Vishal Chandr JAUNKY
Robert LUNDMARK

FOREST PRODUCTS EXPORTS AND ECONOMIC GROWTH

The paper is testing the forest product export-led growth hypothesis for 22 rich economies over the period 1970 to 2011. Various generations of panel unit root and cointegration tests are applied and the series are found to be integrated of order one and cointegrated, especially when applying the third-generation tests. Unidirectional causality running from forest product exports to economic growth is uncovered in both the short-run and the long-run. Moreover, exportation is found to positively affect economic growth in the long-run. This lends support to the export-led growth hypothesis for the rich economies.

Keywords: Forest product exports, economic growth, panel DOLS.

Introduction

Forest resources have been a major source for economic development for many countries. They do not only cater for wood, games, medicines, soil conservation, carbon storage, and landscape beauty but additionally contribute in stimulating foreign exchange earnings, employment and economic growth. Forests indeed epitomize a productive asset which can be employed as a means for attaining national development goals, including equity, stability, investment and growth [FAO 2005]. According to the FAO [2009], the forest sector contributes about US$ 468 billion to national income, representing about 1% of global GDP in 2006.

This paper presents the first study of the link between forest products exports and economic growth using panel data from 22 rich countries[1]

Vishal Chandr JAUNKY, Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, Luleå, Sweden
e-mail: vishal.jaunky@ltu.se
Robert LUNDMARK, Department of Business Administration, Technology and Social Sciences, Luleå University of Technology, Luleå, Sweden
e-mail: robert.lundmark@ltu.se

over the period of 1970-2011. The export-led growth (ELG) is employed to investigate whether a particular sector such as the forestry has contributed significantly to the economic growth for those rich economies. The remainder of this paper is organized as follows: Section 2 reviews the existing literature. Section 3 discusses the testing framework. Section 4 presents the results. Section 5 concludes and provides some the policy implications.

Review of literature

The theoretical foundation of the ELG hypothesis debate goes back to the pioneering works of classical economists such as Adam Smith [1776] and David Ricardo [1817]. They demonstrate the crucial role of international trade on economic growth and the economic gains through enhanced competition and specialization according to comparative advantage. Kernal *et al*. [2002] put forward several arguments in which exports can foster economic growth. First, accumulation of foreign exchange allows the possibility of high-tech imports which could enlarge production possibilities. Second, exports can cause investments to be concentrated in the most efficient sectors. Third, the linkage between the international and domestic markets allows for greater scope of economies of scale. Finally, increased trade can lower allocative inefficiencies through enhanced competition.

Giles and Williams [2000] and Medina-Smith [2001] provide a thorough review of the literature on the linkage between economic growth and exports. The empirical literature in connection to the ELG paradigm can be segmented into three groups: (i) cross-sectional [e.g. Lussier 1993] (ii) country-specific time-series [e.g. Siddique and Selvanathan 1999] and (iii) panel data [e.g. Parida and Sahoo 2007] studies. Economic studies relating to the the impact of forest product trade on economic growth remain scanty. A relevant study has been conducted by Chao and Buongiorno (2002). They investigate the export-led production hypothesis for 15 main exporting countries of wood puld and paperboard between 1961-1995. A bi-directional causality is found to prevail between exports and production. In essence, this paper attempts to contribute to the

[1] The time frame and the selection of countries are purely dictated by the availability of data and the amount of existing forest area. The rich economies follow the classification of the World Bank, at http://go.worldbank.org/ K2CKM78CC0).

literature by showing the importance of the forest sector, especially its exportation, to economic growth.

Data and Research Methodology

Forest data are obtained from the FAO of the United Nations forest database and real gross domestic product (GDP, at constant 2000) are compiled from the 2012 World Development Indicators of the World Bank. To investigate whether forest products ELG hypothesis holds, the following regression can be estimated [Siddique and Selvanathan 1999]:

$$LGDP_{it} = g_0 + g_1 LFOR_{it} + \varepsilon_{it} \qquad \text{----- (1)}$$

where $LGDP_{it}$ captures economic growth and denotes the natural logarithm of GDP (at constant 2000) for country *i* and year *t*. $LFOR_{it}$ denotes the natural logarithm of forest products exportation (at constant 2000) for country *i* over year *t*. g_0 is the constant term and ε_{it} represents the error term. Table 1 shows the mean statistics of $LGPD_{it}$ and $LFOR_{it}$ over the period 1970-2011 together with country-specific forestry data. The share of forest product exports to GDP is rather significant for Canada, Denmark, Finland and Sweden.

