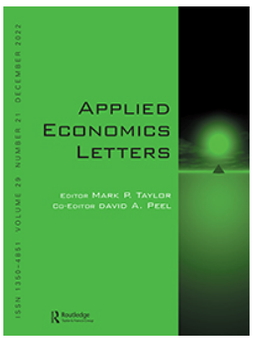

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ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rael20

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To cite this article: Jamel Saadaoui, Chi Keung Marco Lau & Yifei Cai (2022): Testing fiscal sustainability in OECD countries: new evidence from the past centuries, Applied Economics Letters, DOI: 10.1080/13504851.2022.2142502

To link to this article: https://doi.org/10.1080/13504851.2022.2142502

Published online: 03 Nov 2022.

APPLIED ECONOMICS LETTERS
https://doi.org/10.1080/13504851.2022.2142502

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ARTICLE

Testing fiscal sustainability in OECD countries: new evidence from the past centuries

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ABSTRACT

Using three complementary approaches that examine the fulfilment of the intertemporal budget constraint while avoiding explosive behaviour, this study examines the stationarity and the sustainability of public finance for six industrial countries over the period spanning from 1870 to 2017. According to Fourier DF unit root tests, time-varying fiscal reaction functions and threshold reaction functions, we find that longer-run debt sustainability is not rejected for the UK, Sweden, and for the US. The evidence is somewhat equivocal for Canada, Italy and Portugal.

KEYWORDS

Fourier DF unit root test; debt sustainability; public debt; primary balance; time-varying; threshold regressions

JEL CODES

C22; E62; H62

I. Introduction

The public sector's capacity to timely meet its financial obligations is known as fiscal sustainability. Shortly after the onset of the Great Recession and during the pandemic crisis, impressive surges in the public debt-to-GDP ratio were observed. In the US, the total public debt rose from approximately 108% in the first quarter of 2020 to more than 121% in the second quarter of 2022.[1] In several industrialized countries, similar evolutions have raised concerns about the sustainability of public finance in future years, as underlined by Rogoff (2021). To analyse this question, we can derive the so-called present value of the budget constraint,

$$b_{t-1} = \sum_{s=0}^{\infty} \left(\frac{1+y}{1+r}\right)^{(s+1)} [\tau_{t+s} - e_{t+s}] + \lim_{s\to\infty} b_{t+s} \left(\frac{1+y}{1+r}\right)^{(s+1)} \quad (1)$$

where b, stands for the stock of public debt as percent of GDP; τ, denotes the government revenues as percent of GDP; e, represents the government expenditures as percent of GDP, y, stands for the real growth rate, and r, is the long-run real interest rate.

In the absence of Ponzi games, the second term of the right-hand side of equation (1) converges to zero and the intertemporal budget constraint is fulfilled. Thus, the fiscal policy prevents deficits from being used to repay the interests on the debt stock. The fiscal policy is considered sustainable. From equation (1), we can derive a solvency condition when $r > y$, suitable for empirical testing,

$$\lim_{s\to\infty} b_{t+s} \left(\frac{1+y}{1+r}\right)^{(s+1)} = 0 \quad (2)$$

According to some authors,[2] testing the stationarity of the first difference of the stock of public debt is equivalent to testing the absence of Ponzi games. When the null of unit root is rejected the fiscal policy can be regarded as sustainable. Bohn (2007) has criticized this approach. Indeed, he shows that the intertemporal budget constraint is fulfilled for any finite order of integration. Thus, a more relevant approach would be to estimate a fiscal reaction function (hereafter FRF) where the primary balance reacts to the public debt at the previous period, as suggested by Bohn (2007),

$$d_t = \alpha_0 + \rho b_{t-1} + \alpha x_t + \varepsilon_t \quad (3)$$

where, d, is the primary deficit (fiscal deficit net of interest payments) as percent of GDP; b, is the

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[1]U.S. Office of Management and Budget and Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/series/GFDEGDQ188S, October 12, 2022.

