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New Methods for Testing the Sustainability of Government Debt

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Abstract

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New Methods for Testing the Sustainability of Government Debt[1]

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Abstract

Recently, several countries, which include not only developing, but also developed ones, face the severe sovereign crisis. In this circumstance, we introduce the new method for testing the sustainability of government debt. Previous studies which investigate the sustainability of government debt satisfies or not to test the Transversality condition of government debt. But, these studies are criticized by Bohn (1998, 2008) as "ad-hoc" sustainability, because the situation which satisfies transversality condition (in other words, the intertemporal government budget constraint is bind) is merely chance. Bohn (1998, 2008) suggest the sufficiency condition which satisfies the sustainability of government debt if the debt stabilization rule of government debt and primary surplus is satisfied. But, we do not know whether the government debt is really sustainable, at least in view of "Locally Ricardian" which Woodford suggests. Therefore we connect these discussions to apply the covariate augmented Dickey-Fuller (CADF) test to the government debt, and check whether the government debt is unit root or not using U.S data. Moreover, we apply the estimation method Hamilton and Flavin (1986) with covariates to check whether "Globally Ricardian" is really satisfied. In our results, U.S cannot obtain the sustainability at all time, even if the policy stabilization rule á la Bohn (1998, 2008) is satisfied. We show the sustainability rule is not sufficient condition empirically. On the other hand, "Globally Ricardian" is satisfied, and then the result is consistent with Woodford (1995, 1998).

Key Words: the sustainability of government debt, unit root test with covariate.
JEL classification codes: E62, H62, H63.

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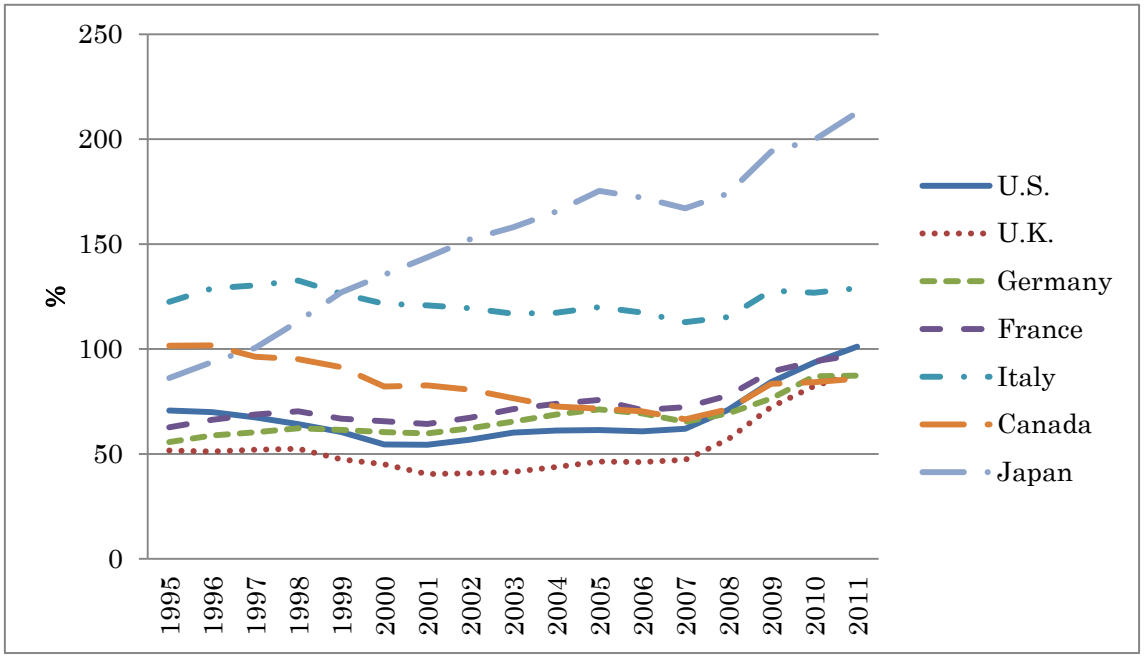
1. Introduction

