The Sustainability of External Debt in OECD Countries: Evidence from Quantile Autoregression

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Abstract

This paper will investigate the sustainability of external debt for 21 OECD countries. We modify the solvency condition in an open economy derived by Sawada (1994). The quantile autoregression (QAR) model is applied to test the stationary property of the net external surplus process. The empirical results show that at each quantitle, the net external surplus process is stationary for six countries. It reveals a unit root behavior for the US at each quantile. However, there is a varied behavior across different quantiles for 14 countries. It indicates the asymmetric dynamic behavior of the net external surplus process.

Keywords: external debt, sustainability, quantile autoregression model

1. Introduction

The rising government deficits and debt levels across the globe have become the headline and political debate. As Figure 1 shows, the general government net borrowing (Note 1) in the emerging and developing economies was 1.69% of GDP in 2000. After the financial crisis in 2008-2009, the general government net borrowing increased to 4.15% of GDP in 2009. On the other hand, in the advanced economies, the general government net borrowing-to-GDP ratio rose from 0.39% in 2000 to 9.46% by 2009. The ongoing fiscal support to stimulate the economy makes the budget deficits be expected to reach historical high in 2009-2010 in several countries. Governments begin to consider the problem of fiscal sustainability and prepare fiscal consolidation strategies for implementation from 2011. Though International Monetary Fund (IMF) estimates that the government net borrowing-to-GDP ratio may follow a descending path, the financial markets still have brought great concern on the reassessment of sovereign risk across the world.

The accumulation of large external debt is the by-product of government deficit. Because the higher external debt raises the risk of country solvency, the Brady announcement in March 1989 has worked out the debt reduction as a strategy to deal with this situation. The Heavily Indebted Poor Country (HIPC) Initiative was launched in 1996 and the debt relief to these poor countries is now supervised by the IMF and the World Bank. This may explain the descending trend in external debt-to-GDP ratio for the emerging market and developing economies as Figure 2 shows. Meanwhile, the debt surges were occurring in most advanced economies during the past decade. Figure 3 indicates the government external debt of the OECD countries (except New Zealand) at the fourth quarter of 2003 and the third quarter of 2013. The general government external debt-to- GDP ratio has increased 13% on average in OECD countries during this period. Moreover, the ratio has increased over 20% in Greece, Ireland, Portugal, France, Slovenia, Hungary, and United States. The danger of default resulted in the downgrading of government debt and caused the collapse of confidence in investment. The fiscal sustainability has been an important issue in the recent years.

To analyze the government solvency in an open economy, this paper will focus on the sustainability of external debt. Sawada (1994) develops an intertemporal budget constraint in an open economy and derives the solvency condition for international borrowing. The condition indicates that the external debt-to-GDP ratio remains finite for any sequence of finite net external surplus. As noted previously about the severe external debt burdens of advanced economies, we construct the series of net external surplus for 21 OECD countries to check whether these countries have external debt overhangs. Allowing for the multiple discrete regimes, this paper will apply a quantile autoregression (QAR) model developed by Koenker and Xiao (2004) to test the unit root at the different quantiles.

The QAR framework can provides us a methodology to investigate the non-linear behavior of external debt.

This rest of this paper is organized as follows. Section 2 reviews the relevant literature. The theoretical model and the econometric method are described in Section 3. Then we will present the empirical results in Section 4. The conclusions are in Section 5.

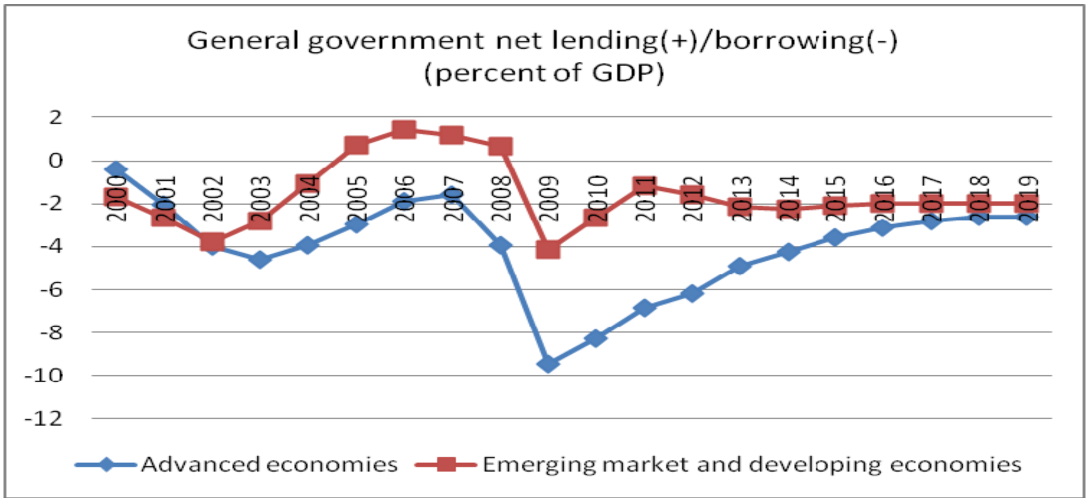


Figure 1. General government net lending (+) or borrowing (-)

Note: The value is estimated by IMF after 2014.

Source: International Monetary Fund, World Economic Outlook Database, April 2014.

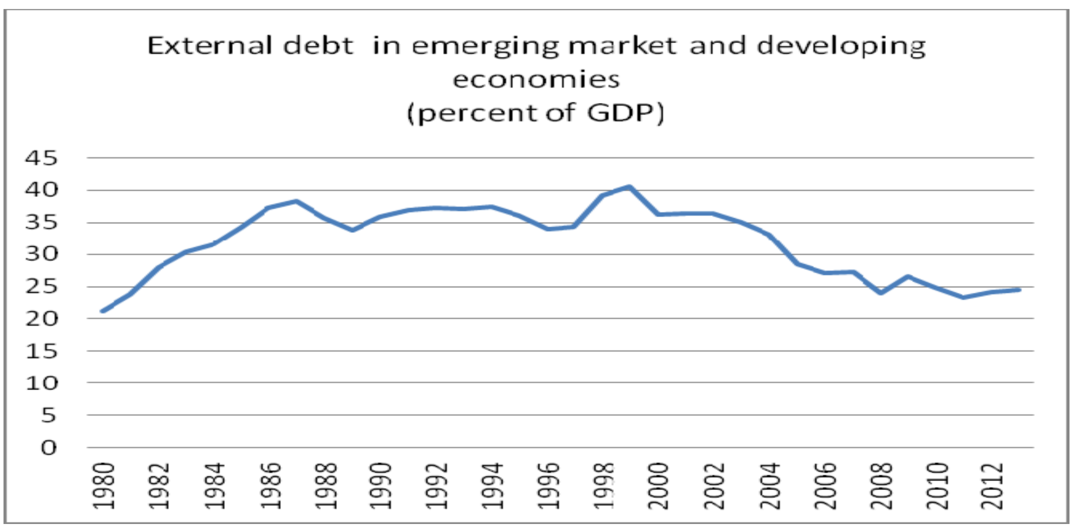


Figure 2. External debt- to- GDP ratio in emerging market and developing economies

