1] Consolidated Fiscal Balance: Korea VS. OECD



However, this paper is distinguished from the literature in 4 ways. First, we use more detailed measures of debt and fiscal balances. Second, we employ the strong solvency condition to test the fiscal stability while earlier ones are conducted based on the weal solvency condition. Third, structural breaks of fiscal variables are endogenously determined in contrast to other works where structural breaks are exogenously given. Fourth, we provide the impact of welfare spending on future debt-to-GDP ratio to assess the role of population ageing to fiscal stability.

[Table 1] International Comparison of Debt-To-GDP Ratio: IMF Standard

	1992	1996	2000	2001	2002	2003	2004	2005	2006	2007
Korea	12.0	8.2	17.4	18.2	18.5	21.9	25.2	29.6	32.2	32.1
United States	48.6	48.4	35.1	33.0	33.9	35.8	36.8	37.0	36.7	36.5
United Kingdom	33.5	48.8	48.5	43.5	43.6	43.9	46.1	48.7	48.8	44.1
OECD average	62.6	72.0	69.5	69.8	71.7	74.0	75.6	77.4	76.0	75.0

Source: IMF Government Finance Statistics except Korea and OECD average. The Korean data is collected from the material released by Treasury Bureau of the Ministry of Finance and Strategy and OECD average is compiled from OECD Economic Outlook.

The rest of the paper is organized as follows: Section 2 examines a theory about fiscal soundness and Section 3 evaluates whether the fiscal management of the past were under stable operation through an empirical analysis. Section 4 discusses fiscal sustainability in an ageing society. Then, Section 5 recaps the major findings and draws a conclusion.

II. FISCAL SUSTAINABILITY

2.1 Model

This section presents a parsimonious model concerning fiscal sustainability. There is no commonly recognized definition of the debt sustainability concept, so far. Buiter and Partel (1990) propose conditions for weak and strong solvency requirement. Weak solvency implies that the debt-to-GDP ratio is first difference stationary and strong solvency requires weak solvency together with a stationary primary surplus-to-GDP ratio. According to these concepts, weak solvency requires a long-run stability of debt-to-GDP ratio while strong solvency insists on stability of fiscal policy at a shorter horizon.

In most literature, a formal derivation of fiscal sustainability tends to begin from dynamic budget constraints of a government. Denote D_t as the debt size at the point of time t, S_t as the primary fiscal balance excluding interest payment, and R_t as the nominal interest rate. In this case, the intertemporal budget constraint is expressed as follows:

$$D_{t+1} = (1+R_t)D_t - S_t . \tag{1}$$

In other words, the debt in the subsequent period is the value that deducts the surplus of primary fiscal balance from the principal and interest of the current debt. Equation (1) can be represented as follows:

$$D_t = \frac{D_{t+1}}{1+R_t} - \frac{S_{t+1}}{1+R_t} . \tag{2}$$

Now iterating D_{t+1} forward recursively, we obtain:

$$D_t = \sum_{j=1}^{\infty} \frac{S_{t+j}}{\prod_{i=0}^{j-1}(1+R_{t+i})} + \lim_{j=\infty} \frac{D_{t+j}}{\prod_{i=0}^{j-1}(1+R_{t+1})} . \quad (3)$$

Here, when the second term in the right side is 0, i.e., $\lim_{j=\infty} \frac{(D_{t+j})}{\prod_{i=0}^{j-1}(1+R_{t+i})} = 0$, it is said that the government's budget constraint satisfies the conditions of No-Ponzi Game (NPG). That the value of second term is larger than 0 means the government pays interests on existing debt through new debt issuance. In this case, the creditor would consider the value of the government bond will not hold up and would refuse to keep it.

Summing up, the government's fiscal sustainability could be expressed in two ways. First, the rate of increase in government debt should be lower than the interest rate. Second, if the government budget satisfies Equation (3) and the present deficit should be corrected by the surpluses of primary fiscal balance of the future.

However, such definition of fiscal sustainability explains little about the debt as a share of GDP which is frequently cited. When assuming an extreme case that the nominal GDP growth rate is lower than the interest rate, it is possible that the growth of the government debt would be higher than the nominal GDP growth rate and lower than the interest rate. In this case, the condition of No-Ponzi Game is satisfied (since the debt growth rate is lower than the interest rate), but the debt ratio against GDP is to rise consistently. On the contrary, when the nominal GDP growth rate is higher than the interest rate and the debt growth rate has the value in between, the debt ratio against GDP will fall consistently, but fail to satisfy fiscal sustainability. What requires attention is that the fiscal sustainability mentioned earlier provides no information as to at what level of the debt ratio against GDP is fiscally sustainable.

In practice, the discussion on fiscal sustainability raises a particular attention to the debt ratio against GDP. In this regard, it is adequate to discuss fiscal sustainability provided that the debt ratio against GDP is stable, putting aside the fiscal sustainability suggested in terms of debt level. To that end, take a look at the dynamic changes in the debt ratio

against GDP. First, denote the debt ratio against GDP as $d_t = \frac{D_t}{Y_t}$, the primary fiscal balance against GDP as $s_t = \frac{S_t}{Y_t}$, real GDP growth rate as y_t, inflation rate as π_t, and real interest rate as r_t. Now, both sides of Equation (1) divided by Y_{t+1} yield the following:

$$\frac{D_{t+1}}{Y_{t+1}} = (1+R_t)\frac{D_t}{Y_t}\frac{Y_t}{Y_{t+1}} - \frac{S_{t+1}}{Y_{t+1}}.$$

Applying the above-defined notation, this equation can be represented as follows:

$$d_{t+1} \approx \frac{(1+r_t)(1+\pi_t)}{(1+y_t)(1+\pi_t)} d_t - s_{t+1}. \tag{4}$$

Equation (4) can be approximated as[2]:

$$d_{t+1} \approx (1+r_t - y_t)d_t - s_{t+1}. \tag{5}$$

Deduct d_t from each term to express in difference of debt-to-GDP ratio:

$$\Delta d_{t+1} \approx (r_t - y_t)d_t - s_{t+1}. \tag{6}$$

The increase in the debt-to-GDP ratio depends on the balance between the growth-adjusted debt service (i.e. $(r_t - y_t)d_t$) and the primary surplus (i.e. s_{t+1}). At a certain time t, a stable debt ratio against GDP means Δd_{t+1} should be non-positive, and the above formula can be concluded as follows[3]:

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[2] I use the convention $\log(1+x) \approx x$, if x is small, i.e. $\frac{(1+r_t)}{(1+y_t)} \approx \frac{\log(r_t)}{\log(y_t)} \approx \log(r_t - y_t)$ $\approx 1 + r_t - y_t$.

[3] This constraint can be also expressed using fiscal balance, not primary fiscal balance. First, denote z_t as fiscal balance against GDP and we will get $s_t = z_t(r_t + \pi_t)d_t$. Then, the equation

$$s_{t+1} \geq (r_t - y_t)d_t \,. \tag{7}$$

The right side of Equation (7) indicates the strong stability insisting the primary surplus-to-GDP ratio should be greater or equal to the growth-adjusted debt service against GDP. In other words, the primary fiscal balance against GDP should be at the level which could correct the growth-adjusted debt service, when the present debt remains unchanged. However, this condition is too strong and fiscal solvency does not require that this constraint should be satisfied at each and every period and it may not be desirable to satisfy those restrictions. As is discussed above, weak solvency demands the first difference of debt/GDP ratio is stationary. Technically speaking, weak solvency condition implies that $[(r_t - y_t)d_t, s_{t+1}]^T$ is cointegrated as in Trehan and Walsh (1988).

