Panel unit root and stationarity tests without structural breaks suggest that for eight Pacific island economies real gross domestic product (GDP) per capita contains a unit root. The panel stationarity test that accommodates structural change in the trend function, however, finds evidence in favour of regime-wise trend stationarity. This result points to the importance of taking structural breaks into account. The finding implies that, for the period considered, the permanent secular component of output is dominated by transitory fluctuations accompanied by infrequent changes in the trend function. The only exceptions are Fiji and Kiribati, for which individual stationarity tests with multiple structural breaks suggest that real GDP per capita contains a unit root.

Since the seminal research of Nelson and Plosser (1982), several studies have examined whether real GDP per capita is stationary around a linear trend. As stressed by Nelson and Plosser (1982), a unit root in real output is inconsistent with the view that business cycles are stationary fluctuations around a deterministic trend. If, however, real GDP per capita contains a unit root, this implies that shocks to real output have permanent effects.

Whether real GDP per capita contains a unit root therefore has important implications for macroeconomic theories and policy. The traditional procedure of decomposing output fluctuations into a long-run trend and short-run cycles is premised on the assumption that the trend component is a deterministic function of time, and the cyclical component represents a stationary movement around this trend. This reasoning falls down if the trend component contains a unit root (Libanio 2005). Moreover, if real GDP per capita contains a unit root, this challenges traditional theories of macroeconomic fluctuations, which assume output to be trend reverting and shocks to have only temporary effects.
If shocks are permanent, this is generally interpreted as meaning that real factors, such as technology shocks, have an important role in contributing to economic fluctuations; although it might also mean that aggregate demand shocks have permanent effects on real output levels in contrast with the natural-rate hypothesis (Campbell and Mankiw 1987; Rapach 2002). Depending on the size of the cyclical and secular component of fluctuations, which is contested, the existence of a unit root in real output has been interpreted as support for real business-cycle theory as well as other theories of the business cycle such as New Keynesian models (see Libanio 2005 for a survey).

These competing perspectives have important policy implications. If there is a unit root in real output, it suggests that after a negative shock an automatic return to a normal trend might not occur, and therefore Keynesian stabilisation policies to stimulate demand and move the economy towards full employment have a role to perform (Libanio 2005). If real output is stationary, fiscal and/or monetary stabilisation policies will be ineffective as output will revert to its natural rate, meaning Keynesian policies might have only temporary effects on output levels (Chang, Nieh and Wei 2005).

A note of caution, however, is needed. If real output contains a unit root, it is also possible to make a case against sharp contractions to slow the economy in the event it is overheating or in response to currency or fiscal crises (Dutt and Ros 2003), since the negative effects of such policies will not dissipate in the short run. The integration properties of real output also carry important implications for econometric modelling, given that real GDP per capita is a key variable in many empirical specifications. The appropriate econometric method—for example, the use of ordinary least squares or co-integration and long-run estimation techniques—crucially turns on the order of integration of the variables (Narayan 2008a).

This study applies the Carrion-i-Silvestre Barrio-Castor and Lopez-Bazo (2005) panel stationarity test with structural breaks to examine whether real GDP per capita is panel stationary for a panel of eight Pacific island countries (Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu) in the period 1985 to 2006.

The rest of the article is set out as follows. The next section discusses the existing literature and provides a motivation for the study. We then present an overview of the data, including a discussion of trends in real GDP per capita in the eight Pacific island countries in section three. The econometric methodology is explained and the results of the panel unit/stationarity tests applied to real GDP per capita in the eight island economies are discussed in section four. The policy implications of the findings and suggestions for future research are considered in the conclusion.

Existing literature and motivation

Much of the research on whether real GDP per capita contains a unit root has focused on industrialised countries. Several studies have examined whether real output in the United States contains a unit root (see, for example, Campbell and Mankiw 1987; Perron and Phillips 1987; Schwert 1987; Zivot and Andrews 1992; Lumsdaine and Papell 1997; Nelson and Murray 2000; Sen 2004; Hurlin 2008). Some studies have examined whether real GDP per capita in Group of Seven (G7) countries contains a unit root (for example, Narayan 2007). Other studies have looked at whether real GDP per capita in countries of the Organisation for Economic Cooperation
and Development (OECD) contain a unit root (see, for example, Wasserfallen 1986; Kormendi and Maguire 1990; Zelhorst and De Haan 1994, 1995; Ben-David and Papell 1995; Flessig and Strauss 1999; Rapach 2002; Ben-David, Lumsdaine and Papell 2003; Carrion-i-Silvestre Barrio-Castro and Lopez-Bazo 2005; Gaffeo Gallegati and Gallegati 2005; Romero-Avila 2007).