Source: International Monetary Fund, World Economic Outlook Database, April 2014.

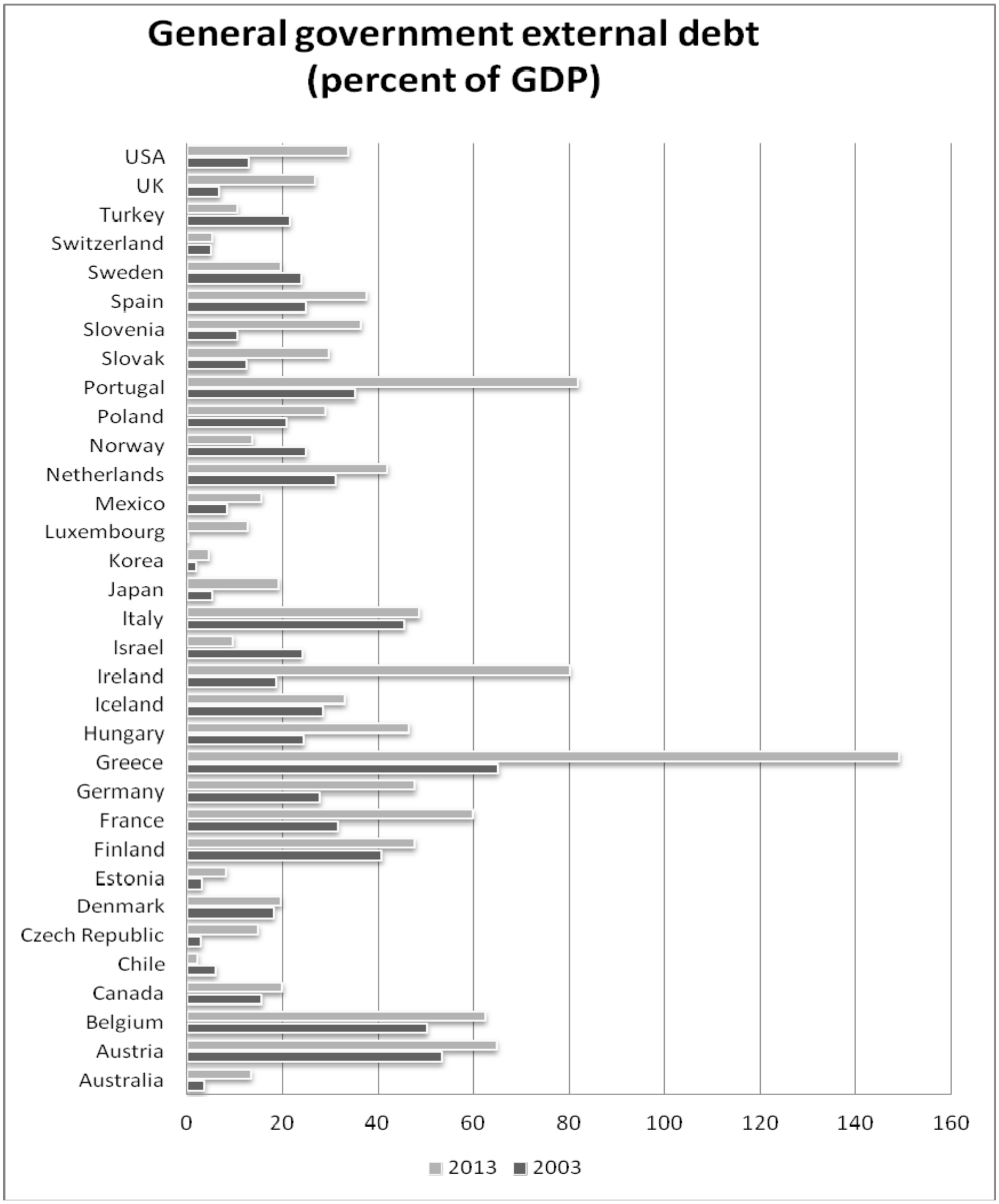


Figure 3. External debt- to- GDP ratio in OECD countries

Source: International Monetary Fund, World Economic Outlook Database, April 2014.

World Bank, *Quarterly External Debt Statistics.*

2. Literature Review

To study the sustainability of fiscal policy, the economists have explicitly investigated whether the government intertemporal budget constraint holds in present value terms. The traditional method is to examine the stationary property of the debt or deficit by the unit root test. Hamilton and Flavin (1986) conclude that the U.S. debt from 1962 to 1984 followed a stationary stochastic process. Wilcox (1989) allows for stochastic real interest rates and finds there was a structural shift of U.S. fiscal policy in 1974. The government debt was greater than the sum of future surpluses that would be generated out of post 1974. Buiter and Patel (1992) apply the unit root test to analyze the property of the public debt series. They conclude that the Indian public debt is nonsustainable. However, Jha and

Sharma (2004) admit the endogenous structural breaks for India data and the evidence reveals the public expenditure and revenue series in India to be $I(1)$ but cointegrated with regime shifts.

The literature noted above deals with the government deficits in a closed economy. Sawada (1994) describes a country's intertemporal budget identity for an open economy. Employing the methodologies developed by Trehan and Walsh (1988), Hakkio and Rush (1991), Sawada (1994) uses the ADF unit root test to evaluate the sustainability of the external deficits for the heavily indebted countries and some Asian countries. The finding is that the solvency conditions are satisfied in Asian countries except the Philippines, but not in the debt-laden Latin American countries. Following the analysis of Sawada (1994), Önel and Utkulu (2006) allow for the possible structural break that may be due to the economic crisis in Turkey. The result shows the Turkish external debt is weakly sustainable in the long run whether the structural breaks are considered or not.