Considering the business cycle effects on fiscal position, a more relevant concept with fiscal sustainability is medium-term solvency condition, which can be construed as to the fiscal sustainability over medium-term fiscal planning. It may be reasonable to accumulate debt in a recession and decumulate in a boom, such that the debt-to-GDP ratio decreases over business cycles. Let n be the planning period by which the fiscal authority needs to satisfy fiscal solvency condition. Then, medium-term solvency condition implies the following:

$$d_{t+n} - d_t \leq 0 \,. \tag{8}$$

This implies the debt-to-GDP ratio at time $t+n$ should be smaller than of time t. Using Equation (5), n-period solvency condition yields:

$$\sum_{j=0}^{n} s_{t+j} \geq \sum_{j=0}^{n-1} (r_{t+j} - y_{t+j})d_{t+j} \,. \tag{9}$$

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(5) is modified as $z_{t+1} \geq -(y_t + \pi_t)d_t$. When a certain debt ratio against GDP is maintained, this formula can be written as equality, and in this case, we can obtain a formula for a stable debt-to-GDP ratio and fiscal balance. Using this formula offers easy understanding of the fact that the fiscal discipline of 3% fiscal deficit against GDP and 60% debt-to-GDP ratio adopted by the Treaty of Maastricht in 1992, is related to maintaining the debt-to-GDP ratio in the assumption of 3% real growth rate and 2% inflation.

With some manipulation, this equation will boil down to:

$$\sum_{j=1}^{n} \frac{S_{t+j}}{\prod_{i=1}^{j-1}(1+r_{t+i}-y_{t+i})} \geq \frac{\prod_{j=0}^{n-1}[(1+r_{t+j}-y_{t+j})-1]d_t}{\prod_{i=0}^{n-1}(1+r_{t+1}-y_{t+1})}. \quad (10)$$

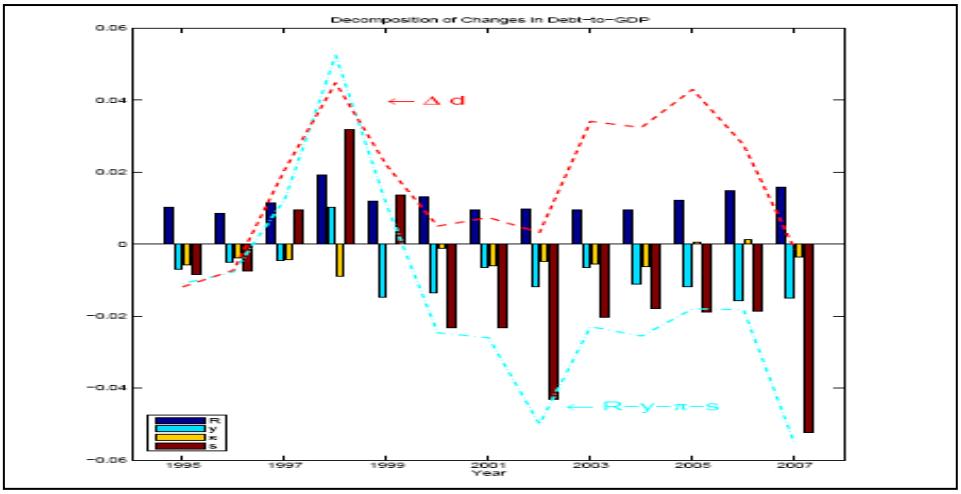
In this case, fiscal solvency depends on n. As n goes to infinity, this condition will coincide with weak solvency condition. Although, this study does not pursue further with this condition, this type of sustainability condition is related to the medium-term expenditure framework introduced in 2004.

2.2. Historical Decomposition

The dynamic budget constraints are affected by interest rate, growth, inflation, and fiscal balance. This section examines the contributions from each of these factors on the changes in debt-to-GDP ratio. Equation (4) can be decomposed as follows:

$$\Delta d_{t+1} = \frac{R}{1+y+\pi} - \frac{y}{1+y+\pi} - \frac{\pi}{1+y+\pi} - s_t. \quad (11)$$

[Figure 2] Decomposition OF ΔD



The left hand side variable, Δd_{t+1}, consists of four components

composed of explained by interest rate, growth, inflation, and fiscal balance. The result from decomposition is presented in Figure 2.

One interesting finding is that the left hand side and the sum of the right hand side of Equation (11) move closely before the year of 2000. After 2000, their movements are dissociated from each other. This observation impels us to consider different measures of debt to allow the model consistent with data, which will be discussed in detail shortly.

III. EMPIRICAL ASSESSMENT OF FISCAL SUSTAINABILITY

The previous section suggests the two conditions for fiscal sustainability; No-Ponzi Game and stabilization of debt-to-GDP ratio. In this section, we test whether Korea's fiscal policies have been managed to satisfy those conditions using various measures on fiscal aggregates.

3.1 Data

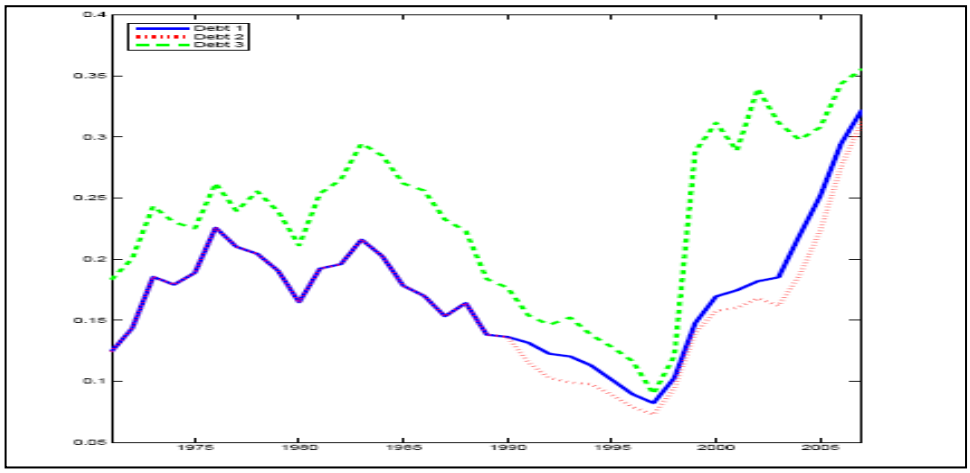
Korea's national debt statistics have fairly comprehensive deviations according to which definition is used for calculation. Depending on whether the statistics includes debts of social security trust fund, and guaranteed liabilities or not, the debt size varies. The problem is that there is estrangement found between the consolidated central government statistics and the national debt. For instance, the foreign exchange stabilization bond is excluded from the public fund of the consolidated central government statistics, but included in the national debt statistics. Also, the national pension account is included in the consolidated central government statistics, while the debt from unrealized pension is excluded from national debt. Recognizing this, the study defines three different national debts and then attempts to analyze them based on these definitions, which are,

- Debt 1 = National debt + Borrowings + Contract resulting in treasury obligation;
- Debt 2 = Debt 1-Debt of the foreign exchange stabilization bond' and
- Debt 3 = Debt 2 + Government guaranteed liabilities.