There are two limitations of the extant literature that this study seeks to address. First, there are no studies that consider whether real GDP per capita in the Pacific island countries contains a unit root. The only related study of which we are aware is Narayan and Narayan (2008), who examine whether real GDP in Fiji contains a unit root as part of a study of the determinants of monetary demand. Second, there is no consensus as to whether real GDP per capita is stationary. Some studies have found real output contains a unit root (see, for example, Campbell and Mankiw 1987; Perron and Phillips 1987; Schwert 1987; Rapach 2002). Other studies have found real output to be trend stationary (Zelhorst and De Haan 1994, 1995; Flessig and Strauss 1999). Several multi-country studies have found evidence of stationarity for some countries, but not others (Ben-David and Papell 1995; Ben-David et al. 2003). Debate about the stationarity properties of real output could therefore be resolved through the use of better techniques.

Mixed results in the literature are, to a large extent, the manifestation of methodological limitations of the unit root or stationarity tests that have been employed. Most of the early studies employed conventional univariate unit root tests such as the augmented Dickey–Fuller (ADF) or Phillips–Perron tests. The power of these traditional unit root tests is distorted when the span of data is short (Campbell and Perron 1991) or when structural breaks are ignored (Perron 1989). One approach has been to allow for one or two endogenous structural breaks in an ADF-type unit root test (Zivot and Andrews 1992; Ben-David and Papell 1995; Lumsdaine and Papell 1997; Ben-David et al. 2003; Smyth and Inder 2004). Lee and Strazicich (2001), however, show that ADF-type tests, which are derived on the assumption of no break(s) under the null hypothesis, suffer from size distortions. Another approach has been to employ the Lee and Strazicich (2003) Lagrange multiplier (LM) unit root test with two structural breaks, which has the advantage that the test is unaffected by breaks under the null hypothesis (see Narayan 2007). A limitation of all univariate unit root tests, including the LM test with structural breaks, is the need for relatively long spans of data, which are not available for many developing countries.

A second approach to improving the power of univariate unit root tests with short spans of data has been to apply panel unit root tests. Most studies have employed conventional panel unit root tests without structural breaks and reached mixed results (Flessig and Strauss 1999; Rapach 2002;
Figure 1  Plot of real GDP per capita for eight Pacific island countries

1 = Fiji  2 = Kiribati  3 = Marshall Islands  4 = Papua New Guinea  5 = Samoa  6 = Solomon Islands  
7 = Tonga  8 = Vanuatu

Hurlin 2008). Rapach (2002) suggested that in light of the mixed results with conventional panel unit root tests, future research should proceed in two directions. First, allow for structural breaks so as to avoid misinterpreting trend stationarity with breaks as difference stationarity. Second, employ a panel stationarity test of the KPSS type (Kwiatkowski et al. 1992), which takes stationarity as the null hypothesis. In response to Rapach’s (2002) call, a small number of studies has applied the Carrion-i-Silvestre et al. (2005) test, which is a panel version of the KPSS test that allows for multiple structural breaks (Romero-Avila 2007; Narayan 2008a, 2008b).

One motivation for the study is to address the limitations in the existing literature on unit root properties of real GDP per capita. An additional motivation for studying the time series properties of real GDP per capita in the Pacific island countries pertains to its relevance to policymaking. As discussed in the next section, these countries have struggled to achieve average growth rates of even 2 per cent in the past two decades, with four countries achieving a growth rate of less than 1 per cent. In light of this poor performance, understanding the impact of shocks on per capita income is crucial.

The poor performance suggests that economic policies implemented to stimulate economic growth have not worked. This suggests that economies have been impacted simultaneously by negative shocks that have negated the expected positive influence of economic policies. Our approach to modelling the time series properties also allows us to investigate the exact nature of the structural shock that we identify as structural breaks in the data series.

Overview of the data

Annual data for real GDP per capita for Fiji, Kiribati, Marshall Islands, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu for the period 1985–2006 were downloaded from the World Bank’s World Development Indicators (World Bank 2008). All data were converted to natural logarithms before implementing the panel tests. The descriptive statistics, however, are based on the raw data. The countries selected for the study and the time frame were dictated by data availability and the need to ensure a balanced panel.