Econometric tests such as unit root and cointegration tests are necessary before assessing the impact of forest product exports on GDP. Most of the unit root tests[2] are based on an augmented Dickey-Fuller (ADF) unit root test type. A variable y_{it} is said to be integrated order of *d*, i.e. $y_{it} \sim I(d)$, if it were to be differenced by *d* times to come to be stationary. Time series unit root tests such as the ADF and Narayan and Popp [2010] tests will be computed for each country. Several generations of panel unit root tests are next employed. First generation panel unit root tests include the Im, Lee and Tieslau [ILT 2005]. But, although it controls for endogeneous breaks, it assumes independence of individual cross-sections and this is very unlikely to hold in practice. Pesaran [2007] proposes a second generation test which allows for different forms of cross-sectional dependence. This test is based on the averages of the

[2] Unit root tests are commonly computed via two different regressions. One regression includes a constant term only and the other includes both a constant term and a time trend. Since macroeconomic data tend to be non-stationary and display a trend over time, it is more suitable to apply a regression with a constant and a trend at level form. First-differencing tends to remove any deterministic trends in the series. The unit root regression should then include a constant term only. For sake of comparison, both regressions are estimated and evaluated.

individual cross-sectionally augmented ADF (CADF) statistics and have good size and power properties even when N and T are relatively small. Finally, as a third generation test, Chang and Song [2009] suggest a test which employs of a set of orthogonal functions as instrument generating function (IGF) to control any dependence.

Next, in case both series are non-stationary and integrated of the same order, several panel cointegration tests are performed. Pedroni [1999] was among the firsts to propose testing for panel cointegration. But this first generation panel cointegration test assumes cross-sectional independence across individuals. With regard to second generation panel cointegration tests, Westerlund (2008) and Westerlund and Edgerton [2008] suggest some panel cointegration tests which can effectively deal with cross-sectional dependence. The latter also allows for unknown structural breaks in both the intercept and slope of the panel cointegrating regression. A third generation panel cointegration test which is robust to short-run and long-run dependence across countries is devised by Di Iorio and Fachin [2012]. None of the above tests is devoid from statistical shortcoming in terms of size and power properties. It is thus more convenient to run a battery of tests in order to make solid inferences about the properties of the panel data.

An ECM-based panel causality test structure between economic growth and forest products exportation can be represented as:

$$\begin{bmatrix} \Delta LFOR_{it} \\ \Delta LGDP_{it} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \end{bmatrix} + \sum_{k=1}^{p} \begin{bmatrix} \beta_{11k} & \beta_{12k} \\ \beta_{21k} & \beta_{22k} \end{bmatrix} \begin{bmatrix} \Delta LFOR_{it-i} \\ \Delta LGDP_{it-i} \end{bmatrix} + \begin{bmatrix} \phi_1 \\ \phi_2 \end{bmatrix} \left[ECM_{it-1} \right] + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \quad \text{----- (2)}$$

where $i = 1, ..., N$, $t = 1, …., T$, Δ denotes first differences, ω_{it} and ϖ_{it} are the intercept terms, f_{1i} and f_{2i} are the fixed effects components while θ_{it}, ϕ_{it}, φ_{it}, ψ_{it},λ_{1i} and λ_{2i} are the parameters to be estimated. The ECM_{it-1} variable denotes the error-correction term and is lagged by one period. It is derived from the cointegrating vector of equation (1) and the error terms μ_{it} and υ_{it} are independent and identically distributed (*i.i.d.*).

A Wald test for joint significance can be applied to determine the direction of any causal relationship. The results from this test should be interpreted as specifying whether previous changes in one variable contribute significantly to the prediction of the future value of the other variable. For e.g., forest products exportation does not Granger-cause economic growth if and only if all of the coefficients $\varphi_q; \forall = 1, \ldots, p$ are not significantly different from zero in equation (2). The dependent variable reacts only to short-term shocks. Likewise, economic growth does not Granger-cause forest product exportation in the short run if and if all of the coefficients $\phi_q; \forall = 1, \ldots, p$ are not statistically significantly different from zero. These can be referred to as the "*short-run Granger causality*" tests. The coefficients on the *ECM*s represent how fast deviations from the long- run equilibrium are eliminated. Another channel of causality can be explored by testing the significance of the *ECM*s. This test can be denoted as the "*long-run Granger causality*" tests.

Traditional regression models such as ordinary least squares (OLS), fixed-effects or random-effects models yield biased results due to the correlation between the lagged dependent variable and the error terms. To tackle this problem, Arellano and Bond [1991] propose a two-step difference generalized method of moments (GMM) method where the lags of explanatory variables in levels are employed as instruments[3]. But the Arellano-Bond GMM estimator suffers from a lack of power of the internal instruments. Blundell and Bond [1998] suggest a two-step system GMM estimator which has superior finite-sample properties. The Hansen [1982] *J* and the Sargan [1958] tests are employed to test for the joint validity of the instruments i.e. whether the model specification is correct or not. The Sargan test is not robust to heteroskedasticity or autocorrelation in contrast to the Hansen test. Too many weak instruments can overload the endogenous variables and thus reduce the accuracy of the tests [Roodman 2009]. A rule of thumb is to maintain the number of instrument less than or equal to the number of groups [Mileva 2007].

Understanding the direction of causality between economic growth and forest product exportations has significant policy implications. If there is no causality, then adopting a conservative resource policy measures to limit the exportation of forest products can be implemented, without the concern of negatively impacting on economic growth. This can eventually cause a reduction in the exploitation of the forest resources and environmental degradation. If causality runs from economic growth

[3] For these instruments to be valid there should not be serial correlation in ε_1 and ε_2. The Arellano-Bond autocorrelation test has a H_0 of no autocorrelation and is applied to the differenced residuals. The tests of AR(1) and AR(2) process in the first-differences are computed. The test for AR(2) test is considered to be more important since it will detect autocorrelation in levels (Mileva, 2007). The optimal lag length, ρ, is chosen when no serial correlation is obtained in the residuals.

to forest products exportation, environmental and resource policies can still be implemented. For e.g, environmental taxes and tariffs can be imposed. These policies will have no impact on economic growth. However, if a unidirectional causality running from forest product exportations to economic growth exists, then resource conservation policies will adversely affect the growth rate of the economy.

