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The Export-led Growth Hypothesis
Evidence from OECD countries

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Abstract

The export-led growth (ELG) hypothesis is examined for 33 OECD countries from 1985 to 2010 using a time series analysis for individual economy as well as a panel data approach. Panel unit root tests and panel cointegration techniques are employed in order to draw sharper conclusions compared to the findings from time series analysis. In this paper, it is investigated the causal relationship between exports and economic growth as well as the impact of other relevant macroeconomic variables such as GDP net of exports, imports, gross fixed capital formation, interest rate, exchange rate, unemployment rate and rate of employment on the export growth. As these variables are closely related, instead of studying the direction of causation between exports and economic growth separately at a time, it is worthwhile to examine multivariate causalities among them. For this reason, Granger causality tests based on VECM are conducted for cointegrated variables.

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1. INTRODUCTION

One of the areas in international and development economics that has received a great deal of attention by researchers is the relation between export growth and economic growth. The nature of the relationship between exports and output growth and magnitude of the effects have been the subject of debate in the development literature in the recent past, yet with little consensus.

The main issue which arises in this debate is whether countries should promote their export sector as opposed to pursuing an inward-oriented trade strategy as a vehicle for promoting economic growth. Export-orientation policies contribute to stimulate economic growth both directly and indirectly through the expansion of the export sector. Based on economic theory, one could easily postulate that an increase in exports leads to an increase in real GDP through the well-known multiplier effect. Export expansion indirectly stimulates economic growth through the use of advanced technology, which results in efficient allocation of resources and higher productivity, greater capacity utilization, exploitation of economies of scale due to large markets, as well as diffusion of foreign technological knowledge through learning by doing and technological innovation stimulated by exposing foreign-market competition (Helpman and Krugman, 1985). The accumulation of foreign exchange from exports allows not only for increasing levels of imports but the import of high quality inputs including capital and intermediate goods, which in turn raise domestic production and thus stimulate output growth. However, it is quite possible that causality runs in an opposite direction; output growth determines the rate of export growth. An increase in real GDP could lead to realization of economies of scale and cost reduction that could, in turn, boost exports.

The causal link between exports and economic growth has long been at the centre of development literature. On the theoretical front, four outcomes are possible. As for the first outcome, export growth is typically considered to be one of the main determinants of an economy's growth in production and employment. This is the so-called export-led growth (ELG) hypothesis. Empirically, ELG is characterized by unidirectional causality from exports to GDP. Michaely (1977), Krueger (1978), Feder (1982) and Marin (1992) found that countries exporting a large share of their output seem to grow faster than others. The growth of exports has a stimulating influence across the economy as a whole in the form of technological spillovers and other externalities. Models by Grossman and Helpman (1991), Rivera-Batiz and Romer (1991), and Romer (1990) posit that expanded international trade increases the number of specialized inputs, increasing growth rates as economies become open to international trade.

As for the second outcome, the growth-led exports (GLE) hypothesis postulates that a rise in GDP generally leads to a corresponding increase in exports. Economic growth through productivity gains at the domestic level, such as productivity improvement or reduction in unit costs, also stimulates exports. Neoclassical trade theory typically stresses the causality that runs from home-factor endowments and productivity to the supply of exports. Empirically, GLE implies unidirectional causality from output to exports. Oxley (1993), Henriques and Sadorsky (1996) and Panas and Vamvoukas (2002) find empirical evidence of growth-driven exports in the cases of Portugal, Canada and Greece, respectively.

The most interesting economic scenarios suggest a two-way causal relationship (feedback) between economic growth and exports. Helpman and Krugman (1985) postulate that exports may rise from the realization of economies of scale due to productivity gains; the rise in exports may further enable cost reductions, which may result in further productivity gains. According to Bhagwati (1988), increased trade (irrespective of cause) produces more income, and more income facilitates more trade – the result being a “virtuous circle”. Awokuse (2005), Chen (2007), Tsen (2007), Taban and Aktar (2008) and Elbeydi et al. (2010) make use of evidence from a single country and find support of both ELG and GLE hypotheses.

There is, finally, potential for no causal relationship between exports and economic growth when the growth paths of the two time series are determined by other, unrelated variables (for example, investment) in the economic system. This possible outcome cannot be overlooked as many studies such as Jung and Marshall (1985), Xu (1996) and Love and Chandra (2005) find empirical evidence from developing countries for neutral relationship between exports and economic growth.

An alternative hypothesis that economic growth is caused by imports is termed import-led growth (ILG). Compared with exports, increased imports have the potential to play a complementary role in promoting economic growth. The transfer of technology from developed to developing countries via imports can serve as an important source of economic growth. Endogenous growth models show that imports can stimulate long-run economic growth because they offer domestic firms with access to needed intermediate factors and foreign knowledge (Grossman and Helpman, 1991). Import growth can serve as a medium for the transfer of growth, enhancing foreign R&D knowledge from developed to developing countries. To the extent that imports act as a conduit for technology transfer, they may play a bigger role in promoting economic growth than exports (Awokuse, 2008). Awokuse (2007) finds empirical evidence for ILG hypothesis from two transition economies as well as Mahadevan and Suardi (2008) support that Japan's GDP growth is import-led.

Despite abundant empirical literature in the last four decades, general validation of this hypothesis has gone through difficulties due to the consideration of different sample periods, countries, data frequency and econometric techniques. Early studies in this area are concentrated largely on using cross-section approaches and have found overwhelming evidence for the export-led growth hypothesis. For example, the studies by Balassa (1978), Tyler (1981), and Kavoussi (1984) support the view that export growth promotes overall economic growth. A large number of time series studies have explored the issue of causality between output growth and exports, including those by Jung and Marshall (1985), Chow (1987), Ahmad and Kwan (1991), Bahmani-Oskooee et al. (1991), Ahmad and Harnhirun (1995), Xu (1996) and Love and Chandra (2005). The majority of time series studies employ the concept of Granger non-causality to test for bivariate causal link between exports and economic growth. This strand of literature has not provided uniform support for the export-led growth hypothesis and, for the most part, does not reach a consensus as to the causal relationship between exports and economic growth.

The time series studies, under a bivariate analysis where the variables involved are some representation of output growth and exports, while providing some evidence of export-led growth hypothesis, the results of these studies are far from conclusive. The causal models in these studies may very well have been miss-specified, as noted by Awokuse (2003), on account of the fact that an important variable may be omitted. The relationship between GDP growth and export growth is extremely complex, and the other key variables such as price fluctuations, investment climate, political conditions, etc., influence their relationship greatly.

In general, the focus of the ELG debate is on whether a country is better served by orienting trade policies to export promotion or to import substitution. The neoclassical view has been that growth can be achieved by ELG; the growth records of Asian newly industrializing countries (NICs), in particular, Hong Kong, Singapore, Korea and Taiwan, and second-generation NICs (Malaysia and Thailand) are cited as such examples (compared with, say, Latin America and Africa). Over the last 30 years these NICs have approximately doubled their standards of living every ten years. China is the latest country to join this group. China's experience during the 1980s and 1990s tends to support the argument that openness to trade is a mechanism for achieving more rapid and efficient growth and better distribution of domestic resources (Findlay and Watson, 1996). The effectiveness of export promotion is, in the end, an empirical issue; over the last 40 years there has been a plethora of such investigations, using a number of statistical techniques. Overall, it is difficult to decide for or against ELG, as there are conflicting results. The support of ELG is not universal. Critics point out that the experiences in the East and Southeast Asian countries are unique in many ways and not necessarily replicable in other countries. Nevertheless, the topic continues to attract research attention.

The present study proposes a re-examination of the ELG hypothesis for 33 OECD countries, namely Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the USA, over the period 1985-2010. This paper empirically investigates the causal relationship between economic growth and exports using other seven key variables such as real GDP net of exports, real imports, domestic investment, interest rate, exchange rate, unemployment rate and rate of employment.

More specifically in this paper, besides time series analysis for individual economy, panel data cointegration techniques and panel causality analysis are employed in order to investigate the export-led growth hypothesis. Panel data approach is implemented because of its advantages over cross-section and time series in using all the information available, which are not detectable in pure cross-sections or in pure time series. In addition, panel data estimation provides improved coefficient estimates over time series techniques by increasing the power of the tests if the data span is short, given the fact that here there are only 26 observations for each country.

The rest of the paper is organized as follows: in Section 2, it is presented a review of the literature as well as a comprehensive survey of 70 papers dealing with the ELG hypothesis. The econometric methodology is presented in Section 3 and the empirical results are discussed in Section 4. A summary of the study and the final conclusions are contained in the final section.

2. LITERATURE REVIEW

The relationship between exports and economic growth has been examined extensively in the theoretical and empirical literature. A large number of empirical studies have been conducted during the last four decades to investigate the role of exports on economic growth or the export-led growth hypothesis, using either time series or cross-section data. These studies have been conducted along a number of divergent lines.

The early studies on this issue examined the simple correlation coefficient between export growth and economic growth. Balassa (1978), one of the predominant writers in the area of ELG hypothesis, using data for the period 1960-1973 for 11 countries finds a positive effect of export growth on economic growth. Tyler (1981) analyses the empirical relationship between economic growth and export expansion in a sample of 55 middle-income developing countries using inter-country cross-section analysis. The results reveal a strong positive association between export growth and economic growth. Kavoussi (1984) tested the correlation between the exports and economic growth in 73 developing countries for 1960-1978 periods and attained the results that expansion in exports resulted in a much more high-level economic performance.

Similarly, Kohli and Singh (1989), Moschos (1989), Sheehey (1990), Dodaro (1991), Esfahani (1991) and Fosu (1996) indicate a statistically significant, positive ELG relationship. These studies generally concluded that there is strong evidence in favor of export-led growth hypothesis based on the fact that export growth and economic growth are highly correlated. The main weakness of this group of studies is that a high degree of positive correlation between the two variables was used as evidence supporting the export-led growth hypothesis.

A common feature of the above studies is their reliance on correlation analysis based on cross-section data sets. However, these studies are subject to the criticism based on methodological issues that they make the a priori assumption that export growth causes output growth and they do not consider the direction of the causal relation between the two variables (Ekanayake, 1999). It is argued that the question of causality is essentially a dynamic one and thus can be meaningfully studied only in a dynamic framework based on time series data. Consequently, a number of studies have examined the export-led growth hypothesis by employing Granger (1969) and Sims (1972) causality tests (Din, 2004).

Since introduction of Granger's and Sims' concept of causality within time series framework, researchers shifted their emphasis toward investigating causality between export growth and output growth. Jung and Marshall (1985) and Chow (1987) are among the earlier studies along this line. The list also includes studies such as Ahmad and Kwan (1991) and Bahmani-Oskooee et al. (1991). In general, these studies have failed to provide strong support for export-led growth or growth-led exports hypothesis.

Jung and Marshall (1985), based on the standard Granger causality tests, analyzed the relationship between export growth and economic growth using time series data for 37 developing countries for the period 1950-1981 and found evidence for the export-led growth hypothesis in only four countries. Chow's (1987) empirical estimates for a sample of eight newly industrializing countries found evidence of exports-to-growth causality only in the case of one country, bidirectional causality for six, and no causal link for one. Bahmani-Oskooee et al. (1991) examine the causal relationship between exports and economic growth for 20 developing countries. They find mixed results; there is evidence for export-led growth hypothesis particularly for the newly emerging industrialized countries. Marin (1992), using quarterly data from four industrialized countries, examines the causal link between exports and productivity and finds that the ELG hypothesis cannot be rejected for Germany, Japan, the United Kingdom and the United States.

Serletis (1992) examines the ELG hypothesis by using single equation techniques to analyse Canadian annual data from 1870 to 1985 and he finds empirical support for the ELG hypothesis in Canada. Henriques and Sadorsky (1996) also focused on the export and output growth relationship for Canada. They employ a multivariate cointegration estimation methodology that accounted for potential feedback and simultaneity effects between the variables. In contrast to

Serletis' earlier result, Henriques and Sadorsky find that changes in GDP precede changes in exports.

The major shortcoming of these causality test results is that the Granger or Sims tests used in these studies are only valid if the original time series are cointegrated. Therefore, one must check for cointegrating properties of original export and output series before using Granger or Sims tests (Ekanayake, 1999). There have been relatively new studies that involve the application of techniques of cointegration and error correction models, for example, Kugler (1991), Ahmad and Harnhirun (1995), Al-Yousif (1999), Abu-Qarn and Abu-Bader (2004), Love and Chandra (2005) and Bahmani-Oskooee and Economidou (2009).

Ahmad and Harnhirun (1995), employ cointegration and error correction modelling using annual data from five ASEAN countries. They provided some support for bidirectional causality in the case of Singapore. Shan and Sun (1998) examined the causal relationship between exports and growth using Granger causality for Hong Kong, Korea and Taiwan for the period 1978-1996. They found that Granger causality runs from exports to economic growth only for Taiwan, while they found evidence of bidirectional Granger causality for Hong Kong and Korea. Ekanayake (1999) tested the ELG hypothesis for eight Asian developing countries for different time periods. He employed cointegration and error correction modelling techniques to investigate whether ELG hypothesis holds for these countries in concerned time period. He found that there exists bidirectional causality between export growth and GDP growth for all eight Asian countries except for Malaysia. The evidence supports short-run Granger causality running from economic growth to export in all cases except for Sri Lanka. Yet, the strong evidence for long-run Granger causality running from export growth to economic growth in all cases also exists. Khalafalla and Webb (2001) test the hypothesis for the Malaysian economy over three different periods and they find support for the ELG hypothesis.

For Bangladesh, Love and Chandra (2005a) extend the study by using Johansen's multivariate framework by adding the terms of trade as an additional variable. The results show that both in the long and short-run causality runs from income to exports. Al Mamun and Nath (2005), in a similar study, test the export-led growth hypothesis for Bangladesh over the 1976-2003 periods. Using the Engle-Granger cointegration and Granger causality tests, they find evidence in support of the ELG hypothesis. However, there were no causal relationships between the variables in the short-run.

Dhawan and Biswal (1999) re-examine the export-led growth hypothesis using the vector autoregressive (VAR) model for India over the period 1961-1993. They conclude that in the long-run causality runs from GDP and terms of trade to exports. However, causality from exports to GDP appears to be evident only in the short-run. Sharma and Panagiotidis (2005) investigated the export rise in India for the period 1971-2001. Strong evidence is found against the cointegration hypothesis between GDP and exports. They also failed to find support for the hypothesis that exports Granger causes both GDP with exports and GDP without exports.

Awokuse (2007) investigated the impact of export and import expansion on growth for Bulgaria, Czech Republic and Poland. He found that trade stimulates economic growth, as well as a bidirectional causal relationship between exports and growth in Bulgaria and causality from imports to economic growth in the Czech Republic and Poland. Narayan et al. (2007) examined the ELG hypothesis over the period 1960-2001 for Fiji and 1961-1999 for Papua New Guinea. Their empirical results implied that for Fiji there is evidence for export-led growth in the long-run, while for Papua New Guinea there is evidence for ELG in the short-run. Mahadevan and Suardi (2008) examined the ELG and ILG hypotheses using quarterly data from Japan, Korea, Taiwan and Hong Kong. They found that economic growth and trade were independent in Korea, while Japan’s economic growth is ILG but not ELG. Mahadevan and Suardi also found a bidirectional causal relationship between exports and growth in Taiwan and exports and imports cause growth in Hong Kong.

In a recent study, Kubo (2011) investigates the causal relationships between trade and production in three Asian developing countries. He applies Johansen’s cointegration techniques and Granger causality tests to 2000-2008 monthly data. Kubo found that causality analyses provide no evidence in support of the export-led growth hypothesis. On the other hand, the empirical results indicate that the growth-led exports hypothesis is applicable in the cases of Korea and Thailand.

Taken as a whole, these studies suggest that in most developing countries there is a positive long-run relationship between exports and output, and that causality is running from exports to output or in both directions. A potential limitation of these studies, however, is the low power of the statistical tests due to the small sample size associated with the use of individual country time series data. In light of this limitation, most recent studies employ panel cointegration methods, which have higher power due to exploitation of both the time series and cross-sectional dimensions of the data.

Dawson and Hubbard (2004) examined the ELG hypothesis for 14 Central and East European countries using annual data over the period 1994-1999 and found strong evidence in support of the ELG hypothesis. Similarly, Bahmani-Oskooee et al. (2005), using data from 61 developing countries over the period 1960-1999, employ panel unit roots and panel cointegration technique to establish the long-run relationship between exports and growth. Cointegration receives support in a model in which export is the dependent variable.

Reppas and Christopoulos (2005) analyse a sample of 22 less developed Asian and African countries over the period 1969-1999. In addition, the structural relationship between output growth and exports is estimated by Fully Modified-OLS techniques appropriate for heterogeneous panel. The empirical findings suggest that output growth causes exports and not the reverse. Hsiao and Hsiao (2006) studied the causal relationship between exports and economic growth, using time series data for the period 1986-2004 for eight developing East and Southeast Asian economies. They found out that there exists bidirectional Granger causality between economic growth and exports.

Konya (2006) investigates the causal relationship between real exports and real GDP in 24 OECD countries from 1960 to 1997.A panel data approach is applied which is based on SUR systems and Wald tests with country specific bootstrap critical values. Two different models are used. A bivariate (GDP-exports) model and a trivariate (GDP-exports-openness) model, both without and with a linear time trend. In each case the analysis focuses on direct, one-periodahead causality between exports and GDP. The results indicate one-way causality from exports to GDP in Belgium, Denmark, Iceland, Ireland, Italy, New Zealand, Spain and Sweden, one-way causality from GDP to exports in Austria, France, Greece, Japan, Mexico, Norway and Portugal, two-way causality between exports and growth in Canada, Finland and the Netherlands, while in the case of Australia, Korea, Luxembourg, Switzerland, the UK and the USA there is no evidence of causality in either direction.

Parida and Sahoo (2007) examine the export-led and manufacturing export-led growth hypothesis for four South Asian countries, using Pedroni's panel cointegration technique for the period 1980-2002. The study finds long-run equilibrium relationship between GDP and exports along with other variables supporting export-led growth hypothesis. The results also substantiate the existence of manufacturing export-led growth hypothesis. Çetintaş and Barişik (2009) investigate the relationships between export, import and economic growth by employing panel cointegration and panel causality tests for 13 transition economies. The empirical results show that there is a unidirectional causality from economic growth to export.

