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TRENDS IN INCOME INEQUALITY

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Trends in income inequality

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Abstract

Literature recently highlights that the income inequality has increased in almost all countries since the 1980s, which leads to the following question; is there a secular trend and shift in income inequality of developing and/or advanced countries? We address this question using the Gini coefficient for a sample of 21 advanced and developing countries over 1960-2015. We also assess the inequality gap between developing and advanced countries. We find that the income inequality exhibits negative, mainly in Latin America countries, positive, or trendless behaviours. The Gini coefficient of developing countries also exhibit different behaviours relative to advanced countries. Overall, a secular trend of inequality cannot be identified across advanced and/or developing countries in our sample. Our findings raise some concerns regarding the efficiency of global policies to reduce of among-country inequality, one of the main goals of United Nations for the next 15 years.

***JEL classification*:** C12; D63

***Keywords*:** Inequality; Gini index; unit root; structural break.

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1. Introduction

Income inequality has become a growing concern for policymakers in the last few decades. In 2015, the United Nations established the Sustainable development goals (SDGs) including "reduce inequality within and among countries" by 2030. A growing strand of literature recently suggests that the income inequality has increased around the world since the 1980s. Piketty (2014) and Piketty and Zucman (2014) show that the income inequality, especially in advanced countries, has increased since the beginning of the 1980s and they attribute this phenomenon to the sustainable increase of the capital-to-income ratio. Furthermore, they expect that the increase in inequality will continue in this century. Ravallion (2014) shows that the within inequality for the developing world as a whole has been slowly rising in the 1990s and thereafter declined slightly since 2000. Alvaredo et al., (2017) and the World inequality reports (2018)[1] suggest that the income inequality has increased rapidly since 1980 across most countries, but at different speeds. These findings lead to the following question; is there a secular trend and shift in income inequality of developing and/or advanced countries? Answering this question is critical to assess the efficiency of global policies[2] on reducing the within and among countries inequality as the more heterogeneous is the behaviour of income inequality across countries, the less appropriate are these policies.

We contribute to this strand of literature by estimating the trend of income inequality. More specifically, we test if there is a secular trend and shift in Gini index. To the best of our knowledge, this is the first study to estimate the inequality trend[3]. Furthermore, we use a new

[1] Check wir2018.wid.world/ for the online version of the report.

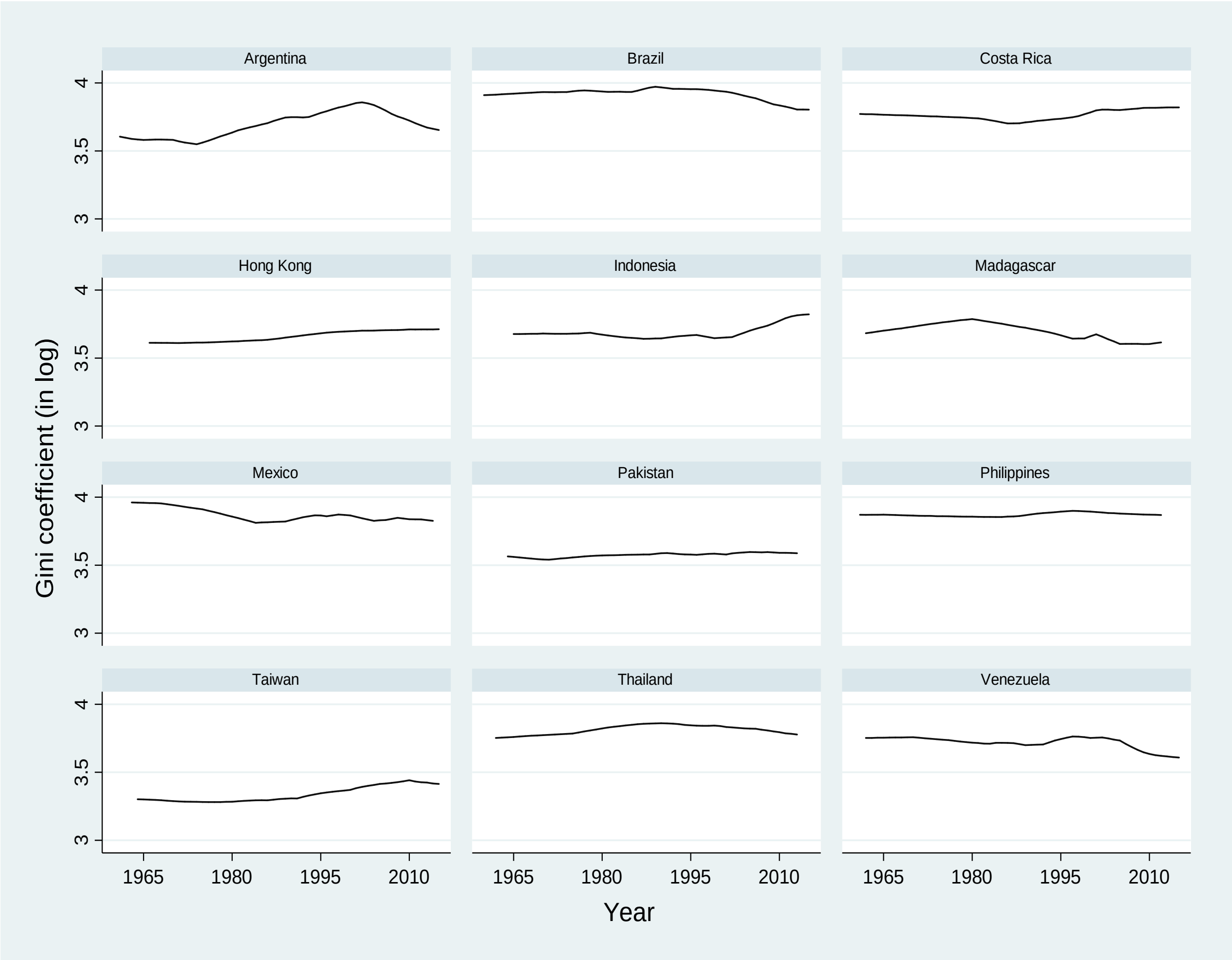
[2] For instance, Official development assistance (ODA) and the other international policies suggested by United Nations e.g. strengthening the voices of developing countries in decision-making forums of international economic and financial institutions.