As mentioned earlier, the national debt used in the analysis is the debt of central government. The statistics of the local governments debt was unofficially made first in 1996, and since 2001 the Ministry of Government Administration and Home Affairs has made the statistics on record but they are not yet reflected in the balance sheet. Since the account for local authorities as well is excluded from the consolidated central government statistics, it is recommended to use the central government debt for the consistency of fiscal statistics. Meanwhile, fiscal balance also needs a few adjustments in the government revenues that include the social security trust fund. Data analysis uses the following two fiscal balance variables:

- PrimeBal 1 = Primary fiscal balance' and
- PrimeBal 2 = Primary fiscal balance − National pension balance.[4]

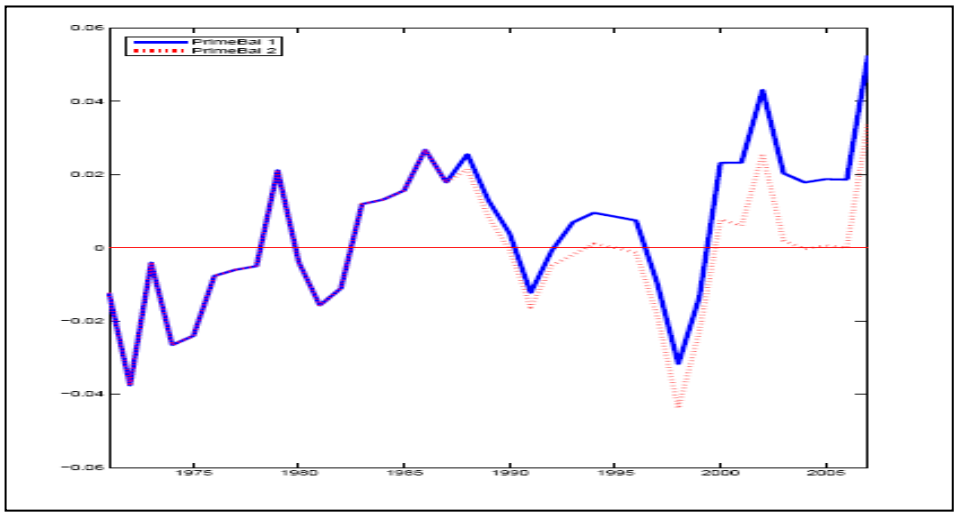
[Figure 3] National Debt against GDP



Note: Debt 1 = National Debt + Borrowings + Contract resulting in treasury obligation.
Debt 2 = Debt 1 - Exchange rate stabilization bond.
Debt 3 = Debt 2 + Government-guaranteed liabilities.

[4] Social security trust fund includes the pension for private school and staff, the industrial accident insurance, and the employment insurance, as well as national pension. But, due to the lack of sufficient data, only the national pension data is included. We believe this would not change the major result of the following analysis, because the proportion of national pension accounts for the majority, i.e. more than 80%, of the social security trust fund.

[Figure 4] Fiscal Balance against GDP



Note: Primebal 1 = Primary fiscal balance.
Primebal 2 = Primebal 1 - National pension balance.

Figures (3)~(4) present the trends of national debt and fiscal balance against GDP by variables. The empirical test of this section is based on 1970-2007. The national debt is on a steep rise since the financial crisis at the bottom of 1997. The primary fiscal balance has recorded a surplus since 2000, which is attributable to the surpluses of national pension balance. The primary fiscal balance excluding social security trust fund balance is observed to record surpluses after 2000, part of which is attributable to a temporary rise in the revenue (6.7 trillion won) that was earned by the sale of Korea Telecom stocks in 2002.

3.2 Stationarity

Most macroeconomic variables are known to have non-stationary time series characteristics (Nelson and Plosser, 1982). So as to check whether the variables have similar characteristics, we conduct a series of unit root tests, based on Augmented Dickey Fuller (ADF) and Phillips-Perron (PP). The ADF test could produce different test statistics depending on the length of time lag. In this study, a unit root test allows for time lag of 12 quarters. PP test is a unit root test that even considers autocorrelation and heteroskedasticity of error terms. After estimating the test statistics of

ADF first, PP test uses estimated error term to transform the ADF test statistics to remove autocorrelation. In this regard, PP test can be understood as more generalized form of ADF test.

The existence of unit root might be triggered by a structural break. To identify structural breaks in the sample period, we conduct Zivot and Andrew test for possible structural breaks and the estimation results are presented in Table 2. We prove 4 different types of model: crash (i.e. breaking intercept) and breaking trend with and without point dummy on breaking time. The table is quite persuasive for the need to consider structural breaks in unit root tests. One conspicuous aspect of the table is that in contrast to the breaking period of fiscal balances, those for debt vary depending on which measures we take. Especially, debt 3/GDP shows no signs of structural break. However, looking at Figure 3, debt 3/GDP measure fluctuates more than the other measures. This could be caused by the short span between the trough and peak in the late 1990s and Zivot and Andrew test statistics is not powerful to detect structural changes which take place in a short span of time. Anyway, the test results on structural breaks can be interpreted as one needs to consider the breaking date in unit root tests.

[Table 2] Zivot-Andrew Test for Structural Break

	Crash w/ TB	Crash w/o TB	Breaking Trend w/ TB	Breaking Trend w/o TB
Debt 1/GDP	1999**	2000**	-	-
Debt 2/GDP	2002***	2004***	-	-
Debt 3/GDP	-	-	-	-
Primebal 1/GDP	1992*	1990*	1993**	1996*
Primebal 2/GDP	-	1990*	1995**	1996*

Note: *, **, and ***denote the statistical significance at 10%, 5% and 1%, respectively.
Crash w/ TB model implies changes in intercept and breaking time dummy included.

Table 3 shows the result of a unit root test of the national debt against GDP, fiscal balance, and GDP growth rate after adjusting for structural breaks. While the fiscal balances and national debts show non-stationary time series characteristics with a unit root, the real GDP growth is found to be stationary. However, fiscal balances and debts are first-differenced,

and they show stationarity, indicating they are I (1) series. These patterns are well-documented in the literature using fiscal aggregates in other countries.

It is generally known that variables that have unit roots can have a long-term equilibrium relation among each other. When variables have a certain form of long-term equilibrium relation, they are said to be cointegrated. If fiscal aggregates satisfy the conditions for fiscal sustainability, these variables should display cointegration relationship. The existence of the cointegration relationship could be confirmed through Johansen test, which will be discussed thoroughly in the next section.

[Table 3] Unit Root Tests

	ADF	PP	
	$t-$value	z_{∂}	$z_{t(\partial)}$
Debt 1/GDP	-0.935	-5.117	-1.265
Debt 2/GDP	-1.082	-6.201	-1.544
Debt 3/GDP	-1.642	-7.095	-1.858
Δ Debt 1/GDP	-3.118	-22.016	-4.221
Δ Debt 2/GDP	-3.252	-22.594	-4.257
Δ Debt 3/GDP	-4.215	-26.237	-5.032
PrimeBal 1/GDP	-2.192	-17.411	-3.456
PrimeBal 2/GDP	-2.407	-16.266	-3.268
GDP Growth	-4.975	-27.459	-5.528
Critical Value(5%)	-2.949	-20.484	-3.461

Note: 1) ADF tests use AIC to select the appropriate time lag.
2) PP test used Parzen window of size 6.
3) Δ denotes difference of a variable, i.e. $\Delta x_t = x_t - x_{t-1}$.