The main features of studies reviewed above and other related work are provided in tables below. Table 1 summarizes the cross-country studies of exports and growth. A selection of time series studies on export-led growth hypothesis are reported in Table 2. Finally, in Table 3, are presented relatively new studies of exports and growth using panel data analysis.

Table 1. Cross-country studies of exports and growth.

Paper	Data	Method and Variables	Empirical Results
Balassa (1978)	11 developing countries, 1960-1973.	Rank correlation (averaged growth of value added in manufacturing and incremental export-output ratios and also averaged growth of manufactured exports); OLS (averaged growth in real GDP on averaged growth in real exports) (total exports; GNP; manufactured exports; manufacturing output).	Statistically significant, positive ELG relationship.
Tyler (1981)	55 middle-income developing countries, 1960-1977.	Rank correlation (averaged real GDP growth on averaged real exports growth or averaged real manufactured export earnings); OLS (averaged real GDP growth on averaged real exports growth) (averaged GDP growth; averaged exports growth; averaged labour force growth; averaged growth in capital formation).	Statistically significant, positive ELG relationship.
Kavoussi (1984)	73 developing countries, 1960-1978.	Rank correlation (averaged real GDP growth on averaged merchandise exports growth); OLS (averaged real GDP growth on averaged merchandise exports growth) (averaged real GDP growth; averaged merchandise exports growth; averaged labour force growth; averaged investment growth).	Statistically significant, positive ELG relationship.

Kohli and Singh (1989)	31 countries, 1960-1970 and 1970-1981.	OLS (averaged real GDP growth on averaged % share of changes in exports in GDP; also quadratic export variable to allow for diminishing returns to exports) (growth of real GDP; growth of real exports; averaged investment share of GDP; averaged population growth; foreign investment share).	Statistically significant, positive ELG relationship.
Moschos (1989)	71 developing countries, 1970-1980.	OLS and IV (averaged real GDP growth on averaged real export growth). (averaged real GDP growth; averaged real export growth; averaged real investment growth; averaged labour force growth).	Statistically significant, positive ELG relationship.
Sheehey (1990)	36 countries, 1960-1970.	OLS (averaged real GDP growth on averaged real exports growth or averaged % share of changes in exports in GDP) (averaged GDP growth; averaged exports growth; averaged investment share of GDP).	Statistically significant, positive ELG relationship.
Dodaro (1991)	84 developing countries, 1965-1970 and 1970-1981.	OLS (averaged real GDP growth on averaged manufacturing exports as % of total merchandise exports or on export share defined by stage of processing) (averaged real GDP growth; averaged manufacturing exports; country dummy=1 if over 50% of exports are made up of fuels, minerals and metals)	Statistically significant, positive ELG relationship but depends on degree of processing in a country's export basket.

Esfahani (1991)	31 semi-industrialized countries, 1960-1973, 1973-1981 and 1980-1986.	TSLS (averaged GDP growth, export growth and import growth equations) (averaged GDP growth; export growth; import growth; relative import shortage; population; area; goods designed for domestic and foreign usage).	Statistically significant, positive ELG relationship.
Fosu (1996)	76 LDCs, 1967-1973, 1973-1980, 1980-1986 and on the overall 1967-1986.	OLS (averaged real GDP on averaged real exports. Repeated with averaged proportion on non-fuel primary exports to total exports replacing exports. Also, with non-export GDP replacing GDP) (growth rates of real GDP; labour; real exports; real GDP less real exports; averaged gross domestic investment as a proportion of GDP).	Statistically significant, positive ELG relationship.

Table 2. Time series studies of exports and growth.

Paper	Data	Method and Variables	Empirical Results
Jung and Marshall (1985)	37 developing countries, 1950-1981 (annual).	Bivariate Granger; 1st differenced VAR and 2nd differenced VAR model with constant for real GNP/GDP growth and export growth (GNP or GDP; exports).	Support of ELG for 5 countries and GLE for 11 countries. Support of both ELG and GLE for 1 country and non-causality for 20 countries.
Chow (1987)	8 countries: Mexico, Brazil, Hong-Kong, Israel, Korea, Singapore, Taiwan and Argentina, 1960-1984 (annual).	Bivariate Sims; VAR with constant (real manufactured exports; real manufactured output).	Support of ELG for Mexico, non-causality for Argentina and bilateral relationship for the rest.
Afxentiou and Serletis (1991)	16 industrial countries, 1950-1985 (annual).	Bivariate Granger; OLS in 1st differences (real GNP; exports).	Support of both ELG and GLE in United States. Support of GLE in Norway, Japan and Canada.
Ahmad and Kwan (1991)	47 African countries, 1981-1987 (annual).	Bivariate Granger; VAR with constant (real GDP per capita and annual growth of real GDP; total real exports; total real manufactured exports; share of real manufactured exports to real exports).	No support of ELG and weak support of GLE.

Bahmani-Oskooee et al. (1991)	20 developing countries, periods within 1951-1987 (annual).	Bivariate Granger; VAR and 1st differenced VAR with constant (real GDP; export growth).	Support of ELG for 5 countries, GLE for 2 countries.
Kugler (1991)	6 countries: USA, Japan, Switzerland, West Germany, UK and France, 1970-1987 (quarterly).	4-variable Granger; VECM for cointegrated countries with constant (real GDP; real exports; total real private consumption; real gross fixed business investment).	Support of ELG in West Germany and France.
Marin (1992)	4 OECD countries: Germany, United Kingdom, United States and Japan, 1960:Q1-1987:Q2.	Bivariate Granger (labour productivity; exports of manufacturing goods; terms of trade; OECD output).	Support of ELG.
Serletis (1992)	Canada, 1870-1944, 1945-1985 and 1870-1985 (annual).	Trivariate Granger (GNP; exports; imports)	Support of ELG for the 1870-1944 and the 1870-1985 periods.
Oxley (1993)	Portugal, 1865-1985 (annual).	Bivariate Granger (GDP; exports).	Support of GLE.
Ahmad and Harnhirun (1995)	5 ASEAN countries: Indonesia, Malaysia, the Philippines, Singapore and Thailand, 1966-1990 (annual).	Bivariate Granger; ECM for cointegrated countries; 1st differenced VAR for non-cointegrated, with constant (GDP; exports).	Support of ELG and GLE in Singapore.

Bodman (1996)	2 countries: Australia and Canada, 1960:Q1-1995:Q4.	Johansen's cointegration technique; VECM (total exported goods and services; exports of manufactured goods; total labour productivity; labour productivity in the manufacturing sector).	Statistically significant, positive ELG relationship.
Boltho (1996)	Japan, 1913-1937, 1952-1973 and 1973-1990 (annual).	Bivariate Granger; demand versus supply shifts; foreign market growth; the level of real exchange rate; disaggregated industrial evidence (growth of real GDP; growth of real exports).	No support of ELG.
Henriques and Sadorsky (1996)	Canada, 1870-1991 (annual).	Trivariate Granger (real GDP; real exports; real terms of trade).	No support of ELG and support of GLE.
Thornton (1996)	Mexico, 1895-1992 (annual).	Bivariate Granger based on ECM (real GDP; real exports).	Support of ELG.
Xu (1996)	32 developing countries, periods within 1951-1990 (annual).	Bivariate Granger; VECM for cointegrated countries; 1st differenced VAR and 2nd differenced VAR for non-cointegrated, with constant (real GDP; exports).	Support of ELG for 12 countries, GLE for 8 countries, bilateral relationship for 9 countries and non-causality for 3 countries.

Al-Yousif (1997)	4 Arab Gulf countries: Saudi Arabia, Kuwait, United Arab Emirates and Oman, 1973-1993 (annual).	OLS (simple regressions between variables) (growth of real GDP; growth of real exports or % share of changes in exports in GDP; labour force growth; gross domestic investment as % of GDP; growth of government expenditure; growth of terms of trade).	Statistically significant, positive ELG relationship.
Shan and Sun (1998)	3 counties: Hong Kong, Korea and Taiwan, 1978:Q1-1996:Q3.	6-variable Granger based on Toda and Yamamoto procedures (industrial output growth; export growth; growth of total persons employed; import growth; energy consumption; gross fixed capital expenditure).	Support of ELG in Taiwan. Support of both ELG and GLE in Hong Kong and Korea.
Al-Yousif (1999)	Malaysia, 1955-1996 (annual).	Multivariate Granger based on VECM using SUR method (real GDP; real exports; labour; real gross fixed capital; real effective exchange rate)	Support of ELG in the short-run and GLE in the long-run.
Dhawan and Biswal (1999)	India, 1961-1993 (annual).	Trivariate Granger (real GDP; real exports; net terms of trade).	Support of both GLE and ELG, but ELG only in the short-run.

Ekanayake (1999)	8 countries: India (1960-1997), Indonesia (1965-1997), Korea (1960-1997), Malaysia (1960-1997), Pakistan (1960-1997), Philippines (1960-1997), Sri Lanka (1960-1997) and Thailand (1962-1997) (annual).	Cointegration and error correction modelling techniques (GDP; exports).	Support of both ELG and GLE for all countries except Malaysia.
Glasure and Lee (1999)	Korea, 1973:Q1-1994:Q4.	VAR models; Variance decompositions; VECM (GDP; exchange rate; government spending; money supply; exports).	Support of GLE when using VAR and support of both ELG and GLE when using VECM.
Chang et al. (2000)	Taiwan, 1971:Q1-1995:Q3.	Granger causality tests based on ECM (real GDP; exports; imports).	No support of ELG.
Fountas (2000)	Ireland, 1950-1990 (annual) and 1981:1-1994:9 (monthly).	Bivariate Granger; ECM for cointegrated countries; 1st differenced VAR for non-cointegrated, with constant (GDP; exports; industrial production).	No support of ELG in the 1950-1990 periods and support of ELG in the 1981-1994 periods.
Wernerheim (2000)	Canada, 1947-1986, 1987-1996 and 1947-1996 (quarterly).	Bivariate and trivariate Granger (GDP; total exports; merchandise exports; GDP of the USA; merchandise exports to the USA).	Support of both ELG and GLE.

Balaguer and Cantavella-Jorda (2001)	Spain, 1901-1999 (annual).	Bivariate Granger (domestic income; exports).	Support of GLE during 1901-1999. No support of ELG either GLE during 1901-1958 while ELG holds during 1958-1999.
Khalafalla and Webb (2001)	Malaysia, 1965:Q1-1980:Q4, 1981:Q1-1996:Q4 and 1965:Q1-1996:Q4.	Trivariate Granger; VECM for cointegrated countries; 1st differenced VAR for non-cointegrated, with constant (real GDP; real exports; real imports).	Support of ELG for the 1965-1980 and the 1965-1996 periods. Support of GLE for the 1981-1996 periods.
Ramos (2001)	Portugal, 1865-1998 (annual).	Trivariate Granger based on VECM (real GDP; real exports; real imports).	Support of both ELG and GLE.
Panas and Vamvoukas (2002)	Greece, 1948-1997 (annual).	Multivariate Granger; ECM (GDP; exports; nominal effective exchange rate; CPI).	Support of GLE.
Awokuse (2003)	Canada, 1961:Q1-2000:Q4.	6-variable VAR; Granger Causality based on VECM (real GDP; real exports; real terms of trade; manufacturing employment as proxy for labour; gross capital formation as proxy for capital; industrial production index for all industrialized nations as the proxy for foreign output shock).	Support of ELG.

Abu-Qarn and Abu-Bader (2004)	9 MENA countries: Algeria, Egypt, Israel, and Morocco (1963-1999), Iran (1976-1999), Jordan (1976-1998), Sudan (1960-1991), Tunisia (1963-1998), and Turkey (1966-1996) (annual).	Trivariate Granger; ECM for cointegrated countries; 1st differenced VAR for non-cointegrated (real GDP; real total exports; real manufactured exports; real imports)	Support of ELG in Iran and support of GLE in Israel, Sudan and Turkey (when considering total exports). Support of ELG in Israel, Tunisia, Morocco and Turkey and support of GLE in Egypt (when considering manufactured exports).
Din (2004)	5 countries: Bangladesh (1973-2002), India (1960-2000), Nepal (1965-2002), Pakistan (1973-2002) and Sri Lanka (1960-2000) (annual).	Granger causality tests based on VECM and VAR in 1st differences (real GDP; exports; imports).	Support of ELG and GLE for Bangladesh, India and Sri Lanka. Support of ELG for Pakistan and GLE for Nepal.
Al Mamun and Nath (2005)	Bangladesh, 1976:Q1-2003:Q3.	Bivariate Granger; ECM for cointegrated variables (industrial production; exports of goods and services; exports of goods only)	Support of ELG.
Awokuse (2005)	Korea, 1963:Q1-2001:Q4.	5-variable VAR; Granger Causality based on ECM and an augmented VAR model (real GDP; real exports; real terms of trade; gross capital formation as proxy for capital; industrial production index for all industrialized nations as the proxy for foreign output shock).	Support of both ELG and GLE.

Awokuse (2005)	Japan, 1960:Q1-1991:Q4.	5-variable VAR; Granger Causality based on an augmented VAR model (productivity; real exports; real terms of trade; gross capital formation as proxy for capital; industrial production index for all industrialized nations as the proxy for foreign output shock).	Support of both ELG and GLE.
Choong et al. (2005)	Malaysia, 1960-2001 (annual).	Bounds testing approach (real GDP; real exports; real imports; labour force; exchange rate).	Support of ELG.
Love and Chandra (2005)	7 South Asian countries: India (1950-1998), Nepal (1964-2000), Sri Lanka (1965-1997), Pakistan (1970-2000), Bangladesh (1973-2000), Maldives (1977-2000) and Bhutan (1980-2000) (annual).	Bivariate Granger; ECM (GDP; exports).	Support of ELG in India, Maldives and Nepal. Support of GLE Bangladesh and Bhutan. No evidence of causality in Pakistan and Sri Lanka.
Sharma and Panagiotidis (2005)	India, 1971-2001 (annual).	Parametric and nonparametic cointegration tests; Granger causality tests; VAR-IRF analysis (GDP; GDP net of exports; real exports; real imports; real gross domestic capital formation; employment in the formal sector).	No support of ELG.

Shirazi and Abdul Manap (2005)	5 South Asian countries: Pakistan (1960-2003), India (1960-2002), Bangladesh (1973-2002), Sri Lanka (1960-2002) and Nepal (1975-2003) (annual).	Trivariate Granger based on Toda and Yamamoto procedure (real GDP; real exports; real imports).	Support of ELG in Pakistan. Suport of both ELG and GLE in Bangladesh and Nepal. No evidence of causality in Sri Lanka and India.
Awokuse (2007)	3 transition economies: Bulgaria, Czech Republic, Poland; 1994:Q1–2004:Q3 (for Bulgaria), 1993:Q1–2002:Q4 (for Czech Republic), and 1995:Q1–2004:Q2 (for Poland).	4-variable VAR; Granger Causality based on ECM (real GDP growth; real exports; real imports; gross capital formation; labour).	Support of ELG and GLE for Bulgaria. Support of ELG ang ILG for the Czech Republic. Support of ILG for Poland.
Chen (2007)	Taiwan, 1976-2004 (annual).	Granger causality tests based on VECM; bounds testing approach (real GDP; real exports; terms of trade; labour productivity).	Support of ELG and GLE.
Huang and Wang (2007)	Korea (1955-1998), Taiwan (1951-1998), Singapore (1960-1998) and Hong Kong (1968-1998) (annual).	Granger noncausality test based on Toda and Phillips and Toda and Yamamoto procedures (real GDP; real exports; real imports; real capital formation)	Support of ELG in Korea and Taiwan (when the TP procedure is applied). Support of GLE in Hong Kong and Korea (when the TY procedure is applied).

Narayan et al. (2007)	2 countries: Fiji (1960-2001) and Papua New Guinea (1961-1999) (annual).	Bounds testing approach; Trivariate Granger (GDP; exports; imports).	Support of ELG in Fiji (in the long-run) and in Papua New Guinea (in the short-run).
Tsen (2007)	7 Middle East countries: Bahrain (1975-2004), Iran (1966-2004), Oman (1975-2004), Qatar (1980-2003), Saudi Arabia (1968-2004), Syria (1963-2002) and Jordan (1976-2003) (annual).	Bounds testing approach; Trivariate Granger; Geweke decomposition of causality (nominal GDP; exports; population; private consumption; government consumption; investment)	Support of both ELG and GLE.
Dilrukshini (2008)	Sri Lanka, 1960-2005 (annual).	Multivariate Granger; IRF (real GDP; real exports; real imports; real investment expenditure; labour force).	No support of ELG.
Mahadevan and Suardi (2008)	4 countries: Japan (1957:Q1-2005:Q2), Korea (1970:Q1-2005:Q2), Taiwan (1961:Q1-2005:Q2) and Hong Kong (1973:Q1-2005:Q2).	Trivariate Granger based on VECM and VECM-GARCH-M (GDP; exports; imports).	Support of ILG in Japan. Support oF ELG and GLE in Taiwan. Support of ELG and ILG in Hong Kong.
Taban and Aktar (2008)	Turkey, 1980:Q1-2007:Q2.	Bivariate Granger based on ECM (real GDP; exports).	Support of both ELG and GLE.

Bahmani-Oskooee and Economidou (2009)	61 developing countries, 1960-1999 (annual).	Johansen's cointegration technique; weak exogeneity tests (GDP; exports; imports; gross capital formation; labour).	The results are country specific.
Dash (2009)	India, 1992:Q1-2007:Q4.	Granger causality tests based on VECM (GDP; exports; imports; trade)	Support of ELG.
Chan and Dang (2010)	111 countries, 1960-2000 (annual).	Bivariate and trivariate Granger; VECM (GDP; trade (exports and imports divided by GDP); WTO).	Support of ELG in the world economy.
Elbeydi et al. (2010)	Libya, 1980-2007 (annual).	Causality based on VECM (GDP; exports; exchange rate)	Support of both ELG and GLE.
Herrerias and Orts (2010)	China, 1964-2004 (annual).	Johansen's cointegration technique based on VAR (GDP; labour productivity; investment; exports; R&D expenditure; real exchange rate; US GDP).	Support of ELG.
Kubo (2011)	3 Asian developing countries: Korea, Singapore and Thailand, 2000:01-2008:06 (monthly).	Johansen's cointegration test; 4-variable Granger based on VECM (industrial production; real exports; real imports; real effective exchange rate)	No support of ELG.