[3] Some studies discuss the trend of income inequality using graphs (e.g. Jaumotte, et al., 2013 and World inequality report 2018) or comparing the inequality averages and distributions across time intervals (e.g. Sala-i-Martin, 2006). However, estimating the inequality slope is essential to check if there is statistically significant trend and whether this trend is deterministic or stochastic. Additionally, it is important to find if there is a break in inequality trend as suggested by the literature, such as Piketty (2014).

approach to test the inequality gap between developing and advanced countries. Particularly, we test the trend of inequality of developing countries relative to advanced countries. SDGs suggest that the income inequality among countries may have been reduced. However, to reduce the inequality among countries, one would expect a negative nexus between the level and the slope of income inequity. In other words, the reduction of inequality across countries implies that income inequality of countries with a high inequality level, which is the case of the most developing countries in our sample, relative to countries with low inequality, such as the advanced countries, exhibits a negative trend. This is important to understand if developing countries converge the inequality level of advanced countries thereby evaluating the change of among countries over time.

To estimate the trend of inequality, we use Gini index and select countries with at least 50 observations. This gives us a sample of 21 advanced and developing countries over the period 1960-2015; thereby we can check if there is secular pattern in inequality across advanced and/or developing countries. We also estimate the trend of Gini coefficients of developing countries relative to the averaged Gini coefficient of advanced countries.

Figure 1 shows the Gini coefficient (in log) for advanced and developing countries in our sample. Gini coefficient for some countries like the United States and Taiwan is trending upward. However, for other countries like Brazil, Venezuela and Mexico, it is trending downward. In some cases, like the United Kingdom, Japan, Korea, Hungary, Argentina and Indonesia, we can notice a break in trend. Therefore, the figure provides initial evidence about different patterns of inequality across countries. Thus, we need more analysis of inequality behaviour.



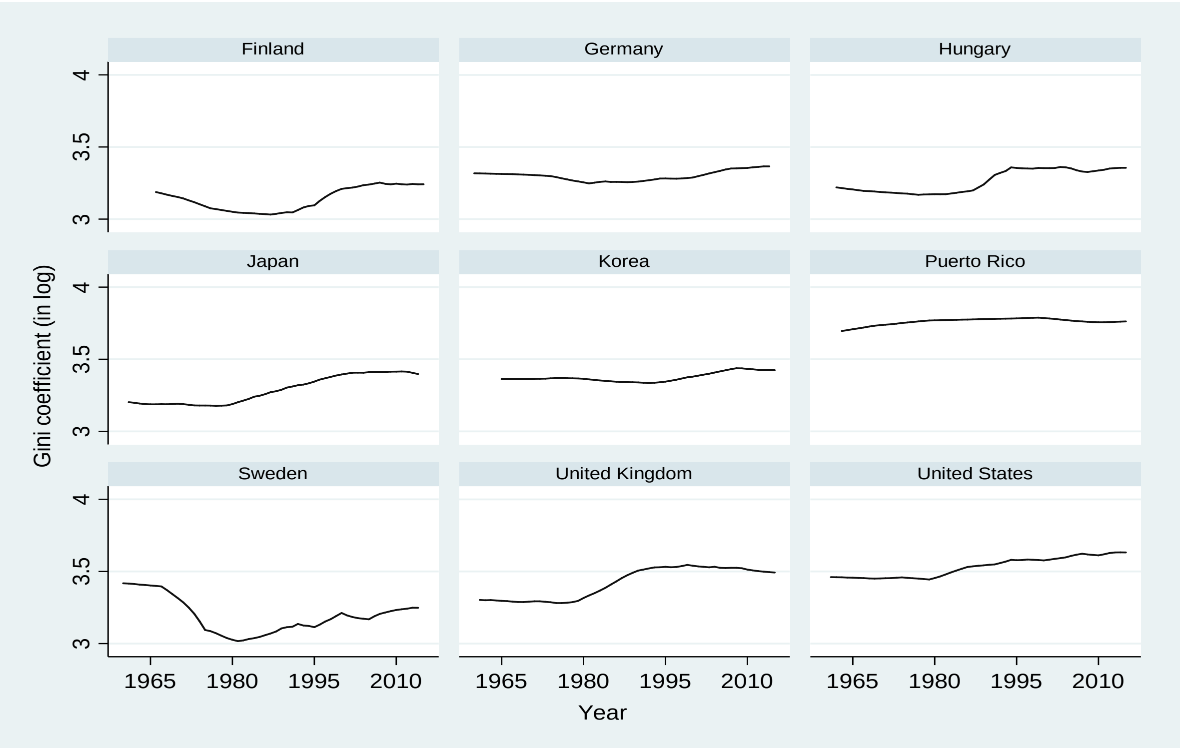


Figure 1 Gini coefficient (in log) in 21 countries (1960–2015).

Methodologically, we use time series analysis rather than panel analysis, which allows us to understand the trend of inequality for each country. To estimate the possibility of the existence of a trend in inequality measures, we use unit root tests to check whether the inequality measures are trend stationary (TS) or difference stationary (DS)[4]. If Gini index exhibits a unit root behaviour, then it is said to contain stochastic trends and thereby shocks to income inequality have permanent effects. If, however, the underlying Gini index is found to be stationary, then the index is considered to be trend stationary and the effect of shocks on income inequality will have temporary effects. Thus, we employ conventional *no-break* unit root tests. However, Perron (1989) illustrates that ignoring the structural break will reduce the power of the unit root test. Therefore, we also use unit root tests to allow for a structural break in trend and intercept. After determining whether Gini coefficient is trend stationary with a structural break or difference stationary, we estimate either the deterministic trend, before and after the break, or the stochastic trend. We conduct these tests also on the relative Gini coefficients of developing countries.

Our main findings show that Gini index exhibits a unit root behaviour for some counties and stationary for other. We find a break in 9 out of 21 countries and the breakpoints differ across countries. The estimated deterministic, before and after the break, and stochastic trends suggest that inequality has been decreased for some countries, increased and/or remained more or less constant for others. Furthermore, the results of developing countries show that most Latin American countries move toward less inequality, but Asian countries do not show similar

[4] Recently, few empirical studies have examined the persistence of inequality, yet they provided mixed pieces of evidence. Islam and Madsen (2015), for instance, test the persistence of Gini coefficients and top 10% income shares for a sample of 21 OECD countries over the period 1870–2011 using the Carrion-i-Silvestre et al. (2005) panel stationarity test, which allows multiple structural breaks. They found that the increasing inequality after 1980 is driven by a deterministic trend as suggested by Piketty (2014). Christopoulos and McAdam (2017) provide opposite evidence. Using Gini index, they test the persistence of inequality for a panel of 47 OECD and non-OECD countries from 1975 to 2012. To do so, they introduce a new panel unit root test to address unknown structural breaks. Their results suggest that inequality measures contain unit root. They conclude that inequality measures are exceptionally persistent, if not strictly a unit root, which implies that shocks to income inequality have permanent, or, at least, very long-lasting, effects.

success. The performance of advanced countries, on the other hand, is mixed. Overall, we cannot observe a secular pattern of inequality across countries or even across advanced countries. The observed breaks in inequality trends could be attributed to different domestic economic and political circumstances that support our message; there is no secular pattern or cause of the inequality, at least in the last five decades. The results of relative Gini coefficients of developing countries confirm this inference. These inconsistent patterns provide less support to the international inequality policies and emphasize the role of domestic policies to reduce the among countries.

