Measuring and Evaluating the Dynamics of Trade Shock Propagation in the Oceania

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Abstract

Oceania's extra-trade performance is quite considerable relative to its intra-trade. This indicates that the Oceania may be susceptible to trade shocks originating from its main trading partners in the global economy. Given that shocks often occur, the presence of such enormous and dynamic external sector makes economic growth in the Oceania vulnerable to shocks. This study, therefore, investigates the dynamics of trade shock transmission between the Oceania and the rest of the global economy. The study constructed generalized trade linkage measures at various degrees of aggregation. The results indicate that the trade linkage between the Oceania and the rest of the global economy is quite substantial, with the *total trade linkage index* having a mean value of 83%. The results also show that USA, China, Canada, France, Germany, and Japan exert dominant influence on Oceania's trade and therefore have the potential to spread trade shocks to it. Overall, the findings show that economies in the Oceania are predominantly net receivers of trade shocks originating from the aforementioned dominant sources, suggesting that policymakers and leaders in the Oceania should coordinate efforts towards safeguarding the region against future adverse trade shocks.

Keywords: Trade Shock Propagation; Global VAR; Oceania; G7; the Global Economy

JEL Classification: F43; F02; N77; O50; N70

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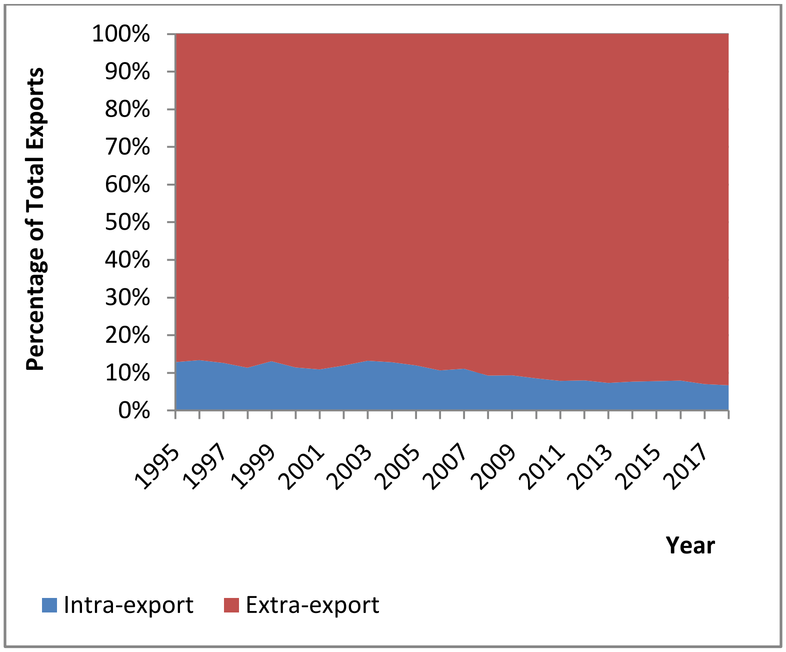
1. Introduction

Oceania is a geographic region or continental group consisting of numerous islands generally spread over the southern Pacific Ocean. It includes fourteen countries, namely: Australia, Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, New Zealand, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. In 2018, International Monetary Fund's World Economic Outlook statistics showed that this continent recorded a total Gross Domestic Product (GDP) of $1.563 trillion. Clearly, the economic output of this continent cannot be called unimportant. Sometimes, people think that Oceania is restricted to Australia and New Zealand. This is because Australia and New Zealand are the two leading economies in Oceania, jointly accounting for 98% of the continent's GDP. Besides, Worldometer's statistics indicate that Oceania had a population of 42.4 million people as of January, 2020 (see https://www.worldometers.info/world-population/oceania-population/), with Australia and New Zealand jointly accounting for 72% of this population.

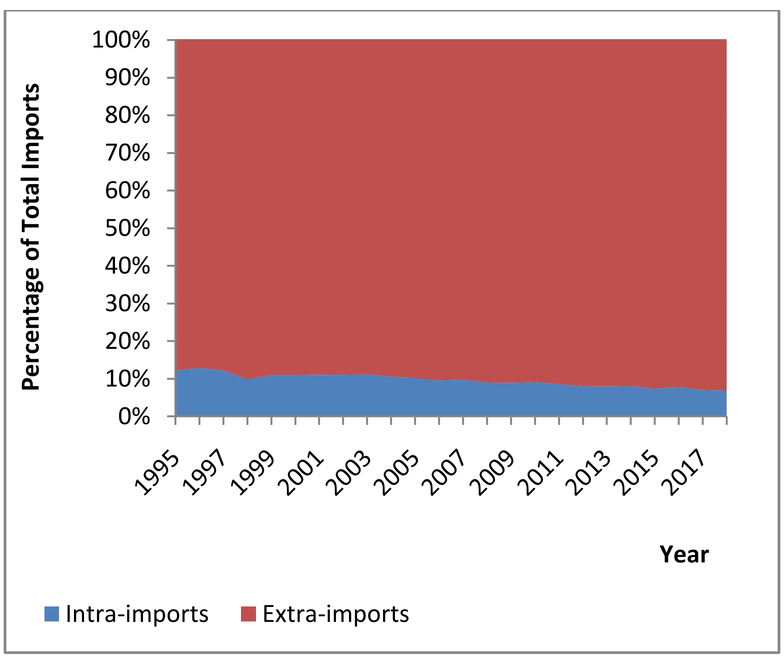
This study is primarily motivated by the fact that Oceania has a large and dynamic external sector, which is susceptible to shocks or contractions in demand. To see this, let us consider the continent's trade statistics taken from UNCTAD's 2019 e-Handbook of Statistics (https://stats.unctad.org/handbook/MerchandiseTrade/ByPartner.html). This statistics indicate that in 2018, intra-Oceania exports stood at $20.5 billion (or 6.68% of total exports), while extra-Oceania exports stood at $286.61 billion (or 93.32% of total exports). In the case of imports, the statistics also indicate that in 2018, intra-Oceania imports stood at $19.92 billion (or 6.78% of total imports), while extra-Oceania imports stood at $273.78 billion (or 93.22% of total imports). This statistics show that extra-Oceania trade is quite large compared to intra-Oceania trade. Figure 1 shows that this has been the pattern of intra- and extra-regional trade in the Oceania in recent decades. Panel A of Figure 1 reports for exports while Panel B reports for imports. The overall patterns indicate that extra-Oceania trade by far outstrips intra-Oceania trade.

Figure 1: Intra-trade and extra-trade in Oceania in percentage of total trade (1995 – 2018)

Panel A (Export Trade)



Panel B (Import Trade)