Some researches discuss the subject from the view of the relationship between current account and external debt. Leachman and Francis (2000) employ the multicointegration framework to investigate the long-run relationship between the components of the U.S. current account and sustainability of foreign debt. Empirical results show the U.S. external budgeting behavior was consistent with a sustainable intertemporal budgeting process in the era of fixed exchange rate. However, in the post-Bretton Woods period, imports and exports fail to exhibit long-run relationship. Takeuchi (2010) uses an extended Markov switching unit root test to investigate the stationarity of current account-to-GDP ratio. The result shows that even though the debt-to-GDP ratio remains relatively high, the probability of sustainability is unexpected high when U.S. dollar depreciation is taken into consideration.

Some literature discusses this issue applying nonlinear framework. Yilanci and Özcan (2008) use the threshold autoregression model to investigate the long-run sustainability of Turkey's external debt. They find the external debt of turkey will be unsustainable for certain state. Nasir and Noman (2012) apply a two-step nonlinear framework to investigate the stationary property of debt-to-external earnings ratio from 36 countries and current account–to-gross national income ratio from 55 countries. The results show strong evidence of non-linearity and sustainability of external debt. They also indicate superior performance of nonlinear unit root over conventional ADF test. This conclusion is also supported by Christopoulos and Leon-Ledesma (2010), and Kim, *et al*. (2009). In addition to these studies, Boengiu, *et al.* (2011) use a quantile autoregression model to test for the external debt sustainability of Romania. They conclude that external debt is not globally sustainable with significance level of 5% and is globally sustainable with significance level of 10%.

Though the sustainability of external debt has been an object of study for a long time, the scholars try to propose new analysis or interpretation for this issue. The sample countries, the sample periods and the econometric methods will make the results different. Previous literature for external debt focuses on the developing countries. This paper will incorporate 21 OECD countries into the samples and apply the unit root quantile autoregression to study this issue.

3. Methodological Issues

3.1 The Solvency Condition

A country's intertemporal budget identity in an open economy described by Sawada (1994) is as follows

$$GDP_t + (B_t - B_{t-1}) + TR_t \equiv A_t + r_t B_t + [N_t - (1+i_t)N_{t-1}] \tag{1}$$

where GDP_t is the gross domestic product; B_t is the gross debt minus gross assets (net external debt); TR_t is the net transfer receipts; A_t is the total expenditure of domestic residents on goods and services; r_t is nominal interest rate ; N_t is the foreign currency reserves of the central bank , and i_t is the interest rate on these reserves. All the variables are in nominal terms. Equation (1) implies that the economy's aggregate income in the left-hand side is equal to the total expenditure in the right-hand side.

By the common definition of national income, the trade balance of a country is expressed as

$$\begin{aligned} TB_t &\equiv EX_t - IM_t = GDP_t - A_t \\ &= r_t B_t - (B_t - B_{t-1}) - TR_t + [N_t - (1+i_t)N_{t-1}] \end{aligned} \tag{2}$$

where EX_t and IM_t denote the nominal exports and imports of goods and services. From equation (2), the dynamic budget equation describing the evolution of the external debt is derived as

$$\Delta B_t = r_t B_{t-1} - S_t \tag{3}$$

where Δ denotes the first difference of the variable; $S_t = TB_t + TR_t - [N_t - (1+i_t)N_{t-1}]$. The term S_t

represents the net external surplus that can be used to finance external debt repayments.

Dividing each term in equation (3) by nominal GDP, the budget constraint in terms of proportions of nominal GDP could be represented as

$$\Delta b_t = (r_t - \pi_t - \eta_t) b_{t-1} - s_t \tag{4}$$

where b_t is nominal net external debt deflated by nominal GDP; s_t is nominal external surplus deflated by nominal GDP; π_t is the inflation rate; η_t is the growth rate of real GDP. Equation (4) could be written as

$$\Delta b_t = \rho_t b_{t-1} - s_t \tag{5}$$

where $\rho_t = r_t - \pi_t - \eta_t$ is the real *ex post* interest rate adjusted for real GDP growth. The solution of equation (5) depends on the value of ρ_t. For simplicity, we assume that $\rho_t = \rho$ is constant and discuss the following two cases.

Case 1: $\rho < 0$ (stable case)

Equation (5) is a stable difference equation, and hence could be solved backwards by successive substitution. Under the rational expectation hypothesis, for $n > 0$, we obtain

$$E_t b_{t+n} = (1+\rho)^n b_t - \sum_{j=0}^{n-1} (1+\rho)^j s_{t+n-j} \tag{6}$$

Taking the limit as $n \to \infty$, equation (6) becomes

$$E_t \lim_{n\to\infty} b_{t+n} = -\lim_{n\to\infty} \sum_{j=0}^{n-1} (1+\rho)^j s_{t+n-j} \tag{7}$$

This implies that the external debt-to-GDP ratio remains finite for any sequence of finite net external surplus s_t.

Case 2: $\rho > 0$ (unstable case)

Equation (5) is an unstable difference equation and must be solved forwards in terms of b_t. Under the rational expectation hypothesis, for $n > 0$, we get

$$b_t = E_t \frac{1}{(1+\rho)^n} b_{t+n} + E_t \sum_{j=1}^{n} \frac{1}{(1+\rho)^j} s_{t+j} \tag{8}$$

Taking the limit as $n \to \infty$, equation (8) could be written as follows:

$$b_t = E_t \lim_{n\to\infty} \frac{1}{(1+\rho)^n} b_{t+n} + E_t \lim_{n\to\infty} \sum_{j=1}^{n} \frac{1}{(1+\rho)^j} s_{t+j} \tag{9}$$

The solvency condition (transversality condition) holds if

$$E_t \lim_{n\to\infty} \frac{1}{(1+\rho)^n} b_{t+n} = 0 \tag{10}$$

It also implies that

$$b_t = E_t \lim_{n\to\infty} \sum_{j=1}^{n} \frac{1}{(1+\rho)^j} s_{t+j} \tag{11}$$

It then follows that the current external debt-to-GDP ratio is offset by the sum of the expected future discounted net external surplus expressed as a proportion of GDP. The implication of this case is the solvency condition of equation (8) required that the external debt-to-GDP ratio could not grow faster than the growth-adjusted real interest rate. Moreover, current external debt could be sustained by any sequence of net external surplus that satisfies equation (11). Therefore, we will investigate the sustainability of external debt by testing for the stationary property of the net external surplus process.