We make three observations from the plots of real GDP per capita for the Pacific island countries (Figure 1). First, for Fiji and Tonga, there is a clear positive trend. Second, for Kiribati, Papua New Guinea and Samoa, while there is a positive trend, the trend appears to be affected by structural breaks. Third, for Marshall Islands, Solomon Islands and Vanuatu, the trend in real GDP per capita is very different from the remainder of the countries. For instance, in the cases of Marshall Islands and Solomon Islands, initially there is rise in per capita GDP, then there is a stable period, followed by a sharp decline about the mid 1990s. Finally, per capita GDP in Vanuatu has a trend and considerable volatility.

We report descriptive statistics relating to real GDP per capita of the eight countries (Table 1). There are a number of interesting features of the data that are worth highlighting. First, mean real GDP per capita for the period 1985–2006 was the highest for Marshall Islands, followed by Fiji, Samoa and Vanuatu. Real GDP per capita was lowest for Kiribati and Papua New Guinea, at US$481 and US$617, respectively. Mean per capita income in these countries is almost four to five times smaller than that of Marshall Islands. Volatility of real GDP per capita is highest
for Marshall Islands and lowest for Kiribati, the least developed country, measured in terms of per capita income.

Second, the maximum per capita GDP is recorded by Marshall Islands. The superior performance of Marshall Islands is due to the fact that it receives substantial assistance from the United States through its Compact of Free Association, with grants accounting for 30 per cent of GDP. The tourism industry in Marshall Islands has also had a positive influence on economic growth (Narayan et al. 2008). We notice, however, that the annual average growth rate for the period 1985–2006 has been less than 1 per cent.

Third, Papua New Guinea, which is among the weakest performing Pacific island countries, has suffered from a number of adverse social and economic issues. On the eve of three decades of independence, Papua New Guinea was performing so badly that some scholars were asking, somewhat provocatively, whether Papua New Guinea was viable (Gosarevski, Hughes and Windybank 2004). Papua New Guinea’s macroeconomic performance has improved in the past few years due to rising global prices for export commodities and strong supply responses from the agricultural and mineral sectors, coupled with a stable political environment (ADB 2007).

On many indicators, however, Papua New Guinea continues to lag behind its Pacific neighbours. Manning (1999) noted six constraints—crime, corruption, poor infrastructure, policy instability, inflation, and tax levies and regulation—as impediments to private sector development. Similarly, Duncan and Lawson (1997) found that the above-mentioned factors raised the cost of doing business in Papua New Guinea. If Papua New Guinea is to show

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiji</td>
<td>1,974.249</td>
<td>2,363.297</td>
<td>1,622.585</td>
<td>224.8699</td>
<td>1.747</td>
<td>1.345</td>
</tr>
<tr>
<td>Kiribati</td>
<td>481.9007</td>
<td>557.2838</td>
<td>405.8681</td>
<td>53.945</td>
<td>1.229</td>
<td>0.123</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>2,360.846</td>
<td>2,744.230</td>
<td>2,030.214</td>
<td>290.9894</td>
<td>0.057</td>
<td>–0.878</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>617.2769</td>
<td>728.8749</td>
<td>517.9476</td>
<td>58.408</td>
<td>0.576</td>
<td>–1.07</td>
</tr>
<tr>
<td>Samoa</td>
<td>1,248.829</td>
<td>1,579.704</td>
<td>1,076.491</td>
<td>160.2846</td>
<td>1.645</td>
<td>3.63</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>791.8432</td>
<td>939.5497</td>
<td>611.9166</td>
<td>105.3585</td>
<td>0.368</td>
<td>–2.446</td>
</tr>
<tr>
<td>Tonga</td>
<td>1,394.656</td>
<td>1,692.557</td>
<td>1,188.309</td>
<td>168.7903</td>
<td>1.621</td>
<td>2.476</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>1,219.603</td>
<td>1,347.980</td>
<td>1,099.396</td>
<td>85.826</td>
<td>0.002</td>
<td>–0.342</td>
</tr>
</tbody>
</table>

Note: The mean, maximum, minimum and standard deviations are computed for 1985–2006.
Source: Authors’ calculations.
rapid economic improvement in the next 15 years, per capita income will still be far behind neighbouring Asia; and even in the most optimistic futurist accounts it will still face major socioeconomic problems such as HIV/AIDS and poverty (Chand 2007). Levantis (1997) found that 70 per cent of unemployed males in Papua New Guinea were involved with criminal gangs, while 40 per cent of unemployed females were involved in prostitution.

Fourth, the weak performance of Kiribati is due to the poor performance of agriculture and fishing—its two main economic activities (Thomas 2002). The agricultural sector has been affected intermittently by natural disasters. Kiribati is, in terms of remoteness, the country furthest from the nearest major port. This geographical disadvantage is a constraint on doing business. Kiribati, given its location, is also considerably exposed to major weather events (UNFCCC 2005).