The remainder of the paper is organised as follows: section 2 describes the Gini income inequality data set. Section 3 discusses the empirical estimation methodology. Section 4 presents the empirical results. Finally, Section 5 concludes.

2. Data

Income inequality is captured by Gini index, which is the most widely used measure of inequality in the empirical literature (e.g., Dollar and Kraay, 2002; Beck et al., 2007; Delis et al., 2013; Islam and Madsen, 2015 and Christopoulos and McAdam, 2017), from the Standardized World Income Inequality Database (SWIID) (Solt, 2016). This database provides the most comprehensive database on Gini index and it is currently the best suited data set to perform cross-national study on income inequality as it standardises consumption and wage income (see Delis et al., 2013; Solt, 2016 and Christopoulos and McAdam, 2017). Gini coefficient is derived from the Lorenz curve and ranges between 0 (perfect equality) and 100 (perfect inequality). In the SWIID data set, data on Gini index are available for 192 countries over the period 1960–2015/16. We use the post-tax Gini index to control the impact of fiscal policy on inequality. Additionally, the pre-tax Gini index is limited[5].

To estimate the trend, especially with allowing for a break in trend, we need a long period, so we select countries with at least 50 observations and no in-sample Not Available (NAs). This gives us an unbalanced panel data set for 21 countries, 12 advanced economies and 9 developing countries, from 1960 to 2015. Table 1 provides details about our sample and summary statistics. The highest income inequality, on average, exists in developing countries, both Asian and Latin American. The average of Gini index for Brazil, Philippines, Mexico, Thailand and Costa Rica is 50.39, 48.03, 47.99, 45.32 and 43.09, respectively. The averages of Gini index of the advanced countries are noticeably lower, almost half, than those of developing countries. Particularly, Finland, Sweden, Hungary, Japan and Germany have the lowest 5 averages of Gini index in our sample, 23.16, 24.52, 26.23, 26.89 and 27.10, respectively. On the other hand, there is no clear difference between developing and advanced countries in term of the volatility of income inequality. Argentina, United Kingdom and Sweden have the most unstable Gini index with standard deviation 3.87, 3.26 and 3.07, respectively, whilst Pakistan, Philippines and Germany have the most stable Gini index with standard deviation 0.57, 0.64 and 0.93, respectively.

Table 1: Summary statistics

Country	Period	Mean	Std. Dev.	Min	Max
Argentina	1961-2015	40.248	3.874	34.79	47.35
Brazil	1960-2015	50.387	2.139	44.88	53.08
Costa Rica	1961-2015	43.086	1.534	40.54	45.64
Finland	1966-2015	23.162	1.869	20.73	25.88
Germany	1960-2014	27.098	0.929	25.74	28.96
Hong Kong	1966-2015	38.890	1.546	36.98	40.94
Hungary	1962-2015	26.232	2.076	23.79	28.83
Indonesia	1965-2015	40.000	2.053	38.15	45.66
Japan	1961-2014	26.888	2.583	23.98	30.42
Korea	1965-2015	29.249	0.944	28.11	31.12

[5] The Gross Gini index with at least 50 observations is available only for 11 countries.

Madagascar	1962-2012	40.447	2.350	36.71	44.13
Mexico	1963-2014	47.987	2.306	45.22	52.54
Pakistan	1964-2013	35.684	0.570	34.47	36.48
Philippines	1961-2012	48.035	0.640	47.19	49.4
Puerto Rico	1963-2015	43.027	0.967	40.28	44.21
Sweden	1960-2014	24.519	3.068	20.43	30.51
Taiwan	1964-2015	28.120	1.616	26.6	31.24
Thailand	1962-2013	45.319	1.546	42.62	47.5
United Kingdom	1961-2015	30.760	3.264	26.6	34.65
United States	1961-2015	34.221	2.334	31.32	37.81
Venezuela	1962-2015	41.265	1.736	36.92	43.07

3. Methodology

To test the trend of inequality, we use methodology commonly employed to test the trend of primary commodity prices relative to manufacturing goods, Prebisch–Singer hypothesis, see for example Kellard and Wohar (2006), Ghoshray (2011) and Arezki et al. (2014). The first step is we need to consider the underlying nature of Gini coefficient. Gini coefficient could be trend stationary (TS) or difference stationary (DS)[6]. If the underlying Gini coefficient series were to be trend stationary, then we test the trend by estimating the following log-linear time trend model:

$$Gini_t = \alpha + \beta t + \varepsilon_t \tag{1}$$

[6] Some studies highlight that the conventional unit root tests are potentially unreliable for bounded variable such as Gini index, values between 0 and 100 (Cavaliere and Xu 2014). However, the adjustment path of Gini index may be highly protracted even if it is ultimately mean reverting (Christopoulos and McAdam, 2017). Furthermore, many bounded series such as nominal interest rates, cannot be strongly negative, and unemployment rate, roughly a percentage, are often treated as possessing a unit root. We follow other studies such as Islam and Madsen (2015) by using the logarithm of Gini index; however, for robustness check, we have followed the suggestion of Wallis (1987) and also conducted all of the analysis on a logistic transformation of Gini index, $Gini_t^{Logistic} = \ln(\frac{Gini_t}{1-Gini_t})$. Results from using the logistic transformation are quantitatively very similar and qualitatively identical to the results obtained from the logarithm series.

where $Gini_t$ is the logarithm of Gini coefficient, t is a linear trend and the random variable ε_t is stationary with mean zero. The focal point of interest is the coefficient β which represents the growth rate of inequality. If $\beta > 0$ then it indicates upward slope of Gini coefficient, i.e. the inequality increases over time, otherwise, for $\beta < 0$, we conclude that inequality has downward slope; thereby it tends to decrease over time. The error process, ε_t, is assumed to follow an ARMA process which allows for cyclical fluctuations of Gini coefficients to be around their long run trend. If Gini coefficient exhibits a unit root behaviour, then we adopt the model as estimating the trend stationary model given by Eq. (1) will generate misleading results about trend, i.e. we may conclude that the trend is significant when it is actually not[7]. More specifically, we cope with this issue by estimating the stochastic trend using the following difference stationary model:

$$\Delta Gini_t = \beta + \nu_t \tag{2}$$

where ν_t is a stationary and invertible error process. As aforementioned, if β is positive (negative) and statistically significant then it indicates upward (downward) slope of Gini coefficient. Importantly, if Gini coefficient is a trend stationary process but is treated as a difference stationary process, then estimating the trend using Eq. (2) is inefficient, lacking power relative to those estimated from Eq. (1) (see Ghoshray, 2011).