Table 3. Panel data studies of exports and growth.

Paper	Data	Method and Variables	Empirical Results
Dawson and Hubbard (2004)	14 countries, 1994-1999 (annual).	Fixed and random effects using panel data (GDP; total exports; gross capital formation; total population).	Statistically significant, positive ELG relationship.
Bahmani-Oskooee et al. (2005)	61 developing countries, 1960-1999 (annual).	Panel cointegration technique (GDP; exports; imports; gross capital formation; labour).	Cointegration when export is the dependent variable.
Reppas and Christopoulos (2005)	22 less developed Asian and African countries, 1969-1999 (annual).	Panel cointegration tests; FM-OLS estimation (real GDP; real exports; share of investment in GDP; employment)	Support of GLE.
Hsiao and Hsiao (2006)	8 Asian countries, 1986-2004 (annual).	Panel data causality analysis (GDP; exports; FDI)	Support of ELG and GLE.
Konya (2006)	24 OECD countries, 1960-1997 (annual).	Bivariate and trivariate Granger based on SUR systems (GDP; exports; openness).	Support of ELG in Belgium, Denmark, Iceland, Ireland, Italy, New Zealand, Spain and Sweden. Support of GLE in Austria, France, Greece, Japan, Mexico, Norway and Portugal. Support of both ELG and GLE in Canada, Finland and the Netherlands. No evidence of causality in Australia, Korea, Luxembourg, Switzerland, the UK and the USA

Parida and Sahoo (2007)	4 South Asian countries: India, Pakistan, Bangladesh and Sri Lanka, 1980-2002 (annual).	Panel cointegration test; FM-OLS estimation (real GDP; non-export real GDP; real total exports; real total manufacturing exports; gross fixed capital formation; manufacturing imports; real public expenditure on health and education).	Statistically significant, positive ELG relationship.
Çetintaş and Barişik (2009)	13 transition economies: Armenia, Belarus, Bulgaria, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Russia, Slovak Republic and Slovenia, 1995:Q2-2006:Q4.	Panel cointegration techniques; panel causality test (GDP; exports; imports).	Support of GLE.

3. ECONOMETRIC METHODOLOGY

3.1 A time series approach

The use of time series analyses, particularly time series methods on unit roots and cointegration, to examine the dynamic relationship between export growth and economic growth has attracted considerable attention among economists. In addition, Granger causality tests have been the principal tool for this investigation. In this section, Granger causality test methodology with cointegration techniques are employed to test the validity of the ELG hypothesis.

3.1.1 Unit root tests

Although time series data are commonly used in econometric studies, formal statistical tests need to be conducted to avoid the problem of spurious regression and the failure to account for the appropriate dynamic specification. The examination of stationarity or non-stationarity in a time series is closely related to the test for unit roots. A number of alternative tests are available for testing whether a series is stationary. Among them, the Augmented Dickey-Fuller (ADF) unit root test, the Dickey-Fuller Generalised Least Squares (DF-GLS) method proposed by Elliot, Rothenberg and Stock (ERS) and the stationarity Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test are the most common.

3.1.1.1 Augmented Dickey-Fuller (ADF) test

When considering the augmented Dickey-Fuller test, the autoregressive model is:

$$\Delta y_t = \beta_1 + \beta_2 t + \delta y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta y_{t-1} + u_t$$

where u_t is white noise error term, y_t is the variable of interest, Δ is the difference operator, m is the length lag and β_1 is the intercept. Since the ADF test results are sensitive to the choice of the lag length, Akaike Information Criteria (AIC) and

Schwarz Bayesian Criteria (SBC) are used to select the optimal lag length of the ADF regression. The test for a unit root using the above equation consists of testing the null hypothesis that $\delta=0$ or that the series is non-stationary against the alternative hypothesis that $\delta<0$ or the series is stationary. The augmented Dickey-Fuller statistic is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit roots at some level of confidence. Dickey and Fuller (1979) proved that the t-statistic of the coefficient δ in this equation has a non-standard distribution and, therefore, they tabulated critical values for selected sample sizes. MacKinnon (1991) estimated the calculation of Dickey-Fuller critical values for any sample size and for any number of variables.

3.1.1.2 The Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test

The KPSS (1992) test differs from the other unit root tests in that the series y_t is assumed to be stationary under the null hypothesis. The KPSS statistic is based on the residuals from the OLS regression of y_t on the exogenous variables x_t:

$$y_t = x_t'\delta + u_t$$

The LM statistic is defined as:

$$LM = T^{-2}\sum_{t=1}^{T} S_t^2 / f_0$$

where f_0 is an estimator of the residual spectrum at frequency zero and S_t is a cumulative residual function:

$$S_t = \sum_{r=1}^{t} \hat{u}_r$$

based on the residuals $\hat{u}_t = y_t - x_t'\hat{\delta}$. The null of trend stationarity is rejected in favour of the unit root alternative if the KPSS statistic is larger than the asymptotic critical values provided by Kwiatkowski et al. (1992).

3.1.1.3 Dickey-Fuller Generalised Least Squares (DF-GLS) test

Elliot, Rothenberg and Stock (1996) developed a unit root test based on a quasi-difference detrending of the series in order to increase power of Dickey-Fuller tests. They suggest the Dickey-Fuller generalized least squares (DF-GLS) test using the following regression:

$$\Delta\tilde{y}_t = \beta_0\tilde{y}_{t-1} + \sum_{j=1}^{k}\beta_j\Delta\tilde{y}_{t-j} + \varepsilon_t$$

where $\tilde{y}_t$ is the locally detrended series y_t. The DF-GLS t-test is performed by testing the null hypothesis $\beta_0=0$ against the alternative $\beta_0<0$. The local detrending series is defined by

$$\tilde{y}_t = y_t - \hat{\psi}'z_t$$

where z_t equals to 1 for the constant mean case and (1,t) for the linear trend case, and $\hat{\psi}$ is the GLS estimator obtained by regressing $\bar{y}$ on $\bar{z}$ where

$$\bar{y} = \left(y_1, (1-\bar{\alpha}B)y_2, \ldots, (1-\bar{\alpha}B)y_T\right)'$$

$$\bar{z} = \left(z_1, (1-\bar{\alpha}B)z_2, \ldots, (1-\bar{\alpha}B)z_T\right)'$$

and $\bar{\alpha} = 1 + \bar{c}/T$.

3.1.2 Cointegration test

Although it has noted that regression of non-stationary variables may lead to a spurious regression, it might be the case that two non-stationary time series may still have a meaningful relationship in the long-run. In this case, it can be said that the two variables are cointegrated (Engle and Granger, 1987). In this study, Johansen cointegration method will be applied for testing the non-stationary variables that are cointegrated.

3.1.2.1 Johansen cointegration test

Johansen´s multiple cointegration test is based on the vector autoregression equation as:

$$X_t = A_1 X_{t-1} + \ldots + A_p X_{t-p} + B Y_t + \varepsilon_t$$

where X_t and Y_t are, respectively, a k-vector of non-stationary variables and a vector of deterministic variables and ε_t is a vector of innovations. The Johansen test is a test to investigate if there are cointegrating relationships among several variables. The null hypothesis states that there are at most r cointegrating relationships. The tests of cointegration are performed sequentially, starting with the hypothesis of zero vectors. Test involves the determination of the optimal number of lags to eliminate autocorrelation. Lag lengths for the cointegration test were selected using Akaike Information Criteria (AIC) and Schwarz Bayesian Criteria (SBC). The Johansen test is a sequential test starting from zero to (n-1) cointegration vector, where n is the number of variables in the system.

In making conclusions about the number of cointegrating relations, two statistics known as the trace statistic and the maximun eigenvalue statistic are used. The trace statistic is determined using the equation as it follows:

$$\lambda_{trace} = -T \sum_{i=r+1}^{m} \ln(1 - \lambda_i)$$

where T is the number of observations, r is the number of cointegrating vectors under the null hypothesis and λ_i is the i*th* eigenvalue. Correspondingly, the maximum eigenvalue is determined using the following formula:

$$\lambda_{\max} = -T \ln(1 - \lambda_{r+1})$$

Trace statistic is a joint test where the null is that the number of cointegrating vectors is less than or equal to r against an unspecified or general alternative that there are more than r. It starts with p eigenvalues, and then successively the largest is removed. The maximum eigenvalue statistic conducts separate tests on each eigenvalue, and has as its null hypothesis that the number of cointegration vectors is r against an alternative of r+1. Critical values for the Johansen cointegration test has been taken form the Osterwald-Lenum (1992) statistical tables.

3.2 A panel data approach

A panel data analysis presents two important advantages with respect to time series data. The first advantage of such data is the larger sample size and hence more powerful significance tests. This is true not only for unit root tests but also for cointegration tests. For example it is well known that univariate unit root tests fail to take advantage of information across countries, thus leading to loss of efficiency in estimation. Moreover, Im, Pesaran and Shin (1997) employing Monte Carlo simulations concluded that a substantial increase in power could be obtained with an increased cross sectional dimension in the panel, even for fairly short time series. Secondly, panel data enables researchers to include country and time specific effects for the presence of mismeasured and unobservable variables that are correlated with the explanatory variables included in the panel (Reppas and Christopoulos, 2005). In this section, panel cointegration tests and panel data causality analysis are implemented in order to investigate the export-led growth hypothesis.

3.2.1 Panel unit root tests

Testing for stationarity in panel data differs somewhat from conducting unit root tests in standard individual time series. The most widely utilized panel unit root tests are the Im, Pesaran, and Shin (1997) W-test (henceforth IPS), Levin, Lin and Chu (1992) t-test (henceforth LLC) and Fisher type unit root test developed by Maddala and Wu (1999) (henceforth Fisher-ADF). When the persistence parameters are common across cross-section then this type of processes is called a common unit root process. Levin, Lin and Chu (LLC) employ this assumption. When the persistent parameters freely move across cross-section then this type of unit root process is called an individual unit root process. The Im, Pesaran and Shin (IPS) and Fisher-ADF test are based on this form.

3.2.1.1 The Im, Pesaran and Shin (IPS) test

The IPS panel unit test is essentially a test for a unit root in series, say, y, and has the following form:

$$\Delta y_{i,t} = \alpha_i + \beta_i y_{i,t-1} + \sum_{j=1}^{k} \psi_{i,j} \Delta y_{i,t-j} + \mu_{i,t}$$

where, Δ is the first difference operator, $y_{i,t}$ is a white noise disturbance term with variance σ^2. The lagged dependent variable is included to allow for serial correlation. The null hypothesis of a unit root in the panel is defined as: $\beta_i = 0$ for all i. To test the hypothesis, Im et al. (2003) propose a standardized t-bar statistic given by:

$$Z_{tbar} = \frac{\sqrt{N}\left\{tbar_{NT} - \frac{1}{N}\Sigma_{i=1}^{N} E\left[t_{iT}(p_i,0) \mid \beta_i = 0\right]\right\}}{\sqrt{\frac{1}{N}\Sigma_{i=1}^{N} Var\left[t_{iT}(p_i,0) \mid \beta_i = 0\right]}} \xrightarrow{T,N} N(0,1)$$

where, N is the number of countries, t_{iT} (p_i,θ_i) is the individual t-statistic for testing $\beta_i = 0$ for all i and $tbar_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{iT}(p_i,\theta_i)$ is the mean of the computed augmented Dickey-Fuller (ADF) statistics for individual countries included in the panel. $E[t_{iT}(p_i,0) \mid \beta_i=0]$ and $Var[t_{iT}(p_i,0) \mid \beta_i=0]$, denote respectively, the moments of mean and variance obtained from Monte Carlo simulation and tabulated by IPS (1997, 2003). The statistic Z_{tbar} approaches in probability a standard normal distribution as N and T tends to infinity.

3.2.1.2 The Levin, Lin and Chu (LLC) test

The LLC test is one of the first tests prepared to be used in panel data field. It tests unit root hypothesis using an ADF equation and proposes a three step procedure. First, the following ADF equation is estimated separately for each country. Appropriate lag level, P_i, is allowed to change between individuals.

$$\Delta y_{i,t} = \alpha_i + \delta_i y_{i,t-1} + \sum_{j=1}^{P_i} \beta_{i,j} \Delta y_{i,t-j} + \varepsilon_{i,t}$$

In the second step, two separate equations are estimated with the same lags in above equation.

$$\Delta y_{i,t} = \alpha_i + \sum_{j=1}^{P_i} \beta_{i,j}\, \Delta y_{i,t-j} + e_{i,t}$$

$$y_{i,t-1} = \alpha_i + \sum_{j=1}^{P_i} \beta_{i,j}\, \Delta y_{i,t-j} + v_{i,t-1}$$

and residuals are transformed, $\tilde{e}_{it} = \frac{\hat{e}_{it}}{\hat{\sigma}_{\varepsilon i}}$, $\tilde{v}_{it-1} = \frac{\hat{v}_{it-1}}{\hat{\sigma}_{\varepsilon i}}$.

In the last step, the following equation is estimated in order to calculate panel test statistic.

$$\tilde{e}_{it} = \delta \tilde{v}_{it-1} + \tilde{\varepsilon}_{it}$$

Through analyzing t statistics of the δ coefficient in this equation, null hypothesis is accepted or rejected. LLC show that under the null, a modified *t*-statistic for the resulting $\hat{\delta}$ is asymptotically normally distributed.

3.2.1.3 The Fisher-ADF test

The Fisher-ADF panel data unit root test is a much more flexible test and is applicable even to unbalanced panels and it is valid for individual ADF tests with different lag lengths. The Fisher-ADF test statistic λ, which has a chi-square distribution with 2N degrees of freedom under the null hypothesis, is expressed as:

$$\lambda = -2 \sum_{i=1}^{N} \log(\pi_i)$$

where π_i refers to the probability values from individual ADF unit root tests for each country in the panel.

3.2.2 Panel cointegration tests

The Engle-Granger (1987) cointegration test is based on an examination of the residuals of a spurious regression performed using non-stationary variables. If the variables are cointegrated, it is necessary to find that the residuals is stationary process, I(0). On the other hand, if the variables are not cointegrated then the residuals will be I(1). Pedroni (1999) and Kao (1999) extend the Engle-Granger framework to tests involving panel data. All these panel cointegration tests allow for heterogeneity in the cointegrating coefficients. Initially, the Engle-Granger two-step methodology was followed for panel cointegration tests where unit root tests are directly applied to the residuals. However, test statistics using this approach would be biased towards accepting stationarity. Pedroni argues that applying panel unit root tests directly to regression residuals is inappropriate for several reasons, such as the lack of exogeneity of the regressors and the dependency of the residuals on the distribution of the estimated coefficients. For these reasons it is important to have a test procedure for cointegration that is robust to the presence of heterogeneity in the alternative.

3.2.2.1 Pedroni cointegration tests

Pedroni (1999) considers the following time series panel regression:

$$y_{it} = \alpha_{it} + \delta_{it}\, t + X_i\, \beta_i + e_{it}$$

where y_{it} and X_{it} are the observable variables with dimension of $(N * T) \times 1$ and $(N * T) \times m$, respectively. He develops asymptotic and finite-sample properties of testing statistics to examine the null hypothesis of non-cointegration in the panel. The tests allow for heterogeneity among individual members of the panel, including heterogeneity in both the long-run cointegrating vectors and in the dynamics, since there is no reason to believe that all parameters are the same across countries. Two types of tests are suggested by Pedroni. The first type is based on the within-dimension approach, which includes four statistics. They are panel ν-statistic, panel ρ-statistic, panel PP-statistic, and panel ADF-statistic. These statistics pool the autoregressive coefficients across different members for the unit root tests on the estimated residuals.

The second type test by Pedroni is based on the between-dimension approach, which includes three statistics. They are group ρ-statistic, group PP-statistic, and group ADF-statistic. These statistics are based on estimators that simply average the individually estimated coefficients for each member. Following Pedroni (1999), the heterogeneous panel and heterogeneous group mean panel cointegration statistics are calculated as follows.

Panel ν-statistic: $Z_v = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \widehat{e}_{it-1}^{2} \right)^{-1}$

Panel ρ-statistic: $Z_\rho = \left(\sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \widehat{e}_{it-1}^{2} \right)^{-1} \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \left(\widehat{e}_{it-1} \Delta \widehat{e}_{it} - \widehat{\lambda}_i \right)$

Panel PP-statistic: $Z_t = \left(\widehat{\sigma}^2 \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \widehat{e}_{it-1}^{2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \left(\widehat{e}_{it-1} \Delta \widehat{e}_{it} - \widehat{\lambda}_i \right)$

Panel ADF-statistic: $Z_t^* = \left(\widehat{s}^{*2} \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \widehat{e}_{it-1}^{*2} \right)^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \widehat{L}_{11i}^{-2} \widehat{e}_{it-1}^{*} \Delta \widehat{e}_{it}^{*}$

Group ρ-statistic: $\widetilde{Z}_\rho = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \widehat{e}_{it-1}^{2} \right)^{-1} \sum_{t=1}^{T} \left(\widehat{e}_{it-1} \Delta \widehat{e}_{it} - \widehat{\lambda}_i \right)$

Group PP-statistic: $\widetilde{Z}_t = \sum_{i=1}^{N} \left(\widehat{\sigma}^2 \sum_{t=1}^{T} \widehat{e}_{it-1}^{2} \right)^{-1/2} \sum_{t=1}^{T} \left(\widehat{e}_{it-1} \Delta \widehat{e}_{it} - \widehat{\lambda}_i \right)$

Group ADF-statistic: $\widetilde{Z}_t^* = \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \widehat{s}_i^2 \widehat{e}_{it-1}^{*2} \right)^{-1/2} \sum_{t=1}^{T} \left(\widehat{e}_{it-1}^{*} \Delta \widehat{e}_{it}^{*} \right)$

Here, $\widehat{e}_{it}$ is the estimated residual from the initial panel regression and $\widehat{L}_{11i}^2$ is the estimated long-run covariance matrix for $\Delta \widehat{e}_{it}$. Similarly, $\widehat{\sigma}_i^2$ and $\widehat{s}_i^2 \left(\widehat{s}_i^{*2} \right)$ are the long-run and contemporaneous variances for individual i, respectively. The other terms are properly defined in Pedroni (1999) with the appropriate lag length determined by the Newey-West method. All seven tests are distributed as being standard normal asymptotically. This requires a standardisation based on the moments of the underlying Brownian motion function. The panel v-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration. The remaining statistics diverge to negative infinitely, which means that large negative values reject the null. The critical values are also tabulated by Pedroni (1999). Small sample size and strength powerful of all of these seven tests are discussed in Pedroni (1999). In samplings in which cross-section unit number is above 100, all statistics produce sufficiently persuasive results. In smaller panels, on the other hand, proofs are variable. However, as the time dimension of the panel is small ($T \approx 20$), Pedroni (1999) states that group ADF-statistics and panel-ADF statistics are generally the best indicators.