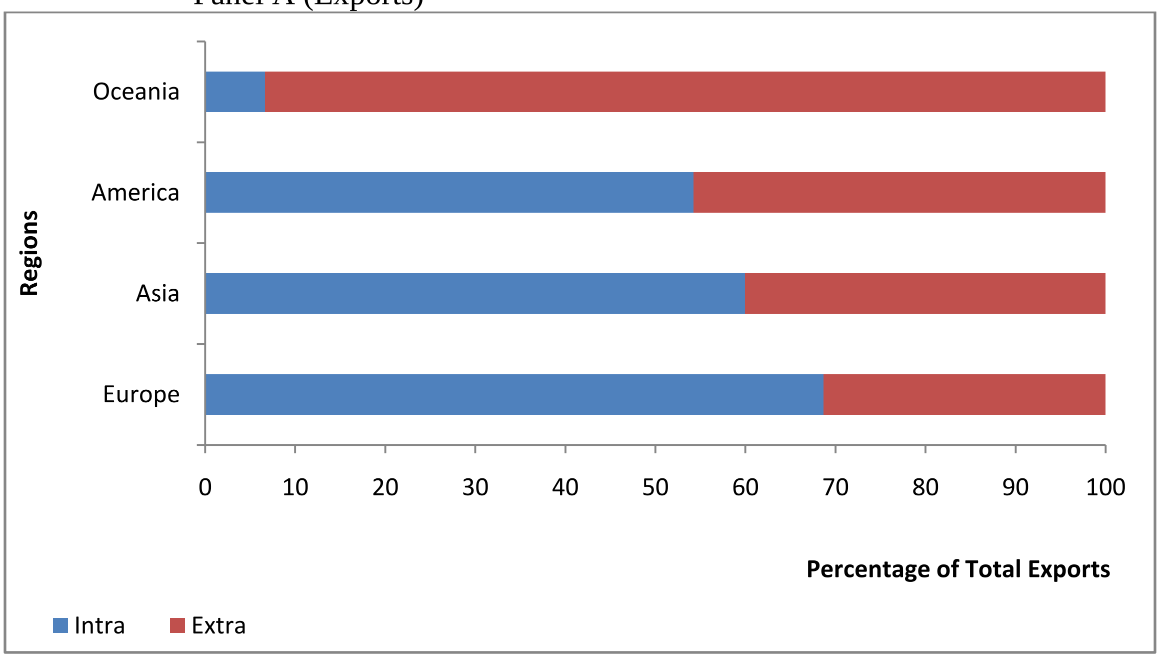


Source: Authors, using UNCTAD trade statistics

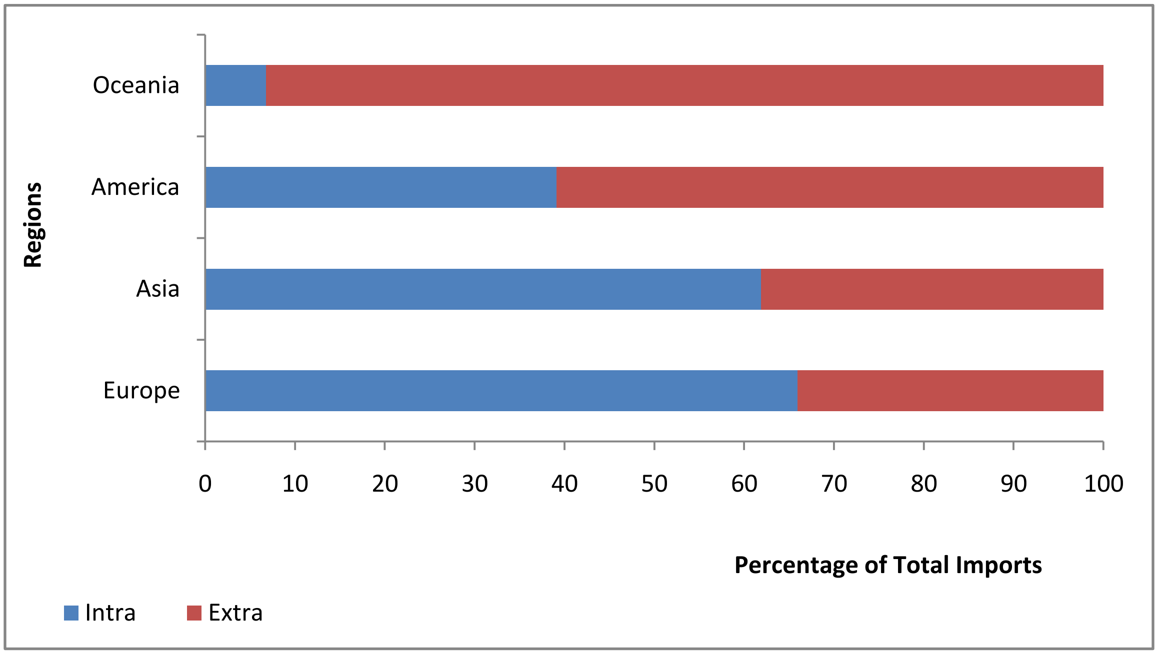
The patterns in the UNCTAD's trade statistics become more interesting when we compare Oceania's trade statistics with those of other regions, such as Asia, Europe, and America. We find that contrary to the established pattern in the Oceania which indicates that extra-regional trade by far exceeds intra-regional trade, the trade statistics of Asia and Europe clearly indicate that their respective intra-regional trade surpasses their extra-regional regional trade by a large amount. These patterns are illustrated in Figure 2, which reports for exports, imports, and total trade in Panels A, B, and C, respectively. In the case of America, extra-imports are higher that intra-imports; while intra-exports are higher than extra-exports. But when the imports and exports are aggregated to obtain the total trade, it is then seen that extra-regional trade is only slightly higher than the intra-regional trade. Clearly, among the four regions captured in Figure 2, the Oceania is the only region whose extra-regional trade considerably exceeded its intra-regional trade.

Figure 2: Intra- and extra-regional trade in percentage of total trade in 2018

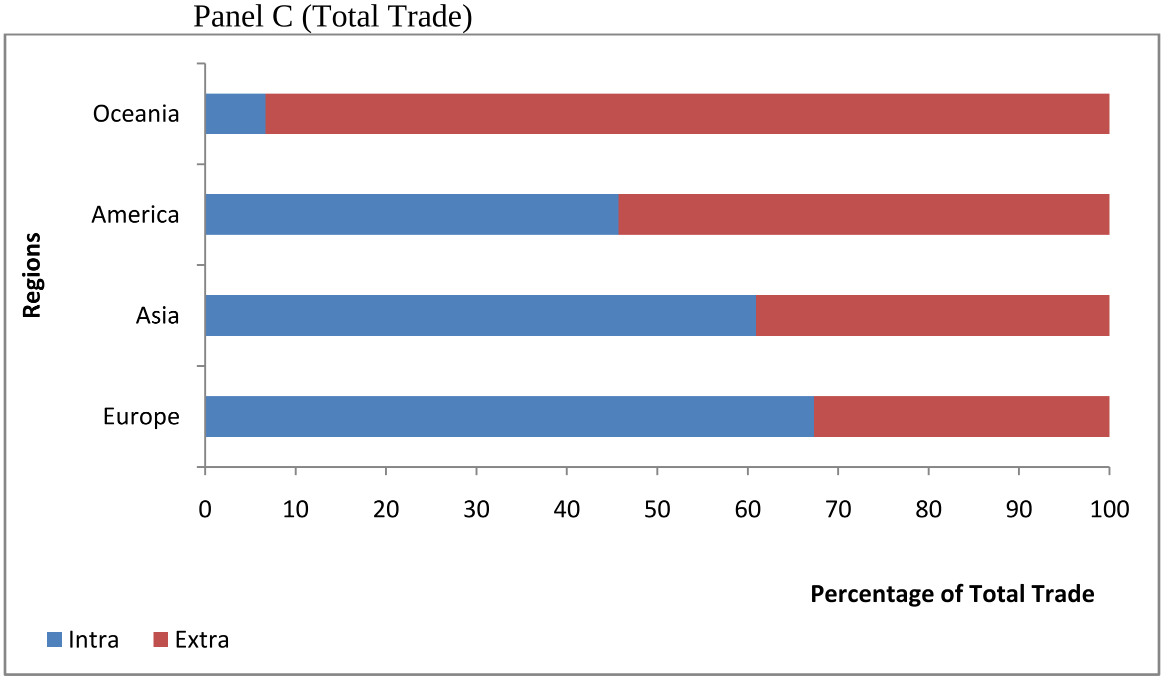
Panel A (Exports)



Panel B (Imports)



Panel C (Total Trade)



Source: Authors, using UNCTAD trade statistics

The foregoing paragraphs evidently indicate that the Oceania region has a huge and vibrant external sector, which makes economic growth in the region vulnerable to shocks or contractions, particularly in demand given the large extra-regional trade that characterizes the region. Given that shocks often occur and that Oceania maintains a huge external sector that is susceptible to shocks, this study takes the view that it is important for policymakers and leaders in this region to understand the dynamics of trade shock propagation between Oceania and its top trading partners across the globe. Indeed, a review of Oceania's top trading partners indicate that the G10 economies (i.e. the group of 10 economies consisting of China, South Korea, India, and the G7 economies that comprises United States, United Kingdom, Japan, Italy, Germany, France, and Canada) maintain enormous trade linkage with it. For Australia, the Observatory of Economic Complexity statistics for 2017 (available at: https://oec.world/en/profile/country/aus/) indicate that China, Japan, South Korea, and India accounted for 35%, 14%, 7.4% and 6.1% of exports; while China, United States, South Korea and Japan accounted for 24%, 10%, 9.3% and 8.2% of imports, respectively. United Kingdom, India, Canada, Germany, Italy and France also contributed substantially to its trade. Its main export commodities include iron ore, coal briquettes, gold, petroleum gas, wheat and wine; while its key import items include cars, refined petroleum, special purpose ships, broadcasting equipment, delivery trucks, computers, and crude petroleum. For New Zealand, the Observatory of Economic Complexity statistics for 2017 indicate that China, Australia, United States, and Japan were the topmost export destinations accounting for 24%, 15%, 9.7%, and 6.4% of exports as well as the topmost sources of imports accounting for 20%, 12%, 9.3% and 7.7% of imports, respectively. South Korea, United Kingdom, Germany, Italy, France, and Canada also contributed substantially to its trade. Its top export items include concentrated milk, sheep and goat meat, butter, rough wood, and frozen bovine meat; while its top import items include cars, crude petroleum, refined petroleum, delivery trucks, and broadcasting equipment.