Fifth, the rest of the countries, including Fiji, Solomon Islands, Vanuatu and Tonga, have all suffered from periods of political and macroeconomic instability, such as inflation and exchange rate depreciation. For most of the Pacific island countries, the agricultural sector, including fishing, has traditionally been the major economic activity. This sector, however, is particularly vulnerable to weather events (UNFCCC 2005), which have had a negative impact on export performance. This is reflected in the growth rates of real GDP per capita reported in the last two columns of Table 1.

None of the Pacific island countries managed to achieve a real GDP per capita growth rate of 2 per cent per annum for the period 1985–2006. In the most recent period (2000–06), however, two countries—Samoa and Tonga—managed to achieve growth rates of 3.6 and 2.5 per cent, respectively. The strong economic growth performance of Samoa was due mainly to structural reforms undertaken in the late 1990s and also the growing importance of workers' remittances. Workers' remittances have also played a significant role in boosting Tonga's economic growth in this more recent period.

Econometric methodology and results

Conventional panel unit root tests

As a benchmarking exercise, we begin by applying the panel unit root tests of Levin, Lin and Chu (2002) (LLC), Im, Pesaran and Shin (2003) (IPS) and Maddala and Wu (MW) to real GDP per capita for the panel of eight countries. The null hypothesis for all four tests is that real GDP per capita contains a panel unit root. The alternative hypothesis in each case is that real GDP per capita is stationary. If the data contain cross-sectional dependence across countries, it is well recognised that panel unit root tests will show large distortions (see O'Connell 1998; Maddala and Wu 1999; Strauss and Yigit 2003; Banerjee, Marcellino and Osbat 2005). To ascertain whether cross-sectional dependence is a problem in this panel, we estimate individual ADF(p) regressions (without cross-section augmentations) for lag lengths—(p) = 1, 2, 3 and 4—and computed pair-wise, cross-section correlation coefficients of the residuals from these regressions (namely, \( \bar{\rho}_{ij} \)). The simple average of these correlation coefficients across all pairs, \( \bar{\rho} \), together with the associated cross-section dependence (CD) test statistics proposed by Pesaran (2004) are presented (Table 2). The null hypothesis that output innovations are cross-sectionally independent cannot be rejected at any lag length. We can therefore conclude that cross-sectional correlation is not a problem in this panel.

We also report the results of the LLC, IPS and MW panel unit root tests (Table 3;
Table 2  Cross-section correlation of the errors in the ADF($p$) regression for GDP per capita across Pacific island countries, 1985–2006

<table>
<thead>
<tr>
<th></th>
<th>1985–2006 (T = 22, N = 8)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P = 1</td>
<td>P = 2</td>
<td>P = 3</td>
<td>P = 4</td>
</tr>
<tr>
<td>Log (GDP per capita)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\hat{\rho}$</td>
<td>0.040</td>
<td>0.017</td>
<td>-0.007</td>
<td>-0.009</td>
</tr>
<tr>
<td>CD</td>
<td>0.892</td>
<td>0.374</td>
<td>-0.157</td>
<td>-0.211</td>
</tr>
</tbody>
</table>

Notes: The CD test statistic is proposed in Pesaran (2004) for testing for cross-sectional dependence in panels. All statistics are based on univariate AR($p$) specifications in the level of the variables with $p \leq 4$. The null hypothesis is that output innovations are cross-sectionally independent. The 10 per cent, 5 per cent and 1 per cent critical values for the CD statistic are 1.64, 1.96 and 2.57, respectively.

Source: Authors’ calculations.

Table 3  Conventional panel unit root tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Log (GDP per capita)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Levels</td>
</tr>
<tr>
<td>Name of test</td>
<td></td>
</tr>
<tr>
<td>IPS</td>
<td>0.033</td>
</tr>
<tr>
<td>LLC</td>
<td>-1.161</td>
</tr>
<tr>
<td>MW–Fisher ADF</td>
<td>15.056</td>
</tr>
<tr>
<td>MW–Fisher PP</td>
<td>22.410</td>
</tr>
</tbody>
</table>

$^a$ denotes statistical significance at the 1 per cent level.

Notes: ‘Differences’ denotes results in first differences. IPS, LLC and MW–Fisher ADF and MW–Fisher PP are the Im et al. (2003), Levin et al. (2002) and Maddala and Wu (1999) ADF and Phillips-Perron unit root tests, respectively. The LLC and IPS tests were performed on de-meaned data. All the unit root tests were performed with the assumption of constant term and linear trend in the logarithm of the series with the null hypothesis of a unit root. The lag length for the IPS, LLC and MW–Fisher ADF test was selected using the modified Hannan-Quinn criteria. The optimal bandwidth for the MW–Fisher PP test was selected with the Newey-West method using Bartlett kernel.