3.2.2.2 Kao cointegration test

In his paper Kao (1999) describes two tests under the null hypothesis of no cointegration for panel data. One is a Dickey-Fuller type test and another is an augmented Dickey-Fuller type test. For the Dickey-Fuller type test Kao presents two sets of specification. In the bivariate case Kao considers the following model:

$$y_{it} = \alpha_i + \beta x_{it} + e_{it}, \qquad \text{for } i=1,\ldots,N \text{ and } t=1,\ldots,T.$$

where,

$$y_{it} = y_{it-1} + u_{it}$$

$$x_{it} = x_{it-1} + \varepsilon_{it}$$

α_i are the fixed effect varying across the cross-section observations, β is the slope parameter, y_{it} and x_{it} are independent random walks for all i .The residual series e_{it} should be I(1) series. Kao then runs either the pooled auxiliary regression,

$$e_{it} = \rho e_{it-1} + \upsilon_{it}$$

or the augmented version of the pooled specification,

$$e_{it} = \tilde{\rho} e_{it-1} + \sum_{j=1}^{p} \psi_j \Delta e_{it-j} + \upsilon_{it}$$

Under the null of no cointegration, Kao shows that following the statistics,

$$DF_\rho = \frac{\sqrt{N}T(\hat{\rho}-1)+3\sqrt{N}}{\sqrt{10.2}}$$

$$DF_t = \sqrt{1.25}t_\rho + \sqrt{1.875N}$$

$$DF_\rho^* = \frac{\sqrt{N}T(\hat{\rho}-1)+3\sqrt{N}\hat{\sigma}_\upsilon^2 / \hat{\sigma}_{0\upsilon}^2}{\sqrt{3+36\hat{\sigma}_\upsilon^4 / (5\hat{\sigma}_{0\upsilon}^4)}}$$

$$DF_t^* = \frac{t_\rho + \sqrt{6N}\hat{\sigma}_\upsilon / (2\hat{\sigma}_{0\upsilon})}{\sqrt{\hat{\sigma}_{0\upsilon}^2 / (2\hat{\sigma}_\upsilon^2) + 3\hat{\sigma}_\upsilon^2 / (10\hat{\sigma}_{0\upsilon}^2)}}$$

and for p>0 (i.e. the augmented version),

$$ADF = \frac{t_{ADF} + \sqrt{6N}\hat{\sigma}_\upsilon / (2\hat{\sigma}_{0\upsilon})}{\sqrt{\hat{\sigma}_{0\upsilon}^2 / (2\hat{\sigma}_\upsilon^2) + 3\hat{\sigma}_\upsilon^2 / (10\hat{\sigma}_{0\upsilon}^2)}}$$

converge to N(0,1) asymptotically, where the estimated variance is $\hat{\sigma}_\upsilon^2 = \hat{\sigma}_u^2 - \hat{\sigma}_{u\varepsilon}^2 \sigma_\varepsilon^{-2}$ with estimated long variance $\hat{\sigma}_{0\upsilon}^2 = \hat{\sigma}_{0u}^2 - \hat{\sigma}_{0u\varepsilon}^2 \sigma_{0\varepsilon}^{-2}$.

3.2.2.3 Fisher Johansen cointegration test

Fisher (1932) derives a combined test that uses the results of the individual independent tests. Maddala and Wu (1999) use Fisher's result to propose an alternative approach to testing for cointegration in panel data by combining tests from individual cross-sections to obtain a test statistic for the full panel. If π_i is the p-value from an individual cointegration test for cross-section i, then under the null hypothesis for the panel

$$-2\sum_{i=1}^{N} \log(\pi_i) \rightarrow \chi_{2N}^2$$

where χ^2 value is based on MacKinnon, Haug and Michelis (1999) p-values for Johansen's cointegration trace test and maximum eigenvalue test.

3.3 Granger causality test

As Granger (1987) points out, if there exists a cointegrating vector between variables there is causality among these variables at least in one direction. Therefore to determine the direction of causality, error correction models (ECM) as in formulas below are estimated:

$$\Delta x_t = \alpha_1 + \beta_1 ect_{t-1} + \sum_{i=1}^{m} a_i \Delta x_{t-i} + \sum_{i=1}^{n} b_i \Delta y_{t-i} + e_{1t}$$

$$\Delta y_t = \alpha_2 + \beta_2 ect_{t-1} + \sum_{i=1}^{m} c_i \Delta y_{t-i} + \sum_{i=1}^{n} d_i \Delta x_{t-i} + e_{2t}$$

where x_t and y_t are the variables which are cointegrated, Δ is the difference operator, m and n are the lag lengths of the variables, ect*s* are the residuals from the cointegrating equations and e_{1t} and e_{2t} are white noise residuals (Engle and Granger, 1987). The error correction model opens up an additional channel for causality through the error correction term which is not present in standard Granger causality tests. Therefore, causality can also be tested by examining the statistical significance of the error correction term by a separate t-test, the joint significance of the lags of each explanatory variable by an F-test or Wald χ^2-test, or by testing the error correction terms and lagged terms of each explanatory variable simultaneously by a joint F-test or Wald χ^2-test.

4. EMPIRICAL RESULTS

4.1 Data

The validity of the ELG hypothesis is tested using data from 33 OECD countries (Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the USA) and cover the annual time frame from 1985-2010. The data on gross domestic product (GDP), exports of goods and services, imports of goods and services, gross fixed capital formation, interest rates, exchange rates (national currency against the US dollar), unemployment rate, employment, GDP deflator, consumer price index (CPI), export and import unit value indices are collected from IMF, the International Financial Statistics Yearbook. The data on labour force is taken from the OECD database. Due to the non-availability of data for all countries for the period 1985-2010, the analysis that follows is based on the annual data on each country for the periods specified in the parentheses: Austria (1990-2010); Chile (2000-2010); the Czech Republic (1993-2010); Estonia (1994-2010); Finland (1988-2010); Germany, Iceland and Poland (1991-2010); Hungary (1992-2010); Korea and Turkey (1989-2010); Mexico (1990-2010); the Netherlands (1986-2010); the Slovak Republic (2000-2008) and Slovenia (1992-2006).

GDP, non-export GDP (GDP minus exports) and gross fixed capital formation as a proxy of domestic investment are deflated by the GDP deflator (2005 = 100). Real exports and real imports are derived by dividing them by their respective unit value index. In the cases of Belgium, Chile, the Czech Republic, Denmark, France, Iceland, Poland, the Slovak Republic and Slovenia unit value indices of exports and imports are not available, therefore, the consumer price indices are used instead. The rate of employment is calculated by dividing employment by the labour force. All but the interest rate, unemployment and employment rate variables are transformed to natural logarithms.

The real GDP is denoted by RGDP, real GDP net of exports by RGDP_less_X, real exports of goods and services by RX, real imports of goods and services by RIMP and real gross fixed capital formation by RINV. Moreover, interest rate is denoted by IR, exchange rate by XR and unemployment rate and rate of employment are denoted by UR and ER, respectively.

4.2 Individual economy's Granger causality tests

In this section, Granger causality relations between output, exports and imports are investigated for each economy using its time series data. Before analyzing the causality relations, unit root tests are employed to check the stationarity properties of each series. In the case of stationary variables, a standard Granger causality would be applied using the levels of time series. If variables are non-stationary in levels and they are stationary in first differences, I(1), the Johansen cointegration test is carried out to determine if a long-term relationship exists among the time series. Once cointegration is detected, causality tests are performed using an error correction model. If no cointegration is detected, a vector autoregression (VAR) model is estimated in first differences and then trivariate Granger causality procedures are applied.

4.2.1 Unit root tests

Before testing for cointegration, it is important to know the stationarity properties of the data to ensure that incorrect inferences are not made. The presence of unit roots in time series is tested using three different tests. The most commonly used tests of a unit root in time series data are the augmented Dickey-Fuller (ADF) test in which the null hypothesis is non-stationarity and the KPSS test proposed by Kwiatkowski, Phillips, Schmidt and Shin (1992) which tests for the null hypothesis of stationarity. In addition, there are some other tests which have higher power in the sense that the tests are more likely to reject the null hypothesis of a unit root and accept the alternative hypothesis of no unit root. The

DF-GLS unit root test proposed by Elliott, Rothenberg and Stock (1996) is conducted for confirmatory analysis. This test requires much shorter sample sizes than the conventional unit root tests to attain the same statistical power. However, the test critical values available for application are calculated for 50 observations. Therefore, we need to be cautious when we interpret the test results. The appropriate lag length selected based on Schwarz Bayesian information criterion (SBC) for ADF and DF-GLS tests whereas the lag length is based on Newey-West using Bartlett kernel for the KPSS test.

Table 4 presents the results from ADF and DF-GLS unit root tests and KPSS stationarity test for the level RGDP series and its first differences, for each country. As regards the level series, the three tests yield very similar results for Chile, Estonia, Germany, Greece, Hungary, Israel, Italy, Japan, Korea, the Netherlands, Norway, Poland, Portugal, the Slovak Republic, Sweden and the USA. In these cases, it is confirmed the existence of unit roots in the level of RGDP but its first difference is stationary under the three tests. Therefore, it is concluded that the RGDP series is integrated in the first differences, I(1), for these countries. Mixed results are provided in the cases of Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, France, Iceland, Ireland, Mexico, New Zealand, Slovenia, Spain, Switzerland and the UK. On the one hand, ADF and DF-GLS tests indicate the presence of a unit root in the level. On the other hand, the null hypothesis of stationarity in KPSS test cannot be rejected at conventional levels of statistical significance. However, all the three tests confirm stationarity in first difference series. Therefore, RGDP series is considered I(1) for these countries. Exceptions are RGDP for Finland and Turkey which are proved integrated in the level, I(0).

Table 4. Unit root tests in level and first difference for real GDP series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-1.8821	0.114786	-1.979963	-3.5475**	0.127245	-3.392321*
Austria	-2.3050	0.115259	-2.551994	-3.4202**	0.146039	-3.478426*
Belgium	-1.5972	0.088608	-1.774618	-4.4183*	0.118619	-4.490651*
Canada	-2.5142	0.094611	-2.661416	-2.9617***	0.112788	-3.028932*
Chile	-2.0993	0.155458**	-2.251424	-2.6249	0.133347	-2.817932**
Czech Republic	-2.9015	0.086113	-3.137902***	-3.9609*	0.085193	-4.262678*
Denmark	-0.7618	0.112794	-2.104196	-3.9111*	0.200755	-3.571622*
Estonia	-2.9310	0.135121***	-2.876821	-3.1696**	0.257191	-3.030201*
Finland	-3.7823**	0.113291	-3.054084***	–	–	–
France	-2.5113	0.097476	-2.851335	-3.1601*	0.265042	-3.223108*
Germany	-2.1853	0.138198***	-2.769298	-3.6434**	0.285775	-3.666488*
Greece	-2.8895	0.156011**	-2.061945	-1.2715	0.165115	-2.185763**
Hungary	-1.0056	0.122710***	-2.801404	-0.3763	0.226338	-0.878091
Iceland	-2.2944	0.089075	-2.793902	-2.2480	0.162298	-2.014472**
Ireland	-1.4285	0.113870	-2.172082	-1.7547	0.248674	-1.816667***
Israel	-1.5272	0.156939**	-1.629568	-4.2075*	0.153582	-4.302176*
Italy	-0.2210	0.183463**	-0.796444	-3.5734**	0.583689**	-3.583879*
Japan	-2.1572	0.160503**	-1.053061	-1.4246	0.495231**	-1.707145***
Korea	-2.3686	0.175871**	-2.259244	-4.3536*	0.383513***	-4.206282*
Mexico	-2.3103	0.093187	-2.530554	-4.5481*	0.130945	-4.564004*
Netherlands	-1.7423	0.173226**	-2.357503	-3.1226**	0.268694	-3.126746*
New Zealand	-2.7680	0.085032	-3.005741***	-3.2002**	0.115693	-3.272104*
Norway	-1.5802	0.130159***	-1.933504	-2.3481	0.246335	-2.312788**
Poland	-1.3156	0.124816***	-2.532072	-3.1213**	0.186662	-3.115493*
Portugal	-1.4813	0.156255**	-1.899284	-2.6679***	0.415604***	-2.663915**
Slovak Republic	-1.1913	0.148786**	-2.366716	-1.5360	0.374431***	-1.621879***
Slovenia	-2.1242	0.099367	-2.412517	-3.8502**	0.112200	-2.742772**
Spain	-2.3252	0.077845	-2.804705	-2.6258***	0.224801	-2.705734*
Sweden	-2.3771	0.121694***	-2.360164	-3.5687**	0.107668	-3.586313*
Switzerland	-2.7094	0.097376	-1.944475	-3.5631**	0.084682	-3.632032*
Turkey	-4.2684**	0.114002	-6.011520*	–	–	–
UK	-2.8290	0.095544	-3.066233***	-3.4028**	0.220934	-2.648770**
USA	-1.6011	0.128547***	-2.108524	-3.1009**	0.283447	-3.110012*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.
* Signifies the rejection of the unit root hypothesis at 1% significance level.
** Signifies the rejection of the unit root hypothesis at 5% significance level.
*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 5. Unit root tests in level and first difference for real GDP net of exports series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-1.5609	0.097802	-1.714001	-5.2630*	0.132187	-5.202765*
Austria	-2.4940	0.130712***	-2.892614***	-4.7827*	0.237749	-4.611690*
Belgium	-3.3711**	0.125386***	-3.575812**	-8.1660*	0.283207	-8.225666*
Canada	-0.6457	0.171759**	-0.887215	-4.0153*	0.251579	-4.098667*
Chile	-3.8230**	0.100800	-3.533933**	–	–	–
Czech Republic	-2.7628	0.139147***	-2.438465	-5.8995*	0.421598***	-5.782406*
Denmark	-1.6284	0.161119**	-1.755983	-6.1626*	0.289381	-5.556944*
Estonia	-3.0158	0.126144***	-3.258399**	-5.1901*	0.500000**	-5.134169*
Finland	-4.5765*	0.135765***	-1.589312	-3.5522**	0.210395	-3.531115*
France	-2.5526	0.067985	-2.353458	-4.8153*	0.284601	-4.502281*
Germany	-2.3344	0.148505**	-2.154203	-4.0887*	0.345039	-4.159969*
Greece	-1.9937	0.167092**	-1.885661	-4.0509*	0.140382	-3.692421*
Hungary	-4.0089*	0.147077**	-2.843526	-3.1779**	0.296908	-3.876836*
Iceland	-2.5218	0.139955***	-3.340032**	-1.8350	0.356776***	-1.490704
Ireland	-0.1767	0.117645	-1.896726	0.8322	0.350242***	-0.363093
Israel	-2.2978	0.113265	-2.220544	-3.6672**	0.137102	-3.751104*
Italy	-1.4711	0.149412**	-1.384316	-3.5339**	0.469934**	-1.774659***
Japan	-4.8263*	0.175120**	-1.397095	-2.7958***	0.547787**	-1.638812***
Korea	-1.9016	0.148163**	-2.122444	-4.7539*	0.318417	-4.814797*
Mexico	-1.5641	0.137892***	-1.947489	-3.8135**	0.265240	-3.812140*
Netherlands	-0.7153	0.192173**	-1.543581	-7.7162*	0.312539	-7.077598*
New Zealand	-4.1581**	0.072861	-4.032183*	–	–	–
Norway	-2.0586	0.167236**	-2.091171	-5.9863*	0.186683	-5.519752*
Poland	-1.3265	0.139272***	-1.754292	-2.9251***	0.280205	-3.001610*
Portugal	-1.3151	0.141264***	-1.398672	-4.0399*	0.371037***	-4.091773*
Slovak Republic	-2.5936	0.338152*	-3.077616***	-2.7192	0.500000**	-2.719755**
Slovenia	0.6704	0.161787**	-1.164236	-1.6786	0.472789**	-1.826958***
Spain	-2.0408	0.064828	-1.600993	-2.2326	0.244245	-2.365177**
Sweden	-2.1232	0.068922	-2.108640	-4.6491*	0.110251	-4.389937*
Switzerland	-2.5024	0.162222**	-2.206888	-4.0616*	0.233718	-4.159455*
Turkey	-6.1537*	0.158374**	-4.472742*	-12.603*	0.310417	-1.020037
UK	-1.3203	0.087290	-1.821241	-2.9895***	0.275312	-2.720917*
USA	-1.3841	0.120609***	-1.931028	-2.2576	0.282949	-2.246120**

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 5 reports the results from unit root tests for the non-export RGDP series. ADF, KPSS and DF-GLS tests indicate unanimously the existence of a unit root in the level of RGDP net of exports series in the cases of Canada, the Czech Republic, Denmark, Germany, Greece, Italy, Korea, Mexico, the Netherlands, Norway, Poland, Portugal, Slovenia, Switzerland and the USA. Furthermore, the three tests show that the first difference of non-export RGDP series for these countries is stationary. As concerns the rest of the countries, the RGDP net of exports may be considered as I(1) series, too. Despite the mixed results from unit root tests in the level for the cases of Australia, Austria, Belgium, Estonia, Finland, France, Hungary, Iceland, Ireland, Israel, Japan, the Slovak Republic, Spain, Sweden, Turkey and the UK, the unit root tests in first differenced series confirm that the RGDP net of exports is I(1). Stationarity in the level of non-export RGDP series is supported by the empirical results only in the cases of Chile and New Zealand.