Thus, it is seen that the identified G10 economies maintain enormous trade linkages with the Oceania. The contribution of China to trade in Oceania is quite remarkable and consistent with the assertion by Anyanwu (2014) that China's economic growth and its capacity to move from underdevelopment and extreme poverty to an emerging global economic power had attracted the attention of many countries. Hence, the need to comprehensively understand the sources and dynamics of trade shocks to the Oceania cannot be over stressed. Apart from the vulnerability of this region to shocks in demand, trade linkage has been adjudged an important feature of global economic linkage between countries. For instance, Kose and Yi (2001) explained that more trade integration could influence the global business cycle and contagion, depending on the nature of trade and type of shocks affecting the economies. Furthermore, World Bank's Global Economic Prospects report posits that growth in most economies is expected to remain flat or decelerate in 2019 while trade tensions would remain elevated (World Bank, 2019). Unanticipated trade shocks may invariably worsen the growth prospects of the region. Hence, there is an urgent need for policymakers and leaders on the continent to clearly appreciate the dynamics of trade shock propagation between the Oceania and the rest of the world. To the best of our knowledge, this study presents the first comprehensive study of trade shock propagation between the Oceania and the rest of the world based on the spillover methodology developed by Diebold and Yilmaz (2009) and using the total trade statistics of the various countries..

This study, therefore, examines trade shock propagation between the Oceania and the rest of the world. Specifically, the study seeks to: (i) measure the degree of trade linkage between the Oceania and the rest of the world; (ii) determine the economies and regional trading blocs dominating Oceania's trade and therefore have the potential to spread trade shocks to it and thus minimize its growth; and (iii) determine the Oceania economy that is most susceptible to trade shocks originating from the rest of the world; and (iv) determine the economies in the rest of the world that are most susceptible to trade shocks originating from the Oceania.

To achieve the above objectives, the paper employed normalized generalized forecast error variance decompositions (NGFEVDs) distilled from an underlying global vector autoregressive model (Global VAR) to build measures of trade linkage and shocks transmission between the Oceania and the rest of the global economy over the period 1990Q1 – 2018Q4. The underlying model is estimated using the total trade statistics of the countries. The time series properties of the data were examined using the Phillips-Perron unit root tests and the Johansen cointegration test in order to determine the form of the model to be estimated. It is expected that if the variables are overwhelmingly stationary at levels, then a basic VAR would be appropriate. However, if the variables are nonstationary, then a VAR in first differences becomes tenable in the absence of equilibrium relationship, otherwise a vector error correction model (VECM) would be estimated.

This study extended the empirical methodology of Diebold and Yilmaz (2009) by using the NGFEVDs to build various measures of trade linkages between the Oceania and the rest of the global economy at different levels of aggregation. The generalized nature of the FEVDs means that they would be invariant to the reordering of the variables in the system. The choice of the global VAR framework is mainly due to its ability to explicitly model the sources of foreign influences on domestic economies in the Oceania and the contributions of these domestic economies to the rest of the world in a transparent and coherent manner. It allows for the impact of shocks to be consistently quantified, aggregated and assessed so that interactions between countries/regions can be analyzed. Simply put, the proposed framework measures both the direction and the strength of linkages among entities in the system, while identifying systemically important or vulnerable entities. Several studies in the literature have exploited this framework in the study of macroeconomic linkages with great success. Examples of such studies include: Pesaran *et al.* (2004); Dees, Mauro, Pesaran and Smith (2007); Dees, Holly, Pesaran and Smith (2007); and more recently Greenwood-Nimmo et al. (2015). This study adopted the same framework and since the data for this study are quarterly, the measures of trade linkages were computed over a 24-quarterly horizon so that the long-run results are better captured.

The rest of the paper is organized as follows. Section 2 undertakes a brief review of relevant literature. Section 3 presents the data and methodology, detailing some preliminary data analysis, while Section 4 discusses the empirical results. Section 5 concludes the study and provides some policy implications, which in the main indicate that the patterns of cross-country trade shock spillovers obtained in this study can assist policymakers and leaders in the Oceania to mediate the effects of trade shocks emanating from the rest of the global economy.

2. An overview of the literature

Economic theories support the view that no economy exists in isolation, and hence, it is difficult for an economy to collapse in isolation. The trade linkages hypothesis states that in the presence of direct trade links, the trade balance and other macroeconomic fundamentals of an economy can be influenced when a crisis in a partner economy leads to fall in income and demand for imports in the partner's economy. In other words, higher trade linkage can influence the global business cycle and financial contagion, depending on the structure of trade and type of shocks affecting the economies (Kose & Yi, 2001). This theoretical aspect is supported by several studies in the extant literature. For instance, Kali and Reyes (2010) shows that a crisis is magnified if the epicenter economy is highly connected in a trading system; while Forbes (2012) shows that an economy becomes more vulnerable to contagion if it has high trade exposure, weak macroeconomic fundamentals, large international portfolio investment liabilities, and a more geared banking system. Rose and Spiegel (2004) established that strong trade links can influence global business cycle and international financial contagion by promoting international loans, engendering similarity in economic structures and encouraging higher foreign direct investment (FDI), especially in export-oriented sectors, depending on whether the trade is mostly inter-industry or intra-industry.

The theory of global business cycle explains that as international trade and financial linkages among entities in the global economy deepen, regional and national business cycles are superseded and harmonized into a broader global business cycle (Kose *et al.*, 2003, 2008). This implies that shocks would be transmitted faster and more strongly across entities, and domestic stabilization policies will have little impact if the business cycle is driven by common exogenous shocks. In general, economic theory predicts that global business cycle and international financial contagion may arise from common economic ties such as trade and financial links.

The monsoonal effects hypothesis is another aspect of economic theory dealing with shock propagation. It states that a common shock can induce contagion so that recessions or major policy changes in advanced economies like changes in commodity prices (such as oil price) can induce crises and huge capital outflows from developing economies (Moser, 2003; Claessens & Forbes, 2001). This hypothesis is traceable to the early work of King and Wadhwani (1990), though the term 'monsoonal effects' is attributed to Masson (1999). Studies such as Gentile and Giordano (2012), Ozkan and Unsal (2012), and Tressel (2010) are consistent with this hypothesis.

The empirical literature indicates that some studies have investigated the impact of trade shocks, also known as spillovers, in large advanced countries on emerging market economies. These studies have generally engendered hot debates in global and national policy circles. Kose and Reizman (1999) examined the role of external shocks in explaining macroeconomic fluctuations in African countries. The study constructed a quantitative, stochastic, dynamic, multi-sector equilibrium model of a small open economy calibrated to represent a typical African economy.

In the framework employed by the study, external shocks consist of trade shocks, modeled as fluctuations in the prices of exported primary commodities, imported capital goods and intermediate inputs, and a financial shock, modeled as fluctuations in the world real interest rate. The results of the study indicated that while trade shocks accounted for roughly 45 percent of economic fluctuations in aggregate output, financial shocks play only a minor role. Interestingly, the study also established that adverse trade shocks induce prolonged recessions.

Another study which has contributed towards a more robust understanding of the trade linkages between Africa and the rest of the world is Çakir and Kabundi (2013), which examined the trade linkages between South Africa and the BRIC (Brazil, Russia, India, and China) countries. The study applied the global vector autoregressive model (global VAR) to investigate the degree of trade linkages and shock transmission between South Africa and the BRIC countries over the period 1995Q1-2009Q4. The model contained 32 countries and had two different estimations: the first one consists of 24 countries and one region, with the 8 countries in the euro area treated as a single economy; and the second estimation contains 20 countries and two regions, with the BRIC and the euro area countries respectively treated as a single economy. The results suggest that trade linkages exist between the focus economies; however, the magnitude differs between countries. Shocks from each BRIC country are shown to have considerable impact on South African real imports and output.

Greenwood-Nimmo *et al.* (2015) extended the Diebold and Yilmaz (2009) technique to a more complex multi-country macroeconomic connectedness among entities in the global economy. The methodology is highly adaptable and may be applied to any model with an approximating VAR representation. The study applied the technique to a global vector autoregressive model containing 169 macroeconomic and financial variables for 25 countries. The study advanced vivid representations of the connectedness of the system and found that the US, the Eurozone and the crude oil market exert a dominant influence over conditions in the global macroeconomy and that China and Brazil are also globally significant economies. Interestingly, both China and Brazil are among the BRIC economies that have huge trade linkages with Africa. Using the technique of recursive analysis over the period of the global financial crisis, Greenwood-Nimmo *et al.* (2015) showed that shocks to global equity markets are rapidly and forcefully transmitted to real trade flows and real GDP.