After September 11 2008 (i.e. Lehman shock), many countries deal with the economic recession to use additive fiscal stimulus. For example, the U.S. Congress passed several fiscal stimulus bills, including the $787 billion American Recovery and Reinvestment Act (ARRA) of 2009. At the same time, this act induced the concern about government deficit sustainability. Actually, President Obama pledged to cut the federal deficit in half by 2013 (Calmes, 2009). On the other hand, Greece crisis made the consciousness about sovereign crises to many countries. The Maastricht criteria for entry into EURO put a ceiling on the overall deficit and debt in order for them to be considered acceptable and sustainable. But, Greece government varnished true deficit to satisfy this criteria, and then crisis arose when Greek Prime Minister Papandreou revealed previous regime's window-dressing settlement in 2010. Represented by Greece, several countries face sovereign crisis (especially, PIIGS (Portugal, Ireland, Italy, Greece and Spain) and Japan are serious). Moreover, recent U.S. government deficit faces the severe situation. Recently, the U.S. government debt faced the debt ceiling crisis, which debated in a U.S. congress about increasing the debt ceiling, and Standard & Poor's credit rating agency downgraded the long-term credit rating of the United States government for the first time in its history, from AAA to AA+. In these situations, interest and concern about government debt is increasing day by day. Figure 1 and Figure 2 show that these developing countries face the severe sovereign problem. Therefore, needless to say, U.S fiscal deficit problem is one of the most important issues in current policy agendas.

This paper introduces two new methods for testing the sustainability of government debt. Our models are better method than former literatures in terms of several economic and statistics points. Moreover, we can connect these methods to discussion of Woodford (1995, 1998)'s "Locally" and "Globally" Ricardian which explain the sustainability of the government debt. That is, our models also investigate the conditions of two Ricardian to connect the fiscal stabilization rule and previous tests about the sustainability of the government debt. Therefore, we can obtain more reliable test of the sustainability of the government debt.

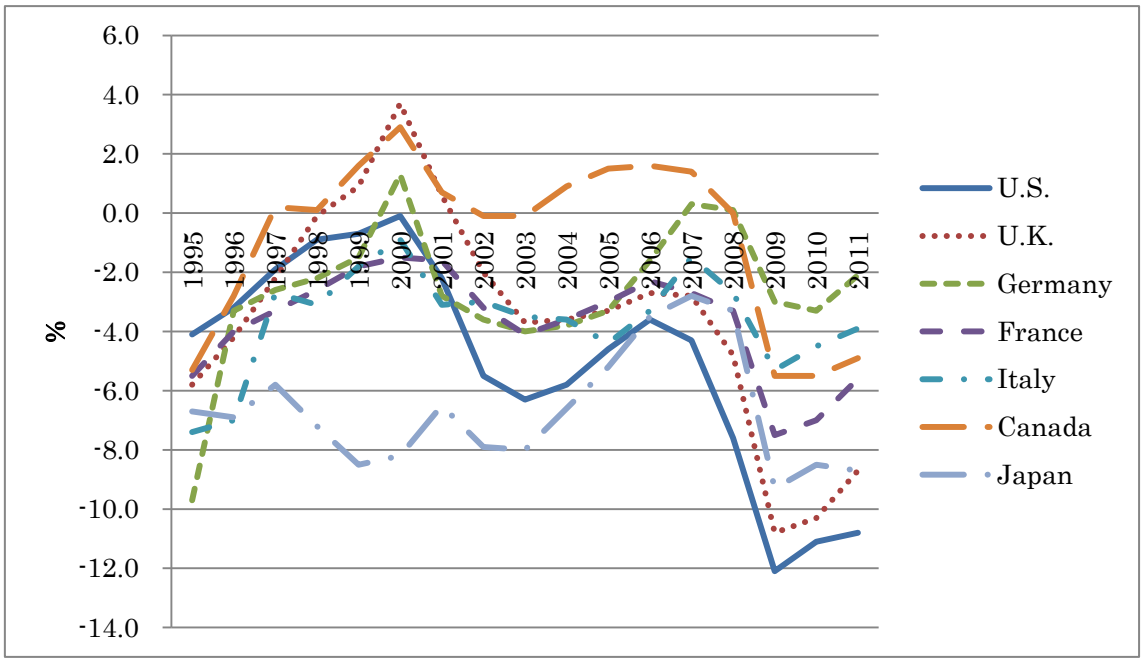
The outline of the paper is as follows. Section 2 reviews the literatures of the sustainability of government debt. Section 3 describes econometric model and Section 4 shows the results. Section 5 states conclusion.