Table 6 provides the results from ADF, KPSS and DF-GLS tests for real exports series. In generally, the presence of a unit root in the level series cannot be rejected at conventional levels of statistical significance whereas the stationarity in the first difference of RX series is supported by the evidence. Only exception is real exports for Switzerland that is stationary in the level, I(0). Therefore, it is concluded that RX series for all countries but Switzerland is integrated in first differences, I(1).

Table 6. Unit root tests in level and first difference for real exports series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-0.7618	0.193828**	-0.905726	-4.3198*	0.547606**	-1.576101
Austria	-1.6553	0.096399	-1.813345	-3.9297*	0.120124	-3.976941*
Belgium	-3.1840	0.068615	-3.274092**	-5.5424*	0.161423	-5.347789*
Canada	0.3266	0.180289**	-1.269065	-3.2013**	0.452247***	-3.266550*
Chile	-1.0468	0.168311**	-2.533477	-0.6115	0.270985	-0.841327
Czech Republic	-3.0234	0.102556	-3.178361***	-3.9647*	0.254446	-3.979446*
Denmark	-2.1335	0.140981	-2.735733	-4.5663*	0.173944	-4.142093*
Estonia	-1.9967	0.134876***	-2.240108	-4.1942*	0.257834	-4.366232*
Finland	-0.9705	0.141377***	-1.373271	-3.8106*	0.210435	-3.859936*
France	-1.9305	0.133214***	-2.036466	-4.7987*	0.112077	-4.268870*
Germany	-3.2595	0.100325	-2.306741	-3.9028*	0.110784	-3.995116*
Greece	-0.9587	0.118826	-1.415004	-4.3350*	0.258371	-3.770160*
Hungary	-1.3101	0.160218**	-1.581343	-4.1037*	0.201512	-3.567562*
Iceland	-1.7306	0.102570	-1.956116	-4.0155*	0.195029	-3.620017*
Ireland	0.4652	0.139422***	-1.250658	-2.9125***	0.265489	-2.762465*
Israel	-0.0123	0.183693**	-0.808188	-3.6300**	0.569513**	-2.994746*
Italy	-0.6295	0.194372**	-1.023185	-4.2197*	0.438985***	-4.308911*
Japan	-2.7154	0.077887	-2.815553	-2.7393***	0.105547	-2.260464**
Korea	-1.7485	0.135858***	-1.912230	-4.1270*	0.109567	-4.140501*
Mexico	-0.8263	0.159443**	-1.400049	-1.4625	0.376290***	-2.793841*
Netherlands	-0.8284	0.146006**	-1.165412	-4.1138*	0.274836	-4.051569*
New Zealand	-1.8400	0.152712**	-2.018474	-5.0048*	0.243715	-4.227138*
Norway	-0.0478	0.202039**	-0.962762	-2.3253	0.686058**	-2.144103**
Poland	-3.1382	0.126234***	-2.911600***	-4.4776*	0.166915	-4.291546*
Portugal	-0.7301	0.162666**	-1.200792	-2.8327***	0.274088	-2.887920*
Slovak Republic	-2.3583	0.120221***	-2.805106	-2.2511	0.437500***	-2.478397**
Slovenia	-1.3511	0.175957**	-1.969629	-3.7420**	0.420633***	-3.865438*
Spain	0.0909	0.157824**	-2.500544	-3.2664**	0.320684	-3.306498*
Sweden	-1.7569	0.100577	-1.773992	-4.3884*	0.143313	-4.467469*
Switzerland	-3.7690**	0.082521	-3.553113**	–	–	–
Turkey	0.7621	0.172085**	-3.223549**	-0.4850	0.443285***	-1.761583***
UK	-0.1859	0.134318***	-1.686274	-3.6590**	0.264619	-3.692896*
USA	-1.8388	0.178449**	-1.683634	-4.0526*	0.344777	-4.147647*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 7. Unit root tests in level and first difference for real imports series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-3.0593	0.127234***	-2.978272***	-4.9513*	0.248789	-4.613395*
Austria	-1.8794	0.125581***	-1.648589	-2.2524	0.190840	-3.720092*
Belgium	-3.3420***	0.071419	-3.375205**	–	–	–
Canada	-1.2780	0.178385**	-1.482399	-4.2233*	0.347070***	-4.051061*
Chile	-3.0346	0.264271*	-3.546716**	-2.7995***	0.281466	-2.310607**
Czech Republic	-4.4052**	0.085831	-4.348063*	–	–	–
Denmark	-2.9526	0.094567	-2.860039	-4.5396*	0.134816	-4.334742-
Estonia	-1.5825	0.127683***	-1.866715	-3.7210**	0.188137	-3.878232*
Finland	-1.5235	0.093026	-1.685050	-3.7851**	0.130377	-3.761480*
France	-2.7248	0.100360	-2.627532	-4.6957*	0.082297	-4.083008*
Germany	-3.1006	0.108310	-2.964939***	-3.6060**	0.092007	-3.727203*
Greece	-1.3700	0.100073	-1.684796	-5.2251*	0.164851	-5.238573*
Hungary	-0.7325	0.184760**	-1.173678	-3.7463**	0.510520**	-3.682712*
Iceland	-3.6386***	0.075239	-4.361122*	–	–	–
Ireland	-0.9253	0.123035***	-1.503686	-2.7341***	0.229717	-2.780093*
Israel	0.6287	0.197665**	-0.857839	-3.7989*	0.622477	-2.973446*
Italy	-1.2940	0.179624**	-1.377669	-4.3065*	0.564691**	-4.147893*
Japan	-1.2146	0.186027**	-0.680007	-2.1760	0.553203**	-1.426859
Korea	-2.8010	0.168063**	-2.664164	-4.7135*	0.381068***	-4.045988*
Mexico	-0.5459	0.164120**	-1.672146	-2.1052	0.444566***	-2.122966**
Netherlands	-0.7749	0.124751***	-1.068524	-3.6886**	0.205260	-3.739179*
New Zealand	-3.0029	0.074383	-3.135000***	-6.0912*	0.212974	-6.236314*
Norway	-3.3409***	0.103411	-1.876429	-4.0331*	0.127796	-3.742206*
Poland	-2.7830	0.076381	-2.651252	-4.0385*	0.116364	-3.286062*
Portugal	-2.1851	0.168008**	-1.768693	-3.0352**	0.472399**	-3.017548*
Slovak Republic	-6.0422**	0.106362	-5.072155*	–	–	–
Slovenia	-1.2044	0.124518***	-2.316419	-2.6350	0.162517	-2.683526**
Spain	-2.2610	0.182339**	-1.105923	-4.7133*	0.571776**	-2.493492**
Sweden	-2.2221	0.093867	-2.333658	-4.3671*	0.113781	-4.155753*
Switzerland	-3.6683**	0.068089	-3.812269*	–	–	–
Turkey	0.9833	0.175082**	-4.217920*	-0.9529	0.494604**	-0.991750
UK	-1.9763	0.108654	-2.370474	-3.3150**	0.229715	-3.336188*
USA	-0.6500	0.119347***	-1.989753	-3.7292**	0.235567	-3.384138*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 7 reports the unit root tests results for real imports series. ADF, KPSS and DF-GLS tests indicate the existence of a unit root in the level as well as stationarity in the first difference of RIMP series in the cases of Austria, Canada, Estonia, Hungary, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, Portugal, Slovenia, Spain and the USA. As regards the level of real imports for Australia, Chile, Denmark, Finland, France, Germany, Greece, New Zealand, Norway, Poland, Sweden, Turkey and the UK, ADF and DF-GLS yield very similar results since the null hypothesis of non-stationarity in both tests cannot be rejected at 5% significance level. However, the null hypothesis of the existence of a unit root is rejected for first differenced series, indicating that RIMP series for these countries are first differenced stationary or integrated of order one, I(1). Exceptions are real imports for Belgium, the Czech Republic, Iceland, the Slovak Republic and Switzerland which are stationary in the level, I(0).

Table 8 summarises the results from unit root tests for real investment series. ADF and DF-GLS unit root tests as well as KPSS stationarity test indicate that the level of RINV for Belgium, the Czech Republic, France, Germany, Iceland, Mexico, Norway, Poland, Spain, Turkey and the UK is stationary, I(0). As a whole, the presence of a unit root in the level of RINV series for the rest of the countries cannot be rejected. Regardless the mixed results of the three tests in the level, the first difference of real investment series is ascertained stationary, I(1), under ADF, KPSS and DF-GLS tests.

The results from unit root tests for interest rate series are depicted in Table 9. It is evident that the level of IR series for Canada, Iceland, the UK and the USA is stationary since the null hypothesis of a unit root in both ADF and DF-GLS tests are rejected whereas the null of stationarity in KPSS test cannot be rejected at conventional levels of significance. As regards the rest of the countries, the three unit root tests detect, in many cases unambiguously, the existence of unit root in level series while the first differenced series is indicated stationary. Therefore, IR series is integrated of order one, I(1), for all cases except for Canada, Iceland, the UK and the USA.

Table 8. Unit root tests in level and first difference for real investment series.

	Level			**First difference**		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-2.4733	0.158538**	-2.371527	-4.0652*	0.149493	-3.251124*
Austria	-1.5081	0.172795**	-1.789291	-3.9820*	0.325540	-3.783901*
Belgium	-3.6889**	0.056082	-3.841736*	–	–	–
Canada	-1.5406	0.126437***	-2.394434	-3.4030**	0.079515	-3.454099*
Chile	-3.1180	0.500000*	-3.539608**	-4.4268**	0.397262***	-4.808093*
Czech Republic	-6.4032*	0.063360	-5.975170*	–	–	–
Denmark	-2.9941	0.101733	-2.973842***	-2.9965**	0.137742	-2.642475**
Estonia	-1.7304	0.118668	-2.404649	-2.1784	0.289886	-2.272608**
Finland	-4.7146*	0.119611***	-3.726638**	-2.5668	0.138101	-2.429997**
France	-3.2667***	0.100660	-3.415991**	–	–	–
Germany	-3.4853***	0.073707	-3.669584**	–	–	–
Greece	-1.9095	0.071343	-2.340703	-3.4778**	0.201142	-3.442371*
Hungary	1.0666	0.177127**	-1.078199	-2.6145	0.405570***	-2.349030**
Iceland	-4.3505**	0.097505	-4.409248*	–	–	–
Ireland	-1.5492	0.125579***	-2.645953	-0.9076	0.274802	-1.072843
Israel	-3.5942***	0.142803***	-2.745987	-2.0899	0.164702	-3.684760*
Italy	-1.6357	0.082658	-1.896989	-4.4998*	0.130085	-4.541977*
Japan	-2.7441	0.140863***	-1.680181	-1.3553	0.390493***	-1.571866
Korea	-3.1743	0.096136	-3.115693***	-4.2753*	0.239768	-3.425073*
Mexico	-3.6798***	0.058469	-3.898553*	–	–	–
Netherlands	-2.7446	0.124457***	-3.113023***	-3.7051**	0.204049	-3.892863*
New Zealand	-2.3256	0.098573	-2.277546	-3.6988**	0.144412	-3.142897*
Norway	-3.6947**	0.082315	-3.754339**	–	–	–
Poland	-4.3896**	0.108297	-4.288490*	–	–	–
Portugal	-2.8732	0.141525***	-2.838942	-3.4192**	0.295169	-3.198205*
Slovak Republic	-3.2890	0.114357	-3.561480**	-2.1568	0.500000**	-2.487859**
Slovenia	-2.5029	0.130586***	-2.547543	-2.1716	0.164864	-2.267532**
Spain	-3.2741***	0.080860	-3.664695**	–	–	–
Sweden	-2.3817	0.135479***	-2.480738	-2.9611***	0.086639	-3.017332*
Switzerland	-2.6308	0.110854	-2.762326	-3.0367**	0.085788	-2.981079*
Turkey	-3.4954***	0.077133	-3.216198**	–	–	–
UK	-3.6052***	0.072531	-3.673471**	–	–	–
USA	-2.5028	0.106303	-2.578456	-2.8070***	0.181445	-2.865748*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 9. Unit root tests in level and first difference for interest rate series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-2.4593	0.166535**	-2.433618	-4.5861*	0.218363	-4.180747*
Austria	-2.6540	0.159993**	-2.303234	-4.1515*	0.246660	-4.276219*
Belgium	-3.0170	0.080066	-3.183328***	-3.7033**	0.065066	-3.604575*
Canada	-3.9455**	0.082664	-4.102565*	–	–	–
Chile	-2.2043	0.145900***	-2.348094	-2.5618	0.173245	-2.680100**
Czech Republic	-2.1384	0.080973	-2.122428	-2.9931***	0.128611	-3.078463*
Denmark	-2.2799	0.097717	-2.410375	-4.7711*	0.064787	-4.743115*
Estonia	-2.5705	0.094162	-2.805795	-3.8477**	0.374765	-3.902989*
Finland	-1.8098	0.145500***	-1.881581	-4.9938*	0.104182	-4.183429*
France	-2.2305	0.080542	-2.329552	-5.0461*	0.056224	-4.367845*
Germany	-3.2235	0.162302**	-2.758717	-4.0999*	0.274937	-4.124967*
Greece	-2.5493	0.096408	-2.369804	-3.3112**	0.146172	-3.338333*
Hungary	-2.2212	0.113516	-2.349152	-4.0871*	0.339571	-3.892945*
Iceland	-4.4901**	0.106582	-4.279987*	–	–	–
Ireland	-2.8245	0.092049	-2.951517***	-5.0024*	0.321753	-5.005521*
Israel	-96.241*	0.130880***	-1.312246	-4.2007*	0.331959	0.325938
Italy	-2.0849	0.092579	-2.187178	-4.8804*	0.099848	-4.520437*
Japan	-1.6903	0.091689	-2.785136	-4.3415*	0.096909	-0.254683
Korea	-2.8882	0.090317	-2.944072***	-5.1813*	0.150020	-5.183216*
Mexico	-2.8518	0.094502	-3.316666**	-4.4032*	0.392859***	-3.497562*
Netherlands	-3.4955***	0.086427	-2.400764	-3.7749**	0.127491	-3.879121*
New Zealand	-3.2105	0.164252**	-2.505132	-6.9858*	0.345376	-4.423114*
Norway	-1.6073	0.170766**	-1.720250	-4.8549*	0.137577	-4.624194*
Poland	-6.5128*	0.143680***	-4.469636*	-4.9983*	0.328957	-0.799454
Portugal	-0.6164	0.191765**	-0.821566	-4.8927*	0.523205**	-0.087308
Slovak Republic	-0.8545	0.141105***	-1.310633	-2.5159	0.282769	-2.736865**
Slovenia	-12.285*	0.152530**	-3.508170**	-13.546*	0.422752***	-1.082474
Spain	-2.1048	0.093559	-2.119498	-5.4557*	0.082650	-5.077998*
Sweden	-2.7650	0.097428	-2.816797	-5.8643*	0.080951	-4.304684*
Switzerland	-2.4049	0.074563	-2.300496	-4.0743*	0.100649	-4.094954*
Turkey	-3.4063***	0.168213**	-3.259153**	-6.9888*	0.320698	-7.019259*
UK	-3.5750***	0.067895	-3.760184**	–	–	–
USA	-5.8253*	0.063470	-6.038721*	–	–	–

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 10. Unit root tests in level and first difference for exchange rate series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-1.0976	0.124014***	-1.356264	-3.6047**	0.191697	-3.692930*
Austria	-2.0302	0.128243***	-2.200180	-2.9671**	0.123396	-3.014991*
Belgium	-3.1537	0.096339	-2.161533	-4.1875*	0.261301	-2.954009*
Canada	-0.5473	0.143741***	-1.391362	-2.8095***	0.211322	-2.891635*
Chile	-3.1293	0.091172	-3.180778***	-2.3422	0.269557	-2.356273**
Czech Republic	-1.2679	0.136069***	-1.861105	-2.5249	0.234458	-2.610777**
Denmark	-3.0726	0.095470	-2.200648	-4.2794*	0.230956	-3.078568*
Estonia	-3.0471	0.143230***	-2.878405	-2.5922	0.196182	-2.543361**
Finland	-2.1611	0.152249**	-2.287211	-4.1192*	0.176378	-4.246772*
France	-2.8952	0.095389	-2.152334	-4.3113*	0.218438	-3.079595*
Germany	-2.3480	0.128585***	-2.569269	-2.8414***	0.118005	-3.337776*
Greece	-0.6030	0.176647**	-1.441470	-3.2697**	0.306379	-3.342169*
Hungary	-2.0981	0.150760**	-2.851498	-1.9058	0.406622***	-1.904333***
Iceland	-2.7735	0.072206	-2.840756	-3.3407**	0.138064	-3.392918*
Ireland	-2.5155	0.101350	-2.085382	-4.3444*	0.152237	-3.145689*
Israel	-0.6919	0.196966**	-0.841753	-4.3241*	0.788366*	0.248515
Italy	-2.0140	0.124754***	-1.993003	-4.1208*	0.138426	-3.056199*
Japan	-2.9862	0.155578**	-1.804080	-3.9733*	0.298953	-2.590866**
Korea	-1.8291	0.150951**	-1.922319	-3.8898*	0.174339	-4.004948*
Mexico	-1.2156	0.149364**	-1.354999	-3.4526**	0.264952	-3.547059*
Netherlands	-1.9559	0.096821	-2.057902	-4.3166*	0.110771	-3.569883*
New Zealand	-2.5599	0.088222	-2.700594	-3.4993**	0.071263	-3.488109*
Norway	-2.0122	0.109892	-1.905343	-4.2346*	0.137413	-3.502832*
Poland	-1.8672	0.151214**	-1.979336	-3.1170**	0.179701	-4.451249*
Portugal	-1.5456	0.131096***	-1.606340	-4.0304*	0.102207	-3.647312*
Slovak Republic	-9.1726*	0.500000*	-11.24117*	-7.3868*	0.500000**	-7.167700*
Slovenia	0.2946	0.154152**	-2.642053	-3.0726***	0.531410**	-2.738488**
Spain	-2.0309	0.109898	-2.025693	-3.6576**	0.159240	-3.053051*
Sweden	-2.3783	0.109771	-2.203882	-4.3947*	0.109283	-3.598774*
Switzerland	-3.4466***	0.108933	-2.648825	-4.5931*	0.168763	-2.970783*
Turkey	0.5568	0.172240**	-2.765003	-0.9385	0.448391***	-1.762287***
UK	-3.0561	0.066745	-2.945365***	-4.0345*	0.215908	-3.482622*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept. Tests results for the USA are not provided since the exchange rate for the USA is 1, the natural logarithm of XR is 0.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

The ADF, KPSS and DF-GLS tests are also implemented to examine the stationarity properties of exchange rate series. The results are reported in Table 10. In general, the presence of unit roots in the level of XR series cannot be rejected at conventional levels of significance for all OECD countries. However, there is evidence for stationarity in first differenced XR series. Therefore, it is concluded that exchange rate series for all countries is integrated in first differences, I(1).