Other studies in the literature have also examined the patterns of macroeconomic linkages and shocks propagation among entities in the global economy. Pesaran *et al.* (2004) posit that financial institutions are ultimately exposed to macroeconomic fluctuations in the global economy and thus they built a compact global model capable of generating forecasts for a core set of macroeconomic factors (or variables) across a number of countries. The model explicitly allows for the interdependencies that exist between national and international factors. Individual region-specific vector error-correcting models were estimated in which the domestic variables were related to corresponding foreign variables constructed exclusively to match the international trade pattern of the country under consideration. The individual country models were then linked in a consistent and cohesive manner to generate forecasts for all of the variables in the world economy simultaneously. The global model was then estimated for 25 countries grouped into 11 regions using quarterly data over 1979Q1–1999Q1. The degree of regional interdependencies was investigated via generalized impulse responses where the effects of shocks to a given variable in a given country on the rest of the world were provided. The model was then used to investigate the effects of various global risk scenarios on a bank's loan portfolio.

Dees, Mauro, Pesaran and Smith (2007) explored the international linkages of the Euro Area under the global VAR (GVAR) framework. The study employed a quarterly global model combining individual country vector error-correcting models in which the domestic variables were related to the country-specific foreign variables. The GVAR model was estimated for 26 countries, the Euro area being treated as a single economy, over the period 1979–2003. The study provided a theoretical framework where the GVAR was derived as an approximation to a global unobserved common factor model. Using the average pair-wise cross-section error correlations, the GVAR approach was shown to be quite effective in dealing with the common factor interdependencies and international co-movements of business cycles. The study developed a sieve bootstrap procedure for simulation of the GVAR as a whole, which was then used in testing the structural stability of the parameters, and for establishing bootstrap confidence bounds for the impulse responses. Finally, in addition to generalized impulse responses, the study considered the use of the GVAR for 'structural' impulse response analysis with focus on external shocks for the Euro area economy, particularly in response to shocks to the US.

Another study, Dees, Holly, Pesaran and Smith (2007), investigated the long run macroeconomic relations for interest rates, equity, prices and exchange rates suggested by arbitrage in financial and goods markets. The study used the GVAR framework to test for long run restrictions in each country/region conditioning on the rest of the world. The study also employed bootstrapping to compute both the empirical distribution of the impulse responses and the log-likelihood ratio statistic for over-identifying restrictions. The speed with which adjustments to the long run relations would take place was also examined through the persistence profiles. The results revealed strong evidence in support of the uncovered interest parity and to a lesser extent the Fisher equation across a number of countries; however, the results for the purchasing power parity were much weaker. Just as in most other studies in the extant literature, the study also found that transmission of shocks and subsequent adjustments in financial markets were much faster than those in goods markets.

On their part, Lubik and Teo (2005) found that world interest rate shocks are the main driving forces of business cycles in small open economies while terms of trade shocks are not. Thus, they challenged the existing results on the contribution of terms of trade and world interest rate shocks to output fluctuations in small open economies which had been found to range from less than 10 per cent to almost 90 per cent. They argue that an identification problems lies at the heart of existing vastly different results, which they overcame by estimating a dynamic stochastic general equilibrium model using a structural Bayesian estimation approach. They applied the methodology to five developed and developing economies. The approach enabled them to efficiently exploit cross-equation restrictions implied by the structural model.

The study by Ogbuabor *et al.* (2016) focused on the real and financial connectedness of selected African economies with the global economy using a network approach. The study found that the connectedness of African economies with the global economy is quite sizable, with the global financial crisis increasing the connectedness measures above their pre-crisis levels. The results show that U.S., EU and Canada dominate Africa's equity markets, while China, India and Japan dominate Africa's real activities. Huidrom *et al.* (2017) also contributed to this literature by studying the cross border spillovers among seven largest emerging market economies, EM7 (namely China, India, Brazil, Russia, Mexico, Indonesia, and Turkey) using a Bayesian vector autoregression model. The results indicate that spillovers from these economies are sizeable, and that a one percentage point increase in the EM7 growth is associated with a 0.9 percentage point increase in growth in other emerging and frontier markets and a 0.6 percentage point increase in world growth at the end of three years. The study also found that sizeable as they are, spillovers from EM7 are still smaller than those from G7 countries. Specifically, growth in other emerging and frontier markets, and the global economy would increase by one-half to three times more due to a similarly sized increase in G7 growth. In addition, the study found that among the EM7, spillovers from China are the largest and permeate globally.

Clearly, the literature on trade shock transmission among entities in the global economy is still an evolving one, while empirical studies focusing on the Oceania are quite scanty. This study fills this important gap in the extant literature by providing comprehensive evidence on the patterns of trade shock transmission between the Oceania and the rest of the global economy based on the spillover methodology of Diebold and Yilmaz (2009). First, this study quantifies the degree of trade linkage between the Oceania and the rest of the global economy. Second, the study extends the empirical method of Diebold and Yilmaz (2009) by constructing generalized trade linkage measures at various degrees of aggregation and in a coherent and transparent manner for ease of replication.

3. Data and Methodology

The data for this study consists of the log of total trade for the period 1990Q1-2018Q4. Here, total trade (or simply trade) was computed as exports plus imports. The choice of this period is based on data availability for all the economies included in the study. The economies included in the study are the two dominant Oceania economies, which are Australia (AUS) and New Zealand (NZL), and the G10 economies that constitute the Oceania's top trading partners, namely: United States of America (USA), United Kingdom (UK), Japan (JPN), Italy (ITL), Germany (GER), France (FRA), Canada (CAN), China (CHN), South Korea (KOR), and India (IND). The entire data were taken from the World Development Indicators (WDI) based on the following indicator names: exports of goods and services (constant 2010 US$) as measure for exports and imports of goods and services (constant 2010 US$) as measure for imports. The choice of WDI is based on the fact that it is easily accessible by other researchers who may want to replicate the study.

The data was converted from annual to quarterly using Eview's quadratic match average option. This is in line with the methodology used in compiling the Global VAR database, which Greenwood-Nimmo *et al.* (2015) used in the study of the connectedness of the global economy. Several other studies in the literature, such as Ogbuabor (2019), have also used this data compilation procedure with great success. To reduce noise and ensure uniform scaling, the entire data was converted into indices (2010Y = 100) and logged prior to estimation. Appendix 1 summarizes the descriptive statistics of the data based on the log transformation of the data. The descriptive statistics indicate that between the two Oceania economies, Australia recorded more volatile trade data as seen from their standard deviations. This suggests that Australia may be more prone to external conditions that New Zealand. China, India and South Korea are the most volatile among the rest of the economies. The maximum and minimum values do not suggest the presence of outliers in the data. The time series plots of the data for all the economies in the sample are presented in Appendix 2 based on the log transformation of the data. A close examination of the plots show close comovement among all the countries, indicating that the series track themselves closely. The implication of this is that the data may be cointegrated, which will in turn affect the form of the underlying model to be estimated in this study. Thus, the study subjected the series to cointegration test as part of the empirical procedures.

3.1. Justification for the Choice of Diebold and Yilmaz (2009) Spillover Framework

A number of methodologies have been employed in the study of macroeconomic linkages among entities in the global economy, particularly in the study of shock propagation among countries. For instance, cross-country correlations-based measures have been used to characterize macroeconomic linkages among countries (Kehoe *et al.*, 1995; Kose *et al.*, 2003; Bollerslev, 1990; Engle *et al.*, 1990; Mantegna, 1999; Tumminello *et al.*, 2005; Taylor, 2007; Gray & Malone, 2008; Engle, 2009; Engle & Kelly, 2012). The pitfalls of this approach are twofold, namely: correlation is simply a pairwise measure of association and it is non-directional. This means that correlation-based approach cannot handle such questions as "what is the degree of trade linkage between the Oceania and the rest of the global economy?" Unlike the correlation-based measures of macroeconomic linkage, the spillover approach of Diebold and Yilmaz (2009) is non-pairwise, yet directional. Granger Causality measures have also been used to characterize networks so that the macroeconomic linkages among entities in the global economy can be described and understood (Caraiani, 2013; Hiemstra & Jones, 1994; Dahlhans & Eichler, 2003; Shojaie & Michailidis, 2010; Billio *et al.*, 2012). The main weakness of the Granger Causality approach is that it captures only pairwise relations and may not be useful in answering important questions like "what is the degree of trade linkage between the Oceania and the rest of the global economy?"[1]

Furthermore, as noted by Diebold and Yilmaz (2016), these alternative methodologies generally dwell exclusively on testing rather than measurement and estimation of macroeconomic linkages, which are the main issues in this study. This study therefore follows the spillover approach of Diebold and Yilmaz (2009) based on its ability to transparently use the size and direction of shocks to build both directional and non-directional trade linkage measures over a given forecast horizon. According to Ogbuabor *et al.* (2016), studies using this approach have four common features, namely: (i) they are generally based on measures of linkage distilled from forecast error variance decompositions (FEVDs) of an approximating vector autoregressive (VAR) model; (ii) they measure the direction and strength of linkages among entities in the system; (iii) they can identify systemically important entities in the system; and (iv) they can study the dynamic nature of shock propagation among entities in the system. In what follows, the underlying VAR model for this study and the construction of the generalized trade linkages measures (GTLMs) are presented to guide the ensuing analysis.