Figure1: Gross government debt per GDP in G7 countries.



Source: OECE "Economic Outlook 89"

Figure2: Primary surplus per GDP in G7 countries.



Source: OECE "Economic Outlook 89"

2. The Related Literatures about fiscal sustainability

There are a lot of papers about the sustainability of government debt. We introduce several of them in this section.

2.1. Testing the No-Ponzi Game condition

First, Hamilton and Flavin (1986) suggests the test for whether the intertemporal government budget constraint or not. The intertemporal government budget constraint means that current government debt equals to the present value of primary surplus. Explaining this feature using the following government budget constraint:

$$\begin{aligned} & B_{t+1} = (1+r)B_t - PS_t \\ & \Leftrightarrow B_t = \frac{1}{1+r}(PS_t + B_{t+1}) \\ & \Leftrightarrow B_t = \frac{1}{1+r}PS_t + \frac{1}{1+r}(PS_{t+1} + B_{t+2}) \\ & \vdots \\ & \Leftrightarrow B_t = \sum_{i=0}^{\infty}\frac{PS_{t+i}}{(1+r)^{i+1}} + \lim_{i\to\infty}\frac{B_{t+i}}{(1+r)^i} \end{aligned} \tag{1}$$

Eq. (1) shows the intertemporal government constraint, and it holds if the following condition:

$$\lim_{i\to\infty}\frac{B_{t+i}}{(1+r)^i} = 0. \tag{2}$$

Hamilton and Flavin (1986) tests whether Eq. (2) satisfies or not using two methods. First, Hamilton and Flavin (1986) check above condition using Augmented Dickey-Fuller test as a unit root test to the government debt. Second, Hamilton and Flavin (1986) check it to apply the test for bubble, such as Flood and Garber (1978). Concretely, Hamilton and Flavin (1986) test the following equation:

$$B_t = c_0 + A_0(1+r)^t + c_1 B_{t-1} + \cdots + c_p B_{t-p} + d_0 PS_t + d_1 PS_{t-1} + \cdots + d_{p-1} PS_{t-p+1} + \varepsilon_t. \tag{3}$$

where A_0 (>0) is the value of the alternative hypothesis to the null hypothesis which Eq. (2) is satisfied. That is, the alternative hypothesis is that Eq. (2) is not satisfied Eq. (2), but is equal to A_0 which is positive 'bubble-term'. As for r, Hamilton and Flavin (1986) use the average value of real bond interest rate. As related literatures, Wilcox (1989) checks the sustainability of government debt using the similar test except for using the actual interest rate instead of average one, and Blanchard et al (1990) check it to test this concept to apply the sustainability of the government debt per GDP[2].

[2] To check the Eq. (2) in per GDP term, we arrange the transversality condition to the

2.2. Bohn (1998, 2008)'s Fiscal Rule

Bohn (1998, 2008) criticizes the tests of Hamilton and Flavin (1986) as a 'ad-hoc' sustainability. That is, he claims that their condition does not involve the rule which the government stabilizes the government debt and actually the government do not decide the fiscal activities taking care of Eq. (2). Bohn (1998, 2008) suggests the necessarily condition for the government debt in the following equations:

$$\lim_{n\to\infty} E_t\left[u_{t,n} b_{t+n}\right] = 0, \tag{4}$$

where $u_{t,n}$ the stochastic discount factor from period t to infinite-forward period, and b is the government debt per GDP. And Bohn (1998, 2008) set the rule

$$\frac{PS_t}{Y_t} = \phi \frac{B_t}{Y_t} + \mu_t, \tag{5}$$

where Y_t is the output (or GDP) and μ_t is constant term and the other stationary components, such as YVAR and GVAR defined by Barro (1986)[3].

Bohn (1998) shows that it is sufficient condition of the government debt sustainability if $\phi > 0$ is statistically significant. There are several researches satisfy the Bohn (1998)'s condition, involving Bohn (1998) itself.