[2]Afonso (2005), Afonso and Rault (2010) and Afonso and Jalles (2014).

stock of debt as percent of GDP, and x, is a set of control variables (like the GDP, the output gap or the rate of inflation). Then, fiscal sustainability is ensured when the coefficient ρ is significantly positive in the reaction function. As noted by Daniel and Shiamptanis (2013), the presence of fiscal limits rules out explosive behaviour for the debt and the primary surplus relative to GDP, invalidating Bohn's criteria in presence of fiscal limits. Thus, cointegration between the primary surplus and the debt may reflect a responsible fiscal rule. A responsible fiscal rule is one that meets the government's intertemporal budget constraint while avoiding explosive behavior.

Using an FRF may not be sufficient when the length of the time span and the consideration of structural breaks are two important dimensions of the examined sample. Thus, we use time-varying FRF and threshold FRF to consider the existence of structural breaks, regime shifts and parameters instability. Some studies have used samples with observations spanning over more than 100 years (for example, Yoon 2012, Bystrov and Mackiewicz, 2020). However, our empirical investigation is the first to simultaneously consider the issues of smooth structural breaks and long-span time series when examining debt sustainability.

Using three complementary approaches that examines the fulfilment of the intertemporal budget constraint while avoiding explosive behaviour, this study examines the stationarity and the sustainability of public finance for six industrial countries over the period spanning from 1870 to 2017. Fourier DF (hereafter FDF) unit root tests along with time-varying FRF and threshold FRF will allow us to assess debt stationarity and sustainability in the longer run in a sample of OECD countries.

II. Data and research methodology

Data descriptions

In order to analyse debt sustainability in the longer run, we use the version 5 of the Jordà-Schularick-Taylor Macrohistory Database (Jordà, Schularick, and Taylor 2017),[3] which has a longer time span than the more recent database of Kose et al. (2022). The following series are selected: nominal GDP in local currency, nominal government revenues in local currency, nominal government expenditures in local currency, and the public debt-to-GDP ratio. The selection of the countries being essentially motivated by data availability, we chose 6 countries out of 18 in order to have complete series for the primary balance and for the debt. These countries are Canada, UK, Italy, Portugal, Sweden and the US. In the online appendix,[4] we present the descriptive statistics.

Research methodology

The double Frequency FDF test proposed by Cai and Omay 2022 has better power properties than previous alternatives and is presented as follows,

$$y_t = c + a.\sin\left(\frac{2\pi k^s t}{T}\right) + b.\cos\left(\frac{2\pi k^c t}{T}\right) + \beta y_{t-1} + \varepsilon_t \tag{4}$$

where k^s and k^c are frequencies to be determined by an updated-driven method.[5] To minimize the sum of squared residuals, they find the optimal frequencies over a pre-determined range, that is $k^s, k^c \in [0, k_{\max}]$ where $k_{\max}$ is the upper bound.[6] We can rewrite equation (4) in the following form,

$$\Delta y_t = c + a.\sin\left(\frac{2\pi k^s t}{T}\right) + b.\cos\left(\frac{2\pi k^c t}{T}\right) + \gamma y_{t-1} + \varepsilon_t \tag{5}$$

where $\gamma = \beta - 1$. Accordingly, the modified test statistic can be expressed as follows,

$$\tau = \frac{\hat{\gamma}}{\sigma_{\hat{\gamma}}} \tag{6}$$

We generate the critical values with 10,000 replications by stochastic simulations. Equation (5)

[3] https://www.macrohistory.net/database/.
[4] https://www.jamelsaadaoui.com/wp-content/uploads/2022/10/appendix-22-April-7.pdf.
[5] Enders and Lee (2012) suggest using single frequency in Fourier Dickey-Fuller unit root tests.
[6] According to Enders and Lee (2012), minimizing the sum of squared residuals is equal to maximizing the F test by imposing the restrictions $a = b = 0$ on equation (4). For more details, please refer to Enders and Lee (2012).