3.2 Model Specification

The broad objective of this study is to examine the propagation of trade shock between the Oceania and the rest of the global economy. Let $\boldsymbol{Z_t}$ be the log of total trade for all the countries selected for this study so that $\boldsymbol{Z_{jt}}$ stands for the logged total trade of the $\boldsymbol{j}$-th country in the system, with $\boldsymbol{j = 1, 2, \dots, N}$ and $\boldsymbol{N}$ is the number of countries selected for the study (which is 12). Following Diebold and Yilmaz (2009), the trade linkage measures for this study are based on the normalized generalized forecast error variance decompositions (NGFEVDs) of an underlying $\boldsymbol{p}$-

[1] Other techniques have also been used in the literature for the study of macroeconomic linkages. Ogbuabor *et al.* (2018) provides an overview of such alternative methodologies such as the dynamic latent factor models of Kose *et al.* (2008) and Canova *et al.* (2007), the CoVaR approach of Adrian and Brunnermeier (2011), and the marginal expected shortfall (MES) approach of Acharya *et al.* (2017) and Brownlees and Engle (2012).

th order VAR model for the $\boldsymbol{N\ x\ 1}$ vector of endogenous variables $\boldsymbol{Z_t}$. The VAR($\boldsymbol{p}$) model is specified as follows:

$$\boldsymbol{Z_t = \alpha_z + \sum_{j=1}^{p} \Phi_j Z_{t-j} \ + \ \varepsilon_t}, \tag{1}$$

where $\boldsymbol{\alpha}$ is $\boldsymbol{Nx1}$ vector of intercepts; $\boldsymbol{\Phi_j}$ is $\boldsymbol{N\ x\ N}$ coefficient matrix; $\boldsymbol{p}$ is the lag order; and the residuals $\boldsymbol{\varepsilon_{it}} \sim \boldsymbol{iid}(\boldsymbol{0}, \sum_{\boldsymbol{\varepsilon},\boldsymbol{ii}})$ so that $\boldsymbol{\varepsilon_t} \sim (\boldsymbol{0}, \sum_{\boldsymbol{\varepsilon}})$, where $\sum_{\boldsymbol{\varepsilon}}$ is positive definite covariance matrix. The optimal VAR lag order selected by Schwarz Information Criterion (SIC) for this study is one. Using the Wold's Representation Theorem, the model in equation (1) is expressed as an infinite order vector moving average representation given by:

$$\boldsymbol{Z_t = \varepsilon_t + \Theta_1 \varepsilon_{t-1} + \Theta_2 \varepsilon_{t-2} + \ \dots \ = \sum_{j=0}^{\infty} \Theta_j \varepsilon_{t-j}} \tag{2}$$

where $\boldsymbol{\Theta_0 = I_N}$, $\boldsymbol{\Theta_j = \Phi^j}$, $\boldsymbol{j = 1, 2}$, ..., and $\boldsymbol{I_N}$ stands for an $\boldsymbol{N \times N}$ identity matrix in which all the principal diagonal elements are ones and all other elements are zeros.

The network approach of Diebold and Yilmaz (2009) requires that after estimating the underlying VAR model, the forecast error variance decompositions (FEVDs) are then generated and used to build trade linkage measures. In this study, the interest is in the shocks to the disturbances, $\boldsymbol{\varepsilon_{jt}}$ in the country-specific equations. Hence, following Pesaran and Shin (1998), Diebold and Yilmaz (2016) and Greenwood-Nimmo *et al.* (2015), this study adopts the order-invariant generalized forecast error variance decompositions (GFEVDs) defined as:

$$\boldsymbol{GFEVD(Z_{it};\ \varepsilon_{jt}, H) = d_{ij}^{gH} = \frac{\sigma_{\varepsilon,jj}^{-1} \sum_{h=0}^{H-1} (e_i' \Theta_h \Sigma_\varepsilon e_j)^2}{\sum_{h=0}^{H-1} (e_i' \Theta_h \Sigma_\varepsilon \Theta_h' e_i)}} \tag{3}$$

where $i, j = 1, \dots, N$; $H = 1, 2, \dots$ is the forecast horizon; $e_i(e_j)$ is $N\ x\ 1$ selection vector whose *i*-th element (*j*-th element) is unity with zeros elsewhere; Θ_h is the coefficient matrix multiplying the *h*-lagged shock vector in the infinite moving-average representation of the non-orthogonalized VAR; $\sum_{\boldsymbol{\varepsilon}}$ is the covariance matrix of the shock vector in the non-orthogonalized VAR; and $\boldsymbol{\sigma_{\varepsilon,jj}}$ is the *j*-th diagonal element of $\sum_{\boldsymbol{\varepsilon}}$ (i.e. the standard deviation of ε_j). We adopted a maximum forecast horizon of 24 quarters throughout in order to ensure that the long-run results are better captured. It must be stressed that the choice of GFEVDs for this study rather than the orthogonalized forecast error variance decompositions (OFEVDs) of Diebold and Yilmaz (2009) is particularly based on the fact that the OFEVDs depend on the reordering of the variables in the system such that once the order of variables in the VAR is reshuffled, a different outcome results.

Diebold and Yilmaz (2014) explain that shocks are rarely orthogonal in the GFEVD environment so that sums of forecast error variance contributions are not necessarily unity, that is, row sums of the generalized variance decomposition matrix, D^{gH} are not necessarily unity. This renders the interpretation of the GFEVDs complicated. Thus, to restore a percentage interpretation of the GFEVDs, this study follows Diebold and Yilmaz (2014) to define the normalized GFEVDs (NGFEVDs) given by[2]:

$$\widetilde{D}^{g} = [\tilde{d}_{ij}^{g}], \text{ where } \tilde{d}_{ij}^{g} = \frac{d_{ij}^{g}}{\sum_{j=1}^{N} d_{ij}^{g}}, \quad d_{ij}^{g} = \boldsymbol{GFEVD}(\boldsymbol{Z_{it}};\ \boldsymbol{\varepsilon_{jt}}, \boldsymbol{H}) \tag{4}$$

By construction, $\sum_{j=1}^{N} \tilde{d}_{ij}^{g} = 1$ and $\sum_{i,j=1}^{N} \tilde{d}_{ij}^{g} = N$, so that the total sum of the generalized forecast error variance share of each variable is normalized to 100%.

3.3 Construction of the Generalized Trade Linkage Measures (GTLMs)

As stated earlier, this study extends the empirical method of Diebold and Yilmaz (2009) by constructing generalized trade linkage measures at various degrees of aggregation. Thus, in what follows, the various trade linkage measures that are relevant for the ensuing analysis are defined. The intuition behind this framework is quite simple. Variance decomposition permits the splitting of the forecast error variances of each variable in the VAR system into parts attributable to the various system shocks. By so doing, it becomes easy to answer the question: What fraction of the h-step-ahead error variance in forecasting $\boldsymbol{Z_{1t}}$ is due to shocks to $\boldsymbol{Z_{1t}}$? Shocks to $\boldsymbol{Z_{2t}}$? Similarly, what fraction of the h-step-ahead error variance in forecasting $\boldsymbol{Z_{2t}}$ is due to shocks to $\boldsymbol{Z_{1t}}$? Shocks to $\boldsymbol{Z_{2t}}$? And in general, what fraction of the h-step-ahead error variance in forecasting $\boldsymbol{Z_{jt}}$ is due to shocks to $\boldsymbol{Z_{it}}$, $\boldsymbol{i = 1, 2, \ldots, N}$. Thus, the approach marries VAR variance decomposition theory and network topology theory by recognizing that variance decompositions of VARs form networks and also characterizing linkages in those variance decomposition networks. This in turn characterizes trade linkages of the variables in our VAR system. This is

[2] In what follows and without loss of generality, the superscript H is dropped whenever it is not needed for clarity so that D^{gH} and d_{ij}^{gH} are simply written as D^{g} and d_{ij}^{g} respectively.

the intuition behind this framework, which we now exploit in the ensuing analysis. Diebold and Yilmaz (2015) authoritatively document this framework and its relation to network theory.