Long-run estimates can be computed via the dynamic OLS (DOLS) panel technique which control for both endogenous and serially correlated regressors. The long-run regression is augmented by lead and lagged difference of the dependent and explanatory variables to control for serial correlation and endogenous feedback effects. The within-dimension-based DOLS model as per Kao and Chiang [2000] can be represented as:

$$LGDP_{it} = \alpha_i + \beta LFOR_{it} + \sum_{q=-\ell}^{\ell} \gamma_j \Delta LFOR_{it-q} + \zeta_{it} \qquad \text{----- (3)}$$

where, α_i denotes the individual fixed effects, β is the homogenenous coefficient across the selected countries, ℓ is the number of leads and lags for the first differenced of the $LGDP_{it}$ series and ζ_{it} is the error terms.

Results

The ADF unit root statistics for individual countries are reported in Tables 2(a)(i) and 2(a)(ii). Following the above discussion about the order of integration, both the $LCOP_t$ and $LGDP_t$ series are found to be I(1) for Canada, Denmark, France, Netherlands, Norway, Portugal, Singapore, South Korea and USA. The ADF test ignores the presence of structural breaks in the series. As per Perron [1989], this can lead to the unit root test to be biased towards the non-rejection of the null hypothesis. The Narayan and Popp test can account for the presence of two endogenous structural breaks. In keeping with Tables 2(b)(i) and 2(b)(ii), the $M1_{B,L}$ test reflects the test equation for two breaks in the level of a trending series while the $M2_{B,L}$ test captures the test equation for two breaks in the level and slope of a trending series. The $M1_{B,L}$ test reveals an I(1) process for both series for Austria and Ireland only while no series are found to simultaneously to follow this process when computing the $M2_{B,L}$ test.

On average, the first break in either series tends to fall around from the end of 1970s to the middle of 1980s. These periods coincide with the 1974-1975 and 1980-1981 oil price shocks, following the Yom Kippur

War and Iranian Revolution respectively. The second break tends to occur around the early 1990's and 2000's. These periods match oil price shocks following the Gulf War in 1990, the 1997 Asian Financial crisis and the 2000-2001 international recessions respective to the Middle East tensions owing to the Second Intifada. Moreover, the habitat conversation rules in the early 1990s in Pacific Northwest did cause supply shock in the international wood product markets [Perez-Garcia, Barr 2005].

Toda [1995] issues a caveat about the poor performance and low power of time-series tests can persist even in the presence of 100 observations. This raises the need to use panel data techniques. As per Table 3(a), the ILT test which accounts for endogenous breaks reveals a stationary process for both series. Cross-sectional dependence[4] can bias the tests towards the alternative hypothesis [Banerjee *et al*. 2004]. As reported Table 3(b), the Pesaran [2007] test shows that both $LGDP_{it}$ and $LFOR_{it}$ series follow an I(1) process. Chang and Song [2009] suggest a test which employs of a set of orthogonal functions as instrument generating function (IGF) to control any dependence. Referring to Table 3(c), the tm_c panel statistic confirm an an I(1) process for $LGDP_{it}$ while with the exception of tm_c, all tests confirm similar process for $LFOR_{it}$.

For consistent inferences, panel unit root tests require a non-stationary process for individual series. According to Karlsson and Lothgren [2000], rejection of the panel unit root null may be driven by a few stationary series and the whole panel can be incorrectly modeled as stationary. For instance, the Chang-Song test statistics are recomputed $LGDP_{it}$ and $LFOR_{it}$ by excluding individual countries such as Denmark, Germany, Greece, Israel, Netherlands, South Korea, Sweden and UK respectively. These are I(0) as per the Narayan and Popp $M1_{B,L}$ test. No major difference to the results has been encountered. In general, the panel unit root tests give support to the *a-priori* expectation of an I(1) process. Panel cointegration tests are subsequently computed.

Panel cointegration tests are subsequently computed. As presented in Table 4(a), only the Pedroni [1999] panel-ν statistic with trend rejects the null. Weak evidence of a cointegrating relationship is found. Based on the

[4] To determine any contemporaneous correlation, the Pesaran [2004] test is computed. First, the fixed and random effects models of Equation (1) type are required. The Hausman test statistic of $\chi^2(1)=0.47$ (p-value=0.492) is computed. The random effects model is thus found to provide more consistent results than the fixed effects model. The Pesaran's test of cross-sectional independence is equal to 56.284 (p-value = 0.000). This provides evidence of cross-sectional correlation.