3.3 Test on Fiscal Sustainability

Empirical analysis on fiscal sustainability includes largely three methods: [1] transversality condition (Hamilton and Flavin, 1986, Wilcox, 1989), [2] co-integration relations between fiscal revenue and expenditure (Trehan and Walsh, 1988, Ahmed and Rogers, 1995), and [3] Bohn test that uses the formula that fiscal balance is a reaction function of debt.

This study attempts to evaluate fiscal soundness based on Bohn test.

Before estimation, we need to look at Figure 5 to see the relationship between fiscal balances and national debts. Figure 5 shows the relation between primary fiscal balance and government debt from 1970 to 2007. Without government guaranteed liabilities deducted from the national debt, it is hard to observe a clear correlation between the two, but including the liabilities presents a positive correlation. The following is the analysis to confirm whether such intuition has an actual and statistical meaning.

Bohn test is based on the tax smoothing model of Barro (1979) and made in a way where in the long-term equilibrium relation formula among variables, cyclical variation of economy, and trend break of government expenditure are added to regression formula. Bohn (1998), based on the fact that when national debt increases, the stability of debt is only secured by corrective actions of fiscal balance, suggests a regression equation as follows:

$$S_t = \alpha + \rho d_{t-1} + \gamma Z_t + \varepsilon_t \tag{12}$$

where Z_t includes several variables that determine fiscal balance. Variables contained in Z_t include temporary government spending (GVAR) whose usability was verified in Barro (1986) and business cycle indicator (YVAR). This is to control impact of changes in fiscal expenditure on fiscal balance. For fiscal stability, government's primary balance and its debt should be related such that increase in debts should be accompanied by increase in fiscal surpluses, implying ρ needs to show a positive sign.

In order to make Equation (12) meaningful, it requires the existence of one cointegration equation in which $(S_t, d_{t-1})^T$ has $(1, -\rho)^T$ as the cointegrating vector. Such relation can be understood in light of debt dynamics. In Equation (6), the left hand side variable, i.e. Δd_{t+1}, is found stationary from our unit test. Hence, the right hand side should also be stationary to match time series properties, implying d_t and s_{t+1} should be cointegrated. The results of Johansen test are given in Table 4. λ_{trace}

and $\lambda_{\max}$ show that of all the formulas, one cointegrating vector turns out to exist, which can be interpreted to mean that there is a long-term stable relation established between primary fiscal balance and government debt.

[Table 4] Johansen Cointegration Test

	Eigenvalue	H_0	$\lambda_{\max}$	Critical value(5%)	λ_{trace}	Critical value(5%)
PrimeBal 1, Debt 1	0.576	0	30.905	15.892	34.976	20.262
	0.107	1	4.070	9.165	4.070	9.165
PrimeBal 1, Debt 2	0.512	0	25.794	15.892	34.063	20.262
	0.205	1	8.268	9.165	8.268	9.165
PrimeBal 1, Debt 3	0.566	0	30.020	15.892	33.644	20.262
	0.096	1	3.623	9.165	3.623	9.165
PrimeBal 2, Debt 1	0.482	0	23.706	15.892	27.465	20.262
	0.099	1	3.759	9.165	3.759	9.165
PrimeBal 2, Debt 2	0.373	0	16.779	15.892	23.540	20.262
	0.171	1	6.760	9.165	6.760	9.165
PrimeBal 2, Debt 3	0.543	0	28.222	15.892	30.852	20.262
	0.070	1	2.63	9.165	2.631	9.165

Note: Intercept term is included in each test.

Based on such result, we construct a regression equation as follows:

$$S_t = \alpha + \rho d_{t-1} + \gamma_1 GVAR_t + \gamma_2 YVAR_t + \varepsilon_t . \tag{13}$$

In actual test, estimation of GVAR and YVAR requires potential or trend GDP and government expenditure. We estimate the trend GDP and government expenditure using Hodrick-Prescott filter.[5] Bohn (1986) evaluates fiscal soundness by looking at the signs on Δd_{t-1}, i.e. ρ. Equation (13) is to see whether government debt-to-GDP satisfies the condition of the NPG (Bohn, 2005). However, even under such condition, it is also possible that the size of government debt could expand without limit, as shown in Section 3. Therefore, it could be meaningful to know if debt does not diverge but converge at a certain level. Whether there is convergence or not could be observed through difference equations and

[5] $GVAR_t = \frac{g_t - g_t^*}{y_t}$ and $YVAR_t = \frac{y_t^* - y_t}{y_t^*}\frac{g_t^*}{y_t}$, where g_t^* and y_t^* are estimated trends through H-P filter.

this could be obtained by substituting the regression formula used in Bohn test, i.e Equation (13), into debt dynamics, which yields:

$$\Delta d_t = -\alpha + (R - y - \pi - \rho) d_{t-1} + \gamma_1 GVAR_t + \gamma_2 YVAR_t . \quad (14)$$

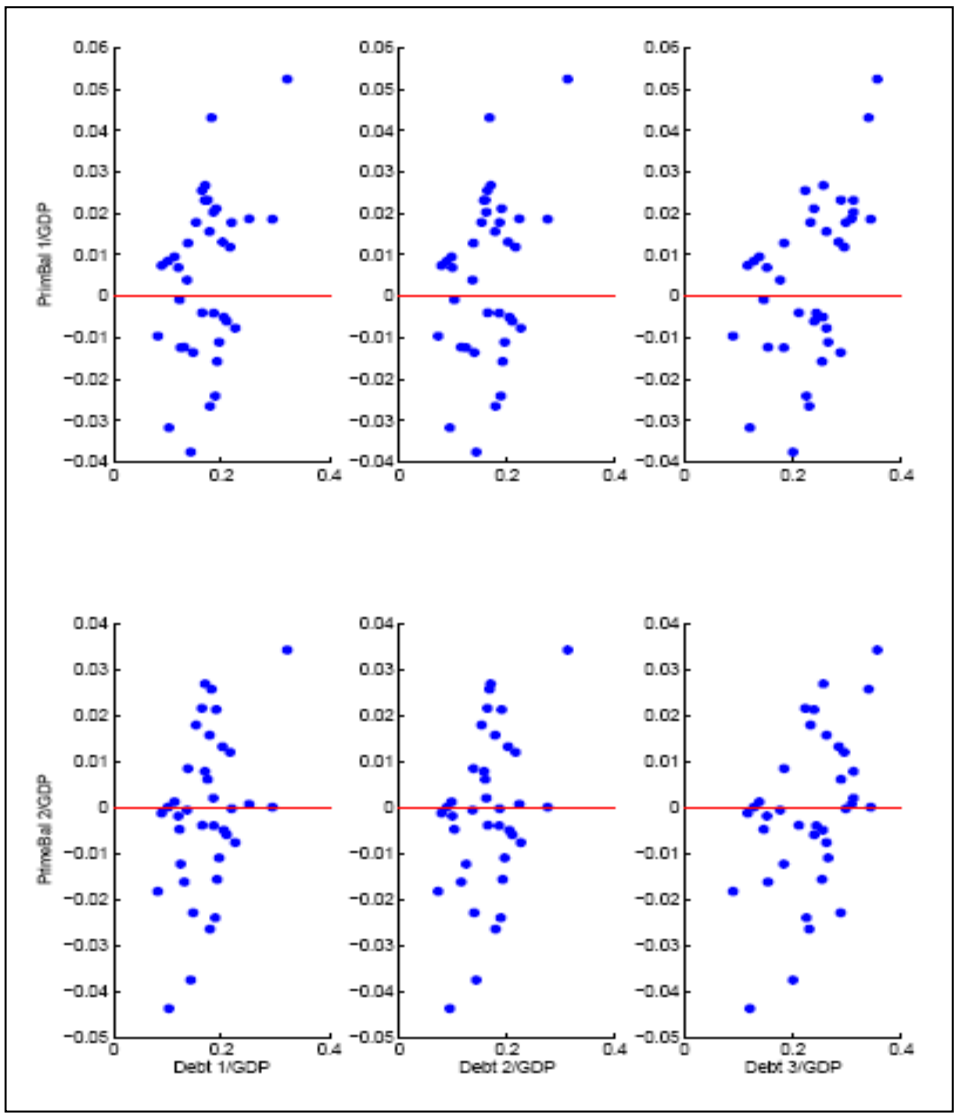
For the government debt to converge at a certain level, $R - y - \pi - \rho$ should be in the interval of (-2, 0).[6] It should be noticed that whether the debt against GDP converges or not depends not only the sign of ρ, but also its size. First of all, the results estimated by Bohn regression are suggested in Table 5. The results show that coefficients on debt, ρ, have all positive signs. The estimated ρ is economically and statistically significant. The signs for GVAR and YVAR as well turn out to be negative, consistent with theoretical prediction, but statistically insignificant.