Table 1. Debt-to-GDP ratio in first difference.

	Enders and Lee (2012)			Omay (2015)			Cai and Omay 2022				Cai and Omay 2022			
	k	Lags	t stat.	k	Lags	t stat.	ks	kc	Lags	t stat.	ks	kc	Lags	t stat.
Canada	2	3	−7.015***	2.5	3	−7.181***	2	3	3	−7.018***	1.2	2.6	3	−7.342***
UK	2	1	−5.773***	1.6	1	−5.855***	2	5	1	−6.017***	2	4.9	1	−6.104***
Italy	1	1	−8.036***	1.5	1	−8.046***	4	1	1	−8.043***	1.5	2.9	1	−8.319***
Portugal	1	1	−7.427***	0.3	1	−7.581***	5	1	1	−7.761***	0.7	4.7	1	−8.294***
Sweden	3	4	−7.522***	3.1	4	−7.514***	3	4	4	−8.075***	3	4	4	−8.075***
US	2	1	−6.830***	1.9	1	−6.829***	2	4	1	−7.028***	2	4.1	1	−7.101***

this procedure only selects optimal single integer frequency over the range from 0 to 5. The critical values are generated by using stochastic simulation with 10,000 replications. ***, ** and * denote 1%, 5% and 10% significance levels, respectively.

augmented with lags of Δy_t is used to solve the autocorrelation issue. A data-driven method is adopted to solve the so-called Davies problem (Davies 1987). By minimizing the sum of squared residuals in equation (4), one can select the optimal frequency pairs. We follow Cai and Omay (2022) by searching for both integer and fractional frequencies over the range $[0, k_{\max}]$. Their simulations suggest more power gains than both Enders and Lee (2012) and Omay (2015).

III. Empirical results

We set out to investigate the debt stationarity with unit root tests. According to previous studies, three popular FDF unit root tests are proposed by: Enders and Lee (2012), Omay (2015) and Cai and Omay (2022), respectively. These papers only differ in the selection of frequency in trig functions (e.g. single against double and integer against fraction). Tables 1 and 2 show the results obtained by using Enders and Lee (2012). With regard to the debt ratio in first difference, all the countries reject the unit root hypothesis. Omay (2015) suggested using fractional frequencies in order to gain additional testing power compared to the test proposed by Enders and Lee (2012). After taking fractional frequencies into account, the unit root hypothesis is rejected for the debt ratio in all countries with the exception of Portugal.

Finally, we employ the double Frequency FDF unit root test proposed by Cai and Omay (2022). We first employ double integer frequencies in trig functions, as in Cai and Chang (2022). According to Table 1, all countries reject the null hypothesis. The frequencies in trig functions are different in all countries.

Considering the primary balance in Table 2, the results are quite consistent with those on the debt ratio. Interestingly, all the time series reject the null hypothesis for the primary balance. The null hypothesis is not rejected for Portugal with the tests of Enders and Lee (2012) and Omay (2015). This result contrasts with those of Tsong et al. (2016) where the government expenditures and revenues are cointegrated for Portugal, but their sample is smaller and they use a single frequency. After considering double fractional frequencies in Tables 1 and 2, both the debt ratio and the primary balance are stationary among all countries. This

Table 2. Primary balance in level.

	Enders and Lee 2012			Omay (2015)			Cai and Omay (2022)				Cai and Omay (2022)			
	k	Lags	t stat.	k	Lags	t stat.	ks	kc	Lags	t stat.	ks	kc	Lags	t stat.
Canada	4	2	−6.293***	4	2	−6.293***	3	4	1	−5.970***	2.9	3.9	2	−6.865***
UK	5	1	−5.279***	1.4	1	−6.011***	2	5	1	−5.744***	4.6	1.5	1	−6.182***
Italy	5	1	−3.444**	4.7	1	−3.430**	2	5	1	−3.885**	3.6	5	1	−4.254***
Portugal	5	2	−2.252	4.9	2	−2.238	1	2	1	−3.744*	2.2	4.8	2	−3.492***
Sweden	1	2	−5.402***	3.7	2	−5.433***	3	4	1	−5.096***	3.5	2.7	2	−6.239***
US	4	1	−6.063***	4	1	−6.063***	2	4	1	−6.298***	0.3	4.1	1	−6.466***

See the note under Table 1.