Durbin-Hausman principle, Westerlund [2008] puts forward two sets of tests such as the *DHg* and *DHp* which are robust against the presence of stationary regressors. The *DHg* test confirms cointegration as presented in Table 4(b). Westerlund and Edgerton [2008] tests are reported in Table 4(c). $Z_{\tau}(N)$ and $Z_{\phi}(N)$ tests also allow for unknown structural breaks in both the intercept and slope of the cointegrating regression. The $Z_{\phi}(N)$ test statistic confirm a cointegrating relationship when controlling for breaks in both the intercept and slope. The Di Iorio and Fachin [2012] test is based on some residual-based Stationary Bootstrap (RSB) tests. As shown in Table 4(c), all the mean, median and maximum ADF test statistics reject the H_0 of no cointegration.

If the $LGDP_{it}$ and $LFOR_{it}$ series are cointegrated, then causality should run in at least one direction [Engle, Granger 1987]. Results of the panel causality test are presented in Table 5. The number of instruments is set to 22. Preliminary tests confirm the validity of these instruments. The computed Sargan and Hansen test statistics cannot reject the H_0 of valid instruments. In addition, the difference-in-Hansen test of exogeneity is conducted under the H_0 of instruments in use are appropriate instruments, i.e. they are exogenous. H_0 cannot be rejected. No second order serial correlation is also established. The lag order ρ of the panel VECM based causality tests is found to be 2. Unidirectional causality running from forest product exports to economic growth is uncovered in both the short-run and long-run. Forest product exports can be used to predict economic growth in the high-income countries such as Australia, Austria, Canada, etc. as well as for the panel as a whole in the long-run.

Finally, the long-run income elasticity of forest product exports can be computed via the panel DOLS. The feedback effects between $LGDP_{it}$ and $LFOR_{it}$ imply an endogeneous process and this can lead to biased results. In addition, Wooldridge's [2002] test statistic of F(1, 21) = 3054.48 (p-value=0.000) reveals autocorrelation. The panel DOLS estimator can effectively correct for endogeneity bias and serial correlation. As exposed in Table 6, a 1% increase in forest product exports will lead to a 0.001% increase in economic growth for the sample countries.

Conclusions

The paper examines the forest product export-led growth hypothesis for 22 rich countries over the period of 1970-2011. Together with two time-series unit root tests, three generations of panel unit root and cointegration tests are applied. Both series are found to be I(1) and cointegrated especially after controlling for cross-sectional dependence. A panel causality test reveals a unidirectional causality running from forest product exports to economic growth in both the short-run and long-run. Also, a 1% rise in forest product exports causes a 0.001% rise in economic growth in the long-run for the whole panel.

These findings have significant implications for policymakers in assisting them to make projections and implementing natural resource and forest policies. The unidirectional causality implies that natural resource conservation policies with regard to forest products can inhibit economic growth. Forest products exports are also found to have a positive impact on GDP in the long-run which emphasizes the key role of the forest industry in driving economic growth for the rich economies. Government schemes to promote innovative technologies at forest industry facilities will lead to higher-value mix of forest products and this will provide greater scope to expand the forest product market. To sum up, it is crucial for the rich economics to preserve their forest and sustain their forestry.

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Table 1. Country statistics

Country	Forest Area (sq. km in 2010)	Forest Area (% of land area in 2010)	Forest Products Export Dependency(%)	*LGDP* (Mean 1970-2011)	*LFOR* (Mean 1970-2011)
Australia	1493000	19.434	0.156	0.156	19.887
Austria	38870	47.155	1.800	1.800	21.787
Canada	3101340	34.105	1.308	1.308	23.510
Denmark	5440	12.821	0.197	0.197	19.607
Finland	221570	72.909	5.354	5.354	22.722
France	159540	29.131	0.298	0.298	21.832
Germany	110760	31.772	0.608	0.608	22.447
Greece	39030	30.279	0.044	0.044	17.889
Hungary	20290	22.412	0.774	0.774	19.269
Ireland	7390	10.727	0.241	0.241	18.796
Israel	1540	7.116	0.028	0.028	17.443
Italy	91490	31.104	0.225	0.225	21.201
Japan	249790	68.529	0.055	0.055	21.358
Netherlands	3650	10.821	0.618	0.618	21.248
Norway	100650	32.949	0.405	0.405	21.020
Portugal	34560	37.783	0.965	0.965	20.681
South Korea	62220	64.078	0.235	0.235	20.697
Spain	181730	36.433	0.340	0.340	20.621
Sweden	282030	68.731	3.214	3.214	22.821
T. & Tobago	2260	44.055	0.055	0.055	14.248
UK	28810	11.908	0.123	0.123	21.233
USA	3040220	33.236	0.174	0.174	23.269

Note: Forest products export dependency is real forest products exports as a percentage of real GDP in 2011. Forest area data are compiled from the World Development Indicators 2012.