Perron (1989) shows that if a structural break is ignored, the power of the unit root test is lowered; thus he suggests a unit root allow for a structural break. His paper, however, was criticised for the fact that he assumed that the date of the structural break is known, exogenous. Stock and Watson (1988 a,b) and Christiano (1992) criticise this test as an exogenously chosen

[7] For example, Kim et al. (2003) show that if one cannot reject unit root for commodity prices, then the estimated slopes using deterministic trend model, Eq. (1) in our paper, are biased downwards. They show that smaller number of commodity prices have negative slopes once they estimate the trend using stochastic trend model, Eq. (2) in our case.

break date may lead to false inferences. Consequently, some researchers, such as Zivot and Andrews (1992) and Perron and Vogelsang (1992 a,b), response to this criticism by developing a unit root test that allows for the break to be unknown and determined endogenously from the data. However, these tests have the limitation that the critical values are derived while assuming no break under the null hypothesis. Nunes et al. (1997) illustrate that this assumption leads to size distortions in the presence of a unit root with structural breaks. As a result, this test may tend to suggest evidence of stationarity with break (Lee and Strazicich, 2003). Lee and Strazicich (2013) propose a one break minimum Lagrange Multiplier (LM) unit root test with alternative hypothesis unambiguously implies the series is trend stationary; thus it is unaffected by break under the null. Additionally, they illustrate that this test is free of size distortions and spurious rejections in the presence of a unit root with break as it employs a different detrending method (Lee et al., 2006) and tends to estimate the break point correctly[8].

Therefore, we employ Lee and Strazicich (2013) test that allows a single structural break[9]. To briefly describe the Lee and Strazicich (2013) method, consider the following data generating process (DGP):

$$Gini_t = \psi' X_t + \upsilon_t \text{ and } \upsilon_t = \emptyset \upsilon_{t-1} + \varepsilon_t \text{ where } \varepsilon_t \sim iidN(0, \sigma^2) \qquad (3)$$

where $Gini_t$ is Gini index and X_t denotes the changes in level and trend as follow $X_t = [1, t, D_t, DT_t]'$ where

$$DT_t = \begin{cases} t - TB \ for \ t \geq TB + 1 \\ 0 \ otherwise \end{cases}$$

[8] We use also Zivot and Andrews (1992) and Perron and Vogelsang and (1992 a,b) tests. However, Lee and Strazicich (2013) is our benchmark.

[9] We focus on one structure break as economists, such as Piketty (2014) and Solow (2014), discuss the change in inequality in 1980s. In addition, as our period is not too long we need to ensure that we have enough observations before and after the break to estimate the trend. Kellard and Wohar (2006) and Ghoshray (2011) allow for two structural breaks; however, the period of their commodity price series is 1900-1998 and 1900-2003, respectively, comparing with 1960-2015 for our Gini coefficient series.

TB refers to breakpoint. As mentioned before, this test contains break both the null hypothesis, when $H_0: (\emptyset = 1)$, and the alternative hypothesis, when $H_A: (\emptyset < 1)$. Note that the critical values depend on the break fraction, $\lambda = TB/T$ where T is the total number of observations.

The statistic of LM test can be estimated using following regression:

$$\Delta Gini_t = \emptyset' \Delta X_t + \gamma \bar{Ʈ}_{t-1} + \sum_{i=1}^{p} \psi_i \Delta \bar{Ʈ}_{t-1} + \upsilon_t$$

Where $\bar{Ʈ}_{t-1} = Gini_t - \mu - X_t \bar{\emptyset}$, $t = 2, 3, \ldots, T$; $\bar{\emptyset}$ are coefficients on the regression of $\Delta Gini_t$ on ΔX_t; μ is given by $Gini_1 - X_1 \bar{\emptyset}$. $Gini_1$ and X_1 are the first observations of the $Gini_t$ and X_t sequences respectively. The lagged terms, $\Delta \bar{Ʈ}_{t-i}$ are added to correct for serial correlation. The appropriate lag length, p, is selected using the general to specific method (GTOS). The LM test statistics are given by the τ statistic testing the null hypothesis $H_0: (\gamma = 1)$. The LM unit root test determines the break points endogenously by utiliszing a grid search. To eliminate endpoints trimming of the *infimum* (inf) is made at 10%. The test determines the breakpoints where the test statistic is minimised. The LM test is given as $LM_\tau = inf\,\hat{\tau}(\lambda)$ where λ is the break fraction as mention above.

After determining whether Gini coefficient is trend stationary (TS) with a structural break or difference stationary (DS), we estimate the deterministic or stochastic trend. For TS Gini coefficients, we test the shift of inequality slope. To do so, we follow Arezki et al., (2104) by considering piecewise regressions. Particularly, we estimate Eq. (1) before, regime 1, and after, regime 2, the breakpoint and we test if the difference between two regimes is statistically significant. For DS Gini coefficients, we estimate Eq. (2) for the whole period.

4. Results and discussion

The results of the unit root testing procedures without and with break are presented in Tables 2 and 3, respectively. The results of estimated deterministic and stochastic trends are shown on Tables 4 and 5, respectively. The results of relative Gini coefficients of developing countries are presented in Tables 6, 7 and 8. Finally, the robustness check findings are discussed in the last subsection.

4.1. Conventional tests with no breaks

We use three conventional *no-break* unit root tests. The preliminary results at this stage are presented in Table 2. The three tests indicate that for all countries, with the exception of ADF and ADF-GLS for Venezuela, the unit root hypothesis cannot be rejected. Thus, the results of first step in the analysis support Christopoulos and McAdam (2017) findings that inequality measure has a unit root. As discussed in methodology section, these tests ignore the possibility of structural break in either the level or trend which can produce misleading results. We address this issue by employing unit root tests allow for one structural break trend and intercept.

