Is the consumption-income ratio stationary? Evidence from linear and nonlinear panel unit root tests for OECD and non-OECD countries

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Abstract

This paper applies recently developed heterogeneous nonlinear and linear panel unit root tests that account for cross-sectional dependence to 24 OECD and 33 non-OECD countries' consumption-income ratios over the period 1951–2003. We apply a recently developed methodology that facilitates the use of panel tests to identify which individual cross-sectional units are stationary and which are nonstationary. This extends evidence provided in the recent literature to consider both linear and nonlinear adjustment in panel unit root tests, to address the issue of cross-sectional dependence, and to substantially expand both time-series and cross sectional dimensions of the data analysed. We find that the majority (65%) of the series are nonstationary with slightly fewer OECD countries' (61%) series exhibiting a unit root than non-OECD countries (68%).

Key words: consumption-income ratio, heterogeneous panel nonlinear unit root test, cross-sectional dependence, OECD and non-OECD countries

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1. Introduction

Economic theory generally suggests that the average propensity to consume (APC) is either constant or converges towards a constant. Hence, one would expect the APC to be stationary. However, many empirical studies have presented evidence indicating that it is non-stationary, for examples, Horioka (1997) and Sarantis and Stewart (hereafter, SS). Arguably the adjustment of consumption (especially durable consumption) is nonlinear and there have been many shocks since the 1950s that would force the APCs of many countries away from their equilibria (or change their equilibria). Hence, we utilise recently developed and heterogeneous panel unit root tests that allow for nonlinear (and linear) adjustment towards equilibrium and that accommodate cross-sectional dependence. We are not aware of any previous studies that have applied nonlinear panel unit root tests or panel tests that address cross-sectional dependence to the APC. Further, we apply these tests to 24 OECD and 33 non-OECD countries over the period 1951 to 2003. We are not aware of any previous studies that apply unit root tests to such a broad range of countries (especially the non-OECD countries) and over such a long time span. Additionally, we utilise a recently developed procedure that facilitates the identification of which cross-sectional units are stationary and which are nonstationary using panel unit root tests rather than their less powerful time-series counterparts. Hence the novelty of the paper is in the application of nonlinear panel unit root tests that allow for cross-sectional dependence and identify which individual units are stationary/nonstationary to a dataset comprising a large number of countries over a long time-span.

The paper is organized as follows. Section 2 reviews the empirical and theoretical literature and discusses our data. The methods, including the panel unit root tests employed, are discussed in Section 3 while the fourth section presents the empirical results. Section 5 concludes the paper.

2. Theoretical insights and empirical findings on the stationarity of the APC

Economic theory offers insight into whether the APC is stationary or not. Keynes's (1936) Absolute Income Hypothesis (AIH) implies that, as income grows, the APC converges towards a constant marginal propensity to consume (MPC). Assuming there is (positive) autonomous consumption and that aggregate income grows at a relatively constant rate through time, this implies that the aggregate APC declines at a decreasing rate through time, converging towards the MPC.

Duesenberry's (1949) Relative Income Hypothesis (RIH) postulates that low income earners try to emulate consumption patterns of high income earners and so the former exhibit larger APCs than the latter. If a country's income distribution changes as income rises through time the aggregate APC may be trended, although it will be constant if the income distribution remains unchanged. The habit persistence form of the RIH implies a constant long-run APC provided that consumption grows at a constant rate.

Friedman's (1957) Permanent Income Hypothesis (PIH) may be interpreted as indicating a constant APC provided that the proportionality coefficient and transitory consumption and income are constant through time. Hadjimatheou (1987) notes that an implication of Modigliani's (1986) characterisation of the Life Cycle Hypothesis

(LCH) is that a nation's saving rate is independent of its level of per-capita income and positively related to its long-run growth rate. Hence, a country's APC should be constant through time unless its long-run income growth rate changes.

Davidson *et al.* (1978) utilise the microeconomic homogeneity postulate that consumption is homogeneous of degree one in income, which indicates a unit-income elasticity with respect to consumption. This implies that the equilibrium natural logarithm of the APC (LAPC) should be constant through time.

The theory cited above predominantly suggests a constant APC or, if it is trended, that it converges towards a constant. Thus, at least in terms of its mean, the APC should be stationary. Indeed, whilst not strictly bounded by zero and one the APC will never greatly exceed these values and it may, therefore, be regarded as unlikely to diverge without bound. Hence, there are strong theoretical reasons to believe the APC is stationary.

However, there has been much evidence indicating that the APC is non-stationary.[2] For example, SS demonstrate, using linear adjustment panel unit root tests, that LAPC is non-stationary for 20 OECD countries employing a maximum sample of 1955–1994. One possible explanation is that if the APC declines at a decreasing rate through time (as implied by the AIH), LAPC will likely feature a linear trend. These patterns are consistent with Figure 1 which plots the consumption-income ratio (CY and RCY) against income (Y and RY) and its natural log (LCY and LRCY) against the natural log of income (LY and LRY) – where CY, Y, LCY and LY are measured in current prices and RCY, RY, LRCY and LRY are in constant prices.[3] These graphs are given for OECD, Non-OECD and both OECD and Non-OECD (denoted All) countries.[4] Data are obtained from version 6.2 of the Penn World Tables (Heston, Summers and Aten, 2006).[5] Hence, in our testing we consider the possibility that LAPC is trend stationary.[6]

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[2] Sarantis and Stewart (1999) cite various papers that provide empirical evidence that the APC is nonstationary.

[3] The current and constant price data (in particular the APCs) are different from each other due to the construction method used in the Penn World Tables. This is because the terms current and constant price are not defined in the standard way – see Heston, Summers and Aten (2006).

[4] The OECD countries are: Australia (AUS), Austria (AUT), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Greece (GRC), Iceland (ISL), Ireland (IRL), Italy (ITA), Japan (JPN), Luxembourg (LUX), Mexico (MEX), Netherlands (NLD), New Zealand (NZL), Norway (NOR), Portugal (PRT), Spain (ESP), Sweden (SWE), Switzerland (CHE), Turkey (TUR), United Kingdom (GBR), United States of America (USA). The non-OECD countries are: Argentina (ARG), Bolivia (BOL), Brazil (BRA), Chile (CHL), Colombia (COL), Costa Rica (CRI), Dominican Republic (DOM), Ecuador (ECU), Egypt (EGY), El Salvador (SLV), Ethiopia (ETH), Guatemala (GTM), Honduras (HND), India (IND), Israel (ISR), Kenya (KEN), Mauritius (MUS), Morocco (MAR), Nicaragua (NIC), Nigeria (NGA), Pakistan (PAK), Panama (PAN), Paraguay (PRY), Peru (PER), Philippines (PHL), South Africa (ZAF), Sri Lanka (LKA), Taiwan (TWN), Thailand (THA), Trinidad and Tobago (TTO), Uganda (UGA), Uruguay (URY), Venezuela (VEN).

[5] In Heston *et al* (2006) Y is defined as real GDP per capita (denoted CGDP) in international dollars at current prices; RY as real GDP per capita (RGDPL) in international dollars at 2000 constant prices (Laspeyres); CY as the consumption share of CGDP (CC) measured as a percentage in current prices; RCY as the consumption share of RGDPL (kc) measured as a percentage in constant 2000 prices.

[6] Upon the basis of time-series tests for individual countries Sarantis and Stewart (1999) found virtually no evidence that LAPC is stationary around a linear trend.

Figures 2 to 5 display time-series graphs for LCY and LRCY for both OECD and non-OECD countries. An unambiguous (for both LCY and LRCY) general downward movement through time is observed for 16 of the 24 OECD countries and 14 of the 33 non-OECD countries.[7] Hence, just over half of the countries are consistent with notions such as the AIH, the LCH with income growth rates that rise through time, and countries where income uncertainty increases over time etc. For 3 OECD and 6 non-OECD countries there is an unambiguous rise through time of LCY and LRCY.[8] This pattern is consistent with an easing of liquidity constraints over time, a temporal decline in income uncertainty and increasing wealth over time etc. In only 1 OECD and 3 Non-OECD countries are LCY and LRCY relatively constant through time.[9] This is consistent with the habit persistence form of the RIH and the unit income-elasticity postulate. LCY and LRCY appear to exhibit different temporal patterns for the other 14 countries. For 8 of these one measure of the series is generally constant whilst the other falls through time.[10] Whilst there is heterogeneity in the underlying trend across countries the majority of countries appear to have a falling APC.

Another potential explanation for the non-stationarity of LAPC is that the assumptions required for a constant APC do not hold. For example, if income growth shifts upwards rather than being constant the APC will shift downwards according to the LCH. Shifts in other factors, such as, inflation (Davidson *et al*, 1978), wealth (Hendry and Ungern-Sternberg, 1981), liquidity constraints (Miles, 1992), income uncertainty (Carroll, 1994), demographic factors (Horioka, 1997), interest rates (Hahm, 1998) and fiscal variables (Pesaran, Haque and Sharma, 2000) may also have shifted the APC.[11] Cook (2005), using the same data as SS, find evidence that LAPC for OECD countries is stationary around a trend with intercept and slope shifts using the time-series test developed by Lee and Strazicich (2003).

