Purchasing Power Parity in the 34 OECD Countries: Evidence from Quantile-Based Unit Root Tests with both Smooth and Sharp Breaks

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Abstract

Conventional unit root tests have mostly failed to validate the PPP. Quantile-based unit root test by previous research have provided some support for the PPP. In this paper we take an additional step and incorporate sharp shifts and smooth breaks into the quantile-based unit root test and re-examine the PPP in each of the 34 OECD countries over the period 1994M01 to 2016M03. We find support for the PPP in 18 countries of Austria, Chile, Estonia, Finland, France, Germany, Italy, Korea, Mexico, Netherlands, New Zealand, Poland, Portugal, Slovenia, Sweden, Switzerland, Turkey, and the United Kingdom.

Keywords: Purchasing Power Parity; OECD Countries; Quantile Unit Root Test; Sharp Shifts; Smooth breaks.

JEL classification: C22; F31

I. Introduction

Purchasing Power Parity (PPP) theory asserts that in the long run the exchange rate between two currencies will be equal to the ratio of prices prevailing in the associated countries. Alternatively, when the nominal exchange rate and relative prices are combined to form the real exchange rate, if PPP is to hold, the real rate must be stationary. While old studies used to test the link between the nominal exchange rate and relative prices to determine how closely they follow each other, more recent studies test for stationarity of the real exchange rate by applying different unit root tests to determine if the real exchange rate contains a unit root, invalidating the PPP hypothesis.[1]

The literature on testing the PPP hypothesis is mixed and most studies have rejected the hypothesis, resulting in what is known as the PPP puzzle.[2] As new unit root tests are introduced, researcher rush to apply these tests with a hope of solving the puzzle. One such new test happens to be the Quantile unit root test. The main attractiveness of this test is that it considers the influence of various sizes of shocks on the real exchange rate whereas, standard unit root tests assumes the speed of adjustment in the real exchange rate towards its equilibrium is usually constant. Ignoring the sizes of shocks may contribute to the puzzle.[3]

The Quantile-based unit root test that is introduced by Koenker and Xiao (2004) has recently gained momentum and has been applied to test the PPP for different group of countries. For example, application of six different univariate unit root tests to real effective exchange rates of 23 OECD countries by Bahmani-Oskooee and Ranjbar (2016) supported their stationarity or the PPP only in five countries. However,

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[1] For a review article see Bahmani-Oskooee and Hegerty (2009).

[2] Some recent examples are Taylor (2004), Taylor and Taylor (2004), Enders and Chumrusphononlert (2004), Bahmani-Oskooee *et al*. (2008), Kim and Perron (2009), Chang and Tzeng (2013), He and Chang (2013), Boero et al., (2015), Bahmani-Oskooee *et al*., (2015), and Baharumshah *et al*., (2015).

[3] For deviation of PPP see Bahmani-Oskooee and Nassir (2005) and Sjolander, P., (2007)

when they applied the quantile unit root test, they supported the PPP in sixteen countries, moving closer and closer towards solving the puzzle. Apparently, incorporating effects of shocks into testing procedure improved testing efficiency and provided more support for the PPP. Perhaps, Bahmani-Oskooee and Ranjbar (2016) could have found even more support for the PPP, had they incorporated sharp shifts and smooth breaks in the real exchange rates into their quantile test.[4]

Therefore, it is our goal in this paper to do this, i.e., modify the standard quantile unit root test by incorporating sharp shifts and smooth breaks to determine if this helps to find support for the PPP in more countries. Indeed, when we apply the modified test to the real effective exchange rate of each of the 34 OECD countries, we validate the PPP if not in all but in more countries. The remainder of this work is organized as follows. Section II discusses the data used in our study. Section III first describes the quantile-based unit root test proposed by Koenker and Xiao (2004) and shows our modification to include sharp and smooth breaks. We then present the empirical results. Section IV concludes.

II. Data

We cover a sample of 34 OECD countries (Australia, Austria, Belgium, Canada, Chile, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States) and use each country's monthly real effective exchange rates that span over the period January 1994 to March 2016. The main reason for our data to begin with January 1994 is that these rates are constructed and

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[4] Note that Bahmani-Oskooee *et al.* (2014) modified the panel unit-root test of Carrion-i-Silvestre *et al.* (2005) by allowing for two different types of multiple structural breaks: first, breaks in the intercept (without linear trend), and second, breaks in the intercept and slope of the linear trend. We like to do the same for the time-series quantile unit root test.

made publicly available by the Bank for International Settlements (BIS).[5] We provide a statistical summary of the data in Table 1. The Jarque-Bera test results indicate that, except in Chile, Denmark, and Sweden, in all others countries, the real effective exchange rate has approximately non-normal distribution which suits well for unconventional unit root testing, such as quantile test.

III. The Methods and Results

As mentioned before, our goal is to modify standard quantile unit root test by incorporating sharp shifts and smooth breaks. In our proposed method, we take two steps. In the first step we adjust the real effective exchange rate for sharp shifts and smooth breaks. In the second step we apply quantile unit root test to adjusted real effective exchange rate to validate the PPP.

To model the mean reversion in real exchange rate with both sharp shifts and smooth breaks we first follow Bahmani-Oskoee *et al.,* (2015) and adopt the following data generating process:

$$rx_t = \alpha + \beta T + \sum_{l=1}^{m+1} \theta_l DU_{l,t} + \sum_{l=1}^{m+1} \rho_l DT_{l,t} + \sum_{k=1}^{n} \gamma_{1,k} \sin(\frac{2\pi kt}{T}) + \sum_{k=1}^{n} \gamma_{2,k} \cos(\frac{2\pi kt}{T}) + \varepsilon_t \tag{1}$$

where *rx* is the log of real effective exchange rate, t, T, and m are time trend, sample size and the optimum number of breaks, respectively. The other regressors in (1) are defined as:

$$DU_{k,t} = \begin{cases} 1 & if \quad TB_{k-1} < t < TB_k \\ 0 & otherwise \end{cases}$$

$$DT_{k,t} = \begin{cases} t - TB_{k-1} & if \quad TB_{k-1} < t < TB_k \\ 0 & otherwise \end{cases}$$

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[5] Here is the web site for the data: http://www.bis.org/statistics/eer.htm

The terms DU and DT are entered into (1) to capture the sharp shifts.[6] The Fourier approximation terms, i.e., $\sum_{k=1}^{n}\gamma_{1k}\sin(\frac{2\pi kt}{T})$ and $\sum_{k=1}^{n}\gamma_{2k}\cos(\frac{2\pi kt}{T})$ are entered to capture smooth transition due to Gallant (1981).[7]

In estimating (1) we need to select values for m, n, and k. Here we follow Becker *et al.* (2006) and set n=1 which helps us to reduce (1) to (2):[8]

$$rx_t = \alpha + \beta T + \sum_{l=1}^{m+1}\theta_l DU_{l,t} + \sum_{l=1}^{m+1}\rho_l DT_{l,t} + \gamma_1\sin(\frac{2\pi kt}{T}) + \gamma_2\cos(\frac{2\pi kt}{T}) + \varepsilon_t \qquad (2)$$

Next we follow the procedure in Bahmani-Oskooee *et al.* (2015) and select an optimum value of for k and m. We then adjust the real exchange rate series using (3) below to arrive at adjusted real effective exchange rate:

$$re_t = rx_t - \hat{\alpha} - \hat{\beta}T - \sum_{l=1}^{m+1}\hat{\theta}_l DU_{l,t} - \sum_{l=1}^{m+1}\hat{\rho}_l DT_{l,t} - \hat{\gamma}_1\sin(\frac{2\pi kt}{T}) - \hat{\gamma}_2\cos(\frac{2\pi kt}{T}) + \varepsilon_t \qquad (3)$$

where *re* is the real effective exchange rate adjusted by the effects of possible structural breaks for both sharp shifts and smooth breaks.