Source: Authors’ calculations.
for technical details of these panel unit root tests, see Hurlin 2008). The LLC test assumes that all countries converge towards the equilibrium value at the same speed under the alternative hypothesis. The IPS test has the advantage over the LLC test that it does not make this assumption and is therefore less restrictive. Karlsson and Lothgren (2000) perform Monte Carlo simulations that show that in most cases the IPS test outperforms the LLC test. In the MW Fisher (1932) type of tests, the null and alternative hypotheses are the same as in IPS. In these tests, however, the strategy consists of combining the observed significant levels from the individual unit root tests. The LLC, IPS and MW panel unit root tests each give the same result. Real GDP per capita in the panel of eight countries contains a unit root.

**Panel stationarity test with structural breaks**

There are two limitations with each of these conventional panel unit root tests. The first limitation is that they assume the null of a unit root. As noted by Bai and Ng (2004), for many economic applications, it is more natural to take stationarity as the null hypothesis, rather than non-stationarity. The second limitation is that none of these tests accommodates structural breaks, which are likely to be a feature of real GDP per capita in the Pacific island countries given the macroeconomic, political and weather-related instability that has characterised several of the countries.

To address these limitations, we implement the panel stationarity test with structural breaks suggested by Carrion-i-Silvestre et al. (2005). This test is a generalisation for the case of multiple changes in level and slope of the panel stationarity test of Hadri (2000), which is computed as the average of univariate KPSS stationarity tests. It is a panel stationarity test that allows for structural shifts in the trend of the individual time series. This test therefore allows for heterogeneity, which permits each country in the panel to have a different number of breaks at different dates. In addition to the panel test statistic, Carrion-i-Silvestre et al.’s (2005) test produces results for individual countries.

In contrast with commonly applied structural break unit root tests, such as the tests of Zivot and Andrews (1992) and Lumsdaine and Papell (1997), Carrion-i-Silvestre et al.’s (2005) test generates only the statistically significant breaks. To estimate the break dates, Carrion-i-Silvestre et al. (2005) apply the Bai and Perron (1998) technique. Trimming is necessary when computing estimates of break dates. We follow the approach recommended by Bai and Perron (1998) and Carrion-i-Silvestre et al. (2005) and use the trimming region \([0.1, 0.9]\), which has been found to produce the most efficient results.

Once all possible break dates are identified, Carrion-i-Silvestre et al. (2005) recommend that the optimal dates be selected using the Liu et al. (1997) modified Schwartz information criterion for trending regressors. This method involves sequential computation and detection of the breaks using a pseudo F-type test statistic. The Carrion-i-Silvestre et al. (2005) test allows for a maximum of five structural breaks. The country-specific results test the null of stationarity allowing for structural breaks in real output for each of the eight countries (Table 4). We report the test statistics, the finite sample critical values based on Monte Carlo simulations with 20,000 replications and break dates (Table 4).

The only countries for which we are able to reject the null hypothesis of stationarity at the 5 per cent level or better are Fiji and Kiribati, for which the null hypothesis is rejected at the 1 per cent level. That real GDP
per capita in Fiji contains a unit root is not surprising. This finding means that shocks to real GDP per capita are not transitory and that, after shocks, real GDP per capita does not return to its long-run growth path within a short time. In the period of the study, Fiji has technically had four political coups—two in 1987, one in 2000 and one in 2006—which have shocked the long-run growth path of real GDP per capita. These political shocks have had an adverse effect on economic growth and made growth rates highly volatile (Narayan and Prasad 2007). The effect of the coups was to increase outward migration, resulting in the loss of considerable human capital (Narayan and Prasad 2007; Prasad and Narayan 2008).

Fiji has also been subject to myriad economic shocks in the past two decades. These shocks include two large devaluations of the Fiji dollar: by 33 per cent in 1987, after the first coups in 1987, and by 20 per cent in 1998, after the onset of the East Asian financial crisis. As well, there was the National Bank of Fiji scandal in 1994–95 in which F$250 million—equivalent to 8 per cent of Fiji’s GDP—was lost due to corruption and mismanagement. These sizeable economic and political shocks are consistent with Fiji being unable to return to its long-run growth path after the shocks.