Table 2: Unit root tests without breaks

Country	ADF^{a}	$ADF - GLS^{a}$	$Phillips\ Perron^{b}$
Argentina	-1.458(2)	-2.851(1)	-0.180(5)
Brazil	-0.547(2)	-1.778(1)	0.301(4)
Costa Rica	-2.116(5)	-1.953(5)	-1.219(5)
Finland	-2.939(3)	-2.408(3)	-2.147(5)
Germany	-1.598(1)	-1.593(1)	-0.514(4)
Hong Kong	-2.372(2)	-2.640(2)	-1.813(5)
Hungary	-2.348(1)	-2.078(1)	-1.979(5)
Indonesia	-1.774(1)	-2.093(1)	0.365(4)
Japan	-2.213(10)	-2.341(3)	-2.006(5)
Korea	-2.571(10)	-2.697(1)	-1.308(5)
Madagascar	-2.515(5)	-1.787(5)	-2.311(3)
Mexico	-2.205(1)	-2.046(1)	-1.491(5)
Pakistan	-2.767(1)	-2.589(1)	-2.530(4)
Philippines	-2.591(1)	-2.675(1)	-1.475(5)
Puerto Rico	-2.594(1)	-1.890(1)	-5.549(5)

Sweden	-1.798(1)	-1.502(1)	-1.092(5)
Taiwan	-1.651(10)	-1.158(10)	-2.199(4)
Thailand	-0.069(1)	-2.251(1)	0.918(5)
United Kingdom	-1.978(1)	-2.709(2)	-0.975(5)
United States	-2.771(1)	-2.208(1)	-2.305(4)
Venezuela	-4.801***(8)	-3.292**(8)	-0.959(5)

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. All tests allow for constant and trend. The numbers in parentheses denote lags or bandwidth.

^{a} Appropriate lag length selected according to AIC.

^{b} Bandwidth selected using Newey–West using Bartlett kernel. The critical values for t-test are from MacKinnon (1996).

4.2. Endogenous break-point unit root tests

Moving on to the inclusion of shift in the deterministic trends, we use Zivot and Andrews (1992), Perron and Vogelsang (1992 a,b) and Lee and Strazicich (2013) tests; the latter is our benchmark. All tests allow for one endogenous breakpoint, i.e. breakpoint is estimated rather than selected a priori. As the breakpoints are determined endogenously, we should expect that they could vary across countries and/or across tests and specifications (Maslyuk and Smyth, 2008 and Ghoshray and Johnson, 2010).

Table 3 shows the results of applying these unit root tests on Gini index of 21 countries. According to Zivot and Andrews and Perron and Vogelsang tests we are unable, for one of these two tests at least, to reject the null of the unit root at any conventional levels of statistical significance for Gini index of 15 countries. The benchmark test, Lee and Strazicich, shows that we are unable to reject the null of the unit root at any conventional levels of statistical significance for 12 countries. For the remaining 9 countries, Argentina, Hong Kong, Hungary, Indonesia, Japan, Korea, Philippines, United Kingdom and Venezuela, the null hypothesis of a unit root was rejected in favour of a trend stationary alternative. All countries found trend stationary using Zivot and Andrews and/or Perron and Vogelsang tests found also trend stationary in Lee and Strazicich, except Sweden, which is trend stationary according to Zivot and Andrews test. The breakpoints, especially, for trend stationary countries are homogeneous across tests. Although the breakpoints differ across countries but most of them occur between the late 1980s and early 1990s as suggested by literature such as Sala-i-Martin (2006) and Piketty (2014). Piketty (2014) suggests the following thesis that since the beginning of the 1980s advanced countries experienced an increase in inequality and this will continue in this century. However, our findings show that only 4 out of 9 advanced countries experienced a break in the slope of inequality. Moreover, some developing, 5 out of 12, countries also experienced a change in inequality. These results imply that shocks of income inequality for these 9 advanced and developing countries have permanent effects and transitory effects for remaining 12 countries.

To summarise, 9 countries, 4 advanced and 5 developing, are classified as TS after allowance for one break in intercept and trend. For the remaining 12 countries, we cannot reject the unit root null. Clearly, given that only one country was found to be TS using conventional *no-break* unit root tests, allowing for the possibility of one structural break under the alternative hypothesis greatly affects the conclusions of unit root tests. The next question that we address in the next section is: what is the direction of these changes?

Table 3: Unit root tests with a single structural break

	Zivot and Andrews		Perron and Vogelsang		Lee and Strazicich	
Country	Statistic	TB	Statistic	TB	Statistic	TB
Argentina	-4.862*(1)	1993	-4.809(1)	1993	-4.724**(10)	1992
Brazil	-4.132(2)	1986	-4.804(1)	1992	-4.070(9)	1984
Costa Rica	-4.615(1)	1982	-4.563(1)	1981	-3.906(10)	1991
Finland	-2.662(1)	1972	-3.844(6)	1984	-3.655(7)	1991
Germany	-4.213(1)	1984	-4.308(10)	1994	-4.072(10)	1986
Hong Kong	-3.227(2)	1987	-4.174(5)	1987	-4.208*(5)	1985
Hungary	-4.997*(1)	1988	-5.075*(1)	1987	-5.671***(9)	1987
Indonesia	-5.407**(1)	1997	-5.703**(8)	1996	-4.232*(3)	1999
Japan	-2.377(1)	2005	-3.010(6)	2008	-4.752**(10)	1992
Korea	-3.926(1)	1989	-7.337***(9)	1983	-9.007***(10)	1979
Madagascar	-3.782(1)	1977	-4.378(10)	2001	-3.894(9)	2001
Mexico	-4.136(1)	1990	-4.584(7)	2004	-3.631(7)	1988
Pakistan	-4.289(1)	1992	-4.400(8)	1991	-3.384(1)	2007
Philippines	-4.416(1)	1989	-4.716(1)	1988	-5.554***(10)	1987

Puerto Rico	-3.738(1)	2000	-3.380(2)	1986	-4.044(9)	1982
Sweden	-4.949*(1)	1973	-4.224(2)	1980	-4.085(6)	1995
Taiwan	-2.028(1)	1970	-2.463(0)	2012	-3.082(10)	2000
Thailand	-3.485(1)	1976	-3.857(7)	2000	-4.160(6)	1990
United Kingdom	-3.716(2)	1997	-4.517(10)	1996	-6.161***(9)	1996
United States	-4.176(1)	1980	-4.1600(1)	1979	-3.330(10)	1984
Venezuela	-5.417**(1)	1993	-6.368***(8)	1992	-8.857***(8)	1991

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The numbers within parentheses denote the lag length. TB denotes the break date. Critical value at 1%, 5% and 10% for Zivot-Andrews test are -5.57, -5.08 and -4.82 respectively. The critical values for t-test are from Vogelsang (1993). For Zivot-Andrews and Perron and Vogelsang tests the appropriate lag length selected according to AIC. Critical values of Lee and Strazicich test vary depending on the location of the break (λ). Critical values are shown at the 1%, 5%, and 10% levels, respectively. Critical values are –5.11, –4.50, and –4.21 for λ = .1; –5.07, –4.47, and –4.20 for λ = .2; –5.15, –4.45, and –4.18 for λ = .3; –5.05, –4.50, and –4.18 for λ = .4; –5.11, –4.51, and –4.17 for λ = .5. The appropriate lag length for the Lee and Strazicich test is selected using GTOS.