Table 2(a)(i). ADF test for individual countries at level form

Country	$LGDP_t$				$LFOR_t$			
	With Constant and Without Trend		With Constant and With Trend		With Constant and Without Trend		With Constant and With Trend	
	ADF	ρ	ADF	ρ	ADF	ρ	ADF	ρ
Australia	0.374	0	-2.798	0	-1.079	4	-3.372	1
Austria	-0.793	0	-2.163	0	-0.562	4	-4.120^{+}	0
Canada	-0.958	1	-2.816	1	-1.649	1	-0.971	1
Denmark	-1.583	0	-1.695	1	-2.112	0	-2.146	0
Finland	-0.841	2	$-3.231^{\ddagger}$	1	-1.819	0	-2.287	0
France	-1.740	0	-0.905	0	-1.084	2	-0.536	2
Germany	-1.395	0	-1.822	0	-0.757	2	-4.267^{+}	0
Greece	$-2.839^{\ddagger}$	3	-4.022^{+}	3	-3.236^{+}	0	$-3.219^{\ddagger}$	0
Hungary	-1.456	1	-2.248	1	-0.949	2	$-2.248^{\ddagger}$	0
Ireland	-0.891	1	-1.818	1	-0.734	0	$-2.463^{\ddagger}$	0
Israel	0.175	2	$-2.948^{\ddagger}$	1	-2.403	1	-3.066	1
Italy	$-2.833^{\ddagger}$	0	-0.233	0	-0.813	4	-4.037^{+}	4
Japan	-3.571^{+}	1	-0.190	0	-2.611	0	$-3.356^{\ddagger}$	1
Netherlands	-0.549	1	-1.958	1	-1.130	1	-1.466	1
Norway	-2.420	2	-1.170	2	-1.154	0	-1.278	0
Portugal	-1.905	2	-0.195	2	-2.018	0	-1.919	0
South Korea	-2.641	0	-0.262	0	-1.291	1	-1.778	1
Spain	-0.301	1	-3.066^{+}	1	-1.541	2	$-3.300^{\ddagger}$	0
Sweden	0.482	2	-2.570	1	0.042	4	-5.008*	0
T. & Tobago	-1.592	2	-3.534^{+}	4	-1.655	0	-1.683	0
UK	-0.812	2	$-2.806^{\ddagger}$	1	-1.185	3	-2.404	3
USA	-1.374	1	-1.893	1	-1.172	0	-2.705	1

Note: The maximum lag length are chosen according to the Bartlett kernel which is equal to $4(T/100)^{2/9} \approx 4$, where $T = 42$ and is pared down as per the Akaike Information Criterion (AIC). The MacKinnon (1991) one-sided critical values for the ADF unit root tests with a constant and without a time are -3.66, -2.97 and -2.62 at 1%, 5% and 10% significance level respectively while those with a constant and a time trend are -4.27, -3.55 and -3.21 respectively. *, $^{+}$ and ‡ denotes 1%, 5% and 1% significance level correspondingly.

Table 2(a)(ii). ADF test for individual countries at first difference

Country	$LGDP_t$				$LFOR_t$			
	With Constant and Without Trend		With Constant and With Trend		With Constant and Without Trend		With Constant and With Trend	
	ADF	ρ	ADF	ρ	ADF	ρ	ADF	ρ
Australia	-5.469*	0	-5.363*	0	-4.921*	4	-6.256*	0
Austria	-5.989*	0	-6.101*	0	-6.486*	1	-6.426*	1
Canada	-4.400*	0	-4.475*	0	-4.297*	0	-4.154^{+}	3
Denmark	-5.102*	0	-5.553 *	0	-4.575*	0	-4.913*	3
Finland	-4.172*	1	-4.153^{+}	1	-5.408*	1	-5.220*	2
France	-4.553*	0	-5.166*	0	-8.900*	0	-6.964*	1
Germany	-5.205*	0	-5.155*	1	-9.325*	0	-9.239*	0
Greece	-1.882	1	-1.878	3	-6.708*	0	-4.258*	3
Hungary	-3.496^{+}	0	-3.420‡	0	-6.039*	0	-6.080*	0
Ireland	-2.833‡	0	-2.833	0	-6.055*	0	-5.953*	0
Israel	-4.662*	1	-4.593*	1	-5.175*	0	-5.086*	0
Italy	-4.964*	0	-6.831*	0	-5.410*	3	-5.411*	3
Japan	-1.413	2	-5.284*	0	-4.718 *	3	-4.909*	3
Netherlands	-4.261*	0	-4.278*	1	-10.625*	0	-10.874*	0
Norway	-3.561^{+}	1	-4.214^{+}	1	-6.112*	0	-5.308*	1
Portugal	-2.656‡	3	-4.076^{+}	3	-6.003*	0	-4.628*	3
South Korea	-4.614*	0	-5.446*	0	-4.525*	0	-4.586*	1
Spain	-2.785‡	0	-2.736	1	-6.068*	1	-6.257*	1
Sweden	-4.596*	1	-4.647*	1	-2.999^{+}	4	-2.912	4
T. & Tobago	-2.520	2	-1.760	1	-6.524*	0	-6.845*	0
UK	-4.123*	1	-2.849	3	-3.241^{+}	4	-3.331‡	4
USA	-4.619*	0	-4.988*	0	-4.987*	0	-4.909*	0

Note: The MacKinnon (1991) one-sided critical values for the ADF unit root tests with a constant and without a time are -3.67, -2.97 and -2.62 at 1%, 5% and 10% significance level respectively while those with a constant and a time trend are -4.28, -3.56 and -3.21 respectively.