3.2 Econometric Model

We briefly describe the quantile autoregression (QAR) framework suggested by Koenker and Xiao (2004). Consider an ADF regression model of the type

$$y_t = \alpha_1 y_{t-1} + \sum_{j=1}^{q} \alpha_{j+1} \Delta y_{t-j} + u_t, \qquad t = 1, ..., n \tag{12}$$

where u_t is an iid random variable with zero mean and constant variance. If $\alpha_1 = 1$, then y_t follows a unit root process, and if $|\alpha_1| < 1$, then y_t is stationary. Following the methodology set by Koenker and Xiao (2004), the τth conditional quantile of y_t, conditional on the past information set Ω_{t-1} can be expressed as

$$Q_{s_t}(\tau | \Omega_{t-1}) = x_t' \alpha(\tau) \tag{13}$$

where $x_t = (1, y_{t-1}, \Delta y_{t-1}, ..., \Delta y_{t-q})'$ and $\alpha(\tau) = (\alpha_0(\tau), \alpha_1(\tau), ..., \alpha_{q+1}(\tau))'$, $\alpha_0(\tau)$ is the τth quantile of u_t. For a given τ, estimating of the QAR model involves solving a minimization problem of weighted residuals.

$$\min_{\alpha \in \mathbb{R}^2} \sum_{t: y_t \geq x_t'\alpha(\tau)} \tau(y_t - x_t'\alpha(\tau)) + \sum_{t: y_t < x_t'\alpha(\tau)} (\tau - 1)(y_t - x_t'\alpha(\tau)) \tag{14}$$

The QAR model could be estimated in “quantreg” package included in R. Like the conventional ADF test, we consider t-ratio statistic ($t_n(\tau)$) to test the unit root behavior at some selected representative quantiles.

$$t_n(\tau) = \frac{\hat{f}(F^{-1}(\tau))}{\sqrt{\tau(1-\tau)}} (Y_{-1}' P_x Y_{-1})^{1/2} (\hat{\alpha}_1(\tau) - 1) \tag{15}$$

where f and F denote the density and distribution function of u_t, $\hat{f}(F^{-1}(\tau))$ is a consistent estimator of $f(F^{-1}(\tau))$, Y_{-1} is the vector of lagged variables (y_{t-1}), and P_x is the projection matrix onto the space orthogonal to x. At any fixed τ, the t-ratio statistic $t_n(\tau)$ is the quantile regression counterpart of the conventional ADF t-ratio test.

Another approach to examine stationary property is to test the unit root over a range of quantiles. The relevant statistic is a Kolmogorov-Smirnov (KS) test. Consider $\tau \in \Gamma$, Koenker and Xiao (2004) suggest

$$QKS = \sup_{\tau \in \Gamma} |t_n(\tau)| \tag{16}$$

The limiting distributions of t-ratio test and QKS test are nonstandard. Koenker and Xiao (2004) propose a re-sampling procedure to approximate the finite-sample distributions. The quantiles under considerations in this paper are $\tau = (0.1, 0.2, ..., 0.9)$. The number of repetitions in the bootstrapping procedure is 5000. And we will use the bootstrap critical values to make inference.

4. Empirical Results

4.1 The Sample and the Data

This paper will use the data of OECD countries for empirical study. We construct the net external surplus process according to the definition, $S_t = TB_t + TR_t - [N_t - (1 + i_t)N_{t-1}]$. Then the variable will be normalized by nominal GDP. We ignore the component of net transfer receipts (TR_t) because the data is missing for most countries. And for those countries with available data, the values of net transfer receipts are trivial. The variables of exports and imports for goods and services, gross domestic product, and total reserves minus gold are measured in U.S. dollar and are obtained from International Monetary Fund’s *International Financial Statistics* (*IFS*). The proxy variable for interest rate is the interest rate on 6-month Eurodollar deposit (London) which is extracted from the website of Board of Governors of the Federal Reserve System. We delete those countries whose data is not sufficient for us to construct the net external surplus process. There are 21 OECD countries included in our samples. Table 1 presents the sample countries, sample periods and the descriptive statistics of the net external surplus process for these countries. The significance of Jarque-Bera test for 16 countries indicates the non-normality of the series. It gives the support for the employment of quantile regression approach.

Table 1. Descriptive statistics for net external surplus

Country	**Sample period**		**Mean**	**Max.**	**Min**	**Std. Dev.**	**Skewness**	**Kurtosis**	**Jarque-Bera**
	Start	**End**							
Australia	1980:1	2013:3	-0.014	0.064	-0.082	0.025	-0.296	3.750	5.134*
Austria	1980:1	2013:3	0.020	0.187	-0.070	0.039	0.557	4.529	20.140**
Belgium	1980:1	2013:3	0.024	0.143	-0.142	0.032	-0.991	8.483	191.221**
Canada	1980:1	2013:3	0.017	0.072	-0.030	0.022	-0.031	2.241	3.261
Denmark	1980:1	2013:3	0.031	0.182	-0.163	0.054	-0.268	4.241	10.283**
Finland	1980:1	2013:2	0.033	0.150	-0.098	0.051	0.043	2.658	0.694
France	1980:1	2013:3	-0.003	0.043	-0.052	0.019	-0.166	2.505	1.955
Germany	1980:1	2013:3	0.035	0.084	-0.096	0.027	-0.980	5.481	56.240**
Israel	1980:1	2013:3	-0.081	0.057	-0.264	0.078	-0.227	2.040	6.345**
Italy	1980:1	2013:2	0.007	0.061	-0.046	0.024	0.287	2.662	2.471
Japan	1980:1	2013:3	0.011	0.040	-0.035	0.014	-0.889	4.297	27.250**
Korea	1980:1	2013:3	0.002	0.203	-0.147	0.042	0.943	7.679	143.149**
Mexico	1981:1	2013:3	-0.002	0.104	-0.061	0.037	1.142	3.737	31.464**
Netherlands	1980:1	2013:3	0.056	0.240	-0.063	0.035	0.314	8.891	197.425**
Norway	1980:1	2013:3	0.087	0.261	-0.101	0.070	0.025	3.207	0.256
Portugal	1980:1	2013:2	-0.081	0.156	-0.254	0.057	0.261	5.352	32.417**
Spain	1980:1	2013:3	-0.016	0.087	-0.093	0.033	0.409	3.419	4.753*
Sweden	1980:1	2013:3	0.042	0.176	-0.102	0.047	-0.405	3.603	5.740*
Switzerland	1980:1	2013:3	0.029	0.354	-0.679	0.113	-3.305	20.463	1961.122**
UK	1980:1	2013:3	-0.007	0.183	-0.217	0.040	0.077	11.119	370.905**
US	1980:1	2013:3	-0.026	0.002	-0.058	0.016	-0.243	2.024	6.690**