Table 1: Trade Linkage Schematic

Variables	$\boldsymbol{Z_1}$	$\boldsymbol{Z_2}$	$\cdots$	$\boldsymbol{Z_N}$	**From Others**
$\boldsymbol{Z_1}$	d_{11}	d_{12}	$\cdots$	d_{1N}	$\sum_{j=1}^{N} d_{1j}\ , \quad j \neq 1$
$\boldsymbol{Z_2}$	d_{21}	d_{22}	$\cdots$	d_{2N}	$\sum_{j=1}^{N} d_{2j}\ , \quad j \neq 2$
$\vdots$	$\vdots$	$\vdots$	$\ddots$	$\vdots$	$\vdots$
$\boldsymbol{Z_N}$	d_{N1}	d_{N2}	$\cdots$	d_{NN}	$\sum_{j=1}^{N} d_{Nj}\ , \quad j \neq N$
To Others	$\sum_{i=1}^{N} d_{i1}$ $i \neq 1$	$\sum_{i=1}^{N} d_{i2}$ $i \neq 2$	$\cdots$	$\sum_{i=1}^{N} d_{iN}$ $i \neq \mathrm{N}$	$\frac{1}{N}\sum_{i,j=1}^{N} d_{ij}\ , \quad i \neq j$

Source: Adapted from Diebold and Yilmaz (2014). **Note**: For simplicity, each time series variable in this table $\boldsymbol{Z_{jt}}$ is written as $\boldsymbol{Z_j}, \boldsymbol{j = 1, 2, \ldots, N}$.

To construct the GTLMs for this study, let us denote the H-step ahead NGFEVDs for the $\boldsymbol{N\ x\ 1}$ vector of endogenous variables $\boldsymbol{Z_t}$ obtained from equation (4) by $\boldsymbol{d_{ij}}$. By cross-tabulating $\boldsymbol{d_{ij}}$, the trade linkage table shown in Table 1 is formed. The sum of each row in Table 1 is normalized to 100% in line with equation (4). This table is now used to define the various GTLMs and their relationships. The diagonal entries in Table 1 measure own variance shares (or *own-effect*), while the off-diagonal entries measure variance shares arising from shocks to other variables in the system and are therefore referred to as pairwise directional linkage. Accordingly, the *own-effect* ($\boldsymbol{H_j}$), also known as the heatwave, is defined as:

$$\boldsymbol{H_j = d_{jj}} \tag{5}$$

The total cross-variable variance share ($\boldsymbol{F_j}$) captures the spillovers from all other variables to $\boldsymbol{Z_{jt}}$ as fractions of the H-step-ahead error variance in the forecasts of $\boldsymbol{Z_{jt}}$ resulting from $\boldsymbol{Z_{it}}$, where $\boldsymbol{i = 1, 2, \ldots, N}$ and $\boldsymbol{i \neq j}$. This measures the total directional linkage from other variables (countries) in the system (i.e. the *from-effect*) to Z_{jt}. This means that the *from-effect* can be used to capture the role each individual economy in the system plays in a given economy in the Oceania, and it is computed in this study by aggregating the spillovers from all the economies in the system to a given economy in the Oceania across all horizons. Hence, the economy contributing the highest of such aggregate spillover is deemed to play a dominant role in the particular Oceania economy. This study therefore defines $\boldsymbol{F_j}$ as:

$$\boldsymbol{F_j = \sum_{i=1, i\neq j}^{N} d_{ji}} \qquad (6)$$

By construction, $\boldsymbol{H_j + F_j = 1} \; \forall \, \boldsymbol{j}$.

This study also defines the total spillover or total contributions of $\boldsymbol{Z_{jt}}$ to all other variables (denoted by $\boldsymbol{T_j}$) as:

$$\boldsymbol{T_j = \sum_{i=1, i\neq j}^{N} d_{ij}} \qquad (7)$$

By construction, $\boldsymbol{T_j}$ measures the total directional linkage from $\boldsymbol{Z_{jt}}$ to other variables in the system (i.e. the *to-effect*). In other words, the *to-effect* measures the directional linkage from a given economy (for instance, a given Oceania economy) to other economies in the system, thereby showing the impact or influence of that particular Oceania economy on other economies in the VAR system. The net directional linkage (or simply *net-effect*) of $\boldsymbol{Z_{jt}}$ is therefore defined as:

$$\boldsymbol{N_j = T_j - F_j} \qquad (8)$$

Since there are N economies in the VAR system, it also follows that there are 2N total directional trade linkages, N capturing the total shocks transmitted to others (i.e. spillover to) and N capturing the total shocks received from others (i.e. spillover from). These measures aptly reflect the bilateral trade patterns between the Oceania and other economies in the system since they mirror the total exports and total imports for each of the N economies in the system, and will therefore facilitate deeper understanding of the trade inter-linkages among the Oceania economies. We shall utilize the *net-effects* to establish the net transmitters/receivers of shocks in the system over time. By construction, $\boldsymbol{\sum_{j=1}^{N} N_j = 0}$.

The most aggregative (non-directional) trade linkage measure in this study which will be used to evaluate the degree of trade linkage between the Oceania and the rest of the global economy is known as the *total trade linkage index* ($\boldsymbol{TTLI}$) or *total-effects*, and it is defined as:

$$\boldsymbol{TTLI = \frac{1}{N}\sum_{j=1}^{N} F_j = \frac{1}{N}\sum_{j=1}^{N} T_j} \qquad (9)$$

This measure captures the grand total of the off-diagonal elements in Table 1, that is, the sum of the "From Others" column or "To Others" row. There is only one total trade linkage measure, which is analogous to total global imports or total global exports, since the two are identical.

An important objective of this study is to determine which of the countries in the rest of the global economy exert the most dominant trade influence on the Oceania and therefore have the potential to spread trade shocks to the Oceania. To achieve this objective, this study defines two indices, *dependence* and *influence indices*. These indices are necessary to determine the dependence of the **j**-th variable (or **j**-th economy) on external shocks and the influence of the **j**-th variable (or **j**-th economy) on the system as a whole. The *dependence index* is defined as:

$$\boldsymbol{O_j^H = \frac{F_j}{H_j + F_j}}, \qquad \forall\, \boldsymbol{j = 1, 2, \dots, N} \tag{10}$$

where $\boldsymbol{0} \leq \boldsymbol{O_j^H} \leq \boldsymbol{1}$. This index expresses the relative importance of external shocks for the **j**-th economy in the VAR system such that if $\boldsymbol{O_j^H} \rightarrow \boldsymbol{1}$, then conditions in the **j**-th economy is open, deeply interlinked and sensitive to external conditions, but if $\boldsymbol{O_j^H} \rightarrow \boldsymbol{0}$, then the **j**-th economy is less sensitive to external shocks.

Similarly, the *influence index* is expressed as:

$$\boldsymbol{I_j^H = \frac{N_j}{T_j + F_j}}, \qquad \forall\, \boldsymbol{j = 1, 2, \dots, N} \tag{11}$$

where $\boldsymbol{-1} \leq \boldsymbol{I_j^H} \leq \boldsymbol{1}$. For a given horizon H, the **j**-th economy is a net receiver of trade shocks if $\boldsymbol{-1} \leq \boldsymbol{I_j^H} < 0$, that is, if the index has a negative value; a net transmitter of trade shocks if $\boldsymbol{0} < \boldsymbol{I_j^H} \leq \boldsymbol{1}$, that is, if the index takes a positive value; and neither a net receiver or transmitter of trade shocks if $\mathrm{I_j^H} = 0$. Thus, the *influence index* measures the extent to which the j-th economy in the system influences or is influenced by external shocks. Overall, the coordinate pair $(\boldsymbol{O_j^H}, \boldsymbol{I_j^H})$ in the *dependence-influence* space provides a good representation of the **j**-th economy's role in global real activities. A priori expectation is that the Oceania economies would be located close to the point (1,-1), while highly influential and dominant economies like the USA and China would be located close to the point (1,1).