In order to investigate sustainability and convergence of debt-to-GDP, it is required to calibrate the yield on Treasury bond (R), GDP growth rate (y), and inflation (π). In the case of analysis based on 2007, the yield on Treasury bond was below GDP growth rate and any positive values of ρ have stable and convergent debt-to-GDP ratios, which is verified in the data. However, convergence should not be determined by only a single year data. Hence, we will discuss the convergence of debt-to-GDP with the average of the periods between 2000～2007. One might argue that the same analysis should include periods before 2000. Considering, however, that the discussion regarding the sustainability of government debt is recently triggered, this study chooses only the period after 2000. Also, before the currency crisis of 1997, the Korean government chose a fiscal principle of spending-within-means. Under this principle, fiscal sustainability is simply and always achieved. The results for convergence are presented in Table 6. We apply the average yields on one-year, three-year, five-year, and ten-year treasury bonds and the housing bond class 1 due to unclear conformity for analysis on yield measures. Using regression coefficients, ρ's, earned from six regressions

[6] This result comes from the convergence condition of difference equations. Consider $x_t = \alpha x_{t-1} + bz_t + c$ where z_t is stationary. Then, the stability condition of the system is $|\alpha| < 1$. A detailed explanation can be found in Chiang (1985).

produce a total of 30 combinations, and by using them, we intend to see how the coefficient on d_{t-1} from the Equation (14) is determined within the duration mentioned above. The calculation shows that all coefficients satisfy conditions for stable convergence of the debt-to-GDP. All these results point to an interpretation that Korea's fiscal status is evaluated sound at present and now converges toward a long-term equilibrium relation.

[Figure 5] Fiscal Balance and National Debt



[Table 5] Bohn's Test

Dep. variable	PrimeBal 1			PrimeBal 2		
	Reg1	Reg2	Reg3	Reg4	Reg5	Reg6
Constant	-0.018	-0.013	-0.026	-0.020	-0.019	-0.025
	(0.009)	(0.009)	(0.011)	(0.009)	(0.008)	(0.007)
Debt 1	0.138			0.113		
	(0.056)			(0.042)		
Debt 2		0.117			0.112	
		(0.066)			(0.044)	
Debt 3			0.136			0.106
			(0.044)			(0.024)
GVAR	-0.048	-0.046	-0.070	-0.067	-0.067	-0.084
	(0.252)	(0.258)	(0.247)	(0.198)	(0.206)	(0.193)
YVAR	-0.021	-0.023	-0.016	-0.010	-0.011	-0.007
	(0.042)	(0.043)	(0.041)	(0.035)	(0.036)	(0.035)
Wald	17.913	14.393	20.686	21.679	17.464	27.712
R^2	0.233	0.199	0.326	0.193	0.194	0.257

Note: Figures in parenthesis denote t-value.

[Table 6] Convergence of Public Debt

	T-Bond (1 yr)	T-Bond (3 yr)	T-Bond (5 yr)	T- Bond (10 yr)	Housing Bond (5 yr)
Yield (R)	5.06	5.34	5.63	5.81	5.77
Inflation Rate (π)			1.64		
Growth Rate (y)			5.18		
$(R-y-\pi-\rho)$					
(Primebal 1, Debt 1)	-0.16	-0.15	-0.15	-0.15	-0.15
(Primebal 1, Debt 2)	-0.13	-0.13	-0.13	-0.13	-0.13
(Primebal 1, Debt 3)	-0.15	-0.15	-0.15	-0.15	-0.15
(Primebal 2, Debt 1)	-0.13	-0.13	-0.12	-0.12	-0.12
(Primebal 2, Debt 2)	-0.13	-0.13	-0.12	-0.12	-0.12
(Primebal 2, Debt 3)	-0.12	-0.12	-0.12	-0.12	-0.12

Note: GDP deflator is used as inflation measure.

3.4. Vector Error Correction Model

Given the stable relationship among fiscal aggregates, it would be natural to ask how fiscal variables adjust themselves over time to ensure

such relations. This section investigates in what way fiscal variables move for change and converge toward a new long-term equilibrium relation in the event of an external impulse on fiscal variables by using Vector Error Correction Model (VECM) which uses cointegration relation among fiscal variables. A VECM model is similar with a VAR in the aspect that these models observe trajectory caused by an exogenous impulse of a particular variable within the simultaneous equation. However, they are different in interpreting the long-run behaviors of the variables and equilibrium concepts. Under a stationary VAR setup, shocks have temporary effects and eventually the system will bounce back to the previous equilibrium as the shocks vanish. Unlike stationary VAR models, a VECM model deals with non-stationary variables which are cointegrated. Due to the non-stationarity, shocks have permanent effects and their effect will not disappear with the lapse of time, hence, they will not go back to the previous equilibrium but to a new equilibrium where the cointegrating relationships between variable still hold. In our paper, a VECM analysis could be more useful than VAR, considering that fiscal aggregates have unit roots. We examine what type of cointegration relation exists among fiscal variables of debt, revenue, expenditure, etc. and then build a VECM model based on this to extract impulse response functions. It is already well known that fiscal variables are non-stationary time series that have unit roots. In a time series, the existence of a unit root is of great significance. Non-stationary status by a unit root means that impulse effect will not disappear but will stay permanently. In other words, once an external shock hits the economy, its effect will not die out. Hence, fiscal variables after the shock will not regress to the previous equilibrium, but instead move to a new equilibrium. An analysis of multivariate time series that has unit roots is completely different from the stationary time series analysis. In order to make this type of time series analysis to be meaningful, economic variables should have consistent relations, and error terms derived from these relations should be stationary. If such consistent relation exists, these variables can be said that they are cointegrated, and that this consistent relation is referred to as cointegrating vector. A multivariate VECM model is generally set as follows:

$$\Delta x_t = \Phi x_{t-1} + \sum_{j=1}^{n-1} A_j \Delta x_{t-j} + u_t \tag{15}$$

where $\Phi = \alpha\beta'$ and α denotes error correction coefficient matrix, and β implies cointegrating vector matrix. A_j indicates a coefficient matrix of lagged variables.[7] The first term in the right means long-term equilibrium relation among variables, and the rest means short-term dynamics. When the long-term equilibrium relation does not exist here, the formula above becomes a VAR that consists of differenced variables. Recall that this exercise is to investigate the existence of cointegration relationship among debt, expenditure, and revenue and then conduct impulse response analysis. To that end, in the government debt dynamics, fiscal balance can be divided into expenditure and revenue, which can be expressed as follows:

$$\tilde{D}_{t+1} = (1+R_t)\tilde{D} + G_t - T_t . \tag{16}$$

Let $D_t = (1+R_t)\tilde{D}_t$, then the formula will be rewritten:

$$D_{t+1} = (1+R_{t+1})(D_t + G_t - T_t) . \tag{17}$$

Log-linearizing around the steady state, this formula can be expressed in the following[8]:

$$\Delta d_{t+1} - \alpha_G (g_t - d_t) + \alpha_T (t_t - d_t) = r_{t+1} \tag{18}$$

where $\alpha_G = \dfrac{G}{D+G-T}$ and $\alpha_T = \dfrac{T}{D+G-T}$. Here, D, G, and T denote the steady state values of respective debt, expenditure and tax. The right hand side of Equation (18) is the interest rate which is stationary time series. Therefore, in order for time series characteristics of each side

[7] See Hamilton(1994) for further discussion.
[8] Note that lower cases imply logrized variables in this section, not as a share of GDP.

to be the same, the left side also needs to be stationary time series. The existence of such relation requires the existence of cointegration relations between (d_t, g_t, t_t). There could be at most 4 cointegrating relations. As usual, the first step is to confirm wheher these variables have unit roots before the formal cointegration test. As shown in Table 7, all these variables are confirmed to have unit roots.

[Table 7] Unit Root Test on Fiscal Variables

	ADF	PP	KPSS
	t-value	Adj. t-Stat	LM-Stat
d_t	-2.098	-2.625	0.609
g_t	-2.835	-3.99	0.730
t_t	-3.553	-3.780	0.729
crit.value(5%)	-2.948	-2.943	0.463

It is already mentioned that a meaningful relation among time series that have unit roots requires stationary error term. Along with a stationary error term, what needs to be sought here is that regression coefficients between (g_t, d_t) and (t_t, d_t) should be 1 if they are correlated. Engle and Granger test is conducted to see if a cointegration vector exists. It is found that ADF and PP tests show no existence of cointegration relations, while KPSS shows one. These tests tend to have high test power when using large size samples, but reveal some limitations when using a small number of samples, which makes it hard to clearly conclude on the existence of cointegration. Also, in order to see if regression coefficients match the results drawn from the cointegration vector, we conduct a t-test. The result cannot dismiss the hypothesis that debt-expenditure and debt-revenue are all ($\beta = 1$), as shown in Table 8.

[Table 8] Engle and Granger Test on Pair-wise Fiscal Aggregates

	β	$t_\beta = 1$	ADF	PP	KPSS
			t-value	Adj. t-Stat	LM-Stat
g_t, d_t	0.97	1.14	-2.303	-2.019	0.108
t_t, d_t	1.00	0.098	-2.183	-2.394	0.120
crit.value(5%).			-2.951	-2.943	0.463

Now, we move to find out that any cointegration relations actually exist in data using all three variables, i.e. (d_t, g_t, t_t), and the results of Johansen test is shown in Table 9. The results show that there exists one cointegrating vector, which is exactly what we are looking for. Subsequent analysis is based on a single cointegrating relation between debt, expenditure, and revenue.

[Table 9] Johansen Cointegration Test on Fiscal Aggregates

$H_0 : \gamma \leqq$	$\lambda_{\max}$	Critical value (5%)	λ_{trace}	Critical value (5%)
0	25.998	21.132	39.282	29.797
1	8.638	14.265	13.284	15.494
2	4.646	3.841	4.646	3.841

The estimated cointegrating vector obtained from the setting of $x_t = (d_t, g_t, t_t)^T$ is as follows:

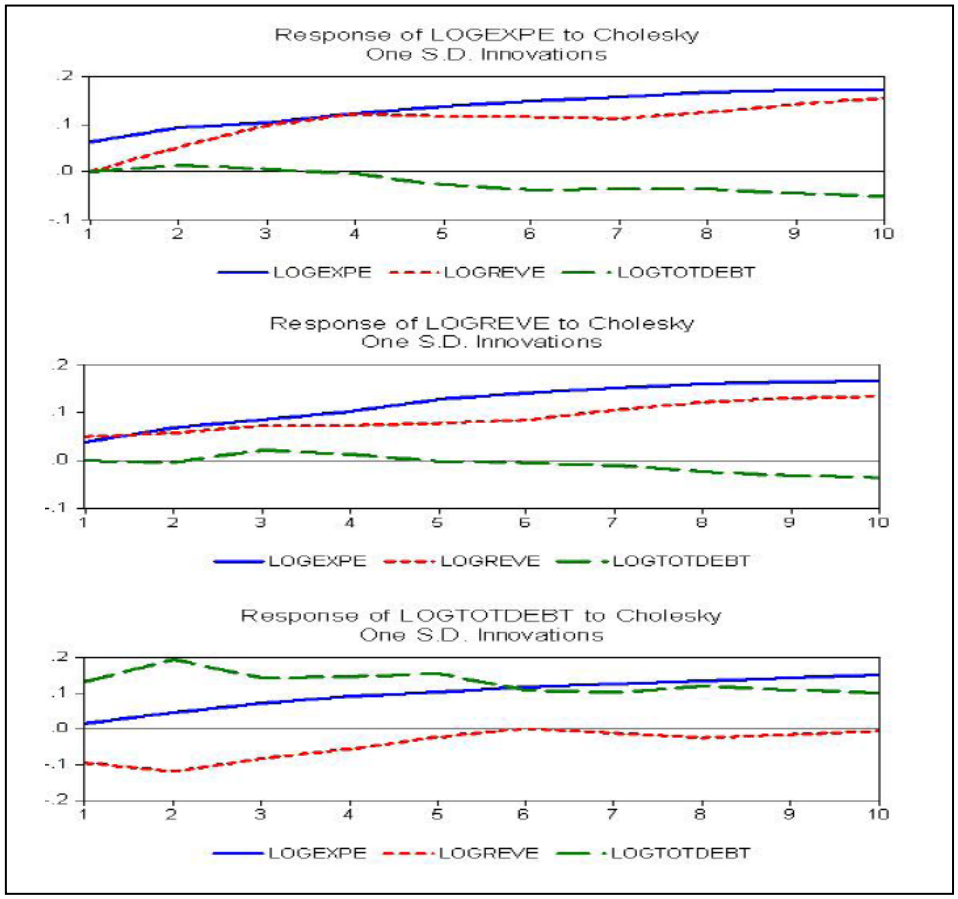
$$d_t = 5.3514 g_t - 6.2267 t_t$$
$$(1.0813) \quad (1.0676)$$

* Standard errors are included in ( ).