This paper examines whether the Bohn (1998)'s fiscal stabilization rule is really sufficient condition of government debt sustainability. Bohn (1998) proves the sufficient condition of government debt sustainability in the stochastic exchange economy á la Lucas (1973). In his assumption, Eq. (5) is certainly sufficient condition. But, relaxed this assumption, it is not necessarily sufficient condition shown by Hiraga (2011), which clarifies Eq. (5) is not sufficient condition of the government debt sustainability in overlapped generations model. In Hiraga (2011) model, decreasing the capital stock increases the interest rate, then there is a case where the more interest payment is unable to sustain the government debt, even if the government has a stabilization rule.

2.3. Woodford's Two "Ricardian"

Before we discuss about model, we need to arrange the above discussion using

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following form: $\lim_{i\to\infty} \frac{(1+g)^i B_{t+i}}{(1+r)^i Y_{t+i}} = 0.$

[3] $GVAR_t = \frac{G_t - G_t^*}{Y_t}$, $YVAR_t = \left(1 - \frac{Y_t}{Y_t^*}\right)\frac{G_t^*}{Y_t}$, where G_t is the government consumption, Y_t^*, G_t^* are the trend components of output and real government consumption.

Woodford (1995, 1998)'s two "Ricardian," that is, "Locally" and "Globally" Ricardian policies[4].

To understand these policies, we set the following policy:

$$PS_t = \lambda_t B_t + \nu_t \tag{6}$$

Where λ_t is a time-varying parameter satisfying $0 < \lambda_t \leq 1$, which represents the government's responsiveness to change in government debt and resembles to the Bohn (1998)'s rule.

By substituting (6) to (1),

$$B_{t+1} = (1 + r - \lambda_t)B_t - \nu_t \tag{7}$$

If λ >r, locally Ricardian is satisfied. That is, locally Ricardian means that government debt converge to zero (or finite value if Eq. (6) contains constant term) and the present value of government debt represented by Eq. (2) is also zero. Then, the government debt is sustainable when locally Ricardian is satisfied. On the other hand, globally Ricardian is satisfied if $0 < \lambda_t \leq r$. "Globally Ricardian" means that the growth rate of government debt is smaller than the interest rate, and the present value of the government debt converge to zero. Therefore, the government debt is sustainable following to the definition of Eq. (2), even if the government debt process explodes. Figure 1 and 2 show the images of two Ricardian.

We investigate whether "Locally Ricardian" and "Globally Ricardian" are satisfied in following section:

[4] For simplicity, we omit money and price level, and discuss about the level of government debt and primary surplus.

Figure 1: The image of "Locally Ricardian"