Notes: **,* indicate significance at 5%, 10% statistical level, respectively.

4.2 Testing for the Unit Root

We first perform conventional unit root test by estimating the ADF regression model. The optimal lag length of autoregression for a particular country is selected by Schwartz Bayesian Criterion (SBC). Table 2 collects the testing results. The null hypothesis of a unit root can be rejected for 13 countries by the conventional ADF test. It leads to the conclusion that the net external surplus process for the other eight countries exhibit unit roots.

For the sake of comparison, the optimal lag length of quantile autoregression is also selected by SBC as shown in Table 2. We first concentrate on QKS test which gives us a general perspective of the unit root behavior of the series. The results of QKS test are also reported in Table 2. The null hypothesis of a unit root can be rejected for 12 countries. The conclusions of the conventional ADF test and QKS test are contrary for three countries (Norway, Sweden and Switzerland). However, the results derived from these two tests are similar for most countries.

Table 2. Results for ADF test and QKS test

Country	Lag	ADF	QKS	Country	Lag	ADF	QKS
Australia	0	-11.264**	10.870**	Korea	0	-7.296**	9.887**
Austria	7	-1.437	2.466	Mexico	4	-2.295	2.875
Belgium	0	-7.588**	9.935**	Netherlands	1	-5.215**	4.566**
Canada	0	-1.960	2.161	Norway	3	-2.419	3.891*
Denmark	0	-8.653**	9.410**	Portugal	0	-7.649**	11.874**
Finland	1	-3.820**	3.724*	Spain	1	-3.889**	4.822**
France	2	-2.582*	4.231**	Sweden	3	-2.727*	2.998
Germany	3	-2.244	2.816	Switzerland	12	-3.011**	2.708
Israel	3	-2.009	1.961	UK	2	-2.771*	8.597**
Italy	2	-3.341**	4.054*	US	1	-1.726	1.597
Japan	1	-1.631	3.249				

Notes: **,* indicate significance at 5%, 10% statistical level, respectively.

For a closer investigation, we examine the unit root behavior at various quantiles. The results of t-ratio test are reported in Table 3 and the autoregressive coefficient estimates ($\hat{\alpha}_1(\tau)$) over different quantiles are visualized in Figure 4. We illustrate the results by the following three cases.

Case 1: Be stationary or nonstationary over all quantiles

Table 3 shows there are six countries (Australia, Belgium, Denmark, Korea, Netherlands and Portugal) where the net external surplus processes are stationary at each quantile. The autoregressive coefficient estimates over different quantiles for these countries are shown in Panel A of Figure 4. The estimated values of autoregressive coefficient are lower than 0.6 for most countries, except for Netherlands. The estimated values of Netherlands, ranging from 0.4 to 0.7, are higher than other countries, but are still different from unity statistically. The rejections of the unit root hypothesis over all quantiles give evidence for a constant stationary behavior in the net external surplus process for these six countries.

On the other hand, the null hypothesis of a unit root cannot be rejected at each quantile in the US. The autoregressive coefficient estimates for the US are plotted in Panel B of Figure 4. The values are very close to unity and it suggests a unit root at each quantile. The smooth patterns indicate that the estimated values are stable over all quantiles. Clearly, the net external surplus for the US follows a constant unit root process across quantiles.

In summary, the results are consistent over all quantiles in this case. The conclusions are similar to the conventional ADF unit root test for these seven countries.

Case 2: Be stationary or nonstationary at some particular quantile

The net external surplus process is stationary over the most range except at certain quantile. For example, the null hypothesis of a unit root cannot be rejected only at the extreme high quantile ($\tau = 0.9$) for Finland, at the median and the extreme high quantile ($\tau = 0.5$, $\tau = 0.9$) for Spain, at the two extreme quantiles ($\tau = 0.1$, $\tau = 0.9$) for the UK. Panel C of Figure 4 visualizes the autoregressive coefficient estimates for these three countries. It is obvious that the autoregressive coefficient estimates take the maximum or higher value at the quantile where a unit root is suggested. And the estimated value is very close to 0.9.

Instead, the net external surplus processes for two countries (Germany and Israel) exhibit the unit root behavior over the whole range except at the extreme high quantile ($\tau = 0.9$). Similarly, the hypothesis of a unit root is only rejected at two quantiles ($\tau = 0.2$, $\tau = 0.4$) for Mexico. See Panel D of Figure 4 for these three countries. The autoregressive coefficient estimates take the minimum value at the extreme high quantile for Germany and Israel. The downward pattern is clearly observed in Germany.

Case 3: Be stationary or nonstationary for some range of quantiles

The net external surplus processes are stationary at the lower quantiles for Canada, at the lower and middle quantiles for two countries (Italy and Norway). The processes exhibit stationary at the middle quantiles for two countries (Austria and Switzerland), at the middle and the upper quantiles for Sweden, and are stationary at the upper quantiles for two countries (France and Japan). Panel E and Panel F of Figure 4 give the visualization for autoregressive coefficient estimates for these countries. In panel E, the estimated values behave as an upward pattern and appear to be higher at the upper quantiles for Canada, Italy and Norway. Conversely, in Panel F, the estimated values display a downward pattern and seem to be higher at the lower quantiles for Sweden, France and Japan.