Table 2(b)(i). Narayan and Popp time series unit root tests at level form

Country	*$LGDP_t$*								*$LFOR_t$*							
	$M1_{B,L}$				$M2_{B,L}$				$M1_{B,L}$				$M2_{B,L}$			
	t	T_{B1}	T_{B2}	ρ	*t*	T_{B1}	T_{B2}	ρ	*t*	T_{B1}	T_{B2}	ρ	*t*	T_{B1}	T_{B2}	ρ
Australia	-2.2	1982	1990	0	-1.3	1982	1990	0	-0.1	1979	1986	3	-2.6	1981	1987	0
Austria	-2.8	1978	1989	0	-3.8	1980	2002	0	-2.5	1978	1992	4	-6.1*	1992	1999	0
Canada	-2.0	1981	1990	1	-4.0	1981	1998	1	-0.5	1993	1995	0	-2.4	1981	1994	0
Denmark	0.3	1985	1993	4	-1.1	1979	1986	0	-6.0*	1979	2000	2	-6.7*	1984	1989	3
Finland	-3.2	1978	1990	1	-3.0	1980	1990	1	-2.0	1978	1993	3	-1.4	1981	1993	3
France	-0.4	1987	1997	4	-1.9	1979	1992	0	-1.1	1983	1998	2	-6.2*	1992	1995	0
Germany	-3.4	1978	1989	1	-5.6^{+}	1981	1989	1	-4.7^{+}	1992	1999	0	-5.6^{+}	1992	1999	0
Greece	-4.2‡	1986	2002	3	-3.5	1983	1987	3	-2.8	1988	1992	0	-3.3	1988	1996	0
Hungary	-0.5	1990	1993	0	-0.9	1990	1995	0	-3.5	1992	1996	0	-2.7	1982	1992	0
Ireland	-1.9	1988	1994	0	-0.6	1989	1994	0	-3.2	1987	1993	0	-2.7	1987	1993	4
Israel	-6.1*	1993	1999	0	-5.4^{+}	1993	1999	1	-5.5*	1994	1999	2	-4.0	1980	1999	0
Italy	-0.9	1978	1987	0	-2.3	1980	1992	0	-2.6	1987	1994	4	-4.0	1979	1987	2
Japan	0.3	1991	1997	0	-3.0	1992	1997	0	-3.0	1986	1988	0	-4.3	1985	1988	2
Netherlands	-1.3	1980	2001	0	-3.8	1980	2002	0	-4.8^{+}	1978	1987	0	-7.6*	1992	2001	0
Norway	-3.9	1982	1993	1	-0.5	1980	1993	4	-1.7	1978	1994	0	-3.5	1987	1994	4
Portugal	0.0	1986	1998	4	-7.3	1978	2002	3	-3.5	1978	1983	0	-6.8*	1983	1990	3
South Korea	0.7	1979	1997	0	-2.9	1979	1997	0	-4.4‡	1981	1996	1	-3.0	1985	1997	0
Spain	-2.1	1980	1993	1	-3.1	1980	1993	4	-3.9	1979	1999	0	-5.1‡	1985	1994	0
Sweden	-2.9	1990	1992	0	-2.2	1983	1992	0	-6.1*	1990	1994	2	-6.6*	1990	1995	0
T. & Tobago	-3.5	1982	2002	4	-1.2	1982	2002	0	-3.7	1979	1989	4	-5.1‡	1989	1992	1
UK	-2.1	1979	1990	3	-3.6	1979	2002	3	-4.5‡	1983	1997	4	-4.2	1978	1983	3
USA	-1.9	1979	1981	1	-0.8	1979	1983	0	-3.5	1978	2000	1	-4.0	1987	2000	1

Note: $M1_{B,L}$: Test equation for two breaks in the level of a trending series. $M2_{B,L}$: Test equation for two breaks in the level and slope of a trending series. T_{B1} and T_{B2} are the dates of the structural breaks. The one-sided critical values are -5.259, -4.514 and -4.143 respectively for model $M1_{B,L}$ and -5.949, -5.181 and -4.789 at 1%, 5% and 10% level of significance (*T*=50) for model $M2_{B,L}$.