The second step in our proposed procedure is to apply quantile unit root test to adjusted series. Following Bahmani-Oskooee and Ranjbar (2016), the AR(q) process of the adjusted real exchange rate at quantile τ can be written as:

$$Q_\tau(re_t \mid re_{t-1},\ldots,re_{t-q}) = \alpha(\tau)re_{t-1} + a(\tau) + \sum_{i=1}^{q-1}\phi_i(\tau)\Delta re_{t-i}. \qquad (4)$$

By estimating (4) at different quantiles $\tau \in (0,1)$, we can get a set of estimates of the persistence measure as $\alpha(\tau)$. We can test if $\alpha(\tau)=1$ at different values of τ to

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[6] Equation (2) is not only an extension of Enders and Holt (2012) but also a combination of Carrion-i-Silvestre et al. (2006) and Becker et al. (2006) tests.

[7] Note that n and k are number of frequencies.

[8] Enders and Lee (2012) also favor setting n=1 in order to save the degrees of freedom and prevent the over-fitting problem.

analyze the persistence of the exchange rate impact of positive and negative shocks and shocks of different magnitude using the quantile autoregression based unit root test proposed by Koenker and Xiao (2004). The test has been extended by Galvao (2009) to include deterministic components, which is essential for unit root tests of drifting time series, such as the real effective exchange rates in our case.

Let $\hat{\alpha}(\tau)$ be the quantile regression estimator. To test $H_0 : \alpha(\tau) = 1$ we use the t-stat for $\hat{\alpha}(\tau)$ proposed by Koenker and Xiao (2004) which can be written as :

$$t_n(\tau) = \frac{\hat{f}\left(F^{-1}(\tau)\right)}{\sqrt{\tau(1-\tau)}}\left(re_{-1} M_z re_{-1}\right)^{1/2}\left(\hat{\alpha}(\tau) - 1\right) \qquad (5)$$

where $f(u)$ and $F(u)$ are the probability and cumulative density functions of ε_t , re_{-1} is the vector of lagged log-real exchange rate, and M_z is the projection matrix onto the space orthogonal to $Z = (1, \Delta re_{t-1}, \Delta re_{t-2}, \ldots, \Delta re_{t-q+1})$. We use the results derived by Koenker and Xiao (2004) and Galvao (2009) to find the critical values of $t_n(\tau)$ for different quantile levels. We can estimate $f\left(F^{-1}(\tau)\right)$ following the rule given in Koenker and Xiao (2004). Besides allowing for asymmetric effects of shocks on the real exchange rate, an important advantage of QAR-based unit root tests over standard unit root tests is that they have more effective accuracy. (Koenker and Xiao, 2004).

In contrast, a more complete inference of the unit root process based on the quantile approach involves exploring the unit root property across a range of quantiles. To this end, Koenker and Xiao (2004) suggest the Quantile Kolmogorov–Smirnov (*QKS*) test, which is given as :

$$QKS = \sup_{\tau \in \Gamma} \left| t_n(\tau) \right| \qquad (6)$$

where $t_n(\tau)$ is given by Equation (5) and $\Gamma = (0.1, 0.2, \ldots\ldots 0.9)'$ in our later applications. In other words, we first calculate $t_n(\tau)$ for all τ_s in Γ, and then construct the *QKS* test statistic by selecting the maximum value across Γ. While the limiting distributions of both $t_n(\tau)$ and *QKS* tests are nonstandard, Koenker and Xiao (2004) suggest the use of a resampling (Number of bootstrap =10,000 in our case) procedure to approximate their small-sample distributions.

IV. The Results

Before we produce the quantile unit root test results, we apply three conventional unit root tests, i.e., the ADF, PP and KPSS tests so that we can see how much our proposed method has contributed. These results are reported in Table 2 and clearly show that both the ADF and the PP tests fail to reject the null of the non-stationary real exchange rate in all OECD countries. KPSS test produce similar results. These are consistent with those of Kilian and Taylor (2003) rejecting the PPP theory in most OECD countries.

Next we apply the Quantile-based unit root test to our adjusted real effective exchange rates. To test the null of $\alpha(\tau) = 1$ for $\tau = 0.1, 0.2, 0.3, 04, ..., 0.9$ more formally, we use the t-statistic ($t_n(\tau)$) based on Equation (5). Table 3 show the point estimates, the t-statistics, the critical values, half-life of a shock, and *QKS* for each OECD country. We find that $H_0 : \alpha(\tau) = 1$ can be rejected at the 10% significance level over the whole conditional real exchange rate distribution based on the QKS test for 18 out of 34 OECD countries (i.e., Austria, Chile, Estonia, Finland, France, Germany, Italy, Korea, Mexico, Netherlands, New Zealand, Poland, Portugal, Slovenia, Sweden, Switzerland, Turkey, United Kingdom). The test result confirms that all types of shocks to the real exchange rate lead to temporary effects. This means that PPP is valid in these 18 countries. Tables 3 also show the persistent estimates of $\alpha(\tau)$ for $\tau = 0.1, 0.2, 0.3, ..., 0.9$ in each OECD country. The persistence parameter estimates are close to one for all the quantiles considered in the Hungary and the UK. The persistent point estimate is slightly above one at the upper tail quantile for the Canada, Greece, Mexico, New Zealand, Portugal, Slovaka, Switzerland and the UK. At the lower tail quintile for Czech Rep., Hungary, Iceland and Poland. Overall, the parameter estimates are relatively homogeneous over the conditional exchange rate distribution.

In sum, PPP is supported in Austria, Chile, Estonia, Finland, France, Germany, Italy, Korea, Mexico, Netherlands, New Zealand, Poland, Portugal, Slovenia, Sweden, Switzerland, Turkey, and the United Kingdom. In Table 3 we also calculate the half-life of a shock in those OECD countries. We find that the estimated half-life based on the quantile autoregressive model is about 7-18 months (0.6-1.5 years).

Next, we we present the optimum breaks and frequency from the mean reverting function in Table 4 along with the estimated F-statistic that enables us to test for the absence of the nonlinear component in equation (2). However, the critical values for the F-test is non-standard due to nuisance parameters (Becker *et al.* 2004), hence we follow Bahmani-Oskooee *et al.* (2015) and use Monte Carlo simulation to compute the critical values based on 10,000 replications. We fixed k at a maximum of 10 and m at a maximum of 7. Results from panel A of Table 4 reveal that the optimum frequency vary from one real exchange rate to another, with a minimum of 1 and maximum of 10 optimal frequencies. In all cases the computed F-statistics are greater than the critical values at least at the 1% level. Hence, the mean reverting function with the nonlinear component is accepted in favor of the one without the nonlinear component.

Turning to panel B we gather that there are a minimum of 3 breaks in many real exchange rate series but even more in some series. For instance, Australia has six break points: 08-1997, 02-2001, 04-2003, 02-2007, 08-2009 and 05-2013; Austria has 7 break points occurring at 12-1996, 03-1999, 04-2003, 06-2005, 08-2007, 12-2009 and 8-2013 while US has 6 break points: 01-1997, 01-2000, 12-2002, 01-2008, 03-2010 and 01-2014. It is interesting to note that the real exchange rates which were affected by the 2007-2008 global financial crisis exhibit breaks as revealed by the results. To demonstrate these breaks further, we plot the actual time paths of the real exchange rates series in Figure 1 which shows that there are structural shifts. This clearly supports our approach of accounting for both sharp shifts and smooth breaks in testing for a unit root. We then superimpose the predicted time paths from our model on the actual time paths. and we observe that the predicted (that is series ending with suffix, _H) tracks the dynamic behavior of the real exchange rates series very closely, suggesting that the decision to include the dummy variables and Fourier approximations is quite reasonable since the data generating process are indeed nonlinear.