Table 3. Time-varying FRF estimated with OLS.

	Canada	UK	Italy	Portugal	Sweden	US
Variables	PB	PB	PB	PB	PB	PB
L.PB	0.8077***	0.8778***	0.8516***	0.8386***	0.8594***	0.7872***
	(0.0585)	(0.0398)	(0.0442)	(0.0505)	(0.0523)	(0.0575)
L.debt	0.0116	0.0158**	0.0076	0.0046	0.0587***	0.0275**
	(0.0093)	(0.0064)	(0.0098)	(0.0041)	(0.0163)	(0.0114)
L.lgdp	−0.0466	0.1423	0.0112	−0.0590*	−0.2655***	−0.2993**
	(0.0855)	(0.1530)	(0.0661)	(0.0327)	(0.0884)	(0.1248)
Constant	−0.9750*	−1.9156**	−1.5453	0.0347	0.8958	0.1526
	(0.5053)	(0.8840)	(1.1250)	(0.3832)	(0.6751)	(0.5513)
Observations	147	147	147	147	147	147
R-squared	0.6056	0.7777	0.7277	0.7895	0.6684	0.5995

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. We follow D'Erasmo, Mendoza, and Zhang (2016) by adding an AR(1) term in the FRF. PB, is the primary balance computed as the ratio between the nominal revenues minus nominal expenditures and nominal; GDP, debt is the debt-to-GDP and lgdp, is the natural logarithm of the nominal GDP. L, stands for the lag operator.

Table 4. Threshold FRF estimated with OLS.

Var.	Canada PB	L.debt < = 92%	L.debt >92%	UK PB	L.debt < = 36%	36% < L.debt < = 125%	L.debt >125%
L.PB	0.9590***			0.8757***			
	(0.0602)			(0.0350)			
L.lgdp	0.0683			0.0153			
	(0.0885)			(0.1361)			
		−0.0019	0.1990***		1.6566***	0.0495***	0.0793***
		(0.0126)	(0.0330)		(0.3562)	(0.0181)	(0.0194)
Cons.		−0.2314	−22.0697***		−57.7954***	−2.6916**	−14.2658***
		(0.6003)	(3.6013)		(11.7636)	(1.2904)	(3.5630)
Obs.	147			147			
Var.	Italy PB	L.debt < = 61%	61% < L.debt < = 81%	L.debt >81%	Portugal PB	L.debt < = 24%	24% < L.debt < = 56%	L.debt >56%
L.PB	0.7785***				0.8077***			
	(0.0427)				(0.0501)			
L.lgdp	−0.0460				−0.1442***			
	(0.0639)				(0.0378)			
		−0.0786	−0.8204***	0.0156		0.1608**	0.0450***	0.0323***
		(0.0531)	(0.2021)	(0.0217)		(0.0678)	(0.0151)	(0.0085)
Cons.		2.3131	55.6189***	−2.0203		−1.7947	−0.7060	−1.3970***
		(2.1116)	(15.0514)	(2.2980)		(1.4542)	(0.7623)	(0.5282)
Obs.	147				147			
Var.	Sweden PB	L.debt			US PB	L.debt < = 78%	L.debt >78%	
L.PB	0.8594***				0.7830***			
	(0.0519)				(0.0557)			
L.lgdp	−0.2655***				−0.1715			
	(0.0877)				(0.1344)			
		0.0587***				0.0089	0.2739***	
		(0.0162)				(0.0161)	(0.0728)	
Cons.	0.8958				−25.1670***			
	(0.6704)				(0.5355)			
Obs.	147				147			

Standard errors in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1. We follow D'Erasmo et al. (2016) by adding an AR(1) term in the FRF. PB, is the primary balance computed as the ratio between the nominal revenues minus nominal expenditures and nominal; GDP, debt is the debt-to-GDP and lgdp, is the natural logarithm of the nominal GDP. L, stands for the lag operator.

result may reflect the presence of responsible fiscal rules.[7] The frequencies in trig functions have an integer value only in Sweden.