4.3. Piecewise regressions

After determining the presence and the locations of structural breaks for the Gini coefficients, we consider piecewise regressions to estimate and compare the slopes before and after the break. For each TS Gini coefficients, we fit a linear trend model using Eq. (1), before, regime 1, and after, regime 2, the breakpoint. The results are summarised in Table 4. $\widehat{\beta_1}$ and $\widehat{\beta_2}$ represent the estimated slope for regime 1 and regime 2 respectively. The values in brackets are the p-values for the corresponding parameters. To test if the difference between slopes in inequality is statistically significant, we compare $\widehat{\beta_1}$ and $\widehat{\beta_2}$ using Wald test, see the last column in Table 4. For the remaining 12 countries which we cannot reject unit root, we estimate the difference-stationary (DS) model using Eq. (2). The results are presented in Table 5.

Table 4 shows that all slopes before break, regime 1, are statistically significant and more than half of them are positive. The slope of regime 1, $\widehat{\beta_1}$, is positive for all advanced economies except Hungry and positive for 2 out of 5 developing countries. The second column in Table 4 presents the slope of regime 2, after break. All slopes are statistically significant, except Philippines. $\widehat{\beta_2}$ is positive for all advanced economies except United Kingdom and positive for 2 out of 4 developing countries. The final step is to test the difference between slopes before and after the break. The last column in Table 4 shows that all TS countries in our sample, except Japan and Philippines, experienced a statistically significant change in the slope of inequality. However, 4 countries have an increase in inequality, Hong Kong, Hungary, Indonesia and Korea, and 3 have a decrease in inequality, Argentina, Japan and United Kingdom.

Out of the 9 advanced economies, 4 countries were found to experience a shift in the slope of inequality and this shift is positive, and the inequality increased, for only 2 of them, Hungary and Korea. Both countries had a reform in their economies. For example, the breakpoint of Hungry represents the collapse of the communist system. From the 1980s onwards, Korea attempts to upgrade its economy technologically by turning post-industrial strategies from the manufacturing of labour-intensive exports and into capital- and skill-intensive products (see Paul and Sekhar, 1997 and Bangura and Larbi, 2006).

For developing countries, 3 out of 12 experienced a significant shift in the trend of inequality and this shift is positive for 2 of them, Hong Kong and Indonesia. The wage inequality increases in Hong Kong since mide-1980s due to the rapid transformation of its economy toward a service sector after opening up of the Chinese economy in the late 1979. The export-oriented Hong Kong manufacturers moved their production base to the Pearl River Delta region and left only their head offices or controlling centres in Hong Kong (see Ho et al., 2005). This leads to a big change in the labour market and earnings structure, leading to a bigger income inequality. Indonesia has experienced drastic increase in inequality after the Asian Financial Crisis in the late 1990s. Ravallion and Lokshin (2007), for example, studied the lasting effect of this crisis on poverty in Indonesia and found that 1998 crisis can explain a large share, possibly half, of the poverty in count in 2002, see also Sala-i-Martin (2006).

In summary, we find mixed patterns of income inequality over the last 5 decades. Only few countries with exceptional circumstances have experienced an increase in income disparity trend post 1980s and 1990s. Some countries, on the other hand, exhibit a remarkable success in reducing the inequality.

Table 4: Piecewise regression for TS Gini coefficients

Countries	$\widehat{\beta_1}$	$\widehat{\beta_2}$	$\widehat{\beta_2} - \widehat{\beta_1}$ †
Argentina	0.006(0.00)	-0.006(0.00)	-0.012(0.00)
Hong Kong	0.001(0.00)	0.002(0.00)	0.001(0.00)
Hungary	-0.001(0.00)	0.002(0.00)	0.003(0.00)
Indonesia	-0.001 (0.00)	0.013(0.00)	0.014(0.00)
Japan	0.004(0.00)	0.003(0.00)	-0.001(0.89)
Korea	0.001(0.00)	0.003(0.00)	0.002(0.012)
Philippines	-0.001(0.00)	-0.000(0.34)	0.000(0.14)
United Kingdom	0.008(0.00)	-0.003(0.00)	-0.011(0.00)
Venezuela	-0.002(0.00)	-0.007(0.00)	-0.005(0.00)

Figures in parentheses are p-values. † Figures in parentheses are p-values of Wald test.

4.4. Difference-stationary model

Table 5 presents the results of the 12 countries, 5 advanced and 7 developing, which we cannot reject unit root. We find statistically significant slope only for 5, 3 positive and 2 negative, out of 12. The results indicate that 4 developing countries out of 7 have a significant trend, 2 upward, Puerto Rico and Taiwan, and 2 downward, Brazil and Mexico. Interestingly, we find that United States is the only advanced economy with a significant trend and this trend is positive. These results support those for TS Gini coefficients presented in Table 4 that there is no secular pattern of inequality in last 50 years.

Table 5: difference-stationary (DS) model

Countries	$\widehat{\beta}$
Brazil	-0.002(0.02)
Costa Rica	0.001(0.19)
Finland	0.001(0.48)

Germany	0.001(0.17)
Madagascar	-0.001(0.27)
Mexico	-0.003(0.01)
Pakistan	0.001(0.28)
Puerto Rico	0.001(0.00)
Sweden	-0.003(0.22)
Taiwan	0.002(0.00)
Thailand	0.001(0.42)
United States	0.003(0.00)

Figures in parentheses are p-values.

Finally, the results in Tables 4 and 5 show that inequality decreased in most Latin American countries. The difference between the inequality trends before and after the breakpoint is negative and significant for Argentina and Venezuela, see Table 4, and the inequity trend is negative and significant for Brazil and Mexico, the trend is positive but insignificant for Costa Rica, see Table 5. None of Asian countries, both developing and advanced, shows a similar success. The trend of Hong Kong and Indonesia shifts toward higher inequality, see Table 4, whilst Taiwan and Korea have a positive significant trend, see Table 5. The trends of income inequality of the rest Asian countries, Philippines, Pakistan, Thailand and Japan, remained more or less constant. These findings differ from Sala-i-Martin (2006) results, which show that the inequality decreased in Asia whilst the change varies over time for Latin America. For the rest non-Asian advanced countries, results are mixed. The inequality increased in Hungry, Puerto Rico and United States, decreased in United Kingdom and does not show significant slope in Finland, Germany, and Sweden. Although the income inequality tends to decrease for some countries, which experienced high inequality such as Brazil, Mexico and Venezuela but other countries with high inequality do not show the same change. For example, there is no significant trend of Gini index for Thailand and Cost Rica, while the inequality tends to increase in some countries, such as Indonesia and Hong Kong. This indicates that the income inequality not only varies within countries but also tends to grow among countries in the next few years. We further investigate this point in next section.