To summarize, there is a varied behavior across different quantiles for 14 countries. It indicates the dynamic behavior of the net external surplus process is asymmetric.

Table 3. Results for quantile unit root tests

Country	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Australia	$\hat{\alpha}_1(\tau)$	-0.112	-0.055	0.088	0.153	0.185	0.100	0.024	0.095	-0.125
	$t_n(\tau)$	-6.232**	-5.892**	-10.275**	-9.500**	-8.798**	-10.322**	-9.194**	-10.870**	-9.263**
Austria	$\hat{\alpha}_1(\tau)$	1.228	1.139	1.003	0.863	0.768	0.779	0.862	0.807	0.786
	$t_n(\tau)$	2.389	1.183	0.022	-1.041	-2.129*	-2.446**	-1.358	-1.073	-1.147
Belgium	$\hat{\alpha}_1(\tau)$	0.257	0.345	0.390	0.422	0.469	0.412	0.354	0.252	0.197
	$t_n(\tau)$	-3.934**	-4.122**	-6.271**	-8.267**	-6.359**	-9.935**	-6.069**	-6.178**	-4.967**
Canada	$\hat{\alpha}_1(\tau)$	0.880	0.927	0.901	0.932	0.959	1.005	1.031	0.978	0.952
	$t_n(\tau)$	-2.153*	-2.161*	-2.181*	-1.601	-0.911	0.141	0.601	-0.410	-1.165
Denmark	$\hat{\alpha}_1(\tau)$	0.245	0.286	0.304	0.341	0.310	0.304	0.317	0.274	0.184
	$t_n(\tau)$	-3.077**	-5.027**	-7.279**	-6.727**	-9.410**	-8.588**	-6.470**	-5.675**	-5.600**
Finland	$\hat{\alpha}_1(\tau)$	0.531	0.728	0.731	0.752	0.707	0.717	0.683	0.626	0.797
	$t_n(\tau)$	-2.414**	-3.425**	-2.625**	-2.881**	-3.557**	-3.724**	-3.237**	-3.052**	-0.961
France	$\hat{\alpha}_1(\tau)$	0.929	0.894	0.864	0.937	0.837	0.836	0.811	0.736	0.637
	$t_n(\tau)$	-0.678	-1.477	-1.735	-0.832	2.472	-3.106**	-4.231**	-2.603**	-2.359**
Germany	$\hat{\alpha}_1(\tau)$	0.975	0.947	0.921	0.936	0.951	0.972	0.863	0.828	0.524
	$t_n(\tau)$	-0.112	-0.403	-1.200	1.056	-0.749	-0.410	-1.703	-1.312	-2.816**
Israel	$\hat{\alpha}_1(\tau)$	1.131	0.888	0.846	0.854	0.881	0.849	0.903	0.839	0.820
	$t_n(\tau)$	0.780	-0.753	-1.605	-1.671	-1.530	-1.688	-0.991	-1.558	-1.961*
Italy	$\hat{\alpha}_1(\tau)$	0.541	0.709	0.717	0.759	0.819	0.868	0.844	0.887	0.823
	$t_n(\tau)$	-3.501**	-4.054**	-3.307**	-2.666**	-2.776**	-1.510	-1.362	-0.820	-1.065
Japan	$\hat{\alpha}_1(\tau)$	1.164	1.001	0.967	0.946	0.975	0.944	0.865	0.813	0.830
	$t_n(\tau)$	1.434	0.019	-0.651	-1.351	-0.542	-1.056	-2.803**	-3.249**	-2.879**
Korea	$\hat{\alpha}_1(\tau)$	0.292	0.347	0.368	0.332	0.421	0.534	0.603	0.524	0.536
	$t_n(\tau)$	-4.950**	-6.836**	-7.554**	-8.673**	-6.644**	-9.887**	-3.874**	-4.736**	-3.303**
Mexico	$\hat{\alpha}_1(\tau)$	0.831	0.868	0.856	0.880	0.935	0.913	0.970	1.008	0.958
	$t_n(\tau)$	-0.014	-2.875**	-0.010	-2.333*	-1.258	-0.006	-0.408	0.0004	-0.743
Netherlands	$\hat{\alpha}_1(\tau)$	0.488	0.675	0.734	0.676	0.666	0.710	0.642	0.534	0.442
	$t_n(\tau)$	-2.904**	-2.558**	-3.252**	-3.358**	-3.597**	-4.566**	-3.652**	-4.911**	-3.804**
Norway	$\hat{\alpha}_1(\tau)$	0.743	0.723	0.750	0.706	0.673	0.657	0.778	0.918	0.951
	$t_n(\tau)$	-1.442	-2.373**	-2.048*	-3.166**	-3.110**	-3.891**	-1.600	-0.494	-0.332
Portugal	$\hat{\alpha}_1(\tau)$	0.243	0.268	0.336	0.391	0.413	0.416	0.463	0.420	0.312
	$t_n(\tau)$	-3.491**	-5.526**	-7.066**	-11.874**	-10.896**	-7.253**	-5.095**	-6.082**	-3.707**
Spain	$\hat{\alpha}_1(\tau)$	0.599	0.559	0.666	0.780	0.883	0.839	0.671	0.663	0.848
	$t_n(\tau)$	-4.128**	-4.483**	-4.822**	-2.959**	-1.275	-2.101*	-3.851**	-3.597**	-1.055
Sweden	$\hat{\alpha}_1(\tau)$	0.662	0.826	0.851	0.781	0.720	0.768	0.748	0.736	0.717
	$t_n(\tau)$	-1.076	-1.209	-1.777	-2.204**	-2.970**	-2.591**	-2.770**	-2.998**	-1.231
Switzerland	$\hat{\alpha}_1(\tau)$	0.188	0.523	0.382	0.332	0.562	0.560	0.501	0.710	0.523
	$t_n(\tau)$	-0.925	-0.987	-1.548	-2.708**	-1.883*	-2.128*	-1.839*	-1.318	-1.270
UK	$\hat{\alpha}_1(\tau)$	0.824	0.685	0.673	0.666	0.654	0.679	0.643	0.558	0.591
	$t_n(\tau)$	-1.153	-4.333**	-6.518**	-6.053**	-8.597**	-6.632**	-4.246**	-5.564**	-1.836
US	$\hat{\alpha}_1(\tau)$	0.984	0.986	0.994	0.988	0.993	0.973	0.970	0.982	0.957
	$t_n(\tau)$	-0.495	-0.527	-0.278	-0.685	-0.467	-1.419	-1.597	-0.511	-0.908

Notes: **,* indicate significance at 5%, 10% statistical level, respectively.