The results from the unit root tests and the stationarity test for the unemployment rate series are presented in Table 11. The ADF, KPSS and DF-GLS tests indicate that the level of unemployment rate for Belgium, Japan, the Netherlands, Norway and the Slovak Republic is stationary, I(0). In addition, the table also shows that the null hypothesis in both ADF and DF-GLS tests cannot be rejected while the null in KPSS test is rejected in the cases of Australia, the Czech Republic, Hungary, Iceland, Ireland, Italy, Portugal, Slovenia and Turkey. Considering that their first differenced series is stationary, one can infer that unemployment rate series for these countries is integrated of order one, I(1). For the rest of the countries, the results from unit root tests in the level of UR may be conflicting but the findings from the analysis in the first differenced series confirm that unemployment rate is integrated in first differences, I(1).

Finally, employment rate series is tested for unit roots. The results from ADF, KPSS and DF-GLS tests are provided in Table 12. Despite trifling differences among the results from unit root tests, it is concluded from Table 12 that the non-stationarity in the level of ER series cannot be rejected for all cases apart from Japan, Norway and Turkey. Furthermore, the presence of unit roots in the first difference of employment rate series is rejected. Therefore, ER series is integrated in first differences, I(1), for all OECD countries but Japan, Norway and Turkey.

Table 11. Unit root tests in level and first difference for unemployment rate series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-2.8731	0.124647***	-2.886137	-4.1089*	0.111733	-3.191778*
Austria	-3.2668	0.099524	-2.838994	-3.5788**	0.181130	-4.275898*
Belgium	-3.3190***	0.081445	-3.495384**	–	–	–
Canada	-3.2200	0.086069	-3.366302**	-3.1719**	0.092264	-3.048740*
Chile	-3.0366	0.500000*	-3.436276**	-4.0564**	0.500000**	-4.239390*
Czech Republic	-2.4358	0.143268***	-2.583993	-3.2713**	0.140659	-3.409478*
Denmark	-2.8595	0.104205	-2.770773	-2.6399***	0.110135	-2.573064**
Estonia	-2.3268	0.096187	-2.826442	-2.4756	0.164539	-2.251245**
Finland	-3.7214**	0.139900***	-3.017541***	-2.1456	0.239799	-2.149923**
France	-2.5225	0.109217	-2.640999	-3.2521**	0.077094	-3.316247*
Germany	-3.0667	0.068384	-3.218640**	-3.1586**	0.131253	-3.197774*
Greece	-2.6515	0.146502**	-2.927799***	-1.6387	0.125240	-1.786703***
Hungary	-0.3802	0.168340**	-0.896971	-3.5376**	0.277614	-3.115838*
Iceland	-1.0668	0.127556***	-2.472889	-3.3491**	0.166199	-3.378413*
Ireland	1.0592	0.142303***	-1.817374	-0.5448	0.303625	-0.763198
Israel	-2.4568	0.090092	-2.579974	-3.2287**	0.150981	-3.296148*
Italy	-2.4299	0.142018***	-2.048210	-3.6328**	0.164228	-3.183924*
Japan	-4.3089**	0.095119	-3.202778**	–	–	–
Korea	-2.7938	0.109103	-2.970176***	-3.8530*	0.140244	-3.946702*
Mexico	-2.4310	0.093558	-1.848243	-3.5899**	0.089484	-3.669445*
Netherlands	-4.8930*	0.112504	-3.446692**	–	–	–
New Zealand	-3.0994	0.118309	-2.727764	-2.6950***	0.142841	-2.756196*
Norway	-4.1894**	0.115272	-3.559030**	–	–	–
Poland	-3.7976**	0.108227	-2.631588	-2.4454	0.128131	-2.400286**
Portugal	-2.3952	0.155767**	-2.247970	-2.2157	0.418426***	-2.264233**
Slovak Republic	-3.6934***	0.116187	-3.849225*	–	–	–
Slovenia	-3.2186	0.158731**	-1.510077	-2.6222	0.341090	-3.687027*
Spain	-2.0521	0.088814	-2.497280	-2.5729	0.158683	-2.516952**
Sweden	-2.6970	0.100625	-2.784215	-2.7550***	0.079028	-2.764737*
Switzerland	-2.9313	0.117109	-3.041033***	-3.6531**	0.079923	-3.714022*
Turkey	-2.4050	0.150849**	-2.313374	-5.1354*	0.207068	-4.188442*
UK	-3.0631	0.118144	-3.353987**	-3.6166**	0.230184	-2.603161**
USA	-2.9155	0.147621**	-3.122522***	-4.0711*	0.295054	-4.196530*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.
* Signifies the rejection of the unit root hypothesis at 1% significance level.
** Signifies the rejection of the unit root hypothesis at 5% significance level.
*** Signifies the rejection of the unit root hypothesis at 10% significance level.

Table 12. Unit root tests in level and first difference for employment rate series.

	Level			First difference		
Country	**ADF**	**KPSS**	**DF-GLS**	**ADF**	**KPSS**	**DF-GLS**
Australia	-2.9161	0.124721***	-2.925126***	-4.2433*	0.115675	-3.132255*
Austria	-3.2511	0.099003	-2.860343	-3.4853**	0.182728	-4.252656*
Belgium	-2.4783	0.074144	-2.618401	-4.7275*	0.128230	-4.817945*
Canada	-3.2053	0.086072	-3.354301**	-3.1632**	0.095295	-3.012200*
Chile	-2.9627	0.213576**	-3.359657**	-4.4043**	0.258653	-4.660767*
Czech Republic	-2.4306	0.143968***	-2.577627	-3.2126**	0.147696	-3.348454*
Denmark	-1.3878	0.092881	-1.672081	-4.4592*	0.144919	-4.024636*
Estonia	-2.4014	0.095730	-2.886514	-2.6257	0.163341	-2.225698**
Finland	-5.8367*	0.123329***	-3.284104**	-3.4384**	0.180857	-3.658818*
France	-2.7716	0.092808	-2.922674***	-3.4814**	0.084245	-3.556891*
Germany	-18.333*	0.174627**	-1.886894	-14.508*	0.311256	-0.368672
Greece	-2.6503	0.138333***	-2.885650	-1.9382	0.126659	-2.103892**
Hungary	0.1221	0.192981**	-1.329508	-3.7740**	0.473034**	-3.214065*
Iceland	-0.9411	0.139026	-1.359217	-3.7218**	0.214790	-3.450463*
Ireland	0.9814	0.137500***	-1.555851	-2.5957	0.342849	-2.648733**
Israel	-1.5443	0.109751	-1.974864	-3.0855**	0.394368***	-2.994946*
Italy	-2.8085	0.082520	-2.793976	-3.5159**	0.139635	-3.241249*
Japan	-3.3757***	0.095636	-3.071966***	–	–	–
Korea	-2.9698	0.109430	-3.143289***	-3.4074**	0.084169	-3.494831*
Mexico	-2.2029	0.085882	-2.321209	-4.4320*	0.093509	-4.554368*
Netherlands	-1.3907	0.132612***	-1.528577	-4.1629*	0.133478	-3.950705*
New Zealand	-3.0652	0.118194	-2.690069	-2.7555***	0.142728	-2.817584*
Norway	-4.0863**	0.112796	-3.506740**	–	–	–
Poland	-2.8118	0.140024***	-3.657939**	-2.8692***	0.249003	-2.102897**
Portugal	-3.1632	0.105573	-3.043434***	-6.4468*	0.203717	-6.592770*
Slovak Republic	-3.1961	0.125401***	-3.185110***	-2.6181	0.256878	-2.712559**
Slovenia	-2.0627	0.151588**	-3.319149**	-3.0142***	0.312868	-3.417726*
Spain	-0.7531	0.088263	-1.172543	-3.9422*	0.206094	-3.894444*
Sweden	-2.4559	0.105340	-2.521104	-2.9548***	0.095129	-3.020656*
Switzerland	-2.0222	0.087909	-2.137236	-4.8677*	0.079750	-4.947202*
Turkey	-3.4053***	0.062826	-3.356599**	–	–	–
UK	-2.9916	0.116196	-3.294238**	-2.5552	0.229121	-2.609612**
USA	-2.9222	0.147096**	-3.136499***	-4.0768*	0.298223	-4.201975*

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags for ADF and DF-GLS and based on Newey-West using Bartlett-kernel for KPSS. Unit root tests in level include trend and intercept while tests in first difference include intercept.

* Signifies the rejection of the unit root hypothesis at 1% significance level.

** Signifies the rejection of the unit root hypothesis at 5% significance level.

*** Signifies the rejection of the unit root hypothesis at 10% significance level.

4.2.2 Cointegration tests

Before proceeding to investigate the validity of export-led growth hypothesis in OECD countries, it is necessary to check if the non-stationary variables are cointegrated. Johansen maximum likelihood procedures are applied to test for cointegration among the three basic variables (output, exports and imports). The Johansen method is employed in two sets of variables. First, cointegration tests are carried out among real GDP, real exports and real imports. Second, it is considered the case of real GDP net of exports, real exports and real imports, in order to avoid “the accounting effect” (Sharma and Panagiotidis, 2005). It is argued that if exports are a substantial component of GDP, there is a possibility of a built-in correlation between GDP and exports. This criticism can be dealt with by testing the causality between exports and GDP netted for exports. The Johansen cointegration test is based on a VAR model and the appropriate lag length of the endogenous variables is selected based on SBC.

According to previous analysis, real GDP, real exports and real imports are jointly integrated in first differences, I(1), in 26 OECD countries. Therefore the cointegration analysis is conducted for these countries; namely, Australia, Austria, Canada, Chile, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovenia, Spain, Sweden, the UK and the USA. The results from the trace test and the maximum eigenvalue test for the first set of variables, under the trend assumption of linear deterministic trend, are reported in Table 13.

Table 13. Johansen cointegration test between RGDP, RX and RIMP.

	λ_{trace}			λ_{max}		
Country	**r=0**	**r≤1**	**r≤2**	**r=0**	**r≤1**	**r≤2**
Australia	32.47526* (0.0240)	12.13239 (0.1507)	4.193026* (0.0406)	20.34287 (0.0642)	7.939368 (0.3849)	4.193026* (0.0406)
Austria	19.03869 (0.4902)	9.656894 (0.3081)	2.505939 (0.1134)	9.381796 (0.8005)	7.150955 (0.4714)	2.505939 (0.1134)
Canada	27.28272 (0.0949)	11.33158 (0.1919)	4.715935* (0.0299)	15.95113 (0.2277)	6.615647 (0.5355)	4.715935* (0.0299)
Chile	33.12346* (0.0200)	9.980505 (0.2822)	0.125088 (0.7236)	23.14296* (0.0257)	9.855417 (0.2216)	0.125088 (0.7236)
Denmark	31.39805* (0.0324)	10.95896 (0.2140)	4.451535* (0.0349)	20.43909 (0.0623)	6.507423 (0.5490)	4.451535* (0.0349)
Estonia	34.93093* (0.0117)	14.44878 (0.0714)	1.082903 (0.2980)	20.48214 (0.0614)	13.36588 (0.0690)	1.082903 (0.2980)
France	46.09346* (0.0003)	19.78217* (0.0106)	2.751392 (0.0972)	26.31129* (0.0085)	17.03078* (0.0178)	2.751392 (0.0972)
Germany	38.73561* (0.0036)	16.87724* (0.0308)	4.609111* (0.0318)	21.85837* (0.0395)	12.26813 (0.1010)	4.609111* (0.0318)
Greece	28.75421 (0.0656)	11.67704 (0.1731)	3.287671 (0.0698)	17.07718 (0.1684)	8.389366 (0.3405)	3.287671 (0.0698)
Hungary	76.59343* (0.0000)	24.40682* (0.0018)	10.89479* (0.0010)	52.18661* (0.0000)	13.51203 (0.0655)	10.89479* (0.0010)
Ireland	31.05349* (0.0357)	12.21756 (0.1468)	0.891311 (0.3451)	18.83593 (0.1017)	11.32625 (0.1386)	0.891311 (0.3451)
Israel	21.26459 (0.3413)	5.741386 (0.7258)	0.538376 (0.4631)	15.52321 (0.2539)	5.203010 (0.7160)	0.538376 (0.4631)
Italy	25.55947 (0.1424)	13.12213 (0.1104)	4.024242* (0.0448)	12.43734 (0.5051)	9.097890 (0.2781)	4.024242* (0.0448)
Japan	31.79815* (0.0290)	9.262319 (0.3417)	2.184573 (0.1394)	22.53583* (0.0315)	7.077746 (0.4800)	2.184573 (0.1394)
Korea	35.81523* (0.0090)	15.52962* (0.0494)	5.210918* (0.0224)	20.28561 (0.0653)	10.31870 (0.1918)	5.210918* (0.0224)
Mexico	23.69772 (0.2135)	9.580891 (0.3144)	2.795926 (0.0945)	14.11683 (0.3555)	6.784965 (0.5149)	2.795926 (0.0945)
Netherlands	28.93574 (0.0626)	13.19700 (0.1078)	2.395039 (0.1217)	15.73874 (0.2405)	10.80196 (0.1644)	2.395039 (0.1217)
New Zealand	31.46311* (0.0318)	13.15682 (0.1092)	0.845003 (0.3580)	18.30629 (0.1188)	12.31182 (0.0995)	0.845003 (0.3580)
Norway	44.57137* (0.0005)	24.07007* (0.0020)	10.34850* (0.0013)	20.50129 (0.0611)	13.72157 (0.0608)	10.34850* (0.0013)
Poland	21.70760 (0.3151)	7.911768 (0.4749)	0.068464 (0.7936)	13.79583 (0.3820)	7.843304 (0.3948)	0.068464 (0.7936)
Portugal	37.53779* (0.0053)	9.441161 (0.3261)	3.665125 (0.0556)	28.09663* (0.0045)	5.776036 (0.6421)	3.665125 (0.0556)
Slovenia	37.91260* (0.0047)	13.87315 (0.0865)	4.342083* (0.0372)	24.03945* (0.0189)	9.531069 (0.2446)	4.342083* (0.0372)

Spain	27.29841 (0.0945)	12.94925 (0.1167)	4.754594* (0.0292)	14.34916 (0.3371)	8.194661 (0.3592)	4.754594* (0.0292)
Sweden	25.34725 (0.1494)	10.31998 (0.2569)	1.722666 (0.1893)	15.02727 (0.2870)	8.597317 (0.3212)	1.722666 (0.1893)
UK	22.82954 (0.2545)	9.766176 (0.2992)	1.293433 (0.2554)	13.06337 (0.4464)	8.472743 (0.3327)	1.293433 (0.2554)
USA	36.39833* (0.0075)	14.77476 (0.0640)	5.664994* (0.0173)	21.62357* (0.0426)	9.109766 (0.2771)	5.664994* (0.0173)

Notes: Critical values for trace test at 5% level for r=0, r≤1 and r≤2 are 29.79707, 15.49471 and 3.841466, respectively. Critical values for maximum eigenvalue test at 5% level for r=0, r≤1 and r≤2 are 21.13162, 14.26460 and 3.841466, respectively. The number in parentheses is the p-value. r denotes the hypothesized number of cointegrating equations.
* denotes the rejection of the hypothesis at 5% level.

Based on trace test in the case of Australia, both the null hypothesis of zero cointegrating vectors and the null of the existence at most two cointegrating vectors are rejected while the null hypothesis that there exists at most one such vector cannot be rejected. Hence, trace test indicates one cointegrating equation at 5% level. However, this conclusion is not supported by the maximum eigenvalue test. According to the maximum eigenvalue test there is no cointegration among RGDP, RX and RIMP since only the null hypothesis of the existence at most two cointegrating vectors is rejected at 5% level. Analogous conclusions are conducted in the case of Denmark. In the cases of Austria and Canada, both trace test and maximum eigenvalue test indicate that there is no long-run relationship among real GDP, real exports and real imports.

The results from trace test in Chile imply the existence of one cointegrating equation between the variables as the null hypothesis of zero cointegrating vectors is rejected whereas the other two null hypotheses cannot be rejected at 5% level. In addition, the maximum eigenvalue test confirms this conclusion as the null of zero cointegrating vectors is rejected too. In Estonia and Ireland, according to trace test there is one cointegrating equation between RGDP, RX and RIMP. However, this conclusion is not supported by the λ_{max} statistic either in Estonia or Ireland. As regards France, both trace test and maximum eigenvalue test indicate that there are two cointegrating equations between the variables.

The empirical results from maximum eigenvalue test in the cases of Germany and Hungary suggest one cointegrating equation between the variables.

In both cases, the trace test implies stationary variables since none of the null hypotheses is accepted at 5% level. In Greece, Israel and Italy no cointegrating relationship among real GDP, real exports and real imports is detected. As regards Japan, both λ_{trace} and λ_{max} statistics indicate one cointegrating equation as the null hypothesis of zero cointegrating vectors is rejected at 5% level. In Korea and Norway, the three null hypotheses in trace test are rejected implying stationary variables. The maximum eigenvalue test indicates that there is no cointegrating relationship between the variables.

The results from cointegration analysis provide no support for long-run relationship between real GDP, real exports and real imports in the cases of Mexico, the Netherlands, Poland, Spain, Sweden and the UK. As regards New Zealand, trace statistic rejects the null hypothesis of zero cointegrating vectors at 5% level implying the existence of one cointegrating equation between the variables. Finally, the empirical results from both trace test and maximum eigenvalue test in the cases of Portugal, Slovenia and the USA indicate the presence of one cointegrating equation between RGDP, RX and RIMP.