Whilst substantial changes have undoubtedly occurred in many countries since the 1950s it may be that abrupt structural breaks occurring in a single period may not be the best characterisation of these changes.[12] For example, Davidson *et al* (1978) argued that the upward shift in UK inflation in the early 1970s caused the *target* APC to shift downwards. However, due to slowness of adjustment the *actual* APC only gradually declined throughout the 1970s. Indeed, any durable component in consumption would likely be particularly slow to adjust. Further, financial deregulation that took place in many economies during the late twentieth century was a range of measures implemented over many years. Hence, changes in the APC due to changes in liquidity constraints would likely occur over several periods rather than in

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[7] The OECD countries are: Belgium, Canada, Denmark, Finland, France, Ireland, Japan, Luxembourg, Mexico, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland and Turkey. The non-OECD countries are: Colombia, Costa Rica, Ethiopia, India, Kenya, Morocco, Nigeria, Pakistan, Panama, Philippines, South Africa, Taiwan, Thailand and Uruguay.

[8] The OECD countries are: Australia, Italy and the USA. The non-OECD countries are: Brazil, Chile, Paraguay, Peru, Uganda and Venezuela.

[9] The OECD country is Greece and the non-OECD countries are Dominican Republic, Honduras, and Israel.

[10] The OECD countries are Iceland and the Netherlands. The non-OECD countries are: Argentina, Bolivia, Ecuador, Guatemala, Sri Lanka and Trinidad and Tobago.

[11] Changes in income uncertainty would alter precautionary savings and, according to the PIH, modify the APC.

[12] Having said this, allowing for one-off structural shifts is one way for capturing such changes and is preferable to applying unit root tests that do not accommodate such changes.

just one. Thus, it is arguable that a test allowing for nonlinear adjustment towards a changing target APC, such one of the methods adopted here, is more appropriate than assuming that all countries are subject to intercept and slope shifts in a single period.[13]

The nonlinear test employed here yields adjustment towards equilibrium when the disequilibrium exceeds a particular threshold with little or no adjustment when the disequilibrium is below this threshold. However, a large disequilibrium will generally not be completely eliminated in one period but over many periods. Such nonlinear adjustment is particularly appropriate for the total consumption measures used here which embody a durable component. This is because fixed adjustment costs may mean that consumers tolerate small departures from the equilibrium durable stock, however, once this disequilibrium exceeds a certain level the consumer abruptly adjusts consumption to make the deviation tolerable – see Caballero (1994) and Sarantis and Stewart (2003).

Both linear and nonlinear panel unit root tests used in this paper account for cross-sectional dependence and are discussed in the next section.

3. Testing methods

This section discusses the nonlinear and linear panel unit root tests as well as the tests for cross-sectional dependence employed in this paper. It also outlines a procedure for using panel unit root tests to determine whether each individual cross-sectional unit in the panel is stationary or nonstationary. In addition, we discuss the method used for identifying whether series are stationary, trend stationary or nonstationary.

3.1 The Cerrato et al (2009) nonlinear panel unit root test

Recently Cerrato, de Peretti, Larsson and Sarantis (2009) proposed a nonlinear panel unit root test. This is a direct extension of the time-series ESTAR test proposed in Kapetanios et al (2003) to a panel setting. The test can be easily computed, under the null hypothesis of a unit root, by estimating the following auxiliary regression

$$\Delta y_{it} = a_i + b_i y_{i,t-1}^3 + \gamma_i f_t + u_{it}$$

where y_{it} on the ith cross section at time t is generated according to the ESTAR model and f_t is a stationary factor accounting for cross sectional dependence and γ_i are country specific factor loadings. f_t can be approximated by the two factors $\Delta \bar{y} = N^{-1} \sum_{j=1}^{N} \Delta y_j$ and $\bar{y}_{i,-1}^{\,3}$, where $\bar{y}_{i,-1} = N^{-1} \sum_{j=1}^{N} y_{j,-1}$.

The following test statistics for each individual time-series are then computed:

[13] It is worth noting that the tests employed by Cook (2005) have only two possible specifications: one shift in both intercept and slope or two shifts in intercept and slope. It is quite conceivable that many countries would not be best portrayed by either of these specifications. For example, the intercept shifts identified in the Australian APC by Cook (2005) are extremely small and do not seem to correspond to any true breaks while the second slope shift appears to be caused by an outlier in the early 1980s. What events these identified breaks correspond to is not obvious and is not explained.

$$t_{iNL}(N,T) = \frac{y_{i,-1}^{3}{}' M \, \Delta y_i}{(\Delta y_i' \, M \, \Delta y_i)^{1/2} (y_{i,-1}^{3}{}' M \, y_{i,-1}^{3})^{1/2}}$$

where $\Delta y_i = (\Delta y_{i1}, \Delta y_{i2}, ..., \Delta y_{i,T})'$, $y_{i,-1}^{3} = (y_{i,0}^{3}, y_{i,1}^{3}, ..., y_{i,T-1}^{3})'$, $X = (\tau, \Delta y_i, \bar{y}_{i,-1}^{3})'$, M the projection onto $\delta(X)$, the orthogonal complement of the span of X, and $\tau' = (1,1,...,1)$.

The panel test is finally given by the average statistic below

$$\bar{t}_{NL}(N,T) = N^{-1} \sum_{i=1}^{N} t_{iNL}(N,T)$$

A Monte Carlo experiment shows that the distribution of the test is not normal therefore Cerrato et al (2009) tabulated critical values for different dimensions of time-series, T, and cross section, N. Finally Monte Carlo experiments showed that this test has better size and power than the Pesaran (2007) test when the data generating process is nonlinear.

3.2 The Pesaran (2007) linear panel unit root test

For comparative purposes we also report Pesaran's (2007) test. This is based upon the following time-series regression which is estimated for each of the N cross-sectional units.

$$\Delta y_{it} = a_i + \alpha_i t + b_i y_{it-1} + c_i \bar{y}_{t-1} + \sum_{j=0}^{p} d_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^{p} \delta_{ij} \Delta y_{it-j} + e_{it}$$

when $\alpha_i = 0$ we have the demeaned (intercept only) case and when $\alpha_i \neq 0$ we have the detrended (intercept and trend) case.

The CADF test statistic for each cross-section is the estimated OLS t-ratio corresponding to the coefficient b_i, denoted $t_i(N,T)$. The panel test statistic, $CIPS$, is given as:

$$CIPS = N^{-1} \sum_{i=1}^{N} t_i(N,T)$$

The critical values for this panel test are given in Tables II(b) and II(c) of Pesaran (2007, pp. 280 – 281).[14]

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[14] A truncated version of the panel test, $CIPS^*$, can be produced based upon the truncated CADF test statistics, Pesaran (2007, p. 277). This can be employed to ameliorate the influence of extreme values of time-series (CADF) test statistics on the panel test. For none of the tests did the statistics exceed the

3.3 Pesaran's (2004) tests for cross-sectional dependence

We also apply Pesaran's (2004, p. 17) CD test statistic for unbalanced panels to the residuals of the N countries' time-series ADF test equations:

$$CD = \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \sqrt{T_{ij}} \, \hat{\rho}_{ij}^{*}$$

where $\hat{\rho}_{ij}^{*}$ is the simple pairwise correlation coefficient of the residuals for cross-section i and j calculated over the sample period common to both sections, which is of size, T_{ij}.[15] The statistic is shown to have a standard normal distribution asymptotically.

Pesaran (2004) demonstrates that this test is robust to structural breaks in coefficients and variances as well as to unit roots in the DGP. It also has the correct size, including in very small samples, and satisfactory power. Indeed, for the intercept only case with N = T = 50 it is correctly sized and has a power close to unity even when allowing for structural breaks.[16] In the case where there is an intercept and trend in the ADF test equation the power is lower.

A modified version of a previously existing test for cross-sectional dependence is cited in Pesaran (2004, p. 5) as:[17]

$$CD_{lm} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T_{ij} \hat{\rho}_{ij}^{*2} - 1 \right)$$

This has a standard normal distribution as T tends to infinity first, followed by N tending to infinity second. Pesaran (2004, p. 5) suggests that CD_{lm} is likely to exhibit substantial size distortion when N is large and T is small and that this size distortion will tend to become worse for fixed T as N increases.

3.4 Identification of stationary and nonstationary series in the panel

The strength of panel unit root tests where the null hypothesis is that *all* series in the panel are nonstationary and the alternative is that *at least one* series is stationary is in

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thresholds identified in Pesaran (2007) and so truncation was not required or applied in any of our applications.

[15] The $\hat{\rho}_{ij}^{*}$ need to account for the possibility that the mean of the residuals for each section may not be zero for the common sample period used.

[16] One issue with this test is that it does not account for the possibility that positive and negative correlation coefficients may cancel in the weighted averages calculated in the statistics. Hence, a zero test statistic could be consistent with very large positive and negative correlation coefficients. To gauge the impact of cancelling we also calculate the average magnitude of the correlation coefficients,

$$\left| \bar{\bar{\rho}} \right| = \left(\frac{2}{N(N-1)} \right) \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left| \hat{\rho}_{ij} \right|.$$

[17] We adjust the test slightly to allow for the correlation coefficients to be estimated from different sample sizes for different country pairings.

the greater confidence in the determination of $I(1)$ series compared to time-series unit root tests due to the relatively greater power. An arguable drawback of the test is that it does not identify which, or how many, series are stationary when one rejects the null. We apply the methodology proposed by Stewart (2010) in the context of panel cointegration tests, modified to apply to panel unit root tests. This procedure utilises the improved power of the panel to distinguish which series in the panel are nonstationary and which are stationary.