The impulse response analysis is useful to observe the response trajectory of variables of models when they are affected by exogenous disturbance factors. In the previous chapter, it is confirmed that Korea's financial status is sound, but no explanation is made on what mutual interaction occurs among fiscal variables. For better understanding of fiscal soundness, it is important to review the response trajectory shown by these variables in the face of exogenous disturbance factors. Figure 6 shows impulse responses and long-term equilibrium dynamics of debt, expenditure, and revenue in the arrival of each shock. The top, middle, and bottom panels illustrate the response of expenditure, revenue, and debt to one standard deviation shock of expenditure, revenues, and debt. Through a temporary rise in each shock, fiscal variables converge toward a new long-term equilibrium relation. One interesting finding from this exercise is the response of debt to a revenue shock. The debt decreases upon the arrival of a revenue shock. However, it tends to increase toward

0 as time passes. This is due to the fact that higher revenue triggers government spending. A favorable revenue shock is offset by an increase in expenditure, and after 10 years, these effects are balanced out. Based on this finding, the fiscal authority seems to be ready to spend any extra income rather than to retire outstanding debts.

[Figure 6] Impulse Responses



Note: LOGEXPE denotes log expenditure, LOGREVE log revenue, and LOGTOTDEBT log debt.

IV. FISCAL DEBT AND POPULATION AGEING

So far, we tried to assess the sustainability of fiscal policies in the past. However, the fiscal soundness of the past does not warrant the fiscal soundness of the future. There are many dormant problems, threatening

fiscal soundness in the future. One of the most serious risks lies in social welfare spending. They represent a major fiscal burden on the fiscal soundness of Korea. Especially, the public pension system has many problems due to generous benefits compared to beneficiaries' contributions, implying that the pension reserve will dry up in a foreseeable future.

Combined with the ever-growing ageing population, this problem will become more serious. According to the National Statistics Office, the aged population, 65 year olds and above, in Korea stood at 7 per cent of total population in 2000, but this population is projected to reach 15 per cent by 2019 and 20 per cent by 2025. The current trend of population ageing will raise expenditure demands for pension and medical spending. It will be reasonable to recognize that the demand for welfare expenditure, which began to emerge these days, will persist in upcoming years.

In this section, we will attempt to project the evolution of future public debt. In order to study the long run projections of public debt, Equation (4) is iterated forward h-period to derive h-period ahead debt-to-GDP ratio. The lower cases imply variables expressed as shares of GDP. Let d_{T+h} be the n-th year ahead projection of debt-to-GDP ratio at time T, then the formula for d_{t+h} can be written as:

$$d_{T+h} = \prod_{i=0}^{h-1}\left(\frac{1+r_{T+i}}{1+y_{T+i}}\right)d_T - \sum_{j=0}^{h-1} Q_{T+h-j}\, s_{T+h-j} \tag{19}$$

where $Q_{T+h-j} = \frac{1+r_{T+h-1}}{1+y_{T+h-1}} \ldots \frac{1+r_{T+h-j}}{1+y_{T+h-j}}$ and $Q_{T+h} = 1$. In the following, we will discuss how the future development of the pension balance affects the overall picture of fiscal standing.[9]

4.1 Estimates of Welfare Spending

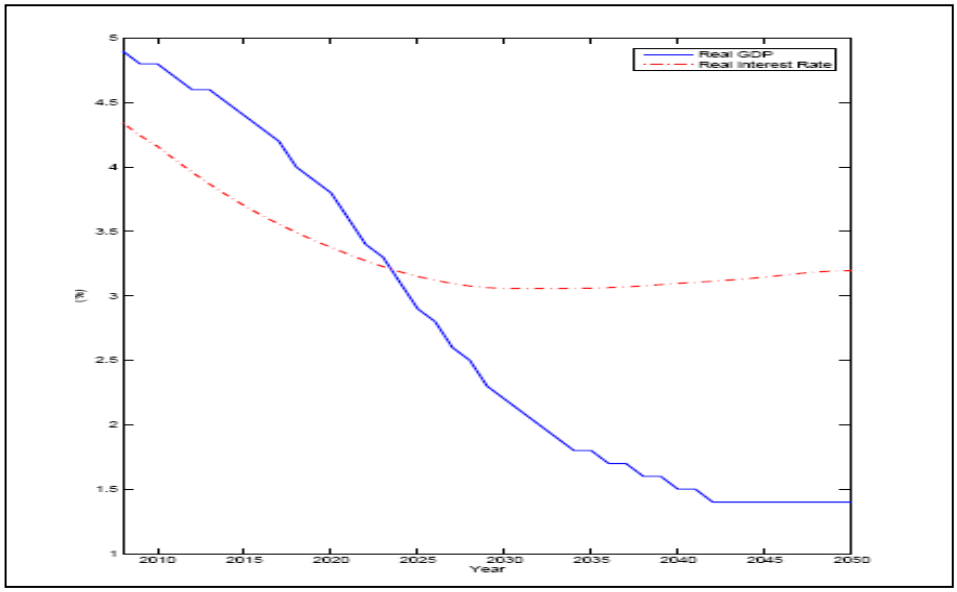
To evaluate the effects of welfare spending on debt-to-GDP ratio, we

[9] I am grateful to Dr. Hyungpyo Moon for generously providing projections on future balances of pensions, such as the national, civil employers' and private teachers' pension.

need a projection on real GDP growth and real interest rate. There are a variety of methods to estimate future GDP growth and interest rate. Here, we apply production function approach as suggested by Hahn et al. (2007).[10]

Figure 7 illustrates the projections of real GDP growth and real interest rate up to 2050. Lower fertility leads to the reduction in the population of those who are economically active, attributing the decline in real GDP growth. Also, reduced labor input lowers marginal productivity of capital, and real interest rate will decline accordingly. However, one will notice the real interest rate tends to hit the bottom and slightly bounce back around 2030. This can be ascribed to the lower capital stock. Increase in old-aged people will contract the national savings rate as they enter the stage of dissaving and decumulated their assets, resulting in the decrease in capital accumulation. Reduction in capital stock increases the marginal productivity of capital. Hence, we observe the slight bounce-back of real interest rate around 2030 because the effect of cut-back in capital overrides that of lessening labor forces.

[Figure 7] Projections on Real GDP Growth and Real Interest Rate



[10] A detailed description of this approach is not provided in this manuscript. Interested readers are referred to Hahn et al. (2007).