Table 2(b)(ii). Narayan and Popp time series unit root tests at first difference

Country	$LGDP_t$								$LFOR_t$							
	$M1_{B,L}$				$M2_{B,L}$				$M1_{B,L}$				$M2_{B,L}$			
	t	T_{B1}	T_{B2}	ρ	t	T_{B1}	T_{B2}	ρ	t	T_{B1}	T_{B2}	ρ	t	T_{B1}	T_{B2}	ρ
Australia	-0.2	1983	2000	3	-4.1	1980	2000	0	-1.5	1987	2001	0	-4.7‡	1988	2001	0
Austria	-6.6*	1982	1990	1	-4.8	1982	1990	1	-4.5^{+}	1986	1992	0	-5.6^{+}	1986	1992	1
Canada	-3.6	1981	1990	3	-2.1	1981	1990	3	-0.6	1992	1999	4	-3.3	1979	1992	4
Denmark	-2.9	1981	1990	0	-2.9	1981	1986	1	-3.5	1991	2000	1	0.1	1982	1987	4
Finland	-6.2*	1985	1990	1	-5.3^{+}	1985	1990	1	-2.1	1981	1992	0	-1.3	1982	1984	0
France	-6.0*	1990	1996	1	-3.9	1980	1990	1	-4.6^{+}	1988	1992	4	-5.4^{+}	1982	1992	1
Germany	-2.0	1981	1990	4	-1.7	1983	1990	4	-2.6	1991	1995	0	-3.9	1991	1995	0
Greece	-1.9	1989	2002	3	-1.2	1981	1989	3	-5.3^{+}	1988	1991	2	-3.5	1988	1992	1
Hungary	-2.8	1981	1990	0	-2.9	1988	1990	0	-2.4	1982	1988	0	-3.8	1982	1988	0
Ireland	-4.8^{+}	1989	1995	0	-0.4	1989	1995	0	-4.8‡	1987	1992	4	-4.8‡	1987	1996	0
Israel	-2.8	1998	2000	1	-2.3	1983	1990	4	-3.4	1987	1994	1	-5.3^{+}	1980	1999	1
Italy	-1.6	1987	2000	4	-4.0	1983	2000	0	-4.7	1994	2000	2	-2.5	1980	1994	0
Japan	-3.7	1980	1997	0	-4.6	1994	1997	0	-2.0	1986	1988	4	-2.8	1986	1988	0
Netherlands	-3.0	1980	1997	0	-1.4	1979	1997	0	-2.8	1986	1988	0	-3.3	1986	1988	0
Norway	-0.9	1987	1990	0	-5.9^{+}	1987	1995	4	-1.2	1992	1996	2	1.0	1994	2000	0
Portugal	-5.7*	1983	1987	3	-7.1*	1983	1986	3	1.9	1993	1999	2	1.8	1993	1999	2
South Korea	-4.3	1979	1984	1	-6.6*	1984	2000	1	-1.5	1985	1992	0	-0.8	1985	1998	4
Spain	-2.0	1979	1997	0	-1.8	1979	1997	0	-2.6	1981	1985	0	-4.1	1985	1997	0
Sweden	-2.4	1983	1990	1	-2.5	1979	1989	1	-4.4‡	1979	1999	0	-3.9	1979	1999	0
T. & Tobago	-3.8	1982	2002	3	-2.1	1982	2002	0	-1.3	1989	1991	0	-2.9	1989	1998	2
UK	-2.7	1979	1982	1	-2.4	1979	1982	1	-1.5	1989	1991	0	-2.3	1989	1998	0
USA	-1.8	1981	1984	1	-4.0	1981	1991	1	-4.7^{+}	1983	1994	1	-4.0	1981	1997	0

Note: $M1_{B,L}$: Test equation for two breaks in the level of a trending series. $M2_{B,L}$: Test equation for two breaks in the level and slope of a trending series. T_{B1} and T_{B2} are the dates of the structural breaks. The one-sided critical values are -5.259, -4.514 and -4.143 respectively for model $M1_{B,L}$ and -5.949, -5.181 and -4.789 at 1%, 5% and 10% level of significance (T=50) for model $M2_{B,L}$.

Table 3(a). ILT panel lm unit root test

Variable	With One Break	With Two Breaks
$LGDP_{it}$	-5.223*	-6.164*
$LFOR_{it}$	-11.241*	-14.078*

Notes: The maximum lag length is based on the Bartlett kernel. Critical values for the LM panel unit root test are distributed asymptotic standard normal and are -2.326, -1.645, and -1.282 at the 1%, 5%, and 10% levels, respectively. Time dummies are included when performing the panel unit root test in the presence of one structural break.

Table 3(b). Pesaran CADF panel unit root test

Variable	Deterministics	Level Form		First-Difference	
		t-bar	Z	t-bar	Z
$LGDP_{it}$	Constant	-1.710	0.298 [0.617]	-4.319	-12.720 [0.000]*
	Constant+trend	-2.060	1.492 [0.932]	-4.376	-10.851 [0.000]*
$LFOR_{it}$	Constant	-1.959	-0.944 [0.173]	-5.011	-16.171 [0.000]*
	Constant+trend	-2.349	-0.049 [0.480]	-4.758	-12.886 [0.000]*

Note: The lag lengths for the panel test are based on those employed in the univariate ADF test. The Z test statistic is compared to the 1%, 5% and 10% significance levels with the one-sided critical values of -2.326, -1.645 and -1.282 correspondingly.

Table 3(c). Chang and Song panel unit root test

Statistics	$LGDP_{it}$		$LFOR_{it}$	
	Level Form	First-Difference	Level Form	First-Difference
ta_c	-2.243$^+$	-5.066*	-0.056	-11.330*
ta_h	1.112	-0.800	-1.030	-3.123*
ta_a	-0.333	-0.646	-0.010	-2.542*
tm_c	-1.219	-3.057$^+$	-3.042$^+$	-4.515*
tm_h	-0.901	-1.954	-1.058	-4.285*
tm_a	-0.790	-2.328	-1.379	-3.689*

Note: The maximum lag length is based on the Bartlett kernel. The nonlinear IV average and minimum tests are denoted by the *ta* and *tm* while the subscripts *c*, *h* and *a* refer to those tests with single IGF and no covariate, with single IGF and covariate and orthogonal IGF with no covariate respectively. The average tests relate to the testing of the H_0 of non-stationarity for all individual countries while the minimum tests evaluate the H_0 of non-stationarity of some individual countries within the panel. The tests include a constant term only. The H_0 of non-stationarity is tested. Each test statistic is compared to the 1%, 5% and 10% significance levels with the one-sided critical values of -2.326, -1.645 and -1.282 for the average test while these are -3.351, -2.870 and -2.635 for minimum test *(N*=25) respectively.