We explain the procedure within the context of Pesaran's (2007) test although we also apply the method using the Cerrato *et al* (2009) test. If the N individual sections' t-ratios, $t_i(N,T)$, are ranked in descending order a set of N panel unit root statistics, $CIPS$, can be calculated for panels containing the first individual unit, the first and second units and so on…. The first test statistic will be based on a panel of one individual cross-sectional unit, which has the largest value of $t_i(N,T)$ in the panel, and, therefore, will be least likely to reject the unit root null. Similarly, the second test statistic will be based on a panel of the two individual cross-sectional units with the two largest values of $t_i(N,T)$ in the panel, which will be the second least likely panel statistic to reject the null. In contrast, the Nth test statistic will incorporate all the individual units in the panel and would be the most likely to reject the unit root null. Based on this set of N ordered panel statistics one can, in principle, identify the individual cross-section where the panel test statistic first rejects the unit root null. If we let this test statistic contain M+1 cross-sectional units then the previous panel unit root tests that contained M units did not reject the null that *all* units in the panel are nonstationary. This implies that it is the M+1th cross-sectional unit, and only the M+1th unit, that is stationary in the panel of M+1 individuals. Our confidence in this result is as strong as our certainty of the power of the test for the panel involving M cross-sections: if there is high power we can have confidence in the test's rejection that any series in the panel are stationary. Further, because the t-ratio for M+2th individual unit is less than that for the M+1th unit, we know that had we replaced the latter by the former in the panel unit root test containing the M+1 cross-sections, it would also reject the null. This implies that the series for units M+1 and M+2 are stationary. Indeed, it implies that units M+1, M+2, …, N are all stationary. Hence, using a set of ordered panel unit root tests, in principle, identifies the first M series as nonstationary and the remaining (N – M) units' series as stationary.

This method of identifying the order of integration of the units in the panel is superior to using the individual $t_i(N,T)$ statistics for two reasons. First, the panel test has superior power when N > 1, hence for M > 1 the panel method will have greater power than using individual unit root tests. Secondly, using statistics based upon a panel of one unit with accommodation for cross-sectional dependence is clearly inappropriate because if there is only one cross-sectional unit there can be no cross-sectional dependence between units. In this case it may be argued that using standard time-series unit root tests (without adjustment for cross-sectional dependence would be appropriate). However, these time-series tests still have lower power than the panel

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test and hence one should have more confidence in the panel test's inference compared to that of the time-series test.[18]

3.5 Determining whether series are stationary, trend stationary or nonstationary

We distinguish between the hypotheses of a unit root, stationarity and trend stationarity as follows. If, using the test for demeaned data (intercept only), the unit root null hypothesis is rejected, we deem the series to be stationary. However, if the null is not rejected, the unit root test is applied to the demeaned and detrended data (intercept and trend) to determine whether the nonstationarity is best characterized by a unit root or trend stationarity. If, after applying the test to demeaned and detrended data, we reject the null hypothesis the series is inferred to be trend stationary, whereas if the null is not rejected we conclude the variable has a unit root.

In the next section we will test whether LAPC is consistent with nonlinear reversion to a mean (or trend) or is non-stationarity using the panels for OECD and non-OECD countries.

4. Results

Table 1 presents the tests for cross-sectional dependence based upon the residuals of time-series ADF tests applied to each country's series in each panel. The tests are applied to all combinations of both OECD and Non-OECD country groupings, both LCY and LRCY series and ADF test equations including just an intercept and both an intercept and time trend. For all eight combinations the magnitudes of both CD and CD_{lm} statistics exceed their 5% critical values.[19] This unambiguously indicates the presence of cross-sectional dependence and justifies our use of panel unit root tests that account for such dependence.

Table 2 reports the results of Pesaran's (2007) cross-sectionally augmented time-series (in the column headed Time-series) and panel unit root (in the column headed Panel) tests for LCY for OECD countries. The time-series tests are listed in descending order of size with those statistics least likely to reject the unit root null appearing higher up in the table. The panel statistic reported in the first row is a panel test including only one country (USA for the intercept only case and Mexico for the intercept and trend case). The panel statistic given in the second row is the panel test incorporating the first two countries listed in the table (USA and UK for the intercept only case and Mexico and Canada for the intercept and trend case). As we move down each row of the table another country (specified in the row) is added to the panel test until we reach the last row which contains the test statistic for the whole panel of, in this instance, 24 OECD countries. Comparing these statistics to their corresponding 5% critical values (reported in the column headed 5% CV) we observe that, for the

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[18] In our application we use an adjustment for cross-sectional dependence based on the averages of all N series in the panel and not solely the subset of units actually employed in constructing each test. We assume that this does not have an adverse influence on the test's results.

[19] In all cases $\left|\overline{\hat{\rho}}\right| > \overline{\hat{\rho}}$. This suggests that some residuals are negatively correlated and others are positively correlated causing some cancelling of the correlation coefficients when using Pesaran's (2004) CD statistic. Nevertheless, with both statistics yielding the same inference of cross-sectional dependence this does not appear to be an issue in this instance.

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intercept only case, the panel tests for first 20 countries cannot reject the unit root null while the null is rejected for the last 4 countries. Hence, following the methodology discussed in Section 3.4, we conclude that LCY is stationary for Sweden, Iceland, Italy and Australia and nonstationary for the remaining 20 OECD countries.

To determine the form of nonstationarity we examine the panel test results for the case where both an intercept and trend are included in the test equations. We find that the first 12 panel tests cannot reject the unit root null whereas a unit root is rejected for the last 12 countries. Excluding the 4 countries that were found to be stationary (based on the intercept only case) from this latter group we therefore conclude that LCY is trend stationary for the following 8 OECD countries: Netherlands, UK, Turkey, Ireland, Spain, Austria, Denmark and New Zealand. Hence, LCY is nonstationary for the remaining 12 OECD countries.

Pesaran's (2007) panel test results for LRCY for OECD countries are reported in Table 3. In this case we find 5 countries' series to be stationary (Australia, Italy, New Zealand, Turkey and Iceland), none are trend stationary (given that LRCY for Iceland and New Zealand have already been established as stationary based upon the intercept only case) and the remaining 19 countries' series are nonstationary. The OECD countries where LRCY is stationary are either stationary or trend stationary for LCY, except for Sweden, which is stationary for the latter and nonstationary for the former. In general, there is less evidence against nonstationarity for LRCY than LCY in OECD countries using Pesaran's (2007) test and at least half the OECD countries' LAPCs appear to be nonstationary.

The results for Pesaran's (2007) tests for non-OECD countries are reported in Tables 4 and 5 for LCY and LRCY, respectively. LCY is stationary for 12 of the 33 countries, trend stationary for a further 4 countries and nonstationary for the remaining 17 countries. Whereas LRCY is stationary for only 5 non-OECD countries, trend stationary for a further 2 countries and nonstationary for 26 countries. Similar to the results for the OECD more countries are nonstationary for LRCY than LCY in non-OECD countries.[20] Another similarity with the results of OECD countries is that we also find that at least half of non-OECD countries' LAPCs are nonstationary.

The results of Cerrato *et al*'s (2009) nonlinear unit root test applied to OECD countries are reported for LCY and LRCY in Table 6 and 7, respectively. For LCY (LRCY) 8 (2) out of 24 LAPCs exhibit nonlinear mean reversion and a further 6 (4) feature nonlinear adjustment towards a trend. The remaining 10 (18) countries' LCYs (LRCYs) are nonstationary. Table 8 and 9 present the results of Cerrato *et al*'s (2009) test applied to non-OECD countries for LCY and LRCY, respectively. For LCY (LRCY) 4 (6) out of 33 countries exhibit nonlinear mean reversion and a further 6 (3) feature nonlinear adjustment towards a trend. The remaining 23 (24) countries' LCYs (LRCYs) are nonstationary. As for the results from Pesaran's test more countries' series are nonstationary for LRCY than LCY when using the nonlinear test. For both OECD and non-OECD countries both tests indicate that the majority of LAPCs are nonstationary. While fewer OECD countries' series are nonstationary using Cerrato *et al*'s (2009) tests compared that of Pesaran (2007) the reverse is true for non-OECD

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[20] All countries that are stationary or trend stationary for LCY are stationary or trend stationary for LRCY, except for Thailand which is trend stationary for LRCY and nonstationary for LCY.

countries. Overall approximately the same number of series are nonstationary for both tests.

5. Conclusion

Applying the method suggested by Stewart (2010) we are able to utilize the greater power of panel unit root tests, relative to time-series tests, to determine whether the individual cross-sectional units in the panel are (trend) stationary or not. Considering all 228 tests conducted for OECD and non-OECD countries, both LCY and LRCY and using both linear and nonlinear panel unit root tests we find that the majority (149 or 65%) indicate that LAPC is nonstationary. Thus, a minority of the results are consistent with the theoretical expectation of reversion to a mean or trend while the majority are in line with previous empirical findings of nonstationarity. However, this inference of a large percentage of nonstationary LAPCs need not be regarded as theoretically implausible. For example, Molana (1989) suggests that an alternative to the "extreme" assumption that consumption has a unit-income elasticity (which is implied by a stationary LAPC) is that consumption is homogeneous of degree one in life-time resources (income and wealth). If this latter hypothesis is true the LAPC will be nonstationary. This would suggest that consumption does not form an irreducible cointegrating vector solely with income – see Davidson (1998).[21] Theories, such as the LCH, suggest that variables beyond income determine the equilibrium level of consumption which, if they are nonstationary, suggest that their inclusion in the consumption function may be necessary to achieve cointegration.