4. Results and Discussions

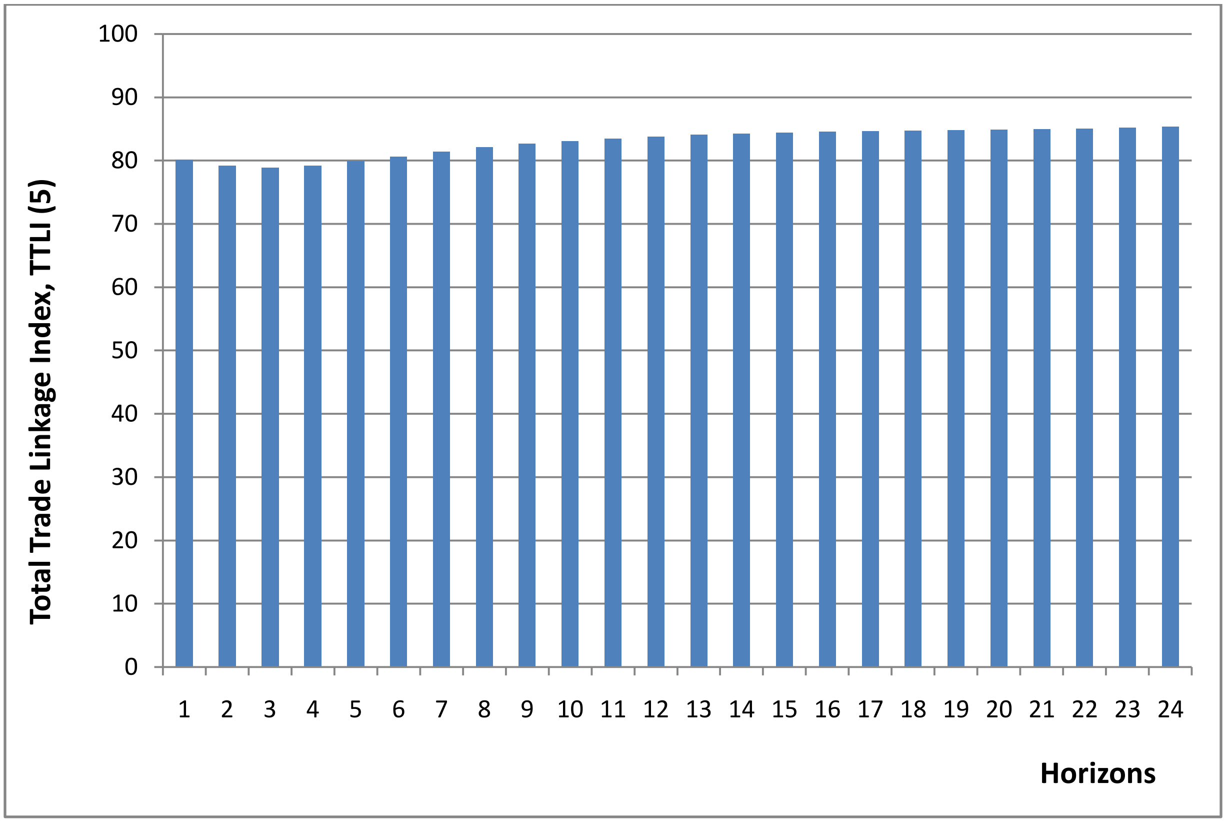
This empirical investigation began by examining the time series properties of the data. The Phillips-Perron unit root tests showed that all the series are I(1) for all the countries (Please see

Appendix 3). However, the test for long-run or equilibrium relationship using the Johansen System Cointegration test showed that both the Trace and Maximum Eigenvalue statistics returned full rank, indicating that the data are not cointegrated (please see Appendix 4 which reports the Trace test in Panel 1 and the Max-Eigenvalue test in Panel 2). Therefore, a VAR in first differences was estimated rather than a vector error correction model (VECM). Thereafter, the GTLMs were computed for all forecasting horizons, $H = 1,2, \dots ,24$. The average values of the GTLMs over all the horizons are reported, since Diebold and Yilmaz (2016) had shown that the measures follow similar patterns regardless of the choice of window lengths and forecast horizons. As earlier stated, we set the maximum forecast horizon at 24 quarters in order to capture the long-run results better.

4.1 Measuring the degree of trade linkage between the Oceania and the rest of the global economy

The first specific objective of this study is to measure the degree of trade linkage between the Oceania and the rest of the global economy. In addition, we examine here how this index changed from the short-run (i.e. from horizon 1) through the long-run (i.e. until horizon 24). To achieve this objective, we estimated the underlying VAR model of equation (1) and used the NGFEVDs distilled from this estimation based on equation (4) to compute the *Total Trade Linkage Index* (TTLI) based on equation (9). This index is reported in Figure 3. This Figure shows how the most aggregated generalized trade linkage measure in this study evolved from the short-run through the long-run. We find that the index started from 80% at horizon 1, declined slightly at horizons 2, 3 and 4, and then rose gradually to 85% at horizon 24. This means that the *total trade linkage index* is higher in the long-run than in the short-run, indicating that the Oceania become more interlinked in the long-run as the business cycles become more synchronized. This finding is consistent with the trend of global macroeconomic interlinkage reported by Greenwood-Nimmo *et al.* (2015), Diebold and Yilmaz (2016), and Ogbuabor *et al.* (2018), indicating that the ongoing globalization process is engendering more significant comovement in industrial production fluctuations. Furthermore, we find that the index recorded an average value of 83%, which shows that the trade linkage between the Oceania and the rest of the global economy is quite substantial. Our findings here aptly capture the pattern of trade between the Oceania and the rest of the world, which shows that the Oceania is deeply integrated into global trading activities. This in turn suggests that the Oceania may be vulnerable to trade shocks like contraction in demand emanating from the rest of the global economy, thereby underlining the relevance of this study.

Figure 3: *Total Trade Linkage Index* (TTLI)



Source: Authors. **Notes**: The *Total trade linkage Index* reported here is the most aggregated non-directional trade linkage index computed for all horizons following equation (9). Notice that the index is smaller in the short-run (i.e. towards horizon 1) than in the long-run (i.e. towards horizon 24), indicating that the Oceania economies become more interlinked in the long-run.

4.2 Determining the countries in the rest of the world that are dominating Oceania's trade and therefore have the potential to spread trade shocks to the Oceania:

An important objective of this study is to determine the countries in the global economy that are dominating Oceania's trade and therefore have the potential to spread trade shocks to the Oceania. To achieve this objective, we follow equation (6) and report the *from-effect* trade linkage from all the economies in the system to each of the two Oceania economies (i.e. Australia and New Zealand) in Table 2. We include the heatwave (or *own-effect*) of equation (5) in this table so that it sums up to 100%. To deepen the analysis, we aggregated the contributions from key regional trading blocs in order to reveal their influence on each Oceania economy. The regional trading blocs accounted for here includes: Asia (comprising China, India, Japan, and South Korea); Europe (comprising UK, France, Germany, and Italy); the Americas (consisting of USA and Canada); and the Oceania (consisting of Australia and New Zealand). Overall, Table 2 decomposes the *from-effect* linkage of each Oceania economy by country and by region.

We find that outside the Oceania, USA is the highest contributor to the NGFEVDs of Australia with 10.6% while South Korea is the highest contributor to New Zealand with 8.8%. Apart from India and UK, other economies in the system contributed at least 5% to Australia, with each of China, Canada, France, and Japan contributing at least 9%. In the case of New Zealand, USA, China, Canada, India, Japan and South Korea contributed at least 5% to its NGFEVDs. In sum, these results suggest the roles of USA, China, Canada, Japan, and South Korea appear quite remarkable in both Australia and New Zealand. We find that Australia contributed 9.4% to New Zealand while New Zealand contributed 5.3% to Australia. This shows that both countries are significant trade partners, which may be due to the proximity between them. Overall, we find that apart from UK, all the economies in the system somewhat exert considerable influence on either Australia or New Zealand, thereby justifying their inclusion in the sample as important trade partners of the Oceania. However, the roles of USA, China, Canada, Japan, and South Korea in the Oceania are quite noteworthy. In Section 4.4, we will consider the *dependence-influence* space of these economies in order to conclusively determine those dominating the system and therefore have the potential to generate systemic shocks. Nonetheless, the foregoing results are consistent with the bulk of the established literature, such as Greenwood-Nimmo *et al.* (2015), Diebold and Yilmaz (2016), and Ogbuabor *et al.* (2018), which shows that USA, China, Japan, and EU are important real activity shock transmitters.