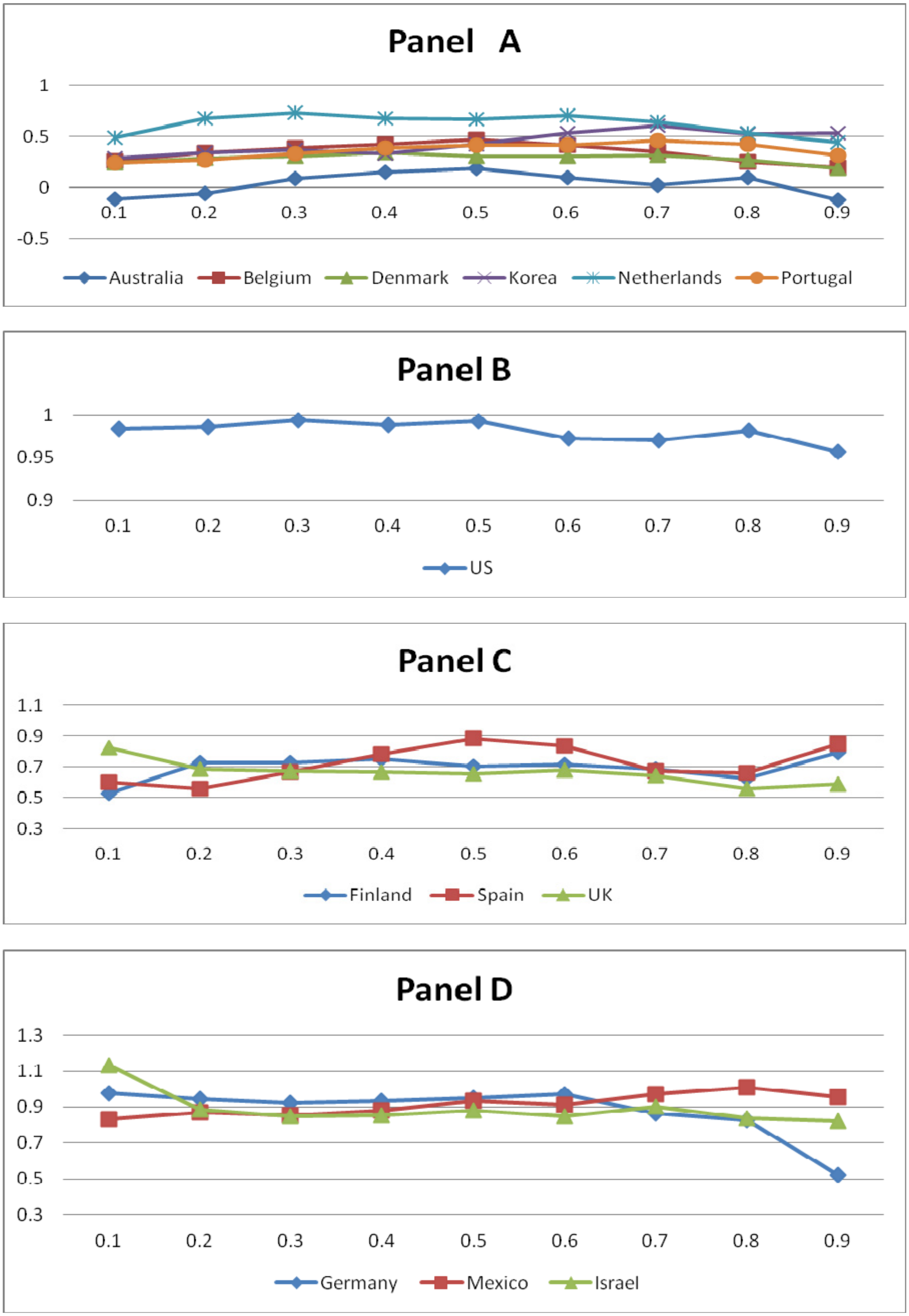
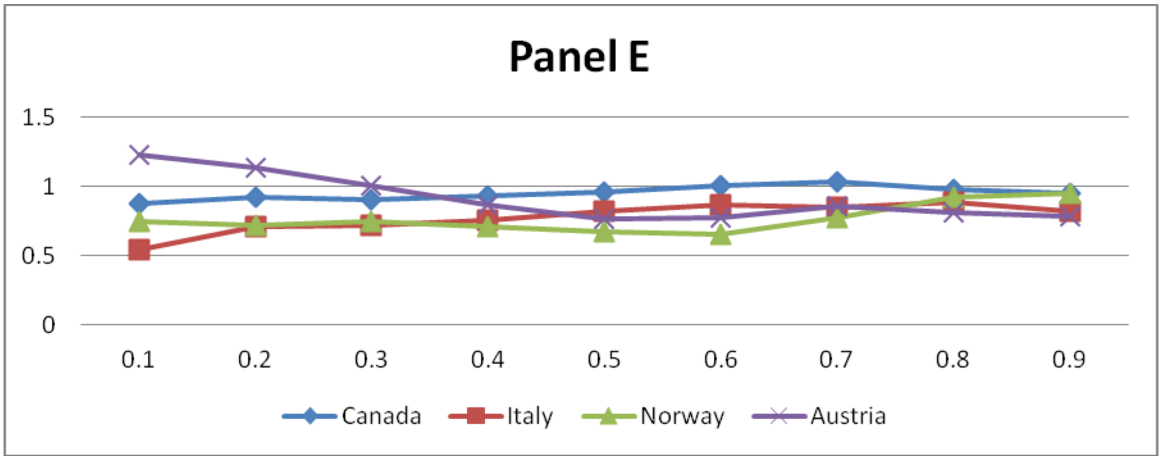