While most of the Pacific island economies are vulnerable to internal and external shocks to differing degrees, which impact on long-run growth paths, the very small Pacific island countries such as Kiribati (and Tuvalu, which is not in the sample) are also particularly susceptible to shocks (Fairbairn 2002). The World Bank (2000) classified Kiribati as one of the countries most vulnerable to the adverse effects of weather events. Because Kiribati is low lying with no hinterland, it is particularly susceptible to changes in rainfall patterns.

<table>
<thead>
<tr>
<th>Country</th>
<th>t-statistic (quadratic)</th>
<th>TB1</th>
<th>TB2</th>
<th>Finite sample critical values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiji</td>
<td>2.288&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1990</td>
<td>1998</td>
<td>0.117</td>
</tr>
<tr>
<td>Kiribati</td>
<td>0.284&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1993</td>
<td>1997</td>
<td>0.137</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>0.148</td>
<td>1987</td>
<td>1995</td>
<td>0.157</td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>0.073</td>
<td>1992</td>
<td>2000</td>
<td>0.127</td>
</tr>
<tr>
<td>Samoa</td>
<td>0.095</td>
<td>1995</td>
<td>2000</td>
<td>0.148</td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>0.12</td>
<td>1988</td>
<td>1999</td>
<td>0.153</td>
</tr>
<tr>
<td>Tonga</td>
<td>0.119</td>
<td>1993</td>
<td>1999</td>
<td>0.120</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>0.075</td>
<td>1992</td>
<td>2000</td>
<td>0.118</td>
</tr>
</tbody>
</table>

<sup>a</sup> denotes significance at the 1 per cent level

*Note*: The finite sample critical values were computed by means of Monte Carlo simulation using 20,000 replications.

*Source*: Authors’ calculations.
and sea level, making its long-run growth path highly vulnerable to extreme events, such as drought and coastal flooding (ADB 2006). Kiribati’s narrow production base also makes its economy vulnerable to external shocks. Exports such as seaweed and pearls, and tourism, of which Kiribati would like to produce more, are vulnerable to external shocks and adverse weather (ADB 2006).

The finding of structural breaks in Fiji in 1990 and 1998 is associated with economic and political events and is broadly consistent with previous studies that have identified structural breaks in key economic variables for Fiji. A series of articles testing for a unit root in tourist arrivals and tourist expenditure in Fiji pinpointed the structural breaks as being associated with the coups in 1987 and 2000 (Narayan 2005a, 2005b, 2005c), and a later study of whether there was a unit root in monetary demand, interest rates and GDP in Fiji identified similar structural breaks to this study (Narayan and Narayan 2008).

In 1990, Fijian Prime Minister Sitiveni Rabuka imposed a constitution that made it impossible for Indo-Fijians to hold power. This event precipitated political instability and uncertainty. It helped to create a divided society and had an adverse effect on economic growth (Narayan and Prasad 2007). The second break occurred at the time of a severe drought and a 20 per cent devaluation in the Fiji dollar in the middle of the East Asian financial crisis (Narayan and Narayan 2007). The second break also occurred in the year an amended constitution—which, in effect, amounted to a new constitution—came into force, which gave Indo-Fijians the same political rights as indigenous Fijians. This event created a relatively positive economic environment and laid the foundation for strong economic growth (Prasad and Narayan 2008). A high growth rate of 9 per cent in 1999 reflected a combination of the introduction of the new constitution, a rebound from the drought and a boost to tourism from the devaluation of the Fiji dollar, which made holidaying in Fiji cheaper than previously (Narayan 2004b).

The structural breaks in the other Pacific island countries are typically associated with bad weather and movements in commodity prices. For example, the break for Samoa in 1995 followed a major tropical cyclone in 1993, which damaged crops and infrastructure. The break for Tonga in 1999 followed Cyclone Ron in 1998, which caused widespread damage that particularly affected the northern islands, generating serious losses of food crops.

The structural break for Papua New Guinea in 1992 was associated with a mineral boom in the early 1990s when a number of new mines, such as the large Kutubu and Porgera mining projects, began production (Faal 2007). The structural break for Papua New Guinea in 1997 was associated with the 1997 drought and lower external demand due to the East Asian financial crisis. In 1997, a drought had a catastrophic impact on Papua New Guinea’s coffee, cocoa and coconut production—the mainstays of the agricultural-based economy and major sources of export earnings. For example, the coffee crop was slashed by up to 50 per cent in 1997 and GDP declined 4.6 per cent (AusAID 2000).