We find that 59 out of 96 (61%) OECD countries' tests indicate nonstationarity whereas 90 of the 132 (68%) non-OECD countries' results are nonstationary. Hence, there is slightly more evidence of non-stationarity in non-OECD countries compared to the OECD. Further, 62 of the 114 (54%) tests for LCY indicate nonstationarity compared to 87 out of 114 (76%) for LRCY. Hence, there is notably more evidence of nonstationarity for LRCY compared to LCY. Comparing Pesaran's (2007) linear unit root test with Cerrato *et al*'s (2009) nonlinear test we find that both indicate virtually the same number of tests indicate nonstationarity (out of the 114), being 74 (65%) and 75 (66%), respectively. Having said this, the results do not provide exactly the same inference for every country and very measure of LAPC. Nevertheless, it is clear that regardless of the test used, the measure employed or whether one considers OECD or non-OECD countries, the majority (but not all) countries series are nonstationary.

Our results contrast with those of SS who found, using linear reversion panel unit root tests that do not account for cross-sectional dependence, that all 20 OECD countries' LAPCs are *I*(1). Given that our sample of OECD contains many of the countries in their sample we believe that our larger sample size, span of data and the use of tests that address cross-sectional dependence explains the difference in results and suggests that our inferences are more reliable in terms of greater power. Our results also contrast with those of Cooke (2005) who, applying time-series tests and using the same data as SS, find that all OECD countries' LAPCs are stationary around data with a shift in mean and/or trend. Our use of Cerrato *et al*'s (2009) test allows nonlinear adjustments and permits large abrupt changes, that could look like breaks, but that do

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[21] An irreducible cointegrating vector is one that is cointegrated and the removal of any one variable from the vector causes the loss of the cointegration property.

not need to be confined to a single jump in one period. This would arguably be most appropriate for large adjustments to, for example, financial deregulation taking place over a few periods rather than in a single period (as required by a structural shift specification). Once again we believe our results are arguably more reliable due to the greater sample size and span as well as the form of test employed.

The results for non-OECD countries are, as far as we are aware, the first to be presented and therefore provide a reference and benchmark for future analyses of consumer behaviour in these countries. This is also the first application of a method that solely employs the relatively powerful panel unit root tests (and not time-series tests) to identify which cross-sectional units are stationary and nonstationary.

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Figure 1: APC Scatter Plots
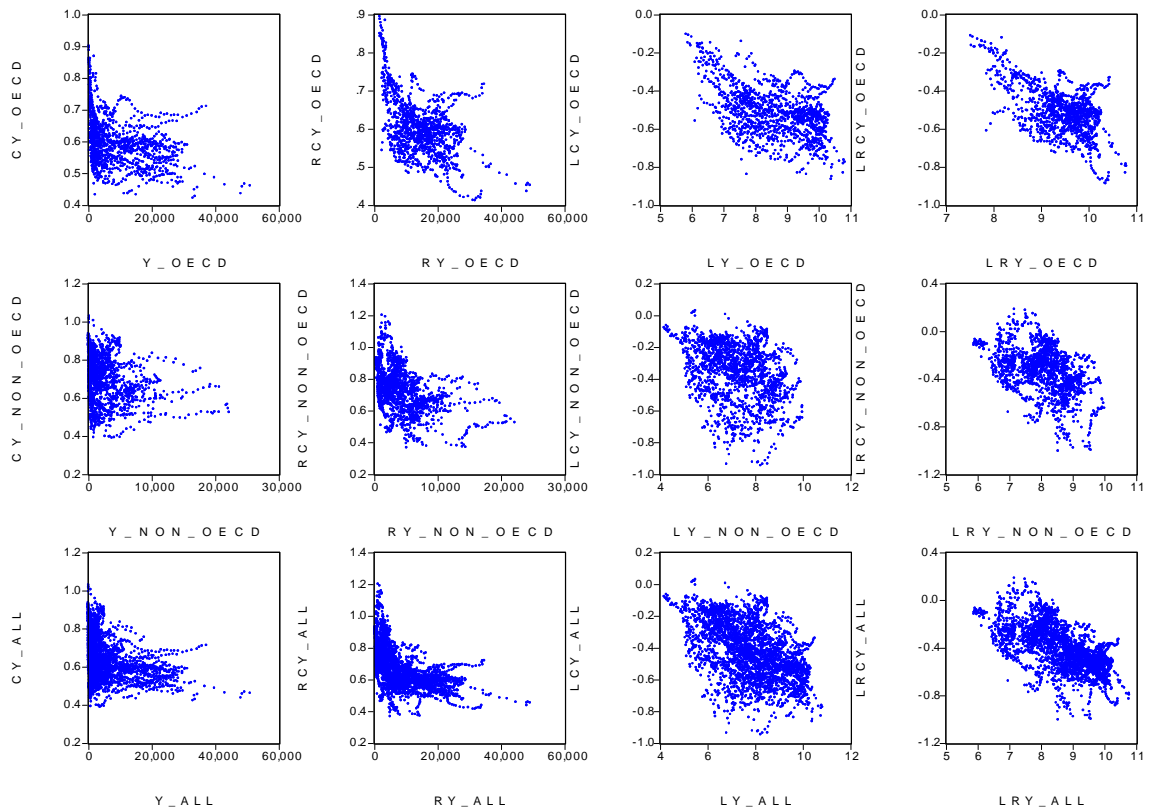
These figures plot the log of the current price consumption-income ratio, CY (LCY), against (the log of) current income, Y (LY) and the (log of the) constant price consumption-income ratio, LCY (LRCY), against (the log of the) constant price income, RY (LRY), for OECD, non-OECD and both OECD and non-OECD (denoted all) countries.