Figure 4. Autoregressive coefficient estimates over different quantiles



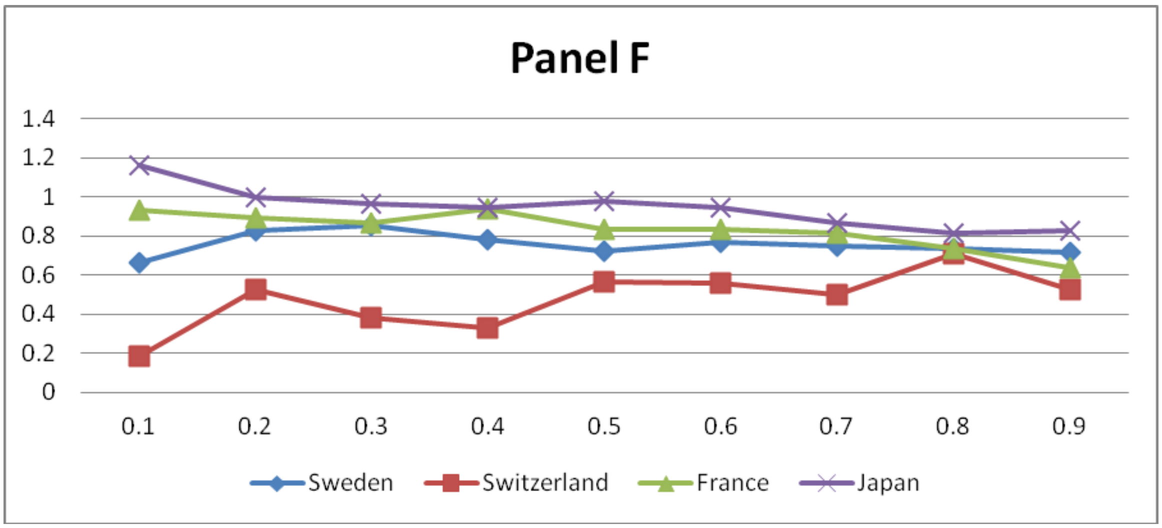


Figure 4. (continued)

5. Conclusions

This paper investigates the sustainability of external debt for 21 OECD countries. Normalizing all the variables in terms of nominal GDP, we modify the solvency condition in an open economy derived by Sawada (1994). Then we apply the quantile autoregression model to test the stationary property of the net external surplus process. The main conclusions are at each quantile, the external surplus process has a constant stationary behavior for six countries, and follows a constant unit root behavior for the US. However, there is a varied behavior across different quantiles for 14 countries. It indicates the dynamic behavior of the net external surplus process is asymmetric. That is, they may be stationary at some quantiles, but contain a unit root at other quantiles. The unit root behavior for the net external surplus process implies the external debt is unsustainable for these countries at some quantiles. The policy implication of this result is that the management of external debt crisis must account for the potential non-linearity in the external surplus process.

Compared to the conventional ADF unit root test, the quantile autoregression model provides a more detail investigation on this issue. In fact, the quantile framework makes no assumptions about the distribution of the net external surplus and enables us to capture the potential heavy-tailed characteristic. The findings give us an insight into the asymmetric dynamic behavior for the external surplus process.

References

Boengiu, T., Triandafil, C.M., & Triandafil, A.M. (2011). Debt ceiling and external debt sustainability in Romania: a quantile autoregression model. *Romanian Journal of Economic Forecasting*, *4*, 15-29.

Buiter, W.H., & Patel, U. (1992). Debts deficits and inflation: an application to public finances in India. *Journal of Public Economics*, *47,* 171-205. http://dx.doi.org/10.1016/0047-2727(92)90047-J

Christopoulos, D., & Leon-Ledesma, M.A. (2010). Current account sustainability in the U.S.: What do we really know about it? *Journal of International Money and Finance*, *29*, 442-459.

Hakkio, C.S., & Rush, M. (1991). Is the budget deficit too large?. *Economic Inquiry*, *29*, 429-445.

Hamilton, J.D., & Flavin, M.A. (1986). On the limitations of government borrowing: a Framework for empirical testing. *American Economic Review*, *76*, 808-819.

Jha, R., & Sharma, A. (2004). Structural breaks, unit roots, and cointegration: a further test of the sustainability of the Indian fiscal deficit. *Public Finance Review*, *32*, 196-219.

Kim, B.H., Min, H., Hwang, Y., & McDonald, J.A. (2009). Are Asian countries' current accounts sustainable? Deficits, even when associated with high investment, are not costless. *Journal of Policy Modeling*, *31*, 163-179.

Koenker, R., & Xiao, Z. (2004). Unit root quantile autoregression inference. *Journal of the American Statistical Association*, *99*, 775-787.

Kremers, J.J.M. (1989). U.S. federal indebtedness and the conduct of fiscal policy. *Journal of Monetary Economics*, *23*, 219-238.

Leachman, L., & Francis, B. (2000). Multicointegration analysis of the sustainability of foreign debt. *Journal of Macroeconomics*, *22*, 207-227. http://dx.doi.org/10.1016/S0164-0704(00)00129-4

Nasir, A., & Noman, A.M. (2012). Sustainability of external debt: further evidence from non-linear framework. *International Review of Applied Economics*, *26*, 673-685. http://dx.doi.org/10.1080/02692171.2012.665853

Önel, G., & Utkulu, U. (2006). Modeling the long-run sustainability of Turkish external debt with structural changes. *Economic Modelling*, *23*, 669-682.

Sawada, Y. (1994). Are the heavily indebted countries solvent?: test of international borrowing constraints. *Journal of Development Economics*, *45*, 325-337.

Takeuchi, F. (2010). US external debt sustainability revisited: Bayesian analysis of extended Markov switching unit root. *Japan and the World Economy*, *22*, 98-106. http://dx.doi.org/10.1016/j.japwor.2009.12.001

Trehan, B., & Walsh, C.E. (1988). Common trends, the government budget constraint and revenue smoothing. *Journal of Economic Dynamics and Control*, *17*, 423-441. http://dx.doi.org/10.1016/0165-1889(88)90048-6

Wilcox, D.W. (1989). The sustainability of government deficits: implications of the present-value constraint. *Journal of Money, Credit and Banking*, *21*, 291-306.

Yilanci, V., & Özcan, B. (2008). External debt sustainability of Turkey: a nonlinear approach. *International Research of Finance and Economics*, *20*, 91-98.

Note

Note 1. General government net lending (+) or borrowing (-) is calculated as revenue minus total expenditure.