For several countries, the second structural break occurred about the time of the East Asian financial crisis. As Fairbairn (2002) noted, the East Asian financial crisis had the potential to cause significant damage to Pacific island countries through its impact on trade, tourism, investment income and personal remittances. Fairbairn (2002) argued that, overall, with the exception of Solomon Islands, and to a lesser extent Vanuatu, the direct trade effects of the East Asian financial crisis on Pacific island
countries were not as severe as they could have been because trade with Asia was relatively small.

The second structural break for Solomon Islands occurred at the end of the East Asian financial crisis. Real GDP per capita was adversely affected during the crisis because of the country’s heavy dependence on the Japanese and South Korean markets for its log exports. It is estimated that, because of the decline in log prices, Solomon Islands’ export earnings declined by 50 per cent in 1997 (Fairbairn 2002). The second structural break for Solomon Islands also occurred at a time of heightened ethnic tension in that country, resulting in a four-month state of emergency in 1999. This instability contributed to poor rates of economic growth for a substantial period.

In Vanuatu, the direct effects of the East Asian financial crisis were not as severe as in Solomon Islands, although prices for beef and timber, Vanuatu’s main exports, fell because of weaker markets in Japan and South Korea. A study by Yari (2003) found that after the East Asian financial crisis, Vanuatu had the most volatile export earnings in the South Pacific. For Vanuatu, the instability of export earnings—measured as the average percentage deviation of export earnings from the exponential trend level for 1998–2000—was 21.5 per cent, which was higher than Nauru (20 per cent), Papua New Guinea (18 per cent), Solomon Islands (17 per cent) and Fiji (14 per cent). In 1998 and 1999, Vanuatu also experienced a substantial fall in tourist revenue due to civil unrest, when people protested in the streets against the misuse of pension funds by the state-owned Vanuatu National Provident Fund (Jayaraman and Ward 2006). Tourist numbers rebounded in 2000, the date of the second break, but fell sharply after the terrorist attacks of 11 September 2001 in New York and Washington DC.

There were indirect effects of the East Asian financial crisis in the other Pacific island countries generated by weaker commodity prices, exchange rate changes and tourist flows. For example, at the height of the crisis in 1998, the weekly flight from Seoul to Nadi was cancelled because of a decline in tourist numbers. In other cases, exchange rate changes might have diverted tourists from traditional sources such as Australia and New Zealand to cheaper destinations in Asia. In Kiribati, investment income surged as a result of exchange rate movements, because it uses the Australian dollar and has a large proportion of its trust fund balances invested in US securities.

The results are shown for the Hadri (2000) panel KPSS test (which assumes no breaks) and the Carrion-i-Silvestre et al. (2005) panel KPSS test (which allows for up to five structural breaks) for the panel of eight countries (Table 5). We allow for the alternative assumptions that the long-run variance is homogenous or heterogeneous. We compute the bootstrap distribution for both tests with 2,000 replications (see Maddala and Wu 1999).

The Hadri (2000) test rejects the null hypothesis of joint stationarity at the 1 per cent level (assuming the long-run variance is homogenous) and at the 5 per cent level (assuming the long-run variance is heterogeneous). The results for the Hadri (2000) test are consistent with the conventional panel unit root tests reported in Table 3. The Carrion-i-Silvestre et al. (2005) test, however, which allows for structural breaks, fails to reject the null hypothesis of joint stationarity at the 5 per cent level or better, assuming either homogeneity or heterogeneity. This result points strongly to the need to take account of structural breaks in the data when examining the unit root properties of real GDP per capita and that conventional panel data tests that do not account for structural change can result in misleading conclusions.

The results for the Carrion-i-Silvestre et al. (2005) test reported here are consistent
with recent studies that have employed either a panel unit root test with a single break in the trend function (Hegwood and Papell 2007) or the KPSS panel stationarity test with multiple structural breaks applied to other data sets. The latter include Carrion-i-Silvestre et al. (2005) and Romero-Avila (2007) (real GDP and real GDP per capita for OECD countries), Narayan (2008a) (Chinese real GDP per capita) and Narayan (2008b) (real GDP per capita for 15 Asian economies).

Conclusions

With conventional unit root tests that specify the null hypothesis as non-stationary and that do not allow for structural breaks in the trend, we find that real GDP per capita in the Pacific island countries contains a panel unit root. When the null hypothesis is specified as stationary, and we allow for structural change in the trend function, we find clear-cut evidence in favour of regime-wise trend stationarity in real GDP per capita for the panel of eight countries. This finding implies that, for the period considered (1985–2006), for the panel of Pacific island countries as a whole, the permanent secular component of output is dominated by transitory fluctuations accompanied by infrequent changes in the trend function.