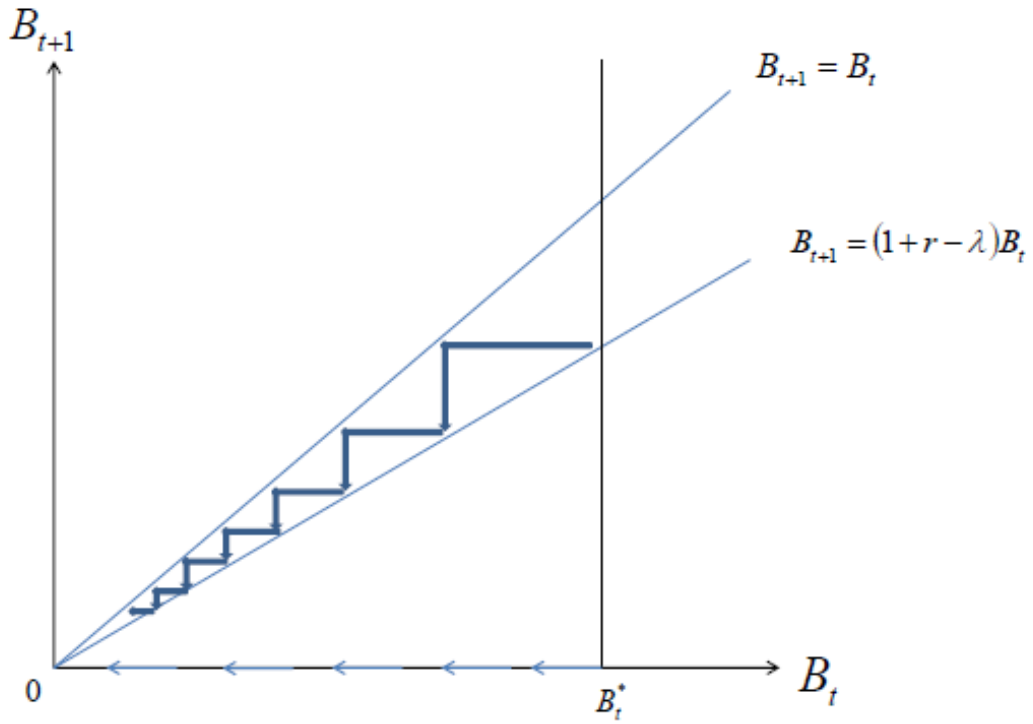
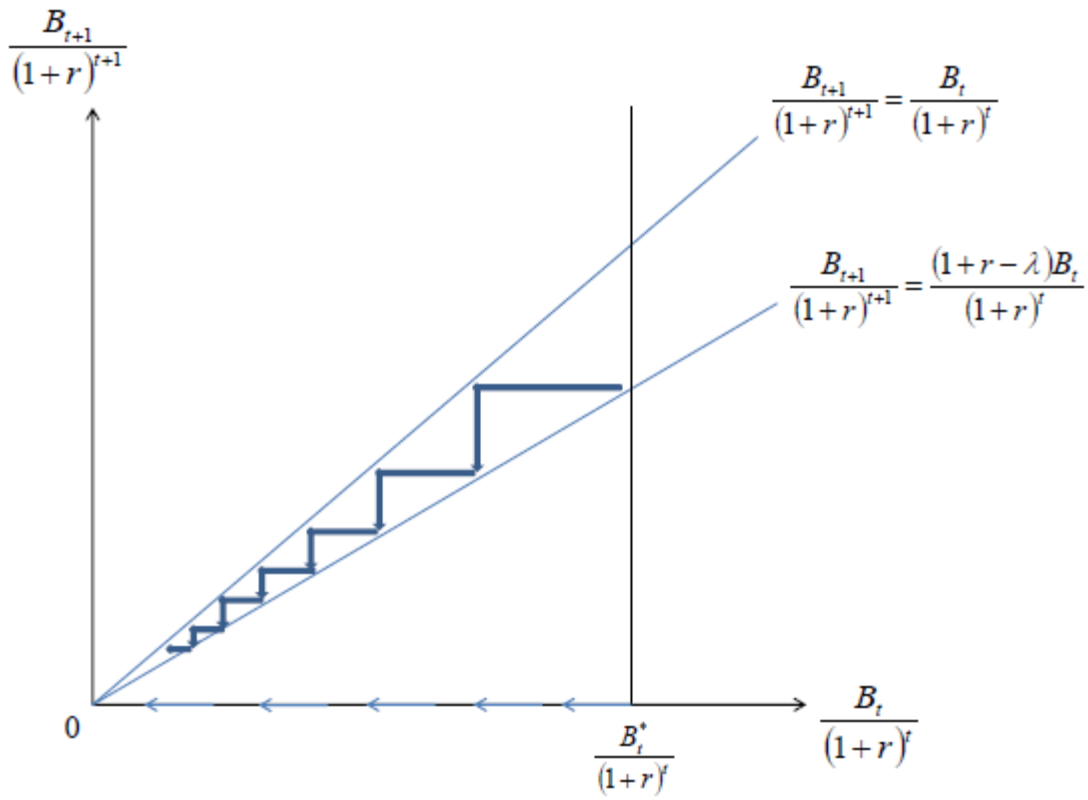


Figure 2: The image of "Globally Ricardian"



3. Two Econometric Models

We suggest two econometric models which check above two "Ricardian".