The results of the time-varying FRF in Table 3 and Figure 1 could provide more insight than those of the FDF unit root tests. In Table 3, we can see that the series of the primary balance are quite persistent and the *R*-squared is above 60% in all the countries. The AR(1) coefficient is always significant and fluctuates between 0.78 and 0.87. In

[7]Using the Engle-Granger's cointegration test between the primary surplus and the public debt, we reject the null of no cointegration at the 1% level in Sweden, the US, Canada and the UK. We reject the null at the 5% level in the case of Italy. We fail to reject the null at the 10% level for Portugal. The results are available upon reasonable request.

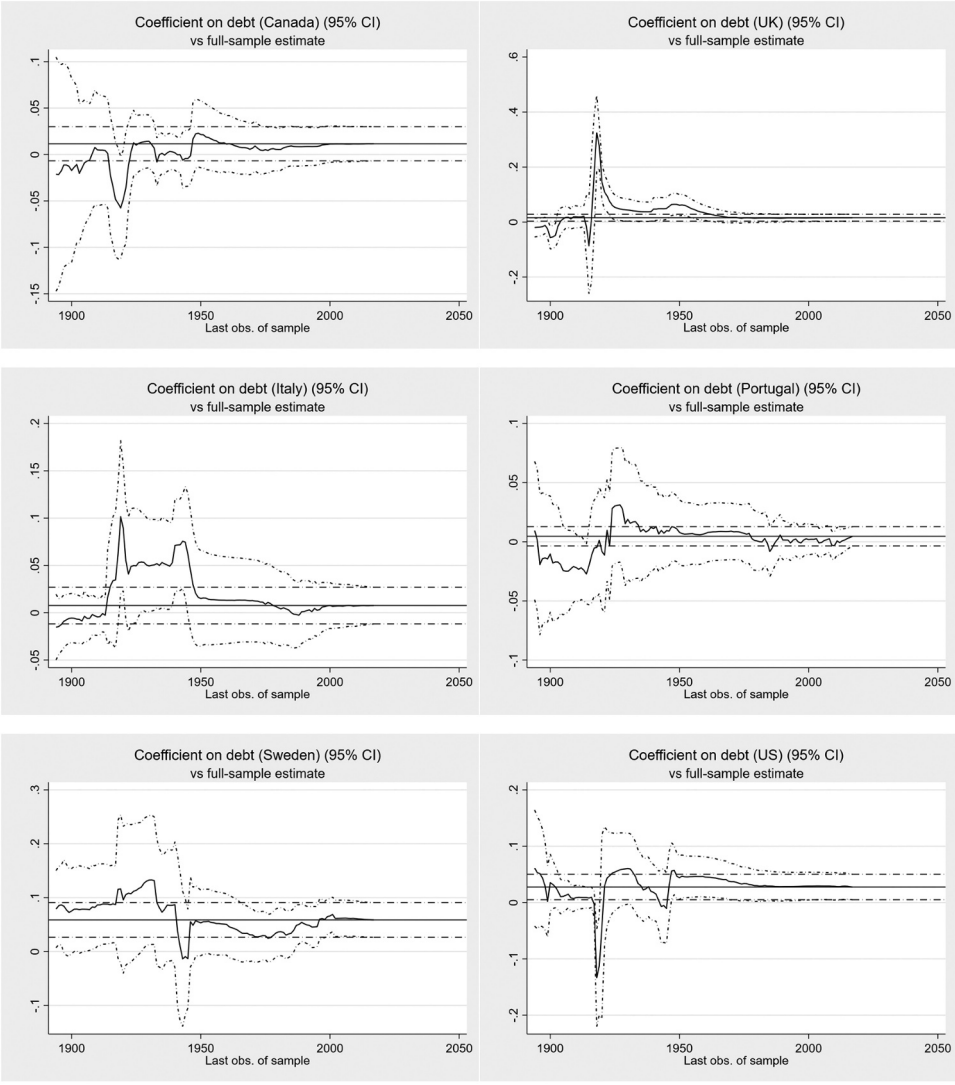

Figure 1. Time-varying FRF estimated with OLS. Rolling regressions estimated with OLS.

the third line of Table 3, the main coefficient of interest is the lagged debt coefficient ρ of Equation (3). The coefficient is significantly positive for three countries out of six, namely the UK, Sweden, and the US. Thus, longer-run fiscal sustainability is not rejected for the UK, Sweden, and the US.[8] In Figure 1, we focus on the convergence of the coefficient towards its longer-run value. We can observe that the coefficient of lagged debt substantially deviates from its full-sample value during WWI and WWII, especially in the US. On the whole, the lagged debt coefficients quickly converge to their full-sample value after WWII.

The evidence is somewhat equivocal for Canada, Italy and Portugal. We can emphasize two polar cases through our empirical analyses. Firstly, debt sustainability is almost certainly ensured in Sweden, as the FDF unit root tests always reject the presence of a unit root and the initial debt coefficient in the time-varying FRF is positive and statistically significant. Secondly, the presence of a unit root in the primary balance and the non-significant debt coefficient in the time-varying FRF may imply that debt sustainability is not ensured for the Portuguese economy.

[8]Interesting extensions of this work could be the use of the Fourier quantile unit root test as in Bahramian and Saliminezhad (2021) or the Fractional frequency flexible Fourier form (FFFFF) for panel cointegration test as in Olayeni, Tiwari, and Wohar (2021).