The only exceptions are Fiji and Kiribati, for which the individual KPSS test with structural breaks suggests that real GDP per capita is non-stationary. The finding that real output in Fiji is non-stationary is consistent with the existence of political instability that frequently shocks the long-run growth path. The results for Kiribati reflect the fact that, because it is a very small island state, its GDP is particularly vulnerable to shocks from external events that impact on commodity prices and from natural disasters such as cyclones that

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Panel KPSS stationarity tests applied to real GDP per capita</th>
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</thead>
<tbody>
<tr>
<td>Panel of eight countries</td>
<td>Bartlett test</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>No breaks (homogenous)</td>
<td>11.587^a</td>
</tr>
<tr>
<td>No breaks (heterogeneous)</td>
<td>19.229^b</td>
</tr>
<tr>
<td>Breaks (homogenous)</td>
<td>5.697</td>
</tr>
<tr>
<td>Breaks (heterogeneous)</td>
<td>24.461</td>
</tr>
<tr>
<td>Quadratic test</td>
<td>Bootstrap critical values</td>
</tr>
<tr>
<td></td>
<td>5 per cent</td>
</tr>
<tr>
<td>No breaks (homogenous)</td>
<td>11.326^a</td>
</tr>
<tr>
<td>No breaks (heterogeneous)</td>
<td>15.067^b</td>
</tr>
<tr>
<td>Breaks (homogenous)</td>
<td>5.847</td>
</tr>
<tr>
<td>Breaks (heterogeneous)</td>
<td>27.043</td>
</tr>
</tbody>
</table>

^a denotes statistical significance at the 1 per cent level  
^b denotes statistical significance at the 5 per cent level  
Note: The bootstrap distribution is based on 2,000 replications.  
Source: Authors’ calculations
generate permanent shocks to the long-run equilibrium growth path.

This result has important policy implications: it suggests that because shocks to real output are transitory, for the panel as a whole, stabilisation policies will have only temporary effects on output levels. This is consistent with the fact that countries such as Marshall Islands, Samoa, Solomon Islands and Tonga have had sustained fiscal deficits since the beginning of the 1990s with no stimulating impact on growth. As there is a unit root in real output in Fiji and Kiribati, however, these economies will not return to the normal trend path after a shock, and therefore full employment policies could have a role to perform. For example, in the case of Fiji, the belief among policymakers is that with full employment of resources the economy should grow at 5 per cent per annum (Narayan and Prasad 2007). In the past couple of decades, however, it has grown at less than 2 per cent. Because Fiji’s current equilibrium point is well below its potential, finding a unit root in real output implies that policies can be implemented to take Fiji to its potential level.

For Fiji and Kiribati, it can be argued that stabilisation policies have been offset by negative shocks generated by political instability and weak terms of trade. Rising budget deficits in Fiji and declining budget surpluses in Kiribati since the early 1990s have been unable to offset the negative persistent effects due to shocks.

A limitation of the findings is the relatively short span of data. If we considered a much longer period, the equilibrium path of the economy might be different. This shortcoming can be addressed only when longer time series become available.

A final implication for policy relates to regional trade agreements or monetary policy-related proposals such as the formation of a monetary union or the adoption of a common currency.

A prerequisite for any such agreement, particularly a monetary union, is that countries collectively share some common macroeconomic features. While this is not necessary, as witnessed in the case of the formation of the European Union, some common properties of macroeconomic variables help make the transition to a common monetary union much easier. Our finding that per capita real income collectively (that is, for the panel of eight countries) is stationary implies that, at least when viewed from the point of real income, shocks to the panel of these countries have similar (transitory) effects. Similar results were found for the real effective exchange rate series by Narayan and Prasad (2008), although they had a much smaller panel than ours. It follows that additional panel data-based analysis of the other key macroeconomic variables, such as inflation and interest rates, can be construed as active areas for future research on Pacific island countries.

Empirical research on many of the Pacific island countries has been hampered by the lack of reasonably long spans of time series data. In this respect, progress on several fronts can be made by exploiting the panel properties of the data. In addition to examining whether key macroeconomic variables are stationary, future research could examine whether fiscal deficits are sustainable in the Pacific island countries using panel unit root or panel stationarity tests. This issue is of considerable policy importance given most Pacific island countries run budget deficits. Other research could use panel unit root, panel co-integration and long-run structural equation modelling to examine issues such as the effectiveness of foreign aid in the Pacific island countries. To this point, there are few studies that use panel data (exceptions are Narayan and Prasad 2008; Narayan et al. 2008), with most studies of this kind confined largely to one or two
Pacific island countries, such as Fiji and Papua New Guinea, for which there is sufficiently lengthy time series data for a single-country study.

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