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Figure 2: Time-series plots of LCY (OECD)
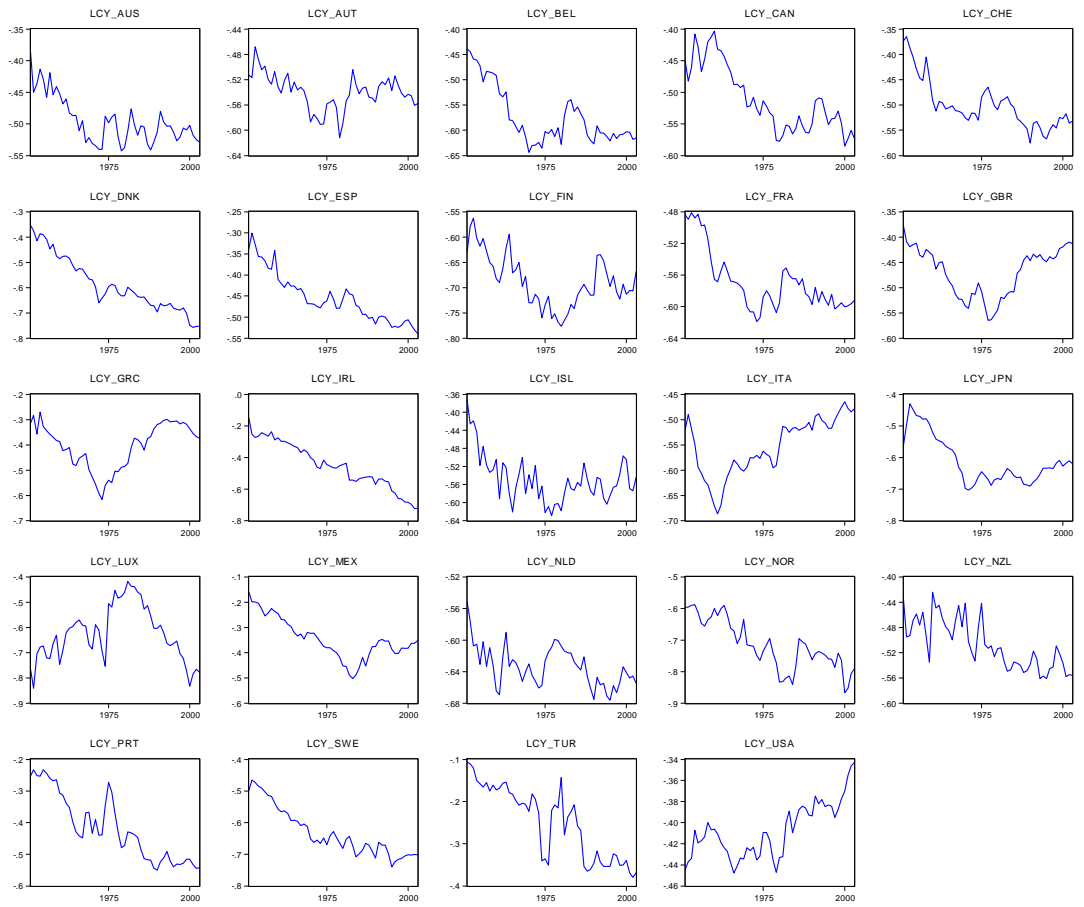
Figure 3: Time-series plots of LRCY (OECD)
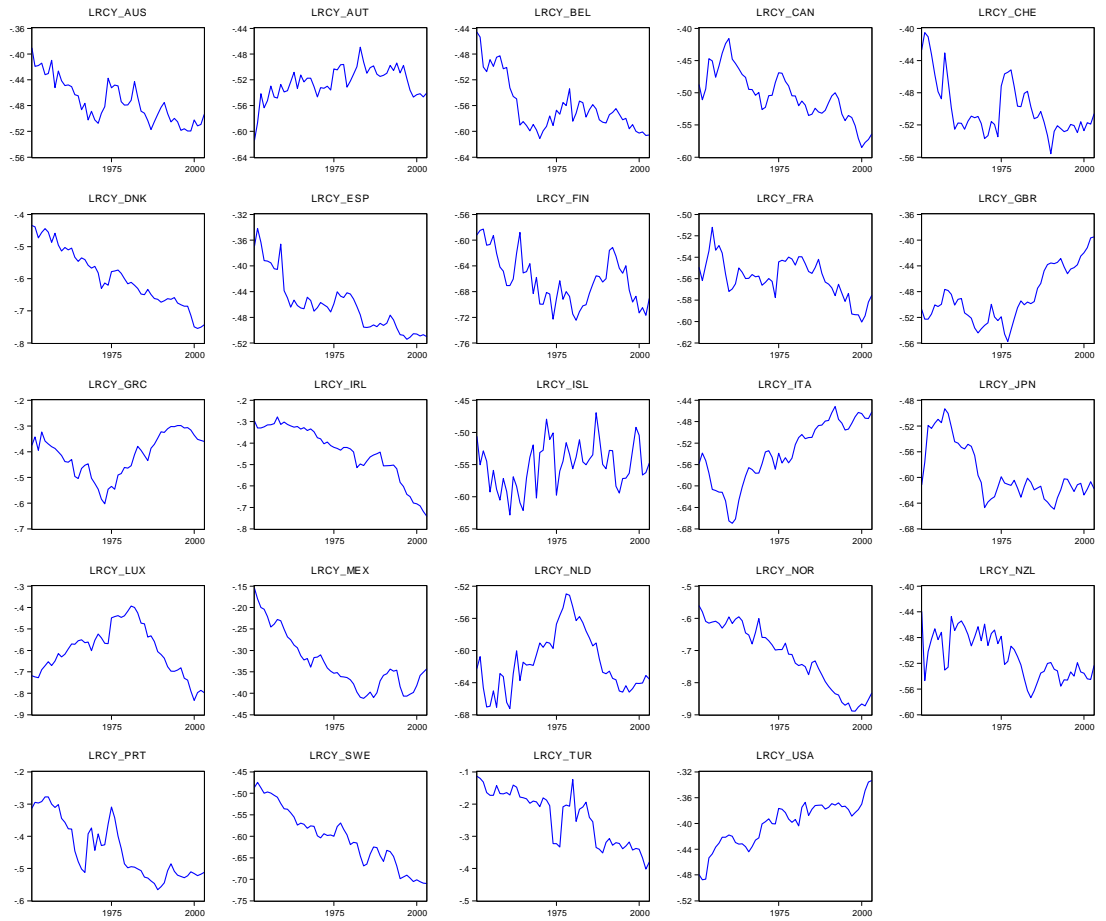
Figure 4: Time-series plots of LCY (Non-OECD)
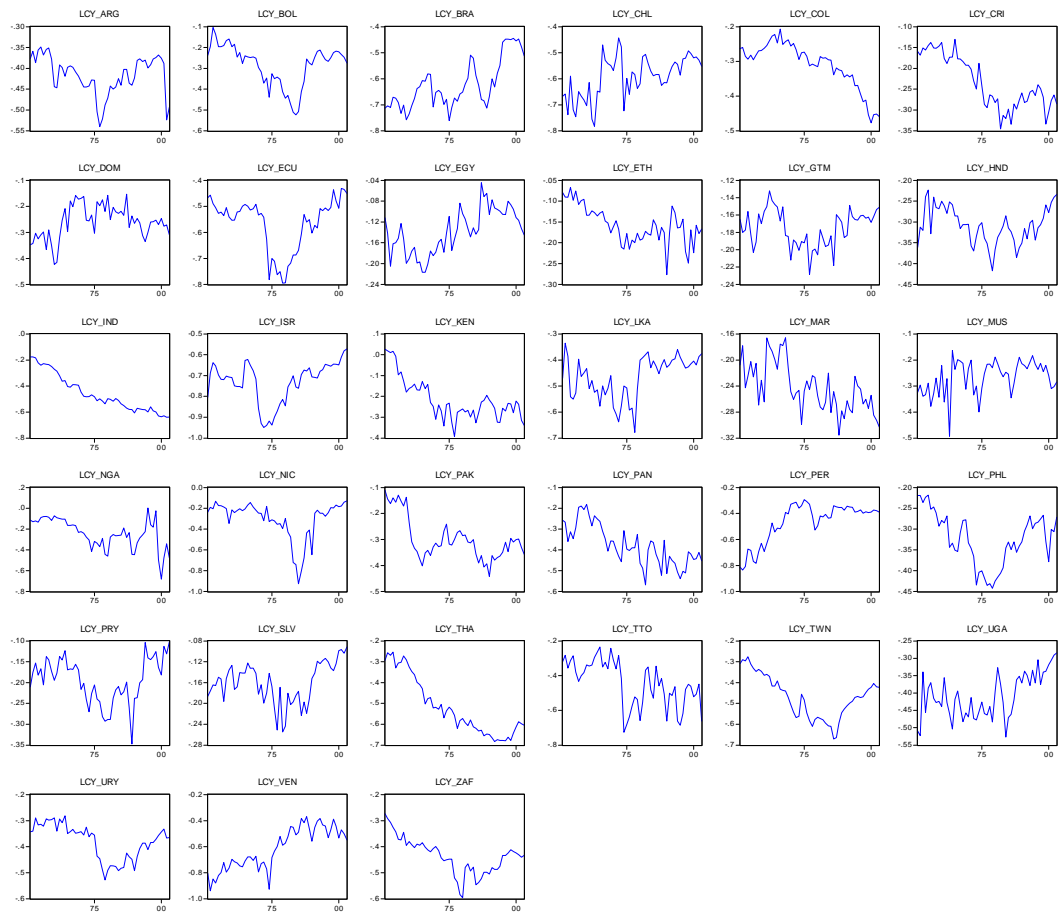
Figure 5: Time-series plots of LRCY (Non-OECD)
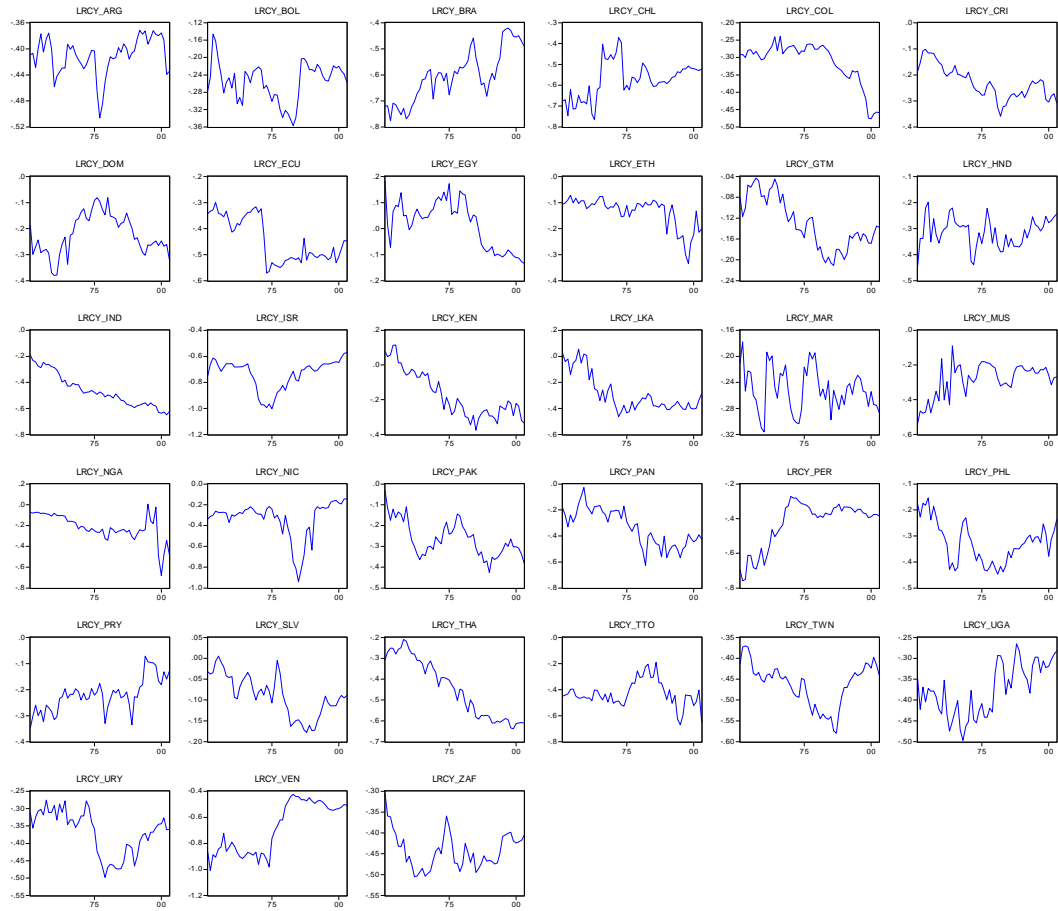
Table 1: Tests for cross section dependence

	OECD		Non OECD	
	LCY	LRCY	LCY	LRCY
Intercept only				
$\bar{\hat{\rho}}$	0.132	0.069	0.058	0.031
$\left|\bar{\hat{\rho}}\right|$	0.183	0.144	0.136	0.128
CD	15.771	8.299	9.548	5.137
CD_{lm}	17.978	7.784	8.667	4.600
Intercept and trend				
$\bar{\hat{\rho}}$	0.145	0.069	0.069	0.028
$\left|\bar{\hat{\rho}}\right|$	0.193	0.145	0.142	0.130
CD	17.381	8.280	11.385	4.646
CD_{lm}	20.742	7.462	10.404	5.487

Pesaran's (2004) test for cross-section dependence, CD, his modified version of the LM test, CD_{lm}, the average correlation coefficient, $\bar{\hat{\rho}}$, and the average magnitude of the correlation coefficient, $\left|\bar{\hat{\rho}}\right|$, are reported. These are based upon the residuals from standard ADF test equations for the $\left(\frac{N(N-1)}{2}\right)$ country pairings of OECD and non-OECD countries, respectively, used in constructing the Pesaran (2007) panel unit root test. For each country the SBC is used to determine the lag length for the ADF regression (allowing 0 to 3 lags) potentially causing sample sizes for the residual series to differ. Correlation coefficients for residual series are calculated using the common sample for each pairing and sample sizes used for different pairings are potentially different. The critical values for both CD and CD_{lm} are ± 1.96.