The projections on pension balances are presented in Figure 8. Population ageing will increase the spending on pensions and medical and healthcare. Healthcare spending at time t are estimated with the following manner:

$$H(t) = \sum_{a,s} h(a,s,t)N(a,s,t) \tag{20}$$

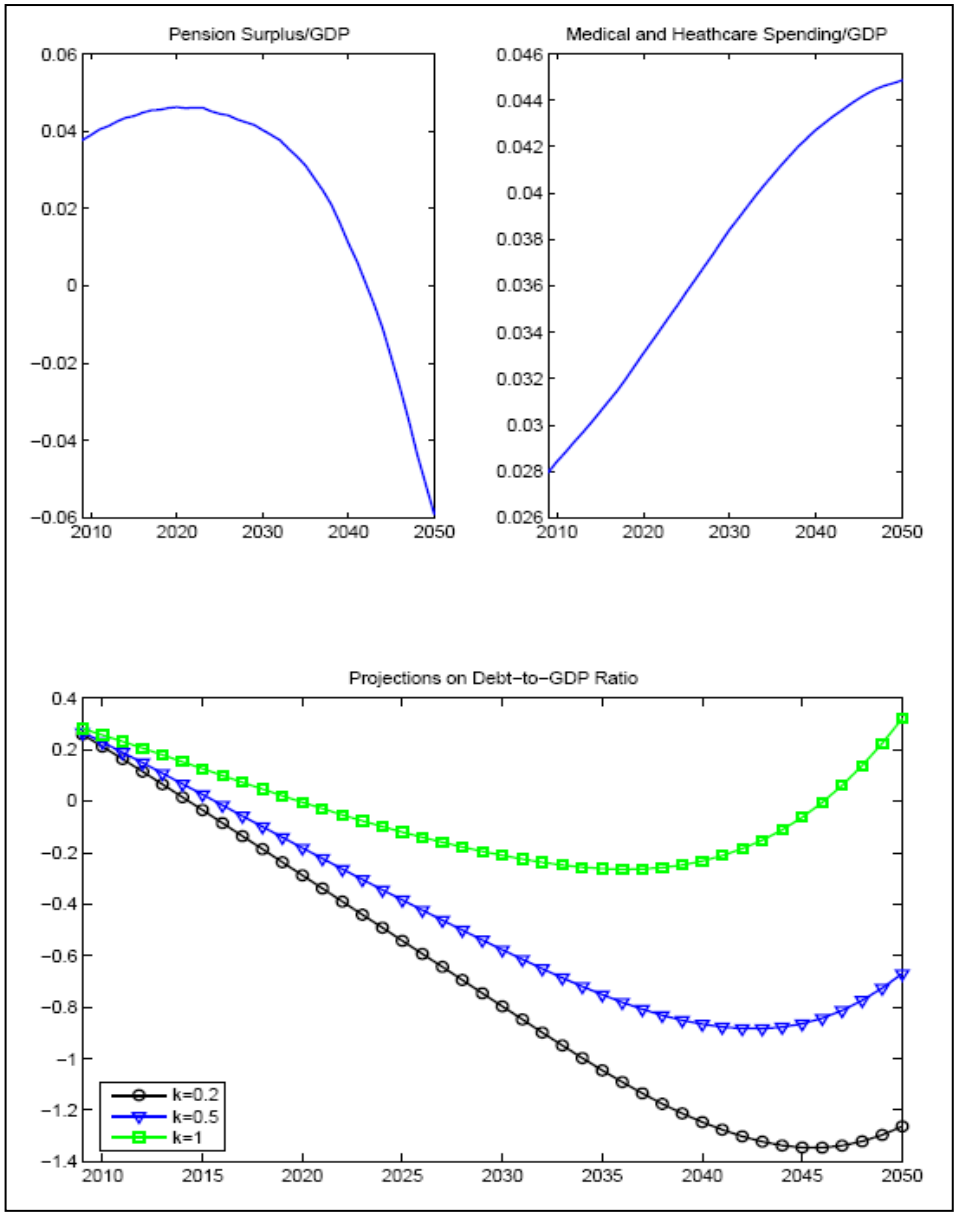
where a and s denote age and sex, respectively. $h(a,s,t)$ implies per capita healthcare spending for age a and gender s at time t and $N(a,s,t)$ is the number of population of that age-sex group at time t. $N(a,s,t)$ is reported by the National Statistical Office and publicly available. Our estimates on medical and healthcare spending are computed on the assumption that per capita medical spending will grow at the same rate as per capita GDP growth, as suggested in OECD (2001). Fiscal contribution to healthcare spending is assumed to be proportional to the total healthcare spending, i.e.,

Fiscal contribution at time $t = kH(t)$.

Adjusting k, we can track the contributions of government to healthcare spending.

Figure 8 illustrates the welfare spending estimates and debt-to-GDP ratios up to 2050. To evaluate the contributions of social spending to debt-to-GDP ratio, fiscal balances, except welfare spending, are set to 0 at all times. Hence, the accumulation of public debt is solely contributed by welfare spending. We provide three scenarios with k 0.2, 0.5, and 1. The figure shows that welfare spending will not be an imminent danger to debt-to-GDP ratio for the next 30 years. This is mainly due to huge surpluses from the national pension. The national pension balance is expected to produce surpluses until 2046 and then it will begin to build up deficits rapidly. Fiscal contributions to healthcare spending affect the turning point of decreasing to increasing debt-to-GDP ratio. Turing years are 2047 ($k = 0.2$), 2045 ($k = 0.5$), and 2039 ($k = 0.1$). Fiscal contributions seem to affect the level of debt-to-GDP rather than turning

[Figure 8] Projections on Debt-to-GDP Ratio



points of the trends. Even with the increasing health spending, huge reserves and surpluses in the national pension will help contain the rising of debt-to-GDP ratio. Hence, welfare spending alone will not disturb fiscal soundness for the time being. If one wants to find near- and medium-term risks of uncontrollable increase in debt-to-GDP ratio, (s)he

should turn to other sources such as public funds to save the financial and corporate sectors from the debris of the U.S. subprime mortgage which is still unfolding of this writing. However, one should not be mistaken that the welfare spending will not have a detrimental effect on the longer-run stability of fiscal standings. As is illustrated in Figure 8, welfare spending will affect debt-to-GDP ratio adversely as soon as the buffer role of the national pension draws to an end in 2047. One of the major issues to insulate the fiscal soundness from the ever-increasing demands for welfare spending is to find a solution to extend and strengthen the buffer role of national pension.

V. CONCLUSION

Fiscal soundness is a prerequisite in sustaining macroeconomic stability. Prolonged fiscal deficit and increasing government debt deteriorate gross savings. This could be adjusted by the decrease in investment and/or the current account deficit, which will hinder the sustainable economic growth in the future.

Korea's fiscal status has remained relatively stable but is foreshadowed by increased debt since the financial crisis in 1997, decreased revenue brought by lowered growth, and ever-increasing demand for government spending to cover national pension and healthcare services for the ageing population and other welfare expenses.

We study various aspects of public finance in terms of fiscal sustainability. In theoretical angle, fiscal sustainability is defined by largely two conditions: No-Ponzi Game condition and the debt ratio against GDP converge toward equilibrium. Using these two conditions, whether fiscal policy of the past has been managed in a way to satisfy fiscal sustainability is examined. Empirical evidence suggests that Korea's finance has been maintained in a sustainable way from the perspective of both conditions. However, the sustainability in the past does not warrant that will hold water in the future

We also investigate the effect of welfare spending, induced by population ageing, on public debt-to-GDP ratio. Unarguably, population ageing is one of the most important risk factors in the long-run stability of fiscal standing. We find that the Korean fiscal position has been managed

in a way to achieve fiscal soundness and stability. Also, near- and medium-term fiscal soundness will not be disrupted by welfare spending due to huge reserves and surpluses produced by the national pension. However, as those surpluses draw to an end by 2047, debt-to-GDP ratio will reverse its course to an increasing trend, inflicting longer-term fiscal soundness. Considering these risk factors, constant review on fiscal sustainability should be implemented and reinforced.

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