3.1. CADF test

We apply the Covariate Augmented Dickey-Fuller (CADF) test to check the locally Ricardian, suggested by Hansen (1995). Hansen (1995) suggests the CADF test the following equations:

$$a(L)\Delta x_t = \delta x_t + \upsilon_t, \tag{8}$$

where x_t is the stochastic variable and $a(L) = 1 - a_1 L - a_2 L^2 - \cdots - a_p L^p$ is a p-th order polynomial in the lag operator and:

$$v_t = b(L)'\Delta z_t + e_t. \tag{9}$$

where z_t the m-vector stationary and covariate variables to x_t and $b(L) = b_0 + b_1 L - b_2 L^2 - \cdots -_q L^q$ is a q-th order polynomial in the lag operator. It can be shown that the error variance of Eq. (7) will be lower than in the usual ADF test. This suggests that δ can be estimated more precisely in the context of combining Eq. (1) and (2), and that the t-test for the hypothesis H_0: $\delta = 0$ will have more power[5]. The power gains are a function of the extent to which the regressors Δz_t is given by the following squared correlation coefficient between v_t and e_t:

$$\rho = \frac{\sigma_{ve}^{w}}{\sigma_v^2 \sigma_e^2}. \tag{10}$$

When the regressors Δz_t explain nearly all the zero-frequency movement in v_t, then $\rho^2 = 0$, whereas if they have no explanatory power, $\rho^2 = 1$.

Hansen (1995) shows that the asymptotic distribution of the t-statistic $t(\hat{\delta}) = \frac{\hat{\delta}}{s(\hat{\delta})}$, under the null hypothesis $\delta = 0$, is a convex mixture of the standard normal and the

[5] Elliott and Jansson (2003) and Fossati (2011) also show that the CADF test can obtain very large power.

Dickey-Fuller (DF) distribution, with the weights determined by the nuisance parameter ρ [2]:

$$t(\hat{\delta}) = \rho \cdot DF + (1-\rho^2)^{\frac{1}{2}} N(0,1). \tag{11}$$

We apply the above relation to connect Eq. (1) and (5) translating the per GDP values. Therefore, we check whether the following unit root test with covariates:

$$a(L)\Delta\left(\frac{B_{t+1}}{Y_{t+1}}\right) = \frac{B_t}{Y_t} + b(L)\Delta\mu_t + \eta_t, \tag{12}$$

where η is white noise. We use $\Delta\mu_t$ are the difference in YVAR and GVAR to sustain the consistency with the CADF test[6]. Some readers seem not to be consistent with the government budget constraint with fiscal rule, but we adjust lag's difference of government debt per GDP's terms. We can see that Eq. (12) checks the "Locally Ricardian".

3.2. Generalized Flood-Garber test with Covariates

To investigate whether the "Globally Ricardian" is satisfied, we apply the generalized Flood-Garber test suggested by Hamilton and Flavin (1986) with covariates. We employ the Blanchard et al (1990) and Uctum and Wickens (1997) type estimation in the following form:

$$\begin{aligned} \frac{B_t}{Y_t} &= c_0 + A_0(1+r)^t + c_1\frac{B_{t-1}}{Y_{t-1}} + \cdots + c_p\frac{B_{t-p}}{Y_{t-p}} \\ &+ d_0\frac{PS_t}{Y_t} + d_1\frac{PS_{t-1}}{Y_{t-1}} + \cdots + d_{p-1}\frac{PS_{t-p+1}}{Y_{t-p+1}} + \varepsilon_t. \end{aligned} \tag{13}$$

where r equals to the interest rate minus the growth rate[7].

Substituting Eq. (5) to Eq. (13), we can obtain the following equation:

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[6] As other applying examples, we show Amara and Pappel (2006), Lee and Tsong (2009)

[7] This relation is shown the following form:

$$\frac{B_t}{Y_t} = \sum_{i=0}^{\infty}(1+r)^{-i}\frac{PS_{t+i}}{Y_{t+i}} + \lim_{i\to\infty}(1+r)^{-i}\frac{B_{t+i}}{Y_{t+i}}$$

$$\Leftrightarrow \frac{B_t}{Y_t} = \sum_{i=0}^{\infty}(1+r)^{-i}\frac{PS_{t+i}}{Y_{t+i}} + A_0(1+r)^{-i}$$

To adjust the serial correlation and primary surplus per GDP is defined by the past government debt, we can rewrite above equation to Eq. (13).

$$\frac{B_t}{Y_t} = \kappa_0 + \theta_0 (1+r)^t + \kappa_1 \frac{B_{t-1}}{Y_{t-1}} + \cdots + \kappa_p \frac{B_{t-p}}{Y_{t-p}} + \psi_0 \mu_t + \psi_1 \mu_{t-1} + \cdots + \psi_{p-1} \mu_{t-p+1} + \varepsilon_t . \tag{14}$$

Therefore, we estimate Eq. (14) and check the null hypothesis H_0: $\theta_0=0$. Table 3 shows the result of estimating Eq. (14).