V. Summary and Conclusion

The Purchasing Power Parity (PPP) theory implies that in the long-run the nominal exchange rate must adjust to inflation differentials. Alternatively, when the nominal rate is combined with the relative prices, the real exchange rate should be stationary or mean reverting in order for the PPP hypothesis to be valid. Like most previous research, conventional unit root tests hardly support stationarity of real exchange rates or the PPP, hence the PPP puzzle.

In this paper we aim at solving the puzzle by applying the quantile-based unit root test of Koenker and Xiao (2004) to the real effective exchange rate data of 34 OECD countries. However, we modify the test by accounting for sharp shifts and smooth breaks. Monthly data over the period January 1994- March 2016 are used to carry the empirical exercise. test proposed by Koenker and Xiao (2004) to revisit the PPP in 34 OECD countries, from the periods 1994M01 to 2016M03. While three traditional unit root tests failed to support the PPP hypothesis, our proposed quantile tests that accounted for sharp shifts and smooth breaks supported the PPP hypothesis in 18 countries. The list included Austria, Chile, Estonia, Finland, France, Germany, Italy, Korea, Mexico, Netherlands, New Zealand, Poland, Portugal, Slovenia, Sweden, Switzerland, Turkey, and United Kingdom, clearly a superior outcome. The estimated half-life based on the quantile autoregressive model is about 7-18 months (0.6-1.5 years). A major policy implication of our findings is that any anti-inflationary policy in each of the 18 countries could help stabilize their exchange rates and promote international trade and investment by increasing international confidence.

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Table 1. Summary statistics for 34 OECD.

Countries	Mean	Max.	Min.	Std. Dev.	Skew.	Kurt.	J.-B.
Australia	4.435638	4.714652	4.168369	0.147512	0.126367	1.886379	14.50729***
Austria	4.625784	4.717606	4.577593	0.02842	1.05143	4.091867	62.45793***
Belgium	4.596565	4.674043	4.506565	0.033549	-0.43687	2.877986	8.658698**
Canada	4.459101	4.67049	4.273048	0.110701	0.128326	1.662571	20.63226***
Chile	4.574551	4.731274	4.388506	0.073961	-0.28337	2.480388	6.577087
Czech Rep.	4.367407	4.71178	3.968781	0.207502	-0.34881	1.811135	21.13833***
Denmark	4.587251	4.655483	4.511628	0.030683	-0.10544	2.484616	3.449797
Estonia	4.462515	4.656528	3.725452	0.186677	-1.44719	5.01842	138.5218***
Finland	4.635213	4.759349	4.555771	0.040956	0.78732	3.764275	34.0826***
France	4.621571	4.71519	4.516667	0.045587	-0.14947	2.252058	7.217697***
Germany	4.644792	4.809579	4.515574	0.062646	0.392027	2.702905	7.820933**
Greece	4.537152	4.63113	4.420766	0.051981	-0.2351	2.085468	11.76205***
Hungary	4.448748	4.748318	4.172848	0.155556	-0.33194	1.662692	24.79911***
Iceland	4.801085	5.102059	4.473009	0.137243	-0.25845	2.471384	6.081223**
Ireland	4.552459	4.74719	4.381652	0.086309	0.17561	2.158414	9.251657***
Israel	4.608326	4.758749	4.434856	0.082514	-0.26206	2.287803	8.698853*
Italy	4.593961	4.656243	4.407938	0.040763	-0.97091	4.782139	77.28143***
Japan	4.610141	5.009768	4.216562	0.173473	-0.28006	2.667224	4.722342*
Korea	4.689903	4.880375	4.274998	0.113015	-0.37848	3.274997	7.215878**
Luxembourg	4.589843	4.633758	4.531847	0.024938	-0.55158	2.295779	19.05601***
Mexico	4.627367	4.891401	4.136925	0.125397	-0.69263	4.012941	32.76307***
Netherlands	4.603506	4.668145	4.500921	0.038953	-0.36074	2.369525	10.21319***
New Zealand	4.568034	4.755571	4.259294	0.113626	-0.72455	2.683505	24.47549***
Norway	4.560712	4.703295	4.396915	0.050768	-0.54161	3.714821	18.73807***
Poland	4.511871	4.803365	4.206482	0.121326	-0.59361	3.036803	15.69582***
Portugal	4.590272	4.644583	4.515027	0.03312	-0.26781	1.859108	17.67197***
Slovakia	4.300131	4.662117	3.867653	0.284788	-0.13841	1.373711	30.27599***
Slovenia	4.575292	4.638508	4.427358	0.034625	-1.39066	6.134462	195.3619***
Spain	4.561429	4.655198	4.464298	0.052153	-0.17178	1.683402	20.59752***
Sweden	4.682249	4.865918	4.498031	0.079449	0.117237	2.721885	1.472124
Switzerland	4.597142	4.792479	4.475175	0.062702	0.353015	2.404795	9.486803***
Turkey	4.376991	4.643236	3.826247	0.171651	-0.71881	2.728131	23.81493***
United Kingdom	4.754571	4.899629	4.545739	0.098656	-0.28024	1.635258	24.21543***
United States	4.680127	4.857562	4.533031	0.084554	0.291326	2.053513	13.74296***

Notes:
1. The time span is from 1994M1 to 2016M03.
2. *** indicates Significance at the 0.01 level. ** indicates significance at the 0.05 level. * indicates significance at the 0.1 level.

Table 2. Univariate unit root tests (ADF, PP and KPSS) for 34 OECD countries.