As regards the second set of variables, ADF, KPSS and DF-GLS tests indicated that real GDP net of exports, real exports and real imports are integrated of the same order, I(1), in 26 OECD countries. Therefore, the Johansen maximum likelihood procedures are applied in the cases of Australia, Austria, Canada, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Mexico, the Netherlands, Norway, Poland, Portugal, Slovenia, Spain, Sweden, Turkey, the UK and the USA. The results from the trace test and the maximum eigenvalue test for the second set of variables, under the trend assumption of linear deterministic trend, are reported in Table 14.

Table 14. Johansen cointegration test between RGDP_less_X, RX and RIMP.

	λ_{trace}			λ_{max}		
Country	**r=0**	**r≤1**	**r≤2**	**r=0**	**r≤1**	**r≤2**
Australia	41.55389* (0.0014)	12.05181 (0.1545)	5.611448* (0.0178)	29.50208* (0.0026)	6.440362 (0.5574)	5.611448* (0.0178)
Austria	25.18898 (0.1548)	12.91969 (0.1178)	4.180564* (0.0409)	12.26929 (0.5213)	8.739123 (0.3085)	4.180564* (0.0409)
Canada	27.26550 (0.0953)	12.78039 (0.1231)	3.663600 (0.0556)	14.48511 (0.3266)	9.116792 (0.2766)	3.663600 (0.0556)
Denmark	56.71221‡ (0.0012)	26.96391‡ (0.0365)	8.934158 (0.1844)	29.74830‡ (0.0144)	18.02975 (0.0778)	8.934158 (0.1844)
Estonia	21.63544 (0.3192)	9.614502 (0.3116)	1.639982 (0.2003)	12.02094 (0.5456)	7.974520 (0.3813)	1.639982 (0.2003)
Finland	31.52507* (0.0313)	11.46561 (0.1844)	2.068052 (0.1504)	20.05946 (0.0701)	9.397553 (0.2545)	2.068052 (0.1504)
France	53.42208* (0.0000)	18.26928* (0.0186)	3.463964 (0.0627)	35.15281* (0.0003)	14.80532* (0.0410)	3.463964 (0.0627)
Germany	31.92096* (0.0280)	7.227958 (0.5513)	2.143271 (0.1432)	24.69300* (0.0151)	5.084687 (0.7311)	2.143271 (0.1432)
Greece	33.03232* (0.0205)	13.09919 (0.1112)	3.492812 (0.0616)	19.93313 (0.0729)	9.606377 (0.2391)	3.492812 (0.0616)
Hungary	75.01987* (0.0000)	30.06362* (0.0002)	3.782936 (0.0518)	44.95625* (0.0000)	26.28068* (0.0004)	3.782936 (0.0518)
Ireland	19.98180 (0.4241)	9.149229 (0.3518)	0.983272 (0.3214)	10.83257 (0.6640)	8.165957 (0.3621)	0.983272 (0.3214)
Israel	26.26479 (0.1210)	6.091810 (0.6847)	0.680789 (0.4093)	20.17298 (0.0676)	5.411021 (0.6893)	0.680789 (0.4093)
Italy	24.59663 (0.1764)	11.78538 (0.1675)	1.859029 (0.1727)	12.81125 (0.4697)	9.926352 (0.2168)	1.859029 (0.1727)
Japan	30.21352* (0.0448)	8.247804 (0.4393)	2.552503 (0.1101)	21.96572* (0.0381)	5.695302 (0.6526)	2.552503 (0.1101)
Korea	25.44467 (0.1462)	5.050804 (0.8034)	0.842669 (0.3586)	20.39386 (0.0632)	4.208135 (0.8368)	0.842669 (0.3586)
Mexico	25.45605 (0.1458)	7.626824 (0.5061)	0.329388 (0.5660)	17.82922 (0.1364)	7.297436 (0.4546)	0.329388 (0.5660)
Netherlands	22.79783 (0.2561)	9.969221 (0.2831)	2.517589 (0.1126)	12.82861 (0.4681)	7.451632 (0.4372)	2.517589 (0.1126)
Norway	37.60401* (0.0052)	17.49212* (0.0247)	5.939778* (0.0148)	20.11189 (0.0689)	11.55234 (0.1286)	5.939778* (0.0148)
Poland	21.59131 (0.3218)	9.261160 (0.3418)	0.001702 (0.9646)	12.33015 (0.5154)	9.259458 (0.2652)	0.001702 (0.9646)
Portugal	36.18130* (0.0080)	9.183918 (0.3487)	4.511278* (0.0337)	26.99738* (0.0066)	4.672640 (0.7824)	4.511278* (0.0337)
Slovenia	38.92087* (0.0034)	13.79216 (0.0888)	3.255926 (0.0712)	25.12872* (0.0129)	10.53623 (0.1790)	3.255926 (0.0712)
Spain	27.72364 (0.0851)	11.02251 (0.2101)	2.871412 (0.0902)	16.70113 (0.1866)	8.151097 (0.3636)	2.871412 (0.0902)

Sweden	22.70163 (0.2610)	5.628703 (0.7389)	0.249860 (0.6172)	17.07293 (0.1686)	5.378844 (0.6934)	0.249860 (0.6172)
Turkey	63.17660* (0.0000)	20.78022* (0.0073)	9.018010* (0.0027)	42.39639* (0.0000)	11.76221 (0.1199)	9.018010* (0.0027)
UK	43.17939* (0.0008)	9.406748 (0.3291)	1.279854 (0.2579)	33.77264* (0.0005)	8.126894 (0.3660)	1.279854 (0.2579)
USA	44.53059* (0.0005)	16.15214* (0.0398)	6.726851* (0.0095)	28.37845* (0.0040)	9.425286 (0.2525)	6.726851* (0.0095)

Notes: Critical values for trace test at 5% level for r=0, r≤1 and r≤2 are 29.79707, 15.49471 and 3.841466, respectively. Critical values for maximum eigenvalue test at 5% level for r=0, r≤1 and r≤2 are 21.13162, 14.26460 and 3.841466, respectively. The number in parentheses is the p-value. r denotes the hypothesized number of cointegrating equations.
‡ denotes the rejection of the hypothesis at 5% level under the assumption of linear deterministic trend (restricted).
* denotes the rejection of the hypothesis at 5% level.

Both trace test and maximum eigenvalue test support that non-export RGDP, real exports and real imports are bound together in the long-run in the case of Australia and there is also one cointegrating equation between them. As concerns Austria, Canada and Estonia, no evidence of cointegrating relationship between the variables has been found. In Denmark, the trace test suggests two cointegrating equations among RGDP_less_X, RX and RIMP whereas the maximum eigenvalue test rejects the null hypothesis of zero cointegrating vectors supporting one cointegrating equation between them. As regards Finland, λ_{trace} statistic demonstrates one cointegrating equation between the second set of variables but λ_{max} statistic establishes no cointegrating relationship between them. Analogous conclusions are conducted in the case of Greece. In France and Hungary, trace test and maximum eigenvalue test yield very similar results as both tests support the existence of two cointegrating equations. Furthermore, both tests confirm one cointegrating equation between the variables in the case of Germany.

No cointegrating relationship among non-export RGDP, real exports and real imports is supported by the empirical results in the cases of Ireland, Israel, Italy, Korea, Mexico and the Netherlands. However, the variables are bound together in the long-run with one cointegrating equation in Japan. As regards Norway, on the one hand, the null hypotheses in trace test are rejected at 5% level implying stationary variables. On the other hand, the null hypotheses in maximum eigenvalue test cannot be rejected indicating no cointegrating relationship between the second set of variables. Furthermore, no evidence for any cointegrating link between non-export RGDP, RX and RIMP has been found in the cases of Poland, Spain and Sweden.

The empirical results from trace test and maximum eigenvalue test, in the cases of Slovenia and the UK, suggest one cointegrating equation between the variables. Finally, the results from Johansen cointegration method in Turkey and the USA are mixed. The λ_{trace} statistic rejects all the null hypotheses at 5% level and demonstrates that the variables may be stationary. However, the λ_{max} statistic rejects both the null hypothesis of zero cointegrating vectors and the null of the existence at most two such vectors at 5% significance level. Therefore, the maximum eigenvalue test indicates one cointegrating equation among non-export RGDP, real exports and real imports in the cases of Turkey and the USA.

4.2.3 Granger causality tests

According to the Granger representation theorem (Engle and Granger, 1987), a system of cointegrated variables has an error correction representation that combines the short-run dynamics of the variables with their long-run properties as implied by the cointegrating relationships. Consequently, vector error correction models (VECM) are estimated to determine the direction of causality between exports, imports, and economic growth.

The previous cointegration analysis indicated a common trend in the movement of real GDP, real exports and real imports in the cases of Australia, Chile, Denmark, Estonia, France, Germany, Hungary, Ireland, Japan, New Zealand, Portugal and the USA. This is followed by estimation of error correction models to investigate the direction of causation between the first set of variables. Since there is no evidence of long-run equilibrium relationships in Austria, Canada, Greece, Israel, Italy, Korea, Mexico, the Netherlands, Norway, Poland, Spain, Sweden and the UK, the standard Granger causality test based on first differenced VAR is performed for these countries. As regards the cases of Belgium, the Czech Republic, Finland, Iceland, the Slovak Republic, Switzerland

and Turkey where the variables are of different integration orders, a VAR model is estimated using the levels and the first differences of stationary and non-stationary variables, respectively. The selection of the appropriate lag length of endogenous variables on VECM and VAR models is based on SBC.

Table 15 presents the results from Granger causality tests. As shown, all the null hypotheses cannot be rejected at conventional levels of significance in the cases of Australia, Austria, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, Israel, Italy, Korea, Mexico, the Netherlands, Norway, Portugal, the Slovak Republic, Slovenia, Sweden, the UK and the USA. One can infer from this that there is no causal relationship between real GDP, real exports and real imports. In Germany, both the null hypothesis that exports does not Granger cause GDP and the null that GDP does not Granger cause exports are rejected at 1% and 10% level, respectively. Hence, a bidirectional causal relationship between real GDP and real exports is supported by the empirical results. Furthermore, Granger causality analysis supports a bidirectional causal link between real GDP and real imports, too. The null hypotheses that imports does not Granger cause GDP and also GDP does not Granger cause imports are rejected at 1% significance level.

The ELG hypothesis is supported by the empirical results for the cases of Hungary, Iceland, Ireland and New Zealand since the null hypothesis that exports does not Granger cause GDP is rejected at 5% level. In addition, the ILG hypothesis is supported by the evidence in Hungary. However, the presence of bidirectional causality between GDP and imports is detected in the cases of Iceland, Ireland and New Zealand. One-way causality from imports to GDP is detected in the cases of Japan, Spain and Switzerland since the null hypothesis that real imports does not Granger cause real GDP is rejected at 10% level for Japan and Switzerland and at 5% level in the case of Spain. Finally, the GLE hypothesis is supported in Poland while evidence that causality runs from real GDP to imports has been found in the cases of Belgium, France and Greece at 10% level as well as in Turkey at 1% level.

Table 15. Granger causality tests between RGDP, RX and RIMP.

	Null Hypothesis:			
Country	**RX$\nrightarrow$RGDP**	**RIMP$\nrightarrow$RGDP**	**RGDP$\nrightarrow$RX**	**RGDP$\nrightarrow$RIMP**
Australia†	0.021533 (0.8833)	0.295396 (0.5868)	2.354016 (0.1250)	2.436748 (0.1185)
Austria	0.246297 (0.6197)	0.058383 (0.8091)	0.226703 (0.6340)	0.247477 (0.6189)
Belgium	0.683847 (0.4083)	0.558156 (0.4550)	2.467442 (0.1162)	3.432981 (0.0639)
Canada	0.002827 (0.9576)	0.001651 (0.9676)	1.150429 (0.2835)	0.493004 (0.4826)
Chile†	1.735051 (0.1878)	0.062439 (0.8027)	0.068348 (0.7938)	0.714658 (0.3979)
Czech Republic	5.685481 (0.1280)	5.733465 (0.1253)	3.757954 (0.2888)	4.553876 (0.2075)
Denmark†	0.135239 (0.7131)	1.472132 (0.2250)	1.483179 (0.2233)	2.325763 (0.1272)
Estonia†	1.290740 (0.2559)	0.512446 (0.4741)	0.069015 (0.7928)	0.044761 (0.8324)
Finland	0.001795 (0.9662)	0.468640 (0.4936)	1.740439 (0.1871)	0.291041 (0.5896)
France†	2.101466 (0.1472)	1.543330 (0.2141)	1.076318 (0.2995)	2.794121 (0.0946)
Germany†	14.95301 (0.0006)	15.88309 (0.0004)	5.761990 (0.0561)	11.99320 (0.0025)
Greece	0.154738 (0.6940)	1.068319 (0.3013)	0.962220 (0.3266)	2.893718 (0.0889)
Hungary†	7.431106 (0.0243)	6.255563 (0.0438)	1.066913 (0.5866)	4.095305 (0.1290)
Iceland	52.47507 (0.0000)	8.310267 (0.0400)	0.510290 (0.9166)	16.83863 (0.0008)
Ireland†	13.27020 (0.0013)	5.544375 (0.0625)	2.795203 (0.2472)	6.191503 (0.0452)
Israel	0.325792 (0.5681)	0.781995 (0.3765)	2.477512 (0.1155)	0.432974 (0.5105)
Italy	0.188713 (0.6640)	0.976410 (0.3231)	0.255063 (0.6135)	0.143886 (0.7044)
Japan†	0.423484 (0.5152)	3.345571 (0.0674)	1.332145 (0.2484)	1.003296 (0.3165)
Korea	1.982607 (0.1591)	0.000116 (0.9914)	0.063561 (0.8010)	0.106664 (0.7440)
Mexico	1.344634 (0.2462)	0.608537 (0.4353)	0.560512 (0.4541)	0.018631 (0.8914)
Netherlands	0.227676 (0.6333)	0.000280 (0.9867)	0.118206 (0.7310)	0.136458 (0.7118)
New Zealand†	5.476059 (0.0193)	3.359193 (0.0668)	0.527086 (0.4678)	4.104895 (0.0428)

Norway	0.005912 (0.9387)	0.852904 (0.3557)	0.504942 (0.4773)	2.668298 (0.1024)
Poland	1.095761 (0.7781)	3.233426 (0.3570)	9.025038 (0.0290)	3.619038 (0.3056)
Portugal†	0.019454 (0.8891)	0.178866 (0.6723)	0.059211 (0.8077)	1.026250 (0.3110)
Slovak Republic	0.361606 (0.5476)	0.480737 (0.4881)	0.069704 (0.7918)	0.036112 (0.8493)
Slovenia†	0.702970 (0.4018)	0.026977 (0.8695)	0.101844 (0.7496)	0.176264 (0.6746)
Spain	0.000528 (0.9817)	3.955036 (0.0467)	2.502123 (0.1137)	0.327376 (0.5672)
Sweden	0.007667 (0.9302)	0.101968 (0.7495)	0.011874 (0.9132)	0.057294 (0.8108)
Switzerland	2.919716 (0.0875)	2.992830 (0.0836)	0.081826 (0.7748)	0.001538 (0.9687)
Turkey	1.985916 (0.1588)	2.043191 (0.1529)	0.474763 (0.4908)	7.343002 (0.0067)
UK	0.138476 (0.7098)	0.588774 (0.4429)	0.036953 (0.8476)	0.346152 (0.5563)
USA†	0.682925 (0.7107)	2.323151 (0.3130)	0.936197 (0.6262)	1.746482 (0.4176)

Notes: The number in parentheses is the p-value.
† signifies Granger causality tests based on VECM.
$\nrightarrow$ represents "does not Granger cause".

Granger causality tests are also performed in order to investigate the direction of causality between non-export real GDP and real exports as well as the causal relationship between real imports and real GDP net of exports. According to previous cointegration analysis, non-export real GDP, real exports and real imports are bound together in the long-run in the cases of Australia, Denmark, Finland, France, Germany, Greece, Hungary, Japan, Portugal Slovenia, Turkey, the UK and the USA. Therefore, Granger causality tests based on VECM are conducted to examine the direction of causation between the second set of variables. Furthermore, Granger causality tests based on first differenced VAR are performed for Austria, Canada, Estonia, Ireland, Israel, Italy, Korea, Mexico, the Netherlands, Norway, Poland, Spain and Sweden, since there is no evidence of long-run equilibrium relationships between the variables in these countries. Finally, in the cases of Belgium, Chile, the Czech Republic, Iceland, New Zealand, the Slovak Republic and Switzerland, where the variables are of different integration orders, a VAR model is estimated using the levels and the first differences of stationary and non-stationary variables, respectively. The selection of the appropriate lag length of endogenous variables on VECM and VAR models is based on SBC.

The results from Granger causality tests between non-export RGDP, RX and RIMP are reported in Table 16. The ELG hypothesis is supported by the evidence in the cases of Australia and the UK since the null hypothesis that real exports does not Granger cause real GDP net of exports is rejected at 5% level. Furthermore, bidirectional causality between real imports and non-export RGDP is suggested by the empirical results in these countries. From Table 16 no causality between the variables is observed in the cases of Austria, Germany, Ireland, Israel, Mexico, Poland, Portugal and the Slovak Republic. However, the GLE hypothesis as well as unidirectional causality from non-export RGDP to imports is supported by the evidence in the cases of Belgium, Estonia, the Netherlands, New Zealand, Norway, Sweden, Switzerland and the USA.

The causality analysis provides support for the ELG hypothesis in the cases of Canada and Denmark. In Canada is also detected one-way causality from RGDP net of exports to imports. A bidirectional causal relationship between non-exports RGDP and exports is supported by the evidence in the Czech Republic and France. In these cases is also detected two-way causality between real imports and real GDP net of exports. Furthermore, unidirectional causality from non-export real GDP to exports as well as a bidirectional causal link between imports and real GDP net of exports is observed in Greece. The GLE hypothesis is supported in the cases of Chile, Hungary, Italy, Korea and Turkey. In addition, the ILG hypothesis is supported by the evidence in the cases of Iceland, Japan and Spain whereas causality runs from real GDP net of exports to imports in Slovenia. Finally, bidirectional causality between non-export RGDP and real imports is detected in Finland.

Table 16. Granger causality tests between RGDP_less_X, RX and RIMP.