In the threshold FRF in Table 4,[9] interestingly, the results are the same as those of the time-varying FRF, as no evidence of threshold effects was found in Sweden. We detect a pattern of stronger value for coefficient ρ of Equation (3) in the US and in Canada. For high levels of public debt, we observe a stronger reaction for the primary balance. These results may reveal that governments could react more promptly to high levels of public debt when in fear that the indebtedness trajectory may provoke a public finance crisis. In Canada and in the US, debt sustainability is ensured for levels of initial debt above 92% and 78%, respectively, as the debt coefficient becomes significantly positive.

We found two thresholds for Italy and Portugal in line with the time-varying FRF of Figure 1 where the lagged debt coefficients converge to the full-sample estimates only at the beginning of the 1990s. Worse, the lagged debt coefficient is significantly negative in Italy for levels of debt between 61 and 81%.

On the whole, our results are in line with the results of Iorio and Fachin (2022), Aldama and Creel (2022) and Cho and Lee (2022). Overall, these three approaches (FDF unit root tests, time-varying FRF and threshold FRF) are complementary and may help reveal interesting evidence about debt stationarity and sustainability in the longer run.

IV. Conclusions

Using complementary econometric techniques that examine the fulfilment of the intertemporal budget constraint while avoiding explosive behaviour, we have considered longer-run debt sustainability when dealing with a longtime span and the presence of structural breaks for a sample of OECD countries. Longer-run debt sustainability is not rejected for the UK, Sweden, and for the US. However, our results cast some doubt on the sustainability of public finance for Canada, Italy and Portugal in the longer run. These results may act as a useful warning for policymakers. To provide a better modelling of FRF, Bayesian threshold FRF could be an interesting extension of this work. We leave this to further research.

Acknowledgment

The authors are grateful to Katharina Priedl for her precious language advice.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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