4.5. The income inequality trend for developing countries relative to advanced countries.

We test the trend of Gini coefficients of 12 developing countries relative to unweighted averaged Gini coefficient of advanced countries. The advanced countries have lower inequality comparing with developing countries. Thus, estimating the slope of relative Gini coefficients of developing countries demonstrates the change in among countries inequality. An upward trend of relative Gini coefficients of developing countries suggests that among countries inequality tends to increase over time, vice versa for downward trend.

Tables 6 and 7 present the unit root test results without and with a structural break, respectively, for relative Gini coefficients of 12 developing countries. Table 5 reports that relative Gini coefficients contain unit root; we cannot reject null hypothesis for 3 countries but only with ADF test. Table 7 shows that, using Lee and Strazicich (2013), the null hypothesis of a unit root was rejected in favour of a trend stationary alternative for 5 countries so that we estimate TS model before and after the break for these countries. For the remaining 7 developing countries, we cannot reject the unit root null, thus we estimate the trend using DS model.

Table 6: Unit root tests without break of developing countries relative to advanced countries

Country	ADF^a	$ADF-GLS^a$	$Phillips\ Perron^b$
Argentina	1.332(1)	-0.003(1)	1.536(2)
Brazil	-0.315(5)	0.360(2)	0.960(17)
Costa Rica	-1.883(1)	-1.879(1)	-1.844(2)
Hong Kong	-0.870(0)	-0.667(0)	-0.898(1)
Indonesia	-2.900(1)	-2.514(1)	-1.407(4)
Madagascar	-3.336*(5)	-2.139(5)	-1.522(3)
Mexico	-2.706(1)	-2.240(1)	-2.416(5)
Pakistan	-4.502***(6)	-1.967(3)	-1.987(5)
Philippines	-4.755***(2)	-2.074(4)	-1.140(5)
Taiwan	-2.015(10)	-1.099(10)	-1.509(3)
Thailand	-3.300*(2)	-1.658(2)	-0.394(1)

Venezuela	-0.381(1)	-1.107(1)	0.288(1)

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. All tests allow for constant and trend. The numbers in parentheses denote lags or bandwidth.
[a] Appropriate lag length selected according to AIC.
[b] Bandwidth selected using Newey–West using Bartlett kernel. The critical values for t-test are from MacKinnon (1996).

Table 7: Unit root tests with a single structural break of developing countries relative to advanced countries

	Zandrews		Perron and Vogelsang		Lee and Strazicich	
Country	Statistic	TB	Statistic	TB	Statistic	TB
Argentina	-4.683(1)	2001	-4.648(1)	1999	-2.954(8)	1991
Brazil	-2.323(0)	1987	-2.424(0)	1985	-3.455(9)	1989
Costa Rica	-2.919(2)	1982	-4.599(1)	1982	-2.686(10)	2007
Hong Kong	-2.582(0)	1981	-3.326(2)	2013	-3.616(9)	1996
Indonesia	-3.397(1)	1971	-3.155(1)	1979	-3.318(1)	1984
Madagascar	-4.017(1)	2002	-4.074(1)	2010	-3.931(9)	2001
Mexico	-4.106(2)	1980	-4.509(7)	2004	-4.260*(7)	1981
Pakistan	-4.675(2)	1972	-2.373(1)	2009	-4.172(6)	1990
Philippines	-5.173***(2)	1975	-11.337***(1)	1979	-5.173***(9)	1981
Taiwan	-1.327(1)	1975	-4.943*(9)	1995	-4.872**(9)	1994
Thailand	-5.771***(2)	1976	-5.852***(2)	1976	-4.515**(1)	1982
Venezuela	-3.580(1)	2001	-3.543(1)	2000	-5.467***(9)	1996

***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. The numbers within parentheses denote the lag length. TB denotes the break date. Critical value at 1%, 5% and 10% for Zivot-Andrews test are -5.57, -5.08 and -4.82 respectively. Critical values of Lee and Strazicich test vary depending on the location of the break (λ). Critical values are shown at the 1%, 5%, and 10% levels, respectively. Critical values are –5.11, –4.50, and –4.21 for λ = .1; –5.07, –4.47, and –4.20 for λ = .2; –5.15, –4.45, and –4.18 for λ = .3; –5.05, –4.50, and –4.18 for λ = .4; –5.11, –4.51, and –4.17 for λ = .5.

Table 8 displays the estimated slopes estimated by TS and DS models. The first column presents the results of DS model and shows that only 2 relative Gini coefficients exhibit negative behviour whilst the remaining 5 exhibit trendless behaviour. Columns 2 and 3 show the results of TS model before and after the break. We find the relative Gini coefficient for 4 countries improves, negative (positive) slope becomes steeper (negative) after the break. For one country, Taiwan, we find the slope is positive after the break.

Table 8: inequality trend of developing countries relative to advanced countries

Countries	DS	*TS*	
	$\widehat{\beta}$	$\widehat{\beta_1}$	$\widehat{\beta_2}$
Argentina	-0.002(0.401)	-	-
Brazil	-0.004**(0.025)	-	-
Costa Rica	-0.002(0.251)	-	-
Hong Kong	-0.001(0.464)	-	-
Indonesia	0.000(0.777)	-	-
Madagascar	-0.004*(0.059)	-	-
Mexico	-	-0.002***	-0.004***
Pakistan	-0.001(0.286)	-	-
Philippines	-	0.002***	-0.004***
Taiwan	-	0.000	0.002***
Thailand	-	0.007***	-0.007***
Venezuela	-	-0.002***	-0.013***

Figures in parentheses are p-values.

The results of TS and DS models suggest that the trend of relative Gini coefficient, and thus the among-countries inequality, is mixed. Again, we cannot observe a secular behviour for inequality in developing countries relative to advanced countries and thus there is no clear evidence about the reduction of among countries.

4.6. Robustness Check

As discussed earlier in methodology section, some studies illustrate that the unit root tests are potentially unreliable for bounded variables such as Gini index. Thus, we have conducted all the results of unit root tests presented in Tables 2 and 3 using logistic transformation of Gini index as suggested by Wallis (1987). The results of conventional *no-break* unit root tests support our findings presented in Table 2; all Gini coefficients exhibit unit root behaviour except Gini coefficient of Venezuela, see appendix 1 Table 2a. The results of unit root tests with a single structural break are very similar to our findings presented in Table 3. For example, Lee and Strazicich' LM test shows the same breakpoints, except for Hong Kong the breakpoint in 1985 is statistical significant at a 10 percent level with log, see Table 3, but insignificant with logistic, see Table 3a in appendix 1. Overall, the results of logarithm are consistent with those of logistic transformation.