Table 2: Pesaran's (2007) panel unit root test (OECD countries, LCY)

LCY, OECD Countries							
Intercept only				Intercept and Trend			
Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
USA	-0.609	-0.609	-3.280	MEX	-1.623	-1.623	-3.790
GBR	-0.710	-0.660	-3.174	CAN	-2.254	-1.939	-3.684
IRL	-0.910	-0.743	-3.069	LUX	-2.343	-2.073	-3.579
GRC	-1.135	-0.841	-2.963	NOR	-2.406	-2.157	-3.473
MEX	-1.726	-1.018	-2.858	CHE	-2.420	-2.209	-3.368
DNK	-1.755	-1.141	-2.752	FRA	-2.673	-2.287	-3.262
LUX	-1.771	-1.231	-2.647	BEL	-2.753	-2.353	-3.157
PRT	-1.952	-1.321	-2.541	USA	-2.852	-2.416	-3.051
FRA	-2.338	-1.434	-2.436	PRT	-2.859	-2.465	-2.946
JPN	-2.364	-1.527	-2.330	JPN	-3.290	-2.547	-2.840
CHE	-2.404	-1.607	-2.314	GRC	-3.561	-2.639	-2.824
CAN	-2.438	-1.676	-2.298	FIN	-3.608	-2.720	-2.808
BEL	-2.451	-1.736	-2.282	NLD	-3.650	*-2.792*	-2.792
FIN	-2.476	-1.789	-2.266	GBR	-3.656	*-2.853*	-2.776
AUT	-2.629	-1.845	-2.250	TUR	-3.784	*-2.915*	-2.760
NOR	-2.647	-1.895	-2.240	IRL	-3.906	*-2.977*	-2.750
TUR	-2.904	-1.954	-2.230	ESP	-4.118	*-3.044*	-2.740
ESP	-3.064	-2.016	-2.220	SWE	-4.310	*-3.115*	-2.730
NLD	-3.566	-2.097	-2.210	AUT	-4.502	*-3.188*	-2.720
NZL	-3.810	-2.183	-2.200	DNK	-4.544	*-3.256*	-2.710
SWE	-3.844	*-2.262*	-2.196	ISL	-4.700	*-3.324*	-2.704
ISL	-4.305	*-2.355*	-2.192	ITA	-5.146	*-3.407*	-2.698
ITA	-4.463	*-2.447*	-2.188	NZL	-5.490	*-3.498*	-2.692
AUS	-5.400	*-2.570*	-2.184	AUS	-5.839	*-3.595*	-2.686

This table reports the unit root test results using cross-sectional means in the regression for both the individual countries (in the column headed Time-series) and the panel as a whole, CIPS, (in the column headed Panel). The panel test reported in the first row includes one country only, the panel test in the second row uses a panel of the first two countries, the panel test in the third row is based on a panel of the first three countries and so on, with the panel statistic in the last involving all 24 countries listed. The number of lags used in the individual country test equations is determined using SBC. The maximum available sample is 1951 – 2003 which with 0 and 1 lags after differencing gives the individual country time-series sample sizes of 52 and 51 observations for 0 and 1 lags, respectively. The 5% critical values are based on those given in Pesaran (2007) and are reported in the columns headed 5% CV. For the intercept only (without truncation) case the critical value in the first row is taken from Table 1b in Pesaran (2007) and corresponds to an individual time-series test with T=50 and N=20. The panel critical values reported in rows 10, 15, 20 (and implicitly 30) are taken from Table 2b in Pesaran (2007) all for T = 50 and with N = 10, 15, 20 (and 30), respectively. The intervening critical values are calculated using linear interpolation. For the intercept and trend only case critical values are taken from Tables 1c and 2c from Pesaran (2007) with intervening values also calculated using linear interpolation. Since no individual country's test statistic needed to be truncated, CIPS = CIPS[*], and no separate truncated critical values are used. A panel statistic highlighted with bold italic emphasis indicates rejection of the unit root null at the 5% level of significance.

Table 3: Pesaran's (2007) panel unit root test (OECD countries, LRCY)

LRCY, OECD Countries							
Intercept only				**Intercept and Trend**			
Country	**Time-series**	**Panel**	**5% CV**	**Country**	**Time-series**	**Panel**	**5% CV**
GBR	-0.593	-0.593	-3.280	**LUX**	-0.792	-0.792	-3.790
GRC	-0.828	-0.711	-3.174	**GBR**	-1.021	-0.907	-3.684
MEX	-1.230	-0.884	-3.069	**IRL**	-1.167	-0.993	-3.579
LUX	-1.234	-0.971	-2.963	**MEX**	-1.215	-1.049	-3.473
IRL	-1.267	-1.030	-2.858	**NLD**	-1.381	-1.115	-3.368
NOR	-1.350	-1.084	-2.752	**GRC**	-1.838	-1.236	-3.262
NLD	-1.835	-1.191	-2.647	**PRT**	-2.307	-1.389	-3.157
PRT	-1.846	-1.273	-2.541	**FIN**	-2.388	-1.514	-3.051
FIN	-1.892	-1.342	-2.436	**CHE**	-2.448	-1.617	-2.946
SWE	-2.273	-1.435	-2.330	**JPN**	-2.533	-1.709	-2.840
CHE	-2.384	-1.521	-2.314	**NOR**	-2.576	-1.788	-2.824
DNK	-2.727	-1.622	-2.298	**USA**	-2.927	-1.883	-2.808
BEL	-2.731	-1.707	-2.282	**CAN**	-2.987	-1.968	-2.792
JPN	-2.824	-1.787	-2.266	**ESP**	-3.260	-2.060	-2.776
USA	-3.002	-1.868	-2.250	**FRA**	-3.311	-2.143	-2.760
CAN	-3.003	-1.939	-2.240	**AUS**	-3.316	-2.217	-2.750
FRA	-3.224	-2.014	-2.230	**BEL**	-3.421	-2.288	-2.740
ESP	-3.292	-2.085	-2.220	**TUR**	-3.507	-2.355	-2.730
AUT	-3.439	-2.157	-2.210	**DNK**	-3.865	-2.435	-2.720
AUS	-3.465	*-2.222*	-2.200	**AUT**	-4.025	-2.514	-2.710
ITA	-3.528	*-2.284*	-2.196	**SWE**	-4.399	-2.604	-2.704
NZL	-3.568	*-2.343*	-2.192	**ITA**	-4.543	-2.692	-2.698
TUR	-3.765	*-2.404*	-2.188	**ISL**	-4.596	*-2.775*	-2.692
ISL	-4.705	*-2.500*	-2.184	**NZL**	-5.308	*-2.880*	-2.686

See notes to Table 2.

Table 4: Pesaran's (2007) panel unit root test (Non-OECD countries, LCY)

Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
LCY, Non-OECD Countries							
Intercept only				**Intercept and Trend**			
COL	0.575	0.575	-3.270	PER	-1.209	-1.209	-3.800
IND	-1.135	-0.280	-3.166	THA	-1.713	-1.461	-3.693
PER	-1.492	-0.684	-3.061	COL	-1.786	-1.569	-3.587
BRA	-1.534	-0.897	-2.957	TWN	-1.858	-1.642	-3.480
ECU	-1.615	-1.040	-2.852	NIC	-2.122	-1.738	-3.373
ISR	-1.898	-1.183	-2.748	IND	-2.150	-1.806	-3.267
THA	-1.917	-1.288	-2.643	PAK	-2.307	-1.878	-3.160
NIC	-2.101	-1.390	-2.539	ARG	-2.529	-1.959	-3.053
KEN	-2.314	-1.492	-2.434	BOL	-2.590	-2.029	-2.947
PAK	-2.364	-1.580	-2.330	ISR	-2.764	-2.103	-2.840
TWN	-2.366	-1.651	-2.314	PHL	-2.804	-2.167	-2.824
CRI	-2.552	-1.726	-2.298	BRA	-3.103	-2.245	-2.808
BOL	-2.57	-1.791	-2.282	URY	-3.162	-2.315	-2.792
PHL	-2.603	-1.849	-2.266	KEN	-3.240	-2.381	-2.776
ARG	-2.701	-1.906	-2.250	LKA	-3.269	-2.440	-2.760
TTO	-2.701	-1.956	-2.240	TTO	-3.288	-2.493	-2.750
LKA	-2.814	-2.006	-2.230	ECU	-3.441	-2.549	-2.740
VEN	-2.854	-2.053	-2.220	GTM	-3.460	-2.600	-2.730
NGA	-2.995	-2.103	-2.210	VEN	-3.462	-2.645	-2.720
CHL	-3.019	-2.149	-2.200	DOM	-3.565	-2.691	-2.710
PAN	-3.061	-2.192	-2.196	CHL	-3.726	*-2.740*	-2.704
URY	-3.264	*-2.241*	-2.192	NGA	-3.769	*-2.787*	-2.698
GTM	-3.317	*-2.287*	-2.188	HND	-4.122	*-2.845*	-2.692
SLV	-3.322	*-2.331*	-2.184	ZAF	-4.169	*-2.900*	-2.686
UGA	-3.411	*-2.374*	-2.180	PAN	-4.322	*-2.957*	-2.680
DOM	-3.629	*-2.422*	-2.176	CRI	-4.357	*-3.011*	-2.674
MAR	-3.672	*-2.468*	-2.172	EGY	-4.433	*-3.064*	-2.668
PRY	-3.677	*-2.512*	-2.168	PRY	-4.670	*-3.121*	-2.662
EGY	-3.733	*-2.554*	-2.164	MAR	-4.812	*-3.179*	-2.656
HND	-4.048	*-2.603*	-2.160	ETH	-5.255	*-3.249*	-2.650
ETH	-4.287	*-2.658*	-2.155	UGA	-5.313	*-3.315*	-2.645
ZAF	-4.467	*-2.714*	-2.150	SLV	-5.344	*-3.379*	-2.640
MUS	-5.608	*-2.802*	-2.145	MUS	-5.927	*-3.456*	-2.635