Countries	Levels			First Difference		
	ADF(k)	PP(k)	KPSS(k)	ADF(k)	PP(k)	KPSS(k)
Australia	-1.742(1)	-1.529(1)	1.569[12]	-11.881(0) ***	-11.616(7) ***	0.090[0]
Austria	-2.118(2)	-2.053(3)	0.766[12]	-12.090(1) ***	-13.267(8) ***	0.073[5]
Belgium	-2.188(1)	-1.940(4)	0.244[12] ***	-12.475(0) ***	-12.529(1) ***	0.071[3]
Canada	-1.457(1)	-1.414(6)	1.265[12]	-12.557(0) ***	-12.545(4) ***	0.162[6]
Chile	-2.884(1)	-2.519(2)	0.270[12] ***	-12.254(0) ***	-11.821(9) ***	0.065[4]
Czech Rep.	-1.923(0)	-1.870(2)	1.937[12]	-13.979(0) ***	-13.955(4) ***	0.329[1]
Denmark	-2.655(1)	-2.297(2)	0.317[12] ***	-12.458(0) ***	-12.248(5) ***	0.111[0]
Estonia	-5.504(2)	-7.906(2)	1.832[12]	-11.512(0) ***	-11.380(6) ***	1.133[8]
Finland	-2.369(1)	-2.061(2)	0.944[12]	-12.397(0) ***	-12.231(5) ***	0.066[0]
France	-0.876(0)	-1.051(4)	0.998[12]	-14.070(0) ***	-14.080(1) ***	0.090[3]
Germany	-1.375(1)	-1.183(1)	1.354[12]	-13.298(0) ***	-13.135(6) ***	0.056[2]
Greece	-1.619(13)	-2.419(43)	1.018[12]	-4.143(12) ***	-16.821(105) ***	0.301[103]
Hungary	-1.493(1)	-1.360(1)	1.671[12]	-12.875(0) ***	-12.806(4) ***	0.160[1]
Iceland	-2.071(1)	-1.709(6)	0.723[12] *	-11.041(1) ***	-11.297(16) ***	0.083[7]
Ireland	-1.429(1)	-1.250(3)	0.913[12]	-12.918(0) ***	-12.886(2) ***	0.268[3]
Israel	-1.628(2)	-1.489(0)	0.622[12] **	-11.832(1) ***	-12.133(4) ***	0.097[1]
Italy	-2.271(2)	-2.390(4)	0.584[12] **	-11.712(1) ***	-12.566(1) ***	0.083[3]
Japan	-1.707(1)	-1.222(1)	1.524[12]	-11.840(0) ***	-11.735(5) ***	0.060[0]
Korea	-2.778(2)	-2.743(5)	0.213[12] ***	-11.578(1) ***	-9.331(22) ***	0.050[7]
Luxembourg	-1.662(7)	-1.853(2)	0.824[12]	-5.869(6) ***	-21.497(6) ***	0.076[3]
Mexico	-2.595(2)	-2.440(4)	0.301[12] ***	-13.465(0) ***	-13.245(10) ***	0.078[6]
Netherlands	-2.595(2)	-2.440(4)	0.301[12] ***	-13.465(0) ***	-13.245(10) ***	0.078[6]
New Zealand	-1.949(1)	-1.878(4)	0.890[12]	-12.557(0) ***	-12.625(3) ***	0.064[3]
Norway	-2.394(1)	-1.996(3)	0.302[12] ***	-12.948(0) ***	-12.685(9) ***	0.192[5]
Poland	-2.824(1)	-2.559(4)	1.258[12]	-11.596(0) ***	-11.547(2) ***	0.174[4]
Portugal	-1.461(13)	-2.125(13)	1.125[12]	-5.254(5) ***	-14.689(16) ***	0.233[14]
Slovakia	-1.153(1)	-1.143(3)	2.078[12]	-12.092(0) ***	-12.093(4) ***	0.250[4]
Slovenia	-4.679(1)	-4.243(3)	1.262[12]	-11.304(0) ***	-11.234(3) ***	0.311[5]
Spain	-1.461(6)	-1.575(11)	1.367[12]	-5.468(5) ***	-12.513(18) ***	0.225[12]
Sweden	-1.857(1)	-1.647(5)	1.477[12]	-12.716(0) ***	-12.650(2) ***	0.034[4]
Switzerland	-1.578(0)	-1.709(5)	0.471[12] **	-14.492(0) ***	-14.399(9) ***	0.117[6]
Turkey	-2.512(2)	-2.137(5)	1.610[12]	-11.299(1) ***	-11.709(13) ***	0.044[6]
United Kingdom	-1.358(1)	-1.366(5)	0.763[12]	-13.392(0) ***	-13.440(3) ***	0.135[5]
United States	-1.709(1)	-1.432(4)	0.673[12]	-11.101(0) ***	-10.835(7) ***	0.153[3]

Notes:

1.The number in parenthesis indicates the lag order selected based on the recursive t-statistic, as suggested by Perron (1989).

2.The number in the brackets indicates the truncation for the Bartlett Kernel, as suggested by the Newey and West (1994).

3.*, **, and *** denote the significance levels at 10%, 5% and 1%, respectively.

Table 3: Results of quantile estimation and unit-root tests with sharp shift and smooth breaks for 34 OECD countries.

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Australia	$\alpha_1(\tau)$	0.9961	0.9818	0.9552	0.9588	0.9565	0.9548	0.9583	0.9533	0.9694
	$t_n(\tau)$	-0.0818	-0.6882	-1.9334	-1.8627	-2.1766	-2.1918	-1.9945	-2.1922	-1.6023
	Critical value	-3.0384	-3.0348	-3.1063	-2.9555	-2.9187	-2.9377	-2.6677	-2.8254	-2.5725
	Half-lives	177.3832	37.73738	15.12281	16.47496	15.58528	14.98587	16.2732	14.49322	22.3035
	QKS statistic: 2.1922		{CV 5%:2.7898}							
Austria	$\alpha_1(\tau)$	0.9652	0.9417	0.9291	0.941	0.9483	0.9546	0.957	0.9524	0.9522
	$t_n(\tau)$	-1.1172	-2.7439	**-3.1563**	**-3.3355**	-2.6292	-2.4215	-2.1558	-1.8433	-1.317
	Critical value	-2.7811	-3.0414	-3.1326	-3.1553	-2.9811	-2.8804	-3.0289	-2.9832	-2.853
	Half-lives	19.5694	11.53927	9.425585	11.39817	13.05746	14.9183	15.77059	14.21253	14.15158
	QKS statistic:3.3355		{CV 5%:2.7840}							
Belgium	$\alpha_1(\tau)$	0.9437	0.9789	0.9858	0.9829	0.9646	0.9771	0.9541	0.9532	0.9321
	$t_n(\tau)$	**-2.7934**	-1.1891	-1.0042	-1.1363	-2.2289	-1.2698	-2.3721	-2.6483	-2.3704
	Critical value	-2.6701	-2.9158	-3.0132	-2.8142	-3.1053	-3.2538	-3.0986	-3.0086	-2.7054
	Half-lives	11.96175	32.50277	48.46578	40.18735	19.23177	29.92052	14.75196	14.4615	9.857718
	QKS statistic:2.7934		{CV 5%:2.8012}							
Canada	$\alpha_1(\tau)$	0.9962	1.0046	0.9973	0.9892	0.9814	0.9831	0.9676	0.9706	0.9831
	$t_n(\tau)$	-0.1331	0.2678	-0.178	-0.7242	-1.2232	-1.0505	-1.948	-1.5369	-0.6951
	Critical value	-2.6966	-2.7752	-2.8578	-2.9598	-2.9916	-3.078	-3.0359	-2.8445	-2.8464
	Half-lives	182.0604	∞	256.3744	63.83309	36.91832	40.66707	21.04496	23.22814	40.66707
	QKS statistic:1.948		{CV 5%:2.7728}							
Chile	$\alpha_1(\tau)$	0.992	0.9903	0.9724	0.9626	0.947	0.9287	0.9275	0.933	0.92
	$t_n(\tau)$	-0.2067	-0.3286	-1.0207	-1.5737	-2.6309	**-3.8541**	**-3.6435**	**-2.8982**	**-2.7137**
	Critical value	-2.7157	-3.0085	-3.0311	-3.0282	-3.0996	-3.108	-2.9445	-2.64	-2.6808
	Half-lives	86.29636	71.11134	24.76584	18.18457	12.72853	9.370713	9.20973	9.994901	8.31295
	QKS statistic:3.8541		{CV 5%:2.7989}							

Notes: The table shows point estimates, t-statistics and critical values for the 5% significance level. If the t-statistic is numerically smaller than the critical value then we reject the null hypothesis of $\alpha(\tau) = 1$ at the 5% level. QKS is the quantile Kolmogorov–Smirnov test. CV is 5 % critical value for QKS based on 10,000 bootstrapping simulations. Half lives (HL) for a simple AR(1) model are computed based on the formula $\ln(0.5)/\ln(\alpha(\tau))$, where a is the autoregressive coefficient under consideration.