Table 4(a). Pedroni Panel Cointegration Test statistics

Statistics	Without Trend	With Trend
Panel ν-statistic	-3.209	15.352*
Panel ρ-statistic	0.553	1.662
Panel pp-statistic	-0.297	1.215
Panel adf-statistic	0.289	0.643
Group ρ-statistic	-0.134	2.260
Group pp-statistic	-0.995	1.365
Group adf-statistic	-0.160	0.100

Note: Four of these statistics are called panel cointegration statistics. These are panel-ν, panel-ρ, and panel-pp which denote the non-parametric variance ratio, Phillips-Perron *ρ*, and student's *t*-statistics respectively while panel-adf is a parametric statistic based on the ADF statistic. Critical values of one-sided tests for 1%, 5% and 10% significance levels are -2.326, -1.645 and -1.282 respectively. The panel ν-statistic is compared to 2.326, 1.645 and 1.282 at 1%, 5% and 10% significance level respectively. The H_0 of no cointegration is tested.

Table 4(b). Westerlund panel cointegration test

Statistics	Value
DHg	1.629‡
DHp	-0.285

Note: The H_0 of no cointegration is tested. Critical values of one-sided tests for 1%, 5% and 10% significance levels are 2.326, 1.645 and 1.282 respectively.

Table 4(c). Westerlund and Edgerton panel cointegration test

Statistics	Without Trend	With Trend
$Z_\tau(N)$	-0.844 [0.199]	-1.249 [0.106]
$Z_\phi(N)$	-0.963 [0.168]	-1.678 [0.047]$^+$

Source: Computed. The maximum lag length is based on the Bartlett kernel. The trimming parameter is set to 0.25. The H_0 of no cointegration is tested. The statistics test is distributed as a one sided standard normal with critical values of one-sided tests for 1%, 5% and 10% significance evels are -2.326, -1.645 and -1.282 respectively.

Table 4(d). Di Iorio and Fachin panel cointegration test

Statistics	Without Trend	With Trend
Median ADF	-6.302 [0.000]*	-6.126 [0.000]*
Mean ADF	-6.545 [0.000]*	-5.823 [0.000]*
Maximum ADF	-3.874 [0.000]*	-3.317 [0.000]*

Note: The maximum lag length is based on the Bartlett kernel. The H_0 of no cointegration is tested. The computed statistics are compared to a one-sided standard normal test with critical values of 1%, 5% and 10% given by -2.326, -1.645 and -1.282. The p-values are obtained through 5000 bootstrap replications.

Table 5. Panel VECM-based causality test

Variable	$\Delta LGDP_{it}$	$\Delta LFOR_{it}$
$\Delta LGDP_{it-1}$	0.402	-0.780
	(0.271)	(1.029)
$\Delta LGDP_{it-2}$	-0.534	0.885
	(0.330)	(0.818)
$\Delta LFOR_{it-1}$	-0.143	0.015
	$(0.068)^{+}$	(0.304)
$\Delta LFOR_{it-2}$	0.073	-0.426
	(0.057)	(0.180)
ECT_{it-1}	-0.053	-0.009
	(0.020)*	(0.050)
Constant	0.034	0.032
	(0.015)*	$(0.012)^{+}$
Observations	858	858
Number of Instruments	22	22
Wald $\chi^2(3)$	13.01	37.06
	$[0.023]^{+}$	[0.000]*
Sargan Test of Over-Identifying Restrictions	18.93	19.85
	[0.272]	[0.227]
Hansen Test of Over-Identifying Restrictions	21.15	21.09
	[0.173]	[0.175]
Difference-in-Hansen Test of Exogeneity of	4.31	7.87
Instrument Subsets: Difference (H_0 = exogenous)	[0.743]	[0.547]
AR(1) Test of Serial Correlation	-1.35	-1.47
	[0.178]	[0.142]
AR(2) Test of Serial Correlation	0.80	1.03
	[0.425]	[0.305]
Short-Run Causality Test	4.33	1.56
	$[0.037]^{+}$	[0.458]
Long-Run Causality Test	6.77	0.03
	[0.009]*	[0.860]

Note: The explanatory variables are assumed to be endogenous and their lags are instrumented in GMM-style [Roodman 2006]. Robust standard errors are given in parenthesis [Windmeijer 2005].

Table 6. Mean Group Panel DOLS Estimation

Variable	Coefficient	Standard Error
$LFOR_{it}$	0.001	$0.003^{\ddagger}$

Note: The critical values of the two-tailed *t*-statistics test at 1%, 5% and 10% levels are -2.326, -1.645 and -1.282 respectively. The leads and lags are set to 2 [Nelson, Donggyu, 2003].