See notes to Table 2. Except note that critical from Pesaran's (2007) Table 1b and 1c for T = 50 and N = 30 are reported in the first row (instead of T = 50 and N = 20 as in Table 2) and, in addition, critical values for T = 50 and N = 50 from Table 2b and 2c are also implicitly used to calculate the reported critical values.

Table 5: Pesaran's (2007) panel unit root test (Non-OECD countries, LRCY)

LRCY, Non-OECD Countries							
Intercept only				**Intercept and Trend**			
Country	**Time-series**	**Panel**	**5% CV**	**Country**	**Time-series**	**Panel**	**5% CV**
COL	0.251	0.251	-3.270	ISR	-0.436	-0.436	-3.800
ISR	-0.594	-0.172	-3.166	TWN	-1.003	-0.720	-3.693
TWN	-0.981	-0.441	-3.061	PER	-1.460	-0.966	-3.587
BRA	-1.610	-0.734	-2.957	DOM	-1.867	-1.192	-3.480
DOM	-1.637	-0.914	-2.852	BOL	-2.032	-1.360	-3.373
PER	-1.647	-1.036	-2.748	EGY	-2.051	-1.475	-3.267
NIC	-1.735	-1.136	-2.643	VEN	-2.063	-1.559	-3.160
VEN	-1.813	-1.221	-2.539	URY	-2.098	-1.626	-3.053
CRI	-1.947	-1.301	-2.434	CRI	-2.171	-1.687	-2.947
IND	-1.981	-1.369	-2.330	NIC	-2.188	-1.737	-2.840
THA	-1.985	-1.425	-2.314	COL	-2.192	-1.778	-2.824
URY	-2.029	-1.476	-2.298	ECU	-2.519	-1.840	-2.808
EGY	-2.058	-1.520	-2.282	LKA	-2.553	-1.895	-2.792
PHL	-2.091	-1.561	-2.266	GTM	-2.603	-1.945	-2.776
TTO	-2.205	-1.604	-2.250	ARG	-2.628	-1.991	-2.760
ETH	-2.297	-1.647	-2.240	PHL	-2.639	-2.031	-2.750
BOL	-2.355	-1.689	-2.230	PAK	-2.649	-2.068	-2.740
CHL	-2.490	-1.734	-2.220	MUS	-2.708	-2.103	-2.730
GTM	-2.604	-1.779	-2.210	CHL	-2.834	-2.142	-2.720
UGA	-2.652	-1.823	-2.200	TTO	-2.840	-2.177	-2.710
ARG	-2.660	-1.863	-2.196	IND	-2.899	-2.211	-2.704
ECU	-2.695	-1.901	-2.192	BRA	-3.003	-2.247	-2.698
KEN	-2.705	-1.936	-2.188	PAN	-3.221	-2.289	-2.692
PAK	-2.853	-1.974	-2.184	UGA	-3.530	-2.341	-2.686
LKA	-2.902	-2.011	-2.180	KEN	-3.555	-2.390	-2.680
MUS	-2.949	-2.047	-2.176	ZAF	-3.572	-2.435	-2.674
ZAF	-3.134	-2.087	-2.172	NGA	-3.620	-2.479	-2.668
PRY	-3.195	-2.127	-2.168	SLV	-3.801	-2.526	-2.662
NGA	-3.203	*-2.164*	-2.164	MAR	-3.966	-2.576	-2.656
PAN	-3.372	*-2.204*	-2.160	PRY	-4.180	-2.629	-2.650
SLV	-3.860	*-2.258*	-2.155	THA	-4.313	*-2.684*	-2.645
MAR	-3.946	*-2.310*	-2.150	ETH	-4.634	*-2.745*	-2.640
HND	-4.998	*-2.392*	-2.145	HND	-5.285	*-2.822*	-2.635

See notes to Table 2 and Table 4.

Table 6: Cerrato et al's (2009) panel unit root test (OECD countries, LCY)

LCY, OECD Countries							
Intercept				Intercept and trend			
Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
USA	-0.109	-0.109	-3.040	MEX	-1.510	-1.510	-3.470
GRC	-1.554	-0.832	-2.942	NOR	-1.600	-1.555	-3.551
IRL	-1.558	-1.074	-2.844	CAN	-1.640	-1.583	-3.433
PRT	-1.681	-1.226	-2.747	USA	-2.070	-1.705	-3.315
GBR	-1.717	-1.324	-2.649	SWE	-2.220	-1.808	-3.197
LUX	-1.769	-1.398	-2.551	PRT	-2.290	-1.888	-3.079
ITA	-1.836	-1.461	-2.453	CHE	-2.330	-1.951	-2.961
ISL	-1.881	-1.513	-2.356	GBR	-2.330	-1.999	-2.843
MEX	-2.191	-1.588	-2.258	FIN	-2.600	-2.066	-2.725
CAN	-2.201	-1.650	-2.160	ISL	-2.620	-2.121	-2.607
FRA	-2.261	-1.705	-2.144	LUX	-2.860	-2.188	-2.588
CHE	-2.305	-1.755	-2.128	GRC	-2.940	-2.251	-2.568
NLD	-2.445	-1.808	-2.112	BEL	-3.180	-2.322	-2.549
TUR	-2.639	-1.868	-2.096	JAP	-3.280	-2.391	-2.530
NOR	-3.098	-1.950	-2.080	ESP	-3.330	-2.453	-2.510
DNK	-3.124	-2.023	-2.074	NLD	-3.430	*-2.514*	-2.503
BEL	-3.158	*-2.090*	-2.068	FRA	-3.440	*-2.569*	-2.496
SWE	-3.762	*-2.183*	-2.062	AUT	-3.820	*-2.638*	-2.489
NZL	-3.788	*-2.267*	-2.056	ITA	-3.840	*-2.702*	-2.481
FIN	-3.807	*-2.344*	-2.050	DNK	-4.130	*-2.773*	-2.474
JAP	-3.991	*-2.423*	-2.045	TUR	-4.870	*-2.873*	-2.468
AUT	-4.001	*-2.494*	-2.040	AUS	-4.970	*-2.968*	-2.462
ESP	-4.969	*-2.602*	-2.035	IRL	-5.470	*-3.077*	-2.456
AUS	-5.245	*-2.712*	-2.030	NZL	-7.220	*-3.250*	-2.450

This table reports the unit root test results using cross-sectional means in the regression for both the individual countries (in the column headed Time-series) and the panel as a whole (in the column headed Panel). The panel test reported in the first row includes one country only, the panel test in the second row uses a panel of the first two countries, the panel test in the third row is based on a panel of the first three countries and so on, with the panel statistic in the last involving all 24 countries listed. The number of lags used in the individual country test equations is determined using SBC. The maximum available sample is 1951 – 2003 which with 0 and 1 lags after differencing gives the individual country time-series sample sizes of 52 and 51 observations for 0 and 1 lags, respectively. The 5% critical values are based on those given in Cerrato *et al* (2009) and are reported in the columns headed 5% CV. For the intercept only case the critical value in the first row is taken from Table 11 in Cerrato *et al* (2009) and corresponds to an individual time-series test with T=50 and N=20. The panel critical values reported in rows 10, 15, 20 (and implicitly 30) are taken from Table 12 in Cerrato *et al* (2009) all for T = 50 and with N = 10, 15, 20 (and 30), respectively. The intervening critical values are calculated using linear interpolation. For the intercept and trend only case we generated critical values for row 1 (a time-series test with N=24 and T=50) and row 24 (a panel test with N=24 and T=50), the latter we denote CV_{24}. To obtain the intervening values we applied the growth rate (as a country is added to the panel) of the critical values for the intercept only case to the first critical value for intercept and trend and repeated this recursively to obtain initial critical values for all panel sizes including an initial value for the whole panel, denoted I_{24}. We then multiplied all of these initial values by (CV_{24}/I_{24}) to obtain the reported critical values. A panel statistic highlighted with bold italic emphasis indicates rejection of the unit root null.