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Czech Rep.	$\alpha_1(\tau)$	0.9598	0.9717	0.9791	0.987	0.9914	0.9977	1.0002	1.0012	1.0219
	$t_n(\tau)$	-1.4021	-1.2822	-1.5061	-0.9488	-0.6182	-0.1439	0.0113	0.0729	0.7441
	Critical value	-2.4081	-2.7451	-2.8991	-2.8883	-2.8655	-2.9071	-2.8866	-2.6049	-2.5909
	Half-lives	16.89352	24.1446	32.81714	52.97168	80.25144	301.0216	∞	∞	∞
	QKS statistic:1.5061		{CV 5%:2.7918}							
Denmark	$\alpha_1(\tau)$	0.9894	0.9732	0.971	0.956	0.9558	0.9585	0.9403	0.9375	0.9744
	$t_n(\tau)$	-0.3818	-1.1587	-1.4653	-2.1315	-2.0472	-2.0371	-2.5412	-2.5531	-0.9413
	Critical value	-2.4805	-2.9435	-3.1442	-3.0645	-3.1266	-3.0075	-3.0637	-3.0092	-2.7631
	Half-lives	65.04405	25.51556	23.55335	15.40417	15.33288	16.35332	11.26038	10.74005	26.72799
	QKS statistic:2.553		{CV 5%:2.7824}							
Estonia	$\alpha_1(\tau)$	0.9925	0.978	0.9717	0.9624	0.9563	0.9572	0.9494	0.9404	0.9173
	$t_n(\tau)$	-0.4354	-1.9281	-2.5748	**-3.1006**	**-3.6621**	**-3.8261**	**-4.0646**	**-3.8457**	**-3.8523**
	Critical value	-2.4427	-2.7801	-2.7851	-2.8124	-2.9649	-2.9484	-2.9299	-2.7259	-2.3117
	Half-lives	92.07262	31.15883	24.1446	18.08598	15.51234	15.84593	13.34899	11.27986	8.029906
	QKS statistic: 4.0646		{CV 5%:2.7765}							
Finland	$\alpha_1(\tau)$	0.9608	0.9533	0.9342	0.9525	0.9472	0.9435	0.9439	0.9135	0.8954
	$t_n(\tau)$	-1.0548	-2.0824	-2.9671	-2.3079	-2.3548	-2.4135	-2.4835	**-2.8816**	-1.9534
	Critical value	-2.7397	-3.0564	-3.173	-3.139	-3.1267	-3.0223	-2.9245	-2.8207	-2.8844
	Half-lives	17.33344	14.49322	10.18365	14.24319	12.77808	11.91816	12.00566	7.661463	6.273692
	QKS statistic:2.9671		{CV 5%:2.791}							
France	$\alpha_1(\tau)$	0.9908	0.9942	0.9738	0.9757	0.9735	0.9732	0.9632	0.9323	0.9242
	$t_n(\tau)$	-0.3665	-0.3034	-1.4213	-1.3996	-1.4131	-1.4787	-1.8288	-2.9821	-2.6038
	Critical value	-2.709	-2.869	-3.1537	-3.0288	-3.1008	-3.0732	-2.9719	-2.9353	-2.7654
	Half-lives	74.99498	119.1612	26.10789	28.17658	25.80837	25.51556	18.48678	9.887888	8.793296
	QKS statistic:2.8821		{CV 5%:2.784}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Germany	$\alpha_1(\tau)$	0.9669	0.9815	0.9755	0.9705	0.9684	0.9781	0.9599	0.9277	0.9251
	$t_n(\tau)$	-1.1549	-0.8976	-1.5359	-1.6436	-1.6062	-1.0348	-1.793	**-3.6809**	-1.8945
	Critical value	-2.7689	-3.1264	-3.0551	-3.1119	-2.9999	-2.8925	-2.9218	-3.0422	-2.8672
	Half-lives	20.59248	37.11976	27.94372	23.14821	21.58661	31.3027	16.93653	9.23619	8.903231
	QKS statistic:3.6809		{CV 5%:2.7753}							
Greece	$\alpha_1(\tau)$	1.0138	0.9964	0.9882	0.9818	0.9811	0.9803	0.9877	0.9574	0.9607
	$t_n(\tau)$	0.4196	-0.1431	-0.6247	-1.0022	-1.0685	-1.0065	-0.5907	-1.6171	-1.3515
	Critical value	-2.7707	-2.7706	-2.9652	-3.1412	-2.9944	-3.1276	-2.802	-2.8794	-2.7968
	Half-lives	∞	192.1941	58.39403	37.73738	36.32678	34.83741	56.00614	15.92197	17.28844
	QKS statistic:1.6171		{CV 5%:2.7869}							
Hungary	$\alpha_1(\tau)$	0.9499	0.9804	0.9851	1.0046	1.0143	1.0272	1.0273	1.0411	1.0399
	$t_n(\tau)$	-1.3841	-0.8812	-0.9678	0.3341	1.0675	1.9101	1.7321	1.7951	1.4473
	Critical value	-2.7543	-2.9612	-3.1511	-3.0093	-2.9716	-2.814	-2.8831	-2.7447	-2.6048
	Half-lives	13.48573	35.01694	46.1725	∞	∞	∞	∞	∞	∞
	QKS statistic:1.9101		{CV 5%:2.7564}							
Iceland	$\alpha_1(\tau)$	0.9181	0.942	0.9631	0.9907	1.0029	1.0103	1.0208	1.0299	1.0334
	$t_n(\tau)$	-2.1995	-2.5591	-2.6498	-0.8483	0.2933	1.1063	1.9076	1.965	1.295
	Critical value	-2.9254	-2.9374	-2.8547	-2.9382	-3.0352	-3.0347	-2.713	-2.7417	-2.6565
	Half-lives	8.111827	11.60079	18.43573	74.18484	∞	∞	∞	∞	∞
	QKS statistic:2.6498		{CV 5%:2.7758}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Ireland	$\alpha_1(\tau)$	0.9934	0.9986	1.0117	1.0148	1.0124	0.9885	0.9877	0.9806	0.9635
	$t_n(\tau)$	-0.4202	-0.0988	0.9297	1.2235	1.0819	-0.9774	-1.0366	-1.7047	-1.7201
	Critical value	-3.22	-3. 1237	-3.1599	-2.9886	-3.0263	-2.9939	-3.1894	-2.8874	-2.6744
	Half-lives	104.6753	494.7585	∞	∞	∞	59.92643	56.00614	35.38153	18.64161
	QKS statistic:1.7201		{CV 5%:2.81}							
Israel	$\alpha_1(\tau)$	0.9485	0.9687	0.9784	0.9848	0.988	0.9958	0.9995	0.9945	0.9918
	$t_n(\tau)$	-1.4909	-1.7013	-1.4431	-1.1814	-0.8181	-0.2943	-0.0329	-0.3461	-0.418
	Critical value	-2.6568	-3.0184	-3.0237	-3.1099	-2.9936	-3.1273	-2.9939	-2.9288	-2.6357
	Half-lives	13.10954	21.79687	31.74231	45.25433	57.41499	164.6882	1385.948	125.6799	84.18309
	QKS statistic:1.7013		{CV 5%:2.7753}							
Italy	$\alpha_1(\tau)$	0.9757	0.9833	0.9691	0.9763	0.9718	0.9598	0.9082	0.9108	0.9132
	$t_n(\tau)$	-0.7084	-1.0126	-1.741	-1.306	-1.4485	-1.9762	**-4.4549**	**-3.7272**	**-2.6178**
	Critical value	-2.9919	-3.0305	-3.0684	-3.0794	-2.8507	-2.8904	-2.8236	-2.7685	-2.5326
	Half-lives	28.17658	41.15827	22.08356	28.89876	24.23146	16.89352	7.198488	7.418739	7.633749
	QKS statistic:4.4549		{CV 5%:2.7481}							
Japan	$\alpha_1(\tau)$	0.9667	0.9671	0.9964	0.9977	0.9894	0.993	0.9551	0.9448	0.9084
	$t_n(\tau)$	-1.3786	-1.3367	-0.1624	-0.1122	-0.5437	-0.3538	-2.0112	-1.7561	-2.4457
	Critical value	-2.5322	-2.6234	-2.9084	-3.0021	-3.1648	-3.1617	-3.0813	-2.8589	-2.8643