4. The Empirical Results

We estimate the above equations using Bohn (2010)'s data[8] which contains the U.S. annual data with respect to government (revenue, primary surplus (with and without interest payment)) and output from 1929 to 2009 and NIPA's data to make the values of YVAR and GVAR. We calculate YVAR and GVAR using Hodrick and Prescott filter (called YVAR1 and GVAR1) and Baxter and King (1997)'s band pass filter (called YVAR2 and GVAR2).

4.1. Re-estimation of Stabilization Rule

Before we estimate CADF test, we would like to check whether Bohn (1998, 2008)'s condition is satisfied or not. Table 1 shows the estimation results of Bohn (1998, 2008) using our data[9]. In our results, the Bohn (1998, 2008)'s linear fiscal stabilization rules are satisfied using both YVAR and GVAR. Then, we obtain sufficient condition of satisfying Eq. (2), and use YVAR and GVAR to Eq. (12) as covariates because these variables are both significant.

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[8] This data is available from his homepage (http://www.econ.ucsb.edu/~bohn/morepapers.html). And we derive interest rate as follow in Bohn's data: (primary surplus included interest payment at period *t*− primary surplus excluded interest payment at period *t*)/(government debt at period *t-1*).

[9] We use the maximum likelihood method to treat the serial correlation problem.

Table 1: The Estimation results a la Bohn (1998, 2008)

Dependent variable: Primary surplus per GDP

Variables	Coefficient of (1)	t-value of (1)	Coefficient of (2)	t-value of (2)
B/Y	0.0743	4.795***	0.0632	3.283***
YVAR1	3.4467	7.208***		
GVAR1	1.3356	10.416***		
YVAR2			3.58	3.669***
GVAR2			1.295	4.912***
Constant	-0.02164	-2.891***	-0.019	-2.054**
$\overline{R}^2$	0.782		0.711	

Note:

The estimation number (1) is using YVAR1 and GVAR1.

The estimation number (2) is using YVAR2 and GVAR2.

*: 10%, **:5% and ***:1% significant

4.2.The CADF test

Next, we test the sustainability of the government debt using the CADF test shown in Eq. (9). We accept the lag operators p=1 and q=0 evaluating AIC. Table 2 shows the result of CADF tests. The critical values for CADF t-statistics of 5% are -2.99 when ρ =0.491 and -3.18 when ρ =0.704, and then the null hypotheses are satisfied in both estimations. Moreover, the average interest rate of the government debt (r=0.051) is smaller than both ϕ .That is, this results show that the sustainability of the government debt is not always satisfied even if the situation which "Globally Ricardian" is satisfied. For example, the point X in Figure 1 is not the unsustainable case even if the Bohn (1998, 2008)'s rule holds shown in Hiraga (2011). Hiraga (2011) analyzes the fiscal rule in overlapped generations model and Ricardian is show that the government debt may not converge to steady state even if initial interest rate is smaller than ϕ which means that Locally Ricardian is satisfied. Therefore, we confirm that the sufficiency of the sustainability is not obvious.

Table 2: The CADF test of the sustainability of the government debt

Variables	Coefficient of (1)	t-value of (1)	Coefficient of (2)	t-value of (2)
B/Y	-0.0421	-1.970	-0.0569	-2.55
⊿(B/Y)	0.8103	11.093***	0.764	10.014
⊿(YVAR1)	3.6893	4.757***		
⊿(GVAR1)	1.425	6.504***		
⊿(YVAR2)			4.2175	3.806***
⊿(GVAR2)			1.504	5.299***
Constant	0.0205	2.015*	0.0259	2.381**
$\overline{R}^2$	0.644		0.598	
ρ	0.491		0.704	

Note:

The estimation number (1) is using YVAR1 and GVAR1.

The estimation number (2) is using YVAR2 and GVAR2.