Table 7: Cerrato et al's (2009) panel unit root test (OECD countries, LRCY)

LRCY, OECD Countries							
Intercept				Intercept and trend			
Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
PRT	-0.877	-0.877	-3.040	GBR	-1.501	-1.501	-3.470
SWE	-0.993	-0.935	-2.942	IRL	-1.530	-1.516	-3.551
GBR	-1.002	-0.957	-2.844	NLD	-1.550	-1.527	-3.433
ITA	-1.177	-1.012	-2.747	SWE	-1.640	-1.555	-3.315
IRL	-1.209	-1.052	-2.649	ITA	-1.900	-1.624	-3.197
NOR	-1.286	-1.091	-2.551	GRC	-2.200	-1.720	-3.079
NLD	-1.376	-1.131	-2.453	CHE	-2.360	-1.812	-2.961
GRC	-1.442	-1.170	-2.356	BEL	-2.560	-1.905	-2.843
MEX	-1.601	-1.218	-2.258	JAP	-2.600	-1.982	-2.725
JAP	-1.694	-1.266	-2.160	USA	-2.660	-2.050	-2.607
USA	-1.740	-1.309	-2.144	MEX	-2.700	-2.109	-2.588
CHE	-1.758	-1.346	-2.128	CAN	-2.740	-2.162	-2.568
CAN	-2.005	-1.397	-2.112	PRT	-2.800	-2.211	-2.549
LUX	-2.273	-1.460	-2.096	FIN	-2.970	-2.265	-2.530
BEL	-2.441	-1.525	-2.080	AUS	-3.060	-2.318	-2.510
AUT	-2.741	-1.601	-2.074	DNK	-3.060	-2.364	-2.503
DNK	-2.831	-1.673	-2.068	NZL	-3.089	-2.407	-2.496
FIN	-2.831	-1.738	-2.062	AUT	-3.180	-2.450	-2.489
ESP	-2.863	-1.797	-2.056	NOR	-3.490	*-2.505*	-2.481
AUS	-3.191	-1.867	-2.050	ISL	-3.900	*-2.575*	-2.474
NZL	-3.191	-1.930	-2.045	LUX	-3.940	*-2.640*	-2.468
FRA	-3.318	-1.993	-2.040	FRA	-4.250	*-2.713*	-2.462
ISL	-3.839	*-2.073*	-2.035	ESP	-4.330	*-2.783*	-2.456
TUR	-3.895	*-2.149*	-2.030	TUR	-5.490	*-2.896*	-2.450

See notes to Table 6.

Table 8: Cerrato et al's (2009) panel unit root test (Non-OECD countries, LCY)

LCY, Non-OECD Countries						
Intercept				Intercept and trend		
Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
COL	-0.374	-0.374	-3.060	ISR	-0.840	-0.840	-3.480
IND	-0.814	-0.594	-2.960	ARG	-1.230	-1.035	-3.592
ISR	-0.936	-0.708	-2.860	THA	-1.240	-1.103	-3.471
THA	-0.984	-0.777	-2.760	PHL	-1.380	-1.173	-3.350
ECU	-1.164	-0.854	-2.660	URY	-1.730	-1.284	-3.228
BRA	-1.248	-0.920	-2.560	BRA	-1.840	-1.377	-3.107
PHL	-1.251	-0.967	-2.460	TTO	-1.890	-1.450	-2.986
ARG	-1.333	-1.013	-2.360	ECU	-1.900	-1.506	-2.864
KEN	-1.362	-1.052	-2.260	TWN	-1.960	-1.557	-2.743
TWN	-1.463	-1.093	-2.160	PER	-2.000	-1.601	-2.621
URY	-1.466	-1.127	-2.144	COL	-2.300	-1.665	-2.602
NIC	-1.597	-1.166	-2.128	PRY	-2.390	-1.725	-2.583
BOL	-1.639	-1.202	-2.112	IND	-2.580	-1.791	-2.563
PER	-1.761	-1.242	-2.096	EGY	-2.600	-1.849	-2.544
TTO	-1.978	-1.291	-2.080	PAK	-2.660	-1.903	-2.524
NGA	-2.065	-1.340	-2.074	DOM	-2.840	-1.961	-2.517
PAK	-2.268	-1.394	-2.068	HND	-2.840	-2.013	-2.510
EGY	-2.417	-1.451	-2.062	CRI	-3.020	-2.069	-2.503
PAN	-2.469	-1.505	-2.056	BOL	-3.180	-2.127	-2.495
GTM	-2.554	-1.557	-2.050	CHL	-3.450	-2.194	-2.488
HND	-2.576	-1.606	-2.045	SLV	-3.480	-2.255	-2.482
PRY	-2.594	-1.651	-2.040	LKA	-3.540	-2.313	-2.476
DOM	-2.633	-1.693	-2.035	NGA	-3.640	-2.371	-2.470
CRI	-2.644	-1.733	-2.030	GTM	-3.730	-2.428	-2.464
MAR	-2.674	-1.771	-2.025	VEN	-3.850	*-2.484*	-2.458
ZAF	-2.899	-1.814	-2.020	PAN	-3.890	*-2.538*	-2.452
SLV	-3.143	-1.863	-2.015	KEN	-3.900	*-2.589*	-2.445
CHL	-3.300	-1.915	-2.010	ZAF	-3.930	*-2.637*	-2.439
ETH	-3.457	-1.968	-2.005	MAR	-3.950	*-2.682*	-2.433
VEN	-3.579	*-2.021*	-2.000	NIC	-4.280	*-2.735*	-2.427
LKA	-3.629	*-2.073*	-1.998	ETH	-4.550	*-2.794*	-2.425
UGA	-4.353	*-2.145*	-1.996	UGA	-5.140	*-2.867*	-2.422
MUS	-5.899	*-2.258*	-1.994	MUS	-6.230	*-2.969*	-2.420

See notes to Table 6. Except note that critical from Cerrato *et al*'s (2009) Table 11 for T = 50 and N = 30 is reported in the first row (instead of T = 50 and N = 20 as in Table 6) for the intercept only case. In addition, the critical values for T = 50 and N = 50 from Table 12 are also implicitly used to calculate the reported critical values for the intercept only case. We simulated the critical values for the first and last row of the table and employed the procedure discussed in table 6 to calculate the intervening critical values.

Table 9: Cerrato et al's (2009) panel unit root test (Non-OECD countries, LRCY)

| LRCY, Non-OECD Countries |||||||
| Intercept ||| Intercept and trend |||
Country	Time-series	Panel	5% CV	Country	Time-series	Panel	5% CV
COL	-0.637	-0.637	-3.060	ISR	-0.930	-0.930	-3.480
ISR	-0.736	-0.687	-2.960	BOL	-0.950	-0.940	-3.592
NGA	-0.802	-0.725	-2.860	COL	-1.086	-0.989	-3.471
BRA	-0.828	-0.751	-2.760	CRI	-1.440	-1.102	-3.350
PER	-0.876	-0.776	-2.660	ECU	-1.450	-1.171	-3.228
BOL	-1.198	-0.846	-2.560	URY	-1.450	-1.218	-3.107
TWN	-1.421	-0.928	-2.460	ARG	-1.690	-1.285	-2.986
CRI	-1.697	-1.024	-2.360	BRA	-1.710	-1.338	-2.864
ARG	-1.699	-1.099	-2.260	PER	-1.910	-1.402	-2.743
IND	-1.784	-1.168	-2.160	TWN	-2.130	-1.475	-2.621
MUS	-1.976	-1.241	-2.144	SLV	-2.220	-1.542	-2.602
UGA	-1.993	-1.304	-2.128	DOM	-2.230	-1.600	-2.583
ETH	-2.022	-1.359	-2.112	ETH	-2.400	-1.661	-2.563
ECU	-2.027	-1.407	-2.096	GTM	-2.660	-1.733	-2.544
DOM	-2.148	-1.456	-2.080	TTO	-2.710	-1.798	-2.524
NIC	-2.161	-1.500	-2.074	PHL	-2.790	-1.860	-2.517
EGY	-2.459	-1.557	-2.068	ZAF	-2.970	-1.925	-2.510
PHL	-2.501	-1.609	-2.062	PAK	-2.980	-1.984	-2.503
TTO	-2.614	-1.662	-2.056	IND	-2.990	-2.037	-2.495
PRY	-2.687	-1.713	-2.050	CHL	-3.080	-2.089	-2.488
VEN	-2.769	-1.764	-2.045	PRY	-3.120	-2.138	-2.482
URY	-2.798	-1.811	-2.040	UGA	-3.160	-2.184	-2.476
ZAF	-2.801	-1.854	-2.035	LKA	-3.290	-2.232	-2.470
THA	-3.314	-1.914	-2.030	VEN	-3.380	-2.280	-2.464
KEN	-3.335	-1.971	-2.025	THA	-3.460	-2.327	-2.458
LKA	-3.335	-2.024	-2.020	NGA	-3.610	-2.377	-2.452
GTM	-3.491	-2.078	-2.015	MUS	-3.620	-2.423	-2.445
SLV	-3.519	*-2.130*	-2.010	HND	-3.880	*-2.475*	-2.439
CHL	-3.602	*-2.180*	-2.005	EGY	-3.890	*-2.524*	-2.433
PAN	-4.203	*-2.248*	-2.000	KEN	-4.060	*-2.575*	-2.427
HND	-4.381	*-2.317*	-1.998	NIC	-4.100	*-2.624*	-2.425
PAK	-4.448	*-2.383*	-1.996	MAR	-4.290	*-2.676*	-2.422
MAR	-4.573	*-2.450*	-1.994	PAN	-4.940	*-2.745*	-2.420

See notes to Table 6 and 8.