	Half-lives	20.4667	20.7198	192.1941	301.0216	65.04405	98.67405	15.08835	12.20716	7.214987
	QKS statistic:2.4457		{CV 5%:2.7863}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Korea	$\alpha_1(\tau)$	0.9944	0.9936	0.9768	0.9721	0.9597	0.957	0.9443	0.9357	0.9313
	$t_n(\tau)$	-0.1332	-0.2914	-1.3722	-2.1643	**-2.9904**	**-3.1996**	**-3.975**	**-5.6795**	**-4.9294**
	Critical value	-2.9522	-2.9092	-2.6514	-2.7922	-2.8898	-2.7067	-2.5612	-2.6873	-2.5575
	Half-lives	123.4294	107.9573	29.5291	24.49578	16.85073	15.77059	12.09441	10.42948	9.738794
	QKS statistic:5.6795		{CV 5%:2.7782}							
Luxembourg	$\alpha_1(\tau)$	0.9811	0.953	0.9652	0.9608	0.9634	0.9718	0.9598	0.9467	0.9377
	$t_n(\tau)$	-0.8368	-2.3562	-1.6312	-1.9078	-1.6749	-1.3043	-1.7611	-2.5947	-2.4222
	Critical value	-2.6881	-2.898	-2.8918	-3.0485	-3.134	-2.8709	-2.8953	-2.8665	-2.6205
	Half-lives	36.32678	14.39846	19.5694	17.33344	18.58972	24.23146	16.89352	12.6549	10.77567
	QKS statistic:2.5947		{CV 5%:2.8058}							
Mexico	$\alpha_1(\tau)$	1.027	0.9994	0.9774	0.9689	0.9526	0.9556	0.9572	0.9463	0.9309
	$t_n(\tau)$	0.3577	-0.0214	-1.0289	-1.7165	**-3.3217**	**-3.5828**	**-2.8833**	**-3.5164**	**-3.6214**
	Critical value	-2.8014	-2.771	-2.7309	-2.6666	-2.7314	-2.7054	-2.5747	-2.5581	-2.3111
	Half-lives	∞	1154.899	30.32234	21.93929	14.27398	15.26223	15.84593	12.55801	9.680364
	QKS statistic:3.6214		{CV 5%:2.7795}							
Netherlands	$\alpha_1(\tau)$	0.9899	0.9769	0.9821	0.9757	0.9731	0.9684	0.963	0.9402	0.929
	$t_n(\tau)$	-0.3601	-1.1855	-0.965	-1.311	-1.5502	-1.6721	-2.003	-2.9976	-1.7619
	Critical value	-2.8294	-3.1506	-3.2818	-3.1419	-3.0667	-3.0848	-2.9829	-2.9007	-2.8688
	Half-lives	68.28127	29.65845	38.37569	28.17658	25.4194	21.58661	18.38496	11.24095	9.411809
	QKS statistic:2.7976		{CV 5%:2.7692}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
New Zealand	$\alpha_1(\tau)$	1.0352	1.0236	1.024	1.0148	0.9834	0.9558	0.9316	0.9392	0.9395
	$t_n(\tau)$	1.5401	1.1979	1.24	0.7655	-0.9417	-2.7002	**-4.2622**	**-3.4879**	**-3.0144**
	Critical value	-2.9844	-3.0578	-3.1081	-3.2311	-3.3456	-3.2767	-3.3268	-3.1217	-2.7716
	Half-lives	∞	∞	∞	∞	41.40831	15.33288	9.783065	11.05025	11.1068
	QKS statistic:4.2622		{CV 5%:3.2228}							
Norway	$\alpha_1(\tau)$	0.933	0.9809	0.9702	0.9513	0.9674	0.9931	0.9577	0.9533	0.9947
	$t_n(\tau)$	-1.1814	-0.5436	-1.1226	-1.8756	-1.3383	-0.2753	-1.7629	-1.4332	-0.1087
	Critical value	-2.8621	-3.0018	-3.1002	-3.0871	-3.0594	-3.1131	-3.131	-2.9135	-2.7242
	Half-lives	9.994901	35.94274	22.91165	13.88354	20.9137	100.1091	16.03739	14.49322	130.4356
	QKS statistic:1.8756		{CV 5%:2.8187}							
Poland	$\alpha_1(\tau)$	0.9135	0.9185	0.938	0.9715	0.9958	1.0045	1.012	1.0231	1.0213
	$t_n(\tau)$	-1.9574	**-3.3551**	**-3.0791**	-1.4199	-0.214	0.2204	0.6214	1.0571	0.9127
	Critical value	-2.6379	-2.8448	-3.0977	-3.0674	-3.1764	-3.1484	-3.0765	-2.9139	-2.4295
	Half-lives	7.661463	8.15339	10.82952	23.97271	164.6882	∞	∞	∞	∞
	QKS statistic:3.3551		{CV 5%:2.7764}							
Portugal	$\alpha_1(\tau)$	1.0011	0.9872	0.9981	0.9878	0.9808	0.9671	0.9458	0.9604	0.942
	$t_n(\tau)$	0.0471	-0.779	-0.126	-0.7645	-1.1547	-1.8803	-3.1473	-1.7346	-1.708
	Critical value	-2.7103	-3.1402	-3.1162	-3.125	-2.9724	-2.9422	-3.0125	-3.0771	-2.6122
	Half-lives	∞	53.80481	364.4676	56.46806	35.75372	20.7198	12.4389	17.15481	11.60079
	QKS statistic:2.9473		{CV 5%:2.7709}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Slovakia	$\alpha_1(\tau)$	1.0118	0.9998	1.003	0.9985	0.9896	0.9936	0.998	0.9821	0.9888
	$t_n(\tau)$	0.4623	-0.0154	0.2817	-0.1733	-1.2326	-0.7004	-0.1636	-1.0695	-0.4161
	Critical value	-2.7988	-3.1075	-3.0634	-3.2497	-3.3078	-3.4087	-3.3687	-3.2397	-3.2146
	Half-lives	∞	∞	∞	461.7515	66.30159	107.9573	346.2269	38.37569	61.54092
	QKS statistic:1.2326		{CV 5%:2.7653}							
Slovenia	$\alpha_1(\tau)$	0.9076	0.9315	0.9443	0.9472	0.9429	0.9609	0.9292	0.9115	0.878
	$t_n(\tau)$	**-2.6846**	-2.127	-2.1111	-2.0772	-2.3628	-1.4769	-2.5527	-2.6821	**-2.9882**
	Critical value	-2.6037	-2.8641	-3.0271	-2.9697	-3.2285	-3.0972	-2.8869	-2.8436	-2.8445
	Half-lives	7.14942	9.768265	12.09441	12.77808	11.78921	17.37867	9.4394	7.480246	5.327447
	QKS statistic:2.9882		{CV 5%:2.7823}							
Spain	$\alpha_1(\tau)$	0.9739	0.9955	0.9831	0.9871	0.9932	0.9713	0.9625	0.9758	0.9863
	$t_n(\tau)$	-1.0659	-0.2371	-0.9829	-0.8007	-0.4184	-1.6895	-2.0392	-1.3084	-0.6133
	Critical value	-2.9355	-2.9116	-3.1662	-3.1666	-3.1457	-3.0046	-3.0064	-2.884	-2.6147
	Half-lives	26.20926	153.6859	40.66707	53.38502	101.5864	23.80321	18.13514	28.29446	50.24731
	QKS statistic:2.0392		{CV 5%:2.8001}							
Sweden	$\alpha_1(\tau)$	0.9781	0.9767	0.9768	0.9436	0.928	0.9383	0.9306	0.9237	0.9104
	$t_n(\tau)$	-0.6499	-0.7764	-0.7679	-2.1325	-3.2431	-2.6978	-2.6937	-2.114	-2.0265
	Critical value	-2.6356	-2.8685	-3.0991	-2.9832	-3.1734	-3.2165	-3.0809	-2.997	-2.7565
	Half-lives	31.3027	29.40087	29.5291	11.93992	9.276155	10.8839	9.636984	8.73334	7.384023
	QKS statistic:3.043		{CV 5%:2.7524}							