	Null Hypothesis:			
Country	**RX ↛ RGDP_less_X**	**RIMP ↛ RGDP_less_X**	**RGDP_less_X↛ RX**	**RGDP_less_X↛ RIMP**
Australia†	12.10595 (0.0024)	6.237722 (0.0442)	3.114131 (0.2108)	6.846828 (0.0326)
Austria	0.329567 (0.5659)	0.002265 (0.9620)	0.417257 (0.5183)	0.268261 (0.6045)
Belgium	0.889391 (0.3456)	0.328191 (0.5667)	14.73264 (0.0001)	15.98556 (0.0001)
Canada	3.102397 (0.0782)	1.417061 (0.2339)	2.543864 (0.1107)	5.364781 (0.0205)
Chile	1.531156 (0.2159)	0.063888 (0.8005)	5.470523 (0.0193)	0.147227 (0.7012)
Czech Republic	11.80409 (0.0081)	9.920366 (0.0193)	22.06966 (0.0001)	8.686060 (0.0338)
Denmark†	8.506910 (0.0035)	2.390651 (0.1221)	2.563203 (0.1094)	1.069459 (0.3011)
Estonia	0.024472 (0.8757)	0.011557 (0.9144)	3.070851 (0.0797)	6.244667 (0.0125)
Finland†	2.238859 (0.1346)	5.506295 (0.0189)	0.754097 (0.3852)	2.952193 (0.0858)
France†	6.970537 (0.0083)	7.520552 (0.0061)	3.067727 (0.0799)	5.534004 (0.0187)
Germany†	0.697102 (0.4038)	0.418241 (0.5178)	0.871199 (0.3506)	0.544122 (0.4607)
Greece†	0.568779 (0.4507)	3.235649 (0.0721)	4.000207 (0.0455)	17.24776 (0.0000)
Hungary†	0.323413 (0.8507)	0.392047 (0.8220)	7.182544 (0.0276)	2.760006 (0.2516)
Iceland	2.137550 (0.1437)	4.553289 (0.0329)	0.213490 (0.6440)	2.116594 (0.1457)
Ireland	0.005155 (0.9428)	1.345627 (0.2460)	1.023338 (0.3117)	1.277147 (0.2584)
Israel	0.045975 (0.8302)	0.284182 (0.5940)	0.135784 (0.7125)	0.359014 (0.5491)
Italy	0.083466 (0.7727)	0.975910 (0.3232)	8.024092 (0.0046)	1.381369 (0.2399)
Japan†	0.085612 (0.7698)	6.547572 (0.0105)	0.748881 (0.3868)	1.117415 (0.2905)
Korea	1.480444 (0.2237)	0.222142 (0.6374)	7.536216 (0.0060)	1.280310 (0.2578)
Mexico	1.351878 (0.2450)	0.444716 (0.5049)	0.153692 (0.6950)	1.527669 (0.2165)
Netherlands	0.254725 (0.6138)	0.358421 (0.5494)	15.70303 (0.0001)	12.51693 (0.0004)
New Zealand	2.611465 (0.2710)	0.047760 (0.9764)	5.267095 (0.0718)	7.488722 (0.0237)

Norway	2.615485 (0.1058)	0.481210 (0.4879)	8.178995 (0.0042)	5.448340 (0.0196)
Poland	0.695337 (0.4044)	0.024084 (0.8767)	0.868540 (0.3514)	0.952148 (0.3292)
Portugal†	0.087012 (0.7680)	0.284220 (0.5939)	0.002713 (0.9585)	0.107748 (0.7427)
Slovak Republic	0.968785 (0.3250)	0.777477 (0.3779)	0.060255 (0.8061)	0.002556 (0.9597)
Slovenia†	0.322207 (0.5703)	1.616505 (0.2036)	0.013695 (0.9068)	3.533401 (0.0601)
Spain	0.002351 (0.9613)	6.434945 (0.0112)	0.207661 (0.6486)	0.004093 (0.9490)
Sweden	0.119892 (0.7292)	0.085625 (0.7698)	9.019189 (0.0027)	5.156041 (0.0232)
Switzerland	0.467882 (0.7914)	1.735164 (0.4200)	5.006302 (0.0818)	17.40800 (0.0002)
Turkey†	3.502183 (0.3205)	3.301673 (0.3474)	22.63762 (0.0000)	2.147834 (0.5423)
UK†	8.788424 (0.0123)	15.55911 (0.0004)	3.736909 (0.1544)	9.466976 (0.0088)
USA†	1.201798 (0.5483)	0.204605 (0.9028)	6.013295 (0.0495)	7.653717 (0.0218)

Notes: The number in parentheses is the p-value.
† signifies Granger causality tests based on VECM.
↛ represents "does not Granger cause".

4.3 Panel data Granger causality tests

A panel data analysis has the merit of using information concerning cross-section and time series analyses. It can also take heterogeneity of each cross-sectional unit explicitly into account by allowing for individual-specific effects and give "more variability, less collinearity among variables, more degrees of freedom and more efficiency" (Baltagi, 2001). Furthermore, the repeated cross-section of observations over time is better suited to study the dynamic of changes like exports, imports and GDP.

In this section, in order to increase the power of Granger causality tests, panel data from 33 OECD countries is used over the period 1985-2010. This study is organized around panel unit root tests and panel cointegration techniques to draw sharper conclusions from the short time series. Finally, panel data Granger causality tests are employed in order to investigate the direction of causality between output, exports and imports.

4.3.1 Panel unit root tests

Panel unit root tests are expected to be much more powerful since they combine information from time series as well as cross-section data. Since different panel unit root tests may yield different testing results, LLC, IPS and Fisher-ADF tests are chosen to perform the panel data unit root test and then we can compare their results. In all tests, the null hypothesis is that of existence of a unit root. The tests are conducted to check for the presence of a unit root both in levels and first differences for each variable. The results are presented in Table 17.

Table 17. Panel unit root tests.

	Level			First difference		
	Trend & Intercept			Intercept		
Variable	**LLC**	**IPS**	**Fisher–ADF**	**LLC**	**IPS**	**Fisher–ADF**
RGDP	1.91680	0.18306	60.6717	-15.5765*	-11.6120*	410.037*
RGDP_less_X	-3.37271*	-3.37669*	125.565*	–	–	–
REXP	3.52977	4.13062	37.9248	-15.1594*	-12.5120*	294.514*
RIMP	1.05737	0.18098	76.4088	-13.2529*	-13.5454*	315.589*
RINV	-3.42322*	-4.14943*	134.045*	–	–	–
IR	-75.9934*	-21.7416*	398.105*	–	–	–
XR	-41.0123*	-11.3437*	85.9399**	–	–	–
UR	-3.26853*	-3.50141*	119.181*	–	–	–
ER	-10.4505*	-4.57981*	115.140*	–	–	–

Notes: The appropriate lag length is selected based on SBC with automatic selection of maximum lags.
* signifies the rejection of the unit root hypothesis at 1% significance level.
** signifies the rejection of the unit root hypothesis at 5% significance level.

The LLC, IPS and Fisher-ADF panel unit root tests indicate the existence of unit roots and therefore non-stationarity in the level of real GDP, real exports and real imports panel series. However, their first differenced series are stationary under the three panel unit root tests. As regards the rest of the variables, the null hypothesis is rejected at conventional levels of statistical significance therefore they are stationary panel level series. Hence, it is concluded that real GDP, real exports and real imports series are integrated in the first difference, I(1), whereas the variables, real GDP net of exports, real investment, interest rate, exchange rate, unemployment rate and rate of employment are integrated in the level, I(0).

4.3.2 Panel cointegration tests

Given that real GDP, real exports and real imports series are stationary in the first difference, I(1), the proper way to investigate the direction of causation between output, exports and imports is certainly to test for a cointegrating relationship among these variables using Pedroni, Kao and Johansen Fisher panel cointegration tests. The results from Pedroni cointegration tests between real GDP, real exports and real imports are presented in Table 18. The null hypothesis of no cointegration is rejected in favour of the alternative since both panel-ADF and group-ADF statistics are significant at conventional levels of significance. Besides ADF-statistics, the results also reveal that panel v-statistic and both group-PP and panel-PP statistics are statistically significant at 5% level. As regards panel-rho statistic, it is significant at 1% level whereas group rho-statistic is statistically not significant at 10% level. According to Kao cointegration test, the null hypothesis of no cointegration is rejected at 1% significance level, therefore it is concluded that real exports and real imports are cointegrated with real output in the long-run. The estimated t-statistic is reported in Table 19.

Table 18. Pedroni panel cointegration test between RGDP, RX and RIMP.

	Statistic	**Prob.**
Panel v-Statistic	3.408751	0.0003
Panel rho-Statistic	-2.482211	0.0065
Panel PP-Statistic	-4.968583	0.0000
Panel ADF-Statistic	-2.352575	0.0093
Group rho-Statistic	1.164461	0.8779
Group PP-Statistic	-1.960121	0.0250
Group ADF-Statistic	-2.397606	0.0083

Table 19. Kao panel cointegration test between RGDP, RX and RIMP.

	t-Statistic	Prob.
ADF	-5.137582	0.0000

Table 20. Johansen Fisher panel cointegration test between RGDP, RX and RIMP.

Hypothesized No. of CE(s)	Fisher Stat. (from trace test)	Prob.	Fisher Stat. (from max-eigen test)	Prob.
None	237.6	0.0000	174.8	0.0000
At most 1	123.1	0.0000	84.66	0.0295
At most 2	145.6	0.0000	145.6	0.0000

Finally, the results from Johansen Fisher panel cointegration test are depicted in Table 20. Fisher statistics from trace test reject all the null hypotheses at conventional levels of significance. This implies that real GDP, real exports and real imports panel series may be stationary panel series. In addition, Fisher statistics from maximum eigenvalue test reject the null hypothesis of zero cointegrating vectors as well as the null of existence at most two such vectors. However, the null hypothesis of existence at most one cointegrating vector cannot be rejected at 1% level of significance. Therefore, maximum eigenvalue test indicates one cointegrating equation between RGDP, RX and RIMP. Overall cointegration results of Pedroni, Kao and Johansen Fisher panel cointegration tests confirm a common trend in the movement of real GDP, real exports and real imports.

4.3.3 Panel Granger causality tests

According to panel cointegration analysis, real GDP, real exports and real imports are bound together in the long-run. Even if it certainly attracts attention to know that there is one or more long-run relationship in the non-stationary data, it is of more interest to discover the nature of these relationships. The existence of cointegrating relationships between real GDP, real exports and real imports implies that an error correction model specification is appropriate. In order to investigate the causality between these variables, Granger causality tests are implemented based on VECM(4). The appropriate lag length is selected based on SBC.

Table 21. Granger causality tests based on VECM.

Dependent variable	Independent variables			Lagged ECT
	ΔRGDP	**ΔRX**	**ΔRIMP**	**ect [t-stat]**
ΔRGDP	–	7.000309 (0.1359)	6.969495 (0.1375)	-0.003477 [-1.67488]
ΔRX	41.32738 (0.0000)	–	6.744559 (0.1500)	0.029361 [4.85641]
ΔRIMP	5.678202 (0.2245)	28.28232 (0.0000)	–	0.030571 [4.94353]

Notes: The numbers in parentheses are p-values. For the ect*s* are given the estimated coefficients. Values in brackets are estimated t-statistics for each cointegrating equation. All other values are asymptotic Granger causality χ^2 tests. Δ denotes the difference operator.

Table 21 reports the results from Granger causality tests. Each row represents an equation for each of the three variables in the system. For each variable, at least one channel of causality is active: short-run Granger causality through the joint significance tests of the lagged-differenced coefficients of the independent variables (χ^2-statistic) or long-run causality through a statistically significant lagged error correction term (t-statistics). A significant lagged ECT coefficient implies that past equilibrium errors affect current outcomes. As regards the output regression, the negative and significant at 10% level error correction coefficient is consistent with the finding of cointegration. Even though the χ^2-statistics are insignificant, the statistical significance of the error correction term in the output equation implies that export and import volume Granger cause output (i.e. lagged exports and imports predict output) and hence provides evidence in favour of the export-led growth and import-led growth hypotheses in the long-run. Furthermore, the lagged error correction coefficient is significant in the export and import equation indicating the presence of long-run causality from both output and imports to exports on the one hand, and from exports and output to imports on the other. In the short-run, there is evidence of unidirectional causality from output to exports as well as one-way causality from exports to imports.

In order to expand the investigation of the causal relationship between exports and other key variables, Granger causality tests between the first differenced real exports and the levels of real GDP net of exports, real investment, interest rate, exchange rate, unemployment rate and rate of employment are conducted based on a VAR(2) model. The appropriate lag length is selected based on SBC. The results from panel Granger causality tests are presented in Table 22. No causality between real GDP net of exports and exports is supported by the evidence. In addition, the empirical results do not suggest causality of any direction between non-export RGDP and real investment. However, there is a bidirectional relationship between interest rate and exports as well as two-way causality between exports and exchange rate. Furthermore, bidirectional causality between exports and unemployment rate is supported by the empirical results since both null hypotheses are rejected at 5% level. Finally, there is no causal relationship between exports and rate of employment.

Table 22. Granger causality tests based on VAR.

Null Hypothesis:	**Chi-sq**	**Prob.**
ΔRX does not Granger Cause RGDP_less_X RGDP_less_X does not Granger Cause ΔRX	3.697305 1.522439	0.1574 0.4671
ΔRX does not Granger Cause RINV RINV does not Granger Cause ΔRX	2.430844 3.900025	0.2966 0.1423
ΔRX does not Granger Cause IR IR does not Granger Cause ΔRX	8.736321 54.82082	0.0127 0.0000
ΔRX does not Granger Cause XR XR does not Granger Cause ΔRX	9.465668 13.80544	0.0088 0.0010
ΔRX does not Granger Cause UR UR does not Granger Cause ΔRX	22.75348 6.032815	0.0000 0.0490
ΔRX does not Granger Cause ER ER does not Granger Cause ΔRX	2.675674 0.804790	0.2624 0.6687

5. CONCLUSIONS

The present study examines the export-led growth hypothesis using annual data from 33 OECD countries. In addition to time series analysis for individual economy, a panel data approach is adopted which considers the interaction among countries and heterogeneity in the panel data causality analysis. The empirical analysis investigates not only the nature of the relationship between exports and economic growth but also the impact of other key variables on export growth. Thus, the analysis includes variables such as imports, non-export GDP, investment, interest rate, exchange rate, unemployment rate and rate of employment.

Time series analysis indicated that all variables are stationary in first difference, I(1), for almost all cases. The cointegration analysis was focused on testing for cointegration among exports, imports and the two measurements of output growth, real GDP and real GDP net of exports. A common trend in the movement of real GDP, real exports and real imports was indicated in the cases of Australia, Chile, Denmark, Estonia, France, Germany, Hungary, Ireland, Japan, New Zealand, Portugal, Slovenia and the USA. The Granger causality analysis provide no evidence for any causal relationship among RGDP, RX and RIMP in the cases of Australia, Austria, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, Israel, Italy, Korea, Mexico, the Netherlands, Norway, Portugal, the Slovak Republic, Slovenia, Sweden, the UK and the USA.

The ILG hypothesis is supported in the cases of Japan, Spain and Switzerland while both ELG and ILG hypotheses are supported in Hungary. Furthermore, the ELG hypothesis and a bidirectional relationship between real GDP and imports are detected in the cases of Iceland, Ireland and New Zealand. The presence of bidirectional causality between real GDP and exports as well as two-way causality between real GDP and imports are observed simultaneously in the case of Germany. The empirical results suggest that causality runs from output growth to exports in Poland while unidirectional causality from real GDP to imports is detected in the cases of Belgium, France, Greece and Turkey.

According to cointegration analysis, non-export real GDP, real exports and real imports are bound together in the long-run in the cases of Australia, Denmark, Finland, France, Germany, Greece, Hungary, Japan, Portugal Slovenia, Turkey, the UK and the USA. The empirical results from Granger causality analysis provide support for the ELG hypothesis in Denmark while evidence for the GLE hypothesis has been found in the cases of Chile, Hungary, Italy, Korea and Turkey. No causality among real GDP net of exports, exports and imports is detected in the cases of Austria, Germany, Ireland, Israel, Mexico, Poland, Portugal and the Slovak Republic.

Bidirectional causality between non-export real GDP and imports is detected in Finland while causality runs from RGDP net of exports to imports in Slovenia. In addition, the causality analysis provides support for the ILG hypothesis in the cases of Iceland, Japan and Spain. Unidirectional causality from output growth to exports as well as one-way causality from output growth to imports is observed in Belgium, Estonia, the Netherlands, New Zealand, Norway, Sweden, Switzerland and the USA. The ELG hypothesis and bidirectional causality between RGDP net of exports and imports are detected in Australia and the UK while the GLE hypothesis and two-way causality between non-export real GDP and imports are supported by the evidence in Greece. In addition, the ELG hypothesis and unidirectional causality from RGDP_less_X to RIMP are detected in Canada. Finally, the presence of bidirectional causality between non-export real GDP and exports as well as two-way causality between real GDP and imports are observed simultaneously in the cases of the Czech Republic and France.

The validity of the ELG hypothesis is also tested using a panel data causality analysis. The LLC, IPS and Fisher-ADF panel unit root tests indicated that RGDP, RX and RIMP are integrated in the first differences, I(1), whereas the rest of the variables are stationary in the levels, I(0). Testing for panel cointegration between I(1) series using Pedroni, Kao and Joahansen Fisher cointegration tests, a common trend in the movement of real GDP, real exports and real imports was detected. The results from Granger causality tests based on VECM for cointegrated panel series indicate the presence of long-run causality from both exports and imports to economic growth, as well as feedback from economic growth to both exports and imports. There is also evidence of short-run unidirectional causality from output to exports as well as one-way causality from exports to imports.

For the rest of the variables, only the short-run causal patterns have been identified owing to the absence of long-run equilibrium relationships. The results indicate that there is bidirectional causality between exports and interest rate but no causality between exports and non-export real GDP is detected. Furthermore, two-way causality between exports and exchange rate is supported by the evidence. The results also provide evidence for no causal relationship between exports and investment. Finally, a bidirectional causal relationship is detected between exports and unemployment rate whereas there is no causality between exports and rate of employment.

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