*: 10%, **:5% and ***:1% significant

4.3. Generalized Flood Garber test with Covariates

We employ p=2 using AIC and the average interest data. Table 3 shows that we cannot obtain the consistency of these results. We can see that these results are inconsistent with the former ones. To check the robustness, we re-estimate the following equation:

$$\begin{aligned}\frac{B_t}{Y_t} &= \kappa_0 + \theta_0 \prod_{i=0}^{t} \left(1 + r_{t-i}\right)^i + \kappa_1 \frac{B_{t-1}}{Y_{t-1}} + \cdots + \kappa_p \frac{B_{t-p}}{Y_{t-p}} \\ &+ \psi_0 \mu_t + \psi_1 \mu_{t-1} + \cdots + \psi_{p-1} \mu_{t-p+1} + \varepsilon_t .\end{aligned} \tag{15}$$

Table 3 and 4 show that we nor can obtain the consistency of these results. That is, coefficient of interest rate are not significant, and then the government debt is sustainable in terms of “Globally Ricardian”.

To summarize this section, “Locally Ricardian” is not satisfied but, “Globally Ricardian” is satisfied and the U.S. government policy is sustainable in terms of satisfying Eq. (2). We may also interpret these results that these economies do not ride equilibrium path to the steady state shown in Hiraga (2011) even if the Eq. (2) is satisfied.

Table 3: The generalized Flood-Garber test with covariates (interest rate is constant (using average interest rate)).

Variables	Coefficient of (1)	t-value of (1)	Coefficient of (2)	t-value of (2)
Interest Rate	0.0274	0.9276	0.0648	1.7081*
B(-1)/Y(-1)	1.4746	13.42236***	1.5106	14.8615***
B(-2)/Y(-2)	-0.0517	-4.7226***	-0.5825	-5.7492***
YVAR1	4.0062	4.6912***		
GVAR1	1.6187	7.0834***		
YVAR1(-1)	-2.1982	-2.4221**		
GVAR1(-1)	-0.7288	-2.5204**		
YVAR2			3.8534	2.8899***
GVAR2			1.766	4.9003***
YVAR2(-1)			-2.326	-1.5125
GVAR2(-1)			-0.7213	-1.7295*
Constant	0.0024	0.1255	-0.0132	-0.5974
$\overline{R}^2$	0.975		0.967	

Note:

The estimation number (1) is using YVAR1 and GVAR1.

The estimation number (2) is using YVAR2 and GVAR2.

*: 10%, **:5% and ***:1% significant

Table 4: The generalized Flood-Garber test with covariates (interest rate varies (using each period's interest rate)).

Variables	Coefficient of (1)	t-value of (1)	Coefficient of (2)	t-value of (2)
Interest Rate	0.0131	1.284	0.0159	1.2793
B(-1)/Y(-1)	1.4432	13.02***	1.5135	14.5559***
B(-2)/Y(-2)	-0.4822	-4.3455***	-0.5675	-5.4446***
YVAR1	3.6664	4.1751***		
GVAR1	1.6014	7.1598***		
YVAR1(-1)	-2.1798	-2.4328**		
GVAR1(-1)	-0.7076	-2.4777**		
YVAR2			3.892	2.8278***
GVAR2			1.8277	5.0816***
YVAR2(-1)			-2.2347	-1.4353
GVAR2(-1)			-0.729	-1.732*
Constant	0.0131	1.284	0.0181	1.5231
$\overline{R}^2$	0.971		0.967	

Note:

The estimation number (1) is using YVAR1 and GVAR1.

The estimation number (2) is using YVAR2 and GVAR2.

*: 10%, **:5% and ***:1% significant

5. Conclusion

This paper investigates whether the sustainability of the government debt is really satisfied or not, if the Bohn (1998, 2008)'s fiscal stabilization rule is satisfied. We obtain the results which the Bohn's condition is not necessarily sufficient condition of the sustainability of the government debt reinvestigating the unit root test and generalized Flood-Garber test with covariates, which are consistent with the fiscal rule in Bohn (1998, 2008). This result also inspires the discussion that the globally Ricardian in Woodford (1995, 1998) satisfies the sustainability of the government debt. On the other hand, weak stabilization policy cannot sustain the equilibrium, diverges the government debt and decreases consumption and capital stock. Therefore, we need to take care of not only the government debt, but also the path of consumption and capital stock when we discuss about the stabilization policy.

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