Table 3:(Continued).

Countries	τ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
Switzerland	$\alpha_1(\tau)$	1.027	0.9994	0.9774	0.9689	0.9526	0.9556	0.9572	0.9463	0.9309
	$t_n(\tau)$	0.3577	-0.0214	-1.0289	-1.7165	**-3.3217**	**-3.5828**	**-2.8833**	**-3.5164**	**-3.6214**
	Critical value	-2.8014	-2.771	-2.7309	-2.6666	-2.7314	-2.7054	-2.5747	-2.5581	-2.31
	Half-lives	∞	∞	30.32234	21.93929	14.27398	15.26223	15.84593	12.55801	9.680364
	QKS statistic:3.6214		{CV 5%:2.7795}							
Turkey	$\alpha_1(\tau)$	0.9899	0.9769	0.9821	0.9757	0.9731	0.9684	0.963	0.9402	0.929
	$t_n(\tau)$	-0.3601	-1.1855	-0.9651	-1.311	-1.5502	-1.6721	-2.003	-2.9976	-1.7619
	Critical value	-2.8294	-3.1506	-3.2818	-3.1419	-3.0667	-3.0848	-2.9829	-2.9007	-2.8688
	Half-lives	68.28127	29.65845	38.37569	28.17658	25.4194	21.58661	18.38496	11.24095	9.411809
	QKS statistic:2.7976		{CV 5%:2.7692}							
United Kingdom	$\alpha_1(\tau)$	1.0352	1.0236	1.024	1.0148	0.9834	0.9558	0.9316	0.9392	0.9395
	$t_n(\tau)$	1.5401	1.1979	1.24	0.7655	-0.9417	-2.7002	**-4.2622**	**-3.4879**	**-3.0144**
	Critical value	-2.9844	-3.0294	-3.1031	-3.111	-3.3456	-3.2767	-3.3268	-3.1217	-2.7716
	Half-lives	∞	∞	∞	∞	41.40831	15.33288	9.783065	11.05025	11.1068
	QKS statistic:4.2622		{CV 5%:3.2228}							
United States	$\alpha_1(\tau)$	0.933	0.9809	0.9702	0.9513	0.9674	0.9931	0.9577	0.9533	0.9947
	$t_n(\tau)$	-1.1814	-0.5436	-1.1226	-1.8756	-1.3383	-0.2753	-1.7629	-1.4332	-0.1087
	Critical value	-2.8621	-3.0018	-3.1002	-3.0871	-3.0594	-3.1131	-3.131	-2.9135	-2.7242
	Half-lives	9.994901	35.94274	22.91165	13.88354	20.9137	100.1091	16.03739	14.49322	130.4356
	QKS statistic:1.8756		{CV 5%:2.8187}							

Table 4: Break Dates and Optimum Frequency from the Mean Reverting Function

Panel A: The results for optimum frequency and the F-statistic and its critical values

Countries	Optimum frequency	F-stat.	90%	95%	97.50%	99%
Australia	3	99.9361	2.2939	2.9095	3.8476	5.2526
Austria	6	58.3393	2.2653	2.8085	3.3367	4.2122
Belgium	7	58.307	2.3495	3.2069	3.9031	5.241
Canada	10	21.7333	2.0636	2.6423	3.2932	4.1362
Chile	5	28.9662	2.3613	3.0359	3.9518	4.9266
Czech Rep.	4	43.1923	2.3192	2.9275	3.8017	4.64
Denmark	6	122.5901	2.1203	2.7418	3.3182	4.2781
Estonia	2	134.1148	2.2313	2.8844	3.5287	4.163
Finland	6	73.5487	2.1997	2.9692	3.4916	4.5102
France	5	157.0734	2.2791	3.0384	3.9247	5.6586
Germany	7	96.5881	2.3869	3.1736	4.1358	4.9538
Greece	9	38.6131	2.3283	2.8844	3.4486	4.2147
Hungary	4	43.2588	2.1866	2.8909	3.3919	4.7567
Iceland	2	170.5933	2.2744	2.7756	3.5626	4.5744
Ireland	4	102.5812	2.3998	3.1316	3.6158	4.9114
Israel	1	73.3403	2.3026	2.9546	3.5023	4.6877
Italy	1	57.2752	2.1937	2.8221	3.5789	4.3344
Japan	4	28.8901	2.2933	2.9295	3.5833	4.4259
Korea	6	101.9351	2.3172	3.022	3.563	4.6879
Luxembourg	7	51.5451	2.524	3.3088	3.9769	4.758
Mexico	2	271.5935	2.1837	2.8603	3.3367	4.3198
Netherlands	6	100.9766	2.1292	2.832	3.1777	4.0337
New Zealand	3	373.2444	2.2849	2.8692	3.6184	4.697
Norway	2	81.7544	2.3347	3.1365	3.6291	4.6465
Poland	5	163.8477	2.3556	3.0276	3.5045	4.688
Portugal	3	109.8832	2.3893	3.1783	3.7197	4.5021
Slovakia	8	82.8545	2.2935	2.9348	3.6417	4.2405
Slovenia	5	82.3789	2.3301	3.0447	3.8742	5.112
Spain	6	89.6576	2.3019	2.9147	3.5356	4.0959
Sweden	3	308.5046	2.1251	2.7453	3.619	4.2545
Switzerland	3	118.5293	2.1437	2.7562	3.5778	4.6327
Turkey	1	279.2918	2.2855	2.9565	3.465	4.4211

United Kingdom	3	69.6811	2.3001	3.0365	3.8649	4.6504
United States	7	86.461	2.4286	3.1008	3.8271	4.8762

Panel B: The results for sharp drift dates

Countries	Break dates						
Australia	08-1997	02-2001	04-2003	02-2007	08-2009	05-2013	0
Austria	12-1996	03-1999	04-2003	06-2005	08-2007	12-2009	08-2013
Belgium	01-1997	01-2000	12-2002	01-2008	03-2010	01-2014	0
Canada	05-1998	04-2003	08-2005	02-2010	12-2013	0	0
Chile	01-1997	04-1999	06-2001	07-2005	05-2008	07-2010	10-2013
Czech Republic	02-1996	04-1998	12-2001	10-2004	11-2007	09-2011	11-2013
Denmark	01-1997	04-1999	01-2003	07-2005	10-2007	01-2010	06-2012
Estonia	02-1996	07-1998	12-2000	02-2003	02-2011	04-2013	0
Finland	02-1996	03-1999	01-2003	06-2005	10-2007	01-2010	0
France	01-1997	05-1999	05-2002	03-2006	07-2008	12-2011	0
Germany	01-1997	02-2000	06-2002	03-2010	0	0	0
Greece	02-1996	06-1999	11-2002	09-2007	11-2011	01-2014	0
Hungary	03-1999	05-2001	02-2004	10-2006	12-2008	01-2014	0
Iceland	11-1996	01-1999	03-2001	05-2008	07-2010	0	0
Ireland	04-1997	07-2002	09-2004	11-2006	01-2009	11-2011	01-2014
Israel	06-1996	01-2000	03-2002	05-2004	12-2007	08-2011	01-2014
Italy	02-1996	01-2000	10-2002	05-2005	01-2010	05-2013	0
Japan	02-1996	09-1998	12-2000	09-2005	09-2008	12-2012	0
Korea	11-1997	01-2000	10-2004	08-2008	01-2012	0	0
Luxembourg	12-1996	02-2000	07-2002	01-2006	03-2008	0	0
Mexico	04-2005	05-2000	07-2011	0	0	0	0
Netherlands	12-1996	03-1999	01-2003	05-2005	08-2007	12-2009	0
New Zealand	11-1997	04-2002	08-2006	10-2008	10-2013	0	0
Norway	05-1997	07-1999	03-2002	10-2004	09-2008	09-2013	0
Poland	12-1997	01-2001	05-2003	10-2006	12-2008	02-2011	05-2013
Portugal	06-1998	05-2002	02-2006	12-2009	0	0	0
Slovakia	02-1996	07-1999	10-2001	12-2003	11-2006	01-2009	0
Slovenia	03-1997	05-1999	08-2001	03-2006	12-2011	0	0
Spain	01-1997	03-1999	06-2001	09-2003	09-2007	12-2009	01-2014
Sweden	12-1996	02-2001	05-2004	08-2006	10-2008	0	0

Switzerland	10-1996	11-2010	01-2014	0	0	0	0
Turkey	02-2001	04-2003	06-2005	08-2007	12-2009	04-2012	0
United Kingdom	10-1996	08-2001	06-2005	02-2008	01-2014	0	0
United States	10-1997	10-2000	12-2002	03-2006	07-2008	01-2014	0

Notes: The maximum number of break was fixed at 7. We compute the critical values using Monte Carlo simulation based on10,000 replications.