5. Conclusion

This paper examines the trends in income inequality in the last 5 decades. We use Gini coefficient of a sample of 21 countries, 9 advanced and 12 developing, over 1960-2015. To estimate the trend of inequality, we employ unit root tests allow for structural break. This allows us to determine wither the inequality measures are trend stationary with structural break or first difference stationary. According to unit root results, we estimate the trend either using trend stationary, before and after the break, or difference stationary model. Additionally, we compare the slopes before and after the break to check the direction and significance of the shift in trend. We evaluate also the inequality gap between developing and advanced countries by conducting these tests on the Gini coefficients of developing countries relative to advanced countries.

Our main findings suggest that the Gini coefficient of 9, 4 advanced and 5 developing, out of 21 countries are found to exhibit trend stationary behaviour allowing for a structural break. Among these 9 countries only 4, 2 advanced (Hungary and Korea) and 2 developing (Hong Kong and Indonesia), experienced a positive significant shift in inequality trend and this shift seems to be driven by domestic exceptional circumstances. The remaining 12 are found to be difference stationary, which implies that shocks to inequality in these countries tend to have a permanent effect and only 3 of them have an upward slope. In addition, we find a decrease in inequality across Latin American countries. None of the Asian countries, including the advanced countries, shows similar performance. The advanced non-Asian countries have mixed patterns. The results of relative Gini coefficients suggest that only half the developing countries in our sample converge the inequality level of advanced countries. Overall, we observe different behaviours in inequality across advanced and developing countries.

In sum, there is no secular pattern or cause of inequality in last five decades. Reducing the income inequality within and among countries is one of the main goals of United Nations that they aim to achieve in next 15 years. Our final thought is that reducing within and among countries inequality requires more attention to the domestic policies such as taxation and redistribution policies rather than Official development assistance (ODA) or the other global policies suggested by United Nations, such as strengthening the voices of developing countries in decision-making forums of international economic and financial institutions and expanding the duty-free treatment and favourable access conditions for developing countries' exports.

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Appendix

Appendix 1

Logistic transformation

Table 2a: Unit root tests without break

Country	ADF^{a}	$ADF-GLS^{a}$	$Phillips\ Perron^{b}$
Argentina	-1.488(2)	-2.976*(1)	-0.210(5)
Brazil	-0.562(2)	-1.763(1)	0.185(4)
Costa Rica	-2.107(5)	-1.948(5)	-1.211(5)
Finland	-2.929(3)	-2.405(3)	-2.56(5)
Germany	-1.599(1)	-1.599(1)	-0.498(4)
Hong Kong	-2.381(2)	-2.620(2)	-1.842(5)
Hungary	-2.336(1)	-2.066(1)	-1.977(5)
Indonesia	-1.825(1)	-2.152(1)	0.469(4)
Japan	-2.231(10)	-2.340(3)	-2.005(5)
Korea	-2.622(10)	-2.683(1)	-1.310(5)
Madagascar	-2.535(5)	-1.822(5)	-2.308(3)
Mexico	-2.193(1)	-2.015(1)	-1.471(5)
Pakistan	-2.770(1)	-2.586(1)	-2.533(4)
Philippines	-2.596(1)	-2.681(1)	-1.474(5)
Puerto Rico	-2.570(1)	-1.885(1)	-2.427(5)
Sweden	-1.816(1)	-1.502(1)	-1.091(5)
Taiwan	-1.685(10)	-1.125(10)	-2.182(4)
Thailand	-0.140(1)	-2.280(6)	0.860(5)
United Kingdom	-2.445(2)	-2.669(2)	-0.959(5)
United States	-2.790(1)	-2.190(1)	-2.332(4)
Venezuela	-4.735***(8)	-3.283**(8)	-1.007(5)

***, ** and * denote significance at the 1%, 5% and 10% levels respectively. All tests allow for constant and trend. The numbers in parentheses denote lags or bandwidth.

^{a} Appropriate lag length selected according to AIC.

^{b} Bandwidth selected using Newey–West using Bartlett kernel. The critical values for t-test are from MacKinnon (1996).

Table 3a: Unit root tests with a single structural break

	Zandrews		Perron and Vogelsang		Lee and Strazicich	
Country	Statistic	TB	Statistic	TB	Statistic	TB
Argentina	-3.962(2)	1993	-5.079*(1)	1993	-4.740**(10)	1992
Brazil	-4..357(2)	1986	-4.954*(1)	1992	-4.030(9)	1984
Costa Rica	-4.579(1)	1982	-5.206**(10)	1981	-3.857(10)	1991
Finland	-2.654(1)	1972	-3.851(6)	1984	-3.644(7)	1991
Germany	-4.192(1)	1984	-4.319(10)	1994	-4.163(10)	1986
Hong Kong	-3.080(2)	1987	-4.067(5)	1987	-4.136(5)	1985
Hungary	-4.926*(1)	1988	-4.994(1)	1987	-5.668***(9)	1987
Indonesia	-5.469**(1)	1997	-5.713(8)	1996	-4.260*(7)	1993
Japan	-2.368(1)	2005	-3.081(6)	2008	-4.842**(10)	1992
Korea	-3.928(1)	1989	-7.418***(9)	1983	-8.981***(10)	1979
Madagascar	-3.628(1)	1977	-4.217(7)	2001	-3.850(9)	2001
Mexico	-4.060(1)	1990	-4.640(7)	2004	-3.669(7)	1988
Pakistan	-4.278(1)	1992	-4.394(8)	1991	-3.378(1)	2007
Philippines	-4.429(1)	1989	-4.714(1)	1988	-5.536***(10)	1987
Puerto Rico	-3.614(1)	2000	-3.719(2)	1986	-4.096(9)	1982
Sweden	-4.947*(1)	1973	-4.319(2)	1980	-4.015(6)	1995
Taiwan	-2.030(1)	1970	2.388(0)	2012	-3.143(10)	2000
Thailand	-3.459(1)	1976	-4.038(7)	2000	-4.234*(7)	1989
United Kingdom	-3.658(2)	1997	-4.527(9)	2003	-6.414***(9)	1996
United States	-4.079(1)	1980	-4.061(1)	1979	-3.359(1)	1983
Venezuela	-5.435**(1)	1993	-6.381***(8)	1992	-8.817***(8)	1991

***, ** and * denote significance at the 1%, 5% and 10% levels respectively. The numbers within parentheses denote the lag length. TB denotes the break date. Critical value at 1%, 5% and 10% for Zivot-Andrews test are -5.57, -5.08 and -4.82 respectively. Critical values of Lee and Strazicich test vary depending on the location of the break (λ). Critical values are shown at the 1%, 5%, and 10% levels, respectively. Critical values are –5.11, –4.50, and –4.21 for λ = .1; –5.07, –4.47, and –4.20 for λ = .2; –5.15, –4.45, and –4.18 for λ = .3; –5.05, –4.50, and –4.18 for λ = .4; –5.11, –4.51, and –4.17 for λ = .5.

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