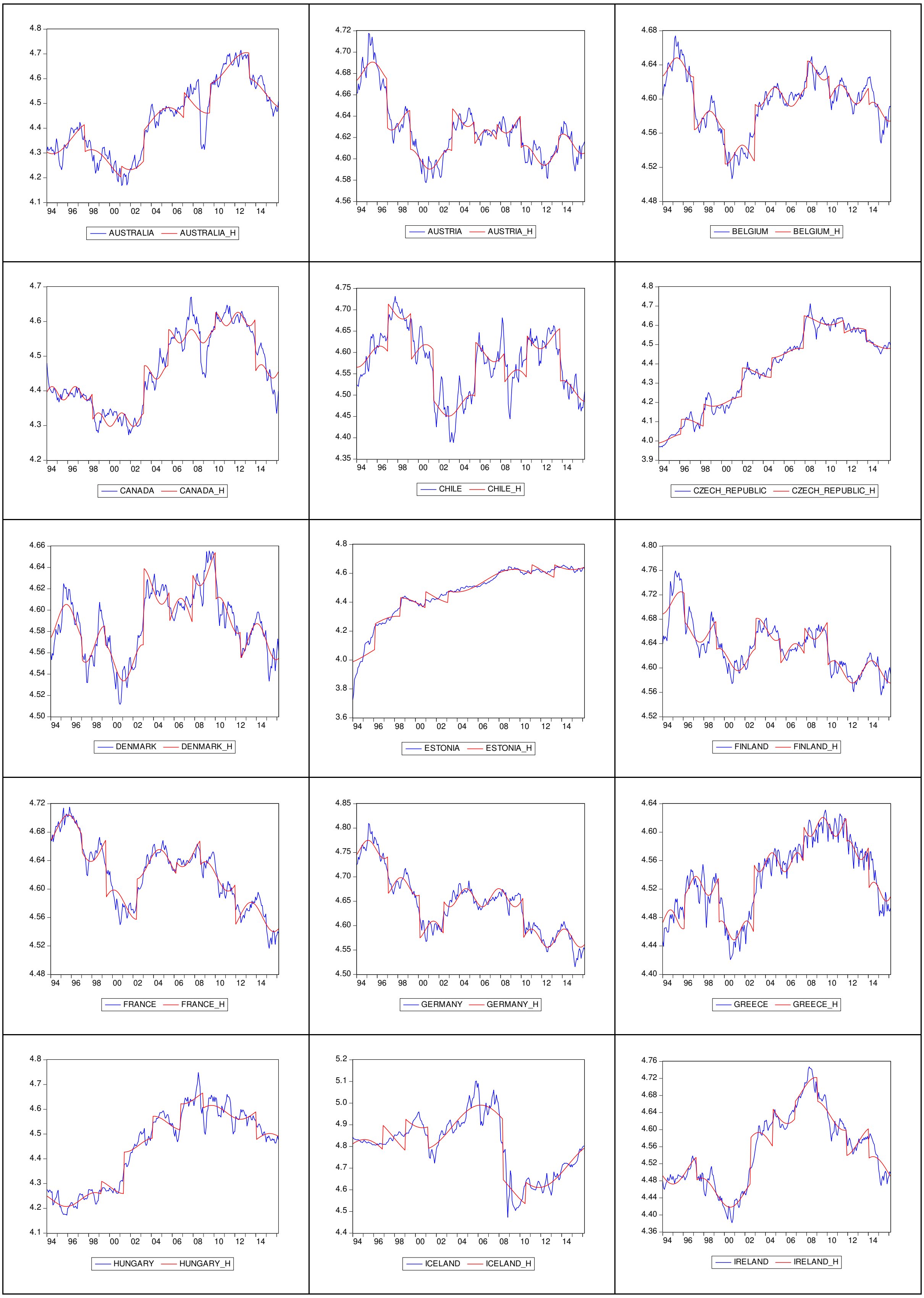

Figure 1. Plots of log of real effective exchange rates and fitted nonlinearities for 34 OECD countries.

Figure 1. (Continued).

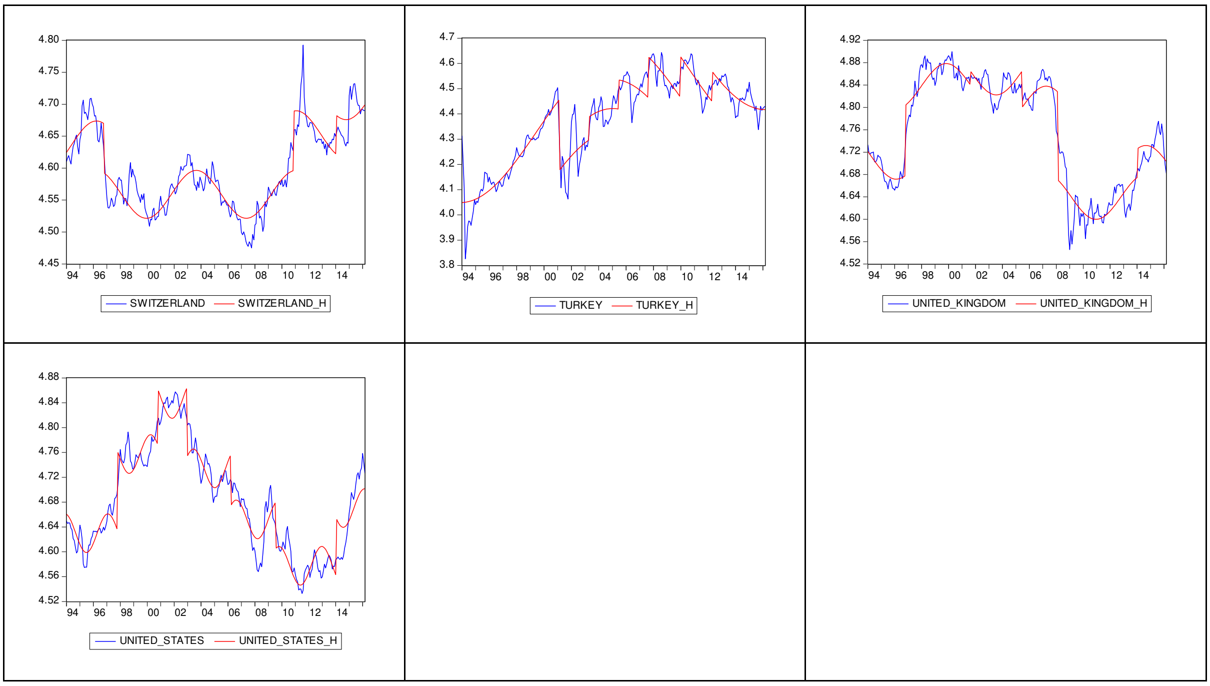

Figure 1. (Continued).