Table 2: The *From-effect* linkage of Oceania economies

Country	Australia	New Zealand
USA	10.5672	5.3789
UK	2.5290	1.6430
Australia	17.8014	9.3669
China	9.1215	4.8750
Canada	9.9232	6.8358
France	9.4101	3.3138
Germany	7.6531	2.9966
India	3.4600	7.4810
Italy	7.6272	2.8618
Japan	9.5059	5.2839
South Korea	7.1180	8.8397
New Zealand	5.2834	41.1236
Total from effect	**100**	**100**
Total from Regional Trading Blocs		
Total from Asia	29.2054	26.4796
Total from Europe	27.2194	10.8152
Total from the Americas	20.4903	12.2147
Total from the Oceania	23.0849	50.4905
Total from effect	**100**	**100**

Source: Authors. **Notes:** This table is a transpose of Table 1. It reports the from-effect of equation (6) for the two Oceania economies (i.e. Australia and New Zealand) and includes the heatwave of equation (5) so that the total for each economy sums up to 100%. The table also aggregates the contributions from key regional trading blocs in the system to each Oceania economy. Here, Asia includes China, India, Japan, and South Korea; Europe includes France, Germany, Italy, and UK; the Americas include Canada, and USA; while the Oceania includes Australia and New Zealand.

4.3 Determining the regional trading blocs that exert dominant influence on the Oceania and therefore have the prospects of spreading trade shocks to it:

In this Section, we seek to determine the regional trading blocs that exert dominant influence on the Oceania and therefore have the potential to spread trade shocks to it. To do this, we consider the contributions from the regional trading blocs to each of Australia and New Zealand as shown in Table 2. We find that the regional contributions ranged from 10.8% (total from Europe to New Zealand) to 29% (total from Asia to Australia). This shows that outside the Oceania, all the regions are making considerable contributions, thereby corroborating the earlier finding that the Oceania is deeply interlinked with the rest of the global economy. An interesting feature of these results is that outside the Oceania, the Asia bloc made the highest contribution to both Australia and New Zealand. The huge contribution from Asia aptly captures the significant role the Asian region is currently playing in global economic activities. This is particularly the case with China, whose role in the global macroeconomy has continued to rise, at least in the last decade. Another interesting aspect of the results in Table 2 is the distribution of the role of idiosyncratic conditions between Australia and New Zealand. We find that regional *heatwave* or *own-effect* contributes 23% in Australia and 50% in New Zealand, indicating that New Zealand is less prone to external shocks than Australia. This is quite consistent with the fact that while Australia contributes 17.8% to its own NGFEVDs, New Zealand contributes as high as 41% to itself. This point will become more obvious when we consider the *dependence-influence* space in Section 4.4. Overall, we find that even though the Asian trading bloc is playing a leading role in the Oceania, the roles of Europe and the Americas trading blocs cannot be called unimportant.

4.4 Determining the Oceania economy that is most susceptible to trade shocks originating from the rest of the global economy

Another important specific objective of this study seeks to determine the Oceania economy that is most vulnerable to trade shocks originating from the rest of the global economy. To achieve this objective, we report the estimates of the *dependence* and *influence indices* following equations (10) and (11), respectively. To provide a robustness check on these estimates, we will also consider the results of the *net-effect* linkage of each Oceania economy following equation (8).

To begin, consider the results of the *dependence* and *influence indices* as shown in Table 3. We find that all the economies in the system are quite open to external conditions as seen in the *dependence index* that ranges from 59% (for New Zealand) to 89% (for Canada). Each of these is closer to one than zero, showing that all the economies in the system are quite open. However, we find that Australia's *dependence index* of 82% is higher than that of New Zealand, indicating that Australia is more open to external conditions than New Zealand. In other words, Australia is more susceptible to trade shocks emanating from the rest of the world. The results become more interesting when we consider the *influence index*. We find that both Australia and New Zealand have negative *influence index*, indicating that both economies are vulnerable or susceptible to trade shocks. However, the results further indicate that Australia recorded higher negative *influence index* than New Zealand, indicating that it is indeed more vulnerable to trade shocks than New Zealand. In sum, this study therefore concludes that the Oceania economies are vulnerable or susceptible to trade shocks emanating from the rest of the global economy. When we subjected this conclusion to the *net-effect* linkages in Table 4, we find that it is quite robust since both economies recorded negative *net-effects* and are therefore net receivers of trade shocks. The results indicate that Australia recorded a higher negative *net-effect* than New Zealand.

The results further indicate that the influential economies in the system include USA, China, Canada, France, Germany, and Japan. These economies recorded positive *influence index* and thus dominate the system. Each of these six influential economies contributed at least 8% to the NGFEVDs of Australia; and except for France and Germany, each of these influential economies contributed at least 5% to New Zealand. France and Germany contributed 3% each to New Zealand. These findings are consistent with the stylized facts on trade in the Oceania, which indicate that these influential economies maintain substantial trade ties with the Oceania. The findings are also robust to the *net-effects* linkage of these economies as shown in Table 4. The *net-effects* linkage results indicate that USA, China, Canada, France, Germany and Japan recorded positive *net-effects* and are therefore net transmitters of trade shocks.

Overall, we find that the Oceania is considerably open but systemically unimportant and vulnerable to trade shocks emanating from the dominant and influential economies in the overall global economy, including USA, China, Canada, France, Germany, and Japan. These findings are consistent with our *a priori* expectations. They are also consistent with some studies in the literature, such as: Çakir and Kabundi (2013), which showed that shocks from China exert considerable influence on the global economy; Greenwood-Nimmo *et al.* (2015), which established that USA, the Eurozone, and China exert dominant influence over conditions in the global macroeconomy; and Ogbuabor *et al.* (2016), which found that USA, China, the EU, Canada, and Japan dominate global economic activities.

Table 3: *Dependence* and *Influence Indices* Results

Country	Dependence Index	Influence Index
USA	0.88248662	0.10687869
UK	0.78622284	-0.10457474
Australia	0.82198557	-0.16042650
China	0.88489954	0.03106901
Canada	0.89007606	0.07619801
France	0.87412271	0.01392884
Germany	0.87497884	0.04241571
India	0.82938668	-0.24439825
Italy	0.86977433	-0.00635751
Japan	0.86892265	0.10653156
South Korea	0.78345106	-0.02913933
New Zealand	0.58876387	-0.01753176

Source: Authors. **Notes:** The dependence and influence indices were computed using equations (10) and (11) respectively.

Table 4: *Net-effect* Linkages

Country	***Net-effect***
USA	21.1965
UK	-14.2627
Australia	-21.6492
China	5.6994
Canada	14.7138
France	2.5980
Germany	7.8974
India	-32.3095
Italy	-1.0212
Japan	21.0065
South Korea	-3.7511
New Zealand	-0.1179

Source: Authors. **Notes:** The *Net-effects* were computed following equations (8).

4.5: Determining the economies in the rest of the global economy that are most susceptible to trade shocks originating from the Oceania

The last specific objective of this study seeks to establish the economies in the rest of the global economy that are most susceptible to trade shocks originating from the Oceania. To achieve this objective, we computed the *to-effect* of equation (7) for both Australia and New Zealand. The results are presented in Table 5. Recall that the *to-effect* measures the directional linkage from a given economy (for instance, a given Oceania economy) to other economies in the system, thereby showing the impact or influence of that particular Oceania economy on other economies in the system. We find that Australia contributed at least 8% to the NGFEVDs of each of China and South Korea; while New Zealand contributed at least 7% to each of China, Canada, Japan, and South Korea. This effectively means that China, Canada, Japan, and South Korea are most susceptible to trade shocks originating from the Oceania. Interestingly, these economies account substantially for trade in the Oceania. Table 5 shows that Australia contributed 9.4% to New Zealand, while New Zealand contributed 5.3% to Australia, which further reinforces our earlier conclusion that they are strong trade partners.

Table 5: *To-effect* Linkages

Country	Australia	New Zealand
USA	4.1886	4.9678
UK	2.8514	0.8084
Australia	17.8014	5.2834
China	7.8881	8.8550
Canada	3.4175	7.6287
France	4.3620	2.5828
Germany	4.2813	3.3723
India	4.2761	3.8586
Italy	4.4480	3.3269
Japan	3.8514	7.4282
South Korea	11.6181	10.6463
New Zealand	9.3669	41.1236

Source: Authors. **Notes:** The *to-effects* were computed following equations (7).

5. Conclusion and Policy Implications

This study examined the dynamics of trade shock propagation between the Oceania and the rest of the global economy using the spillover framework of Diebold and Yilmaz (2009). The paper extended the empirical method by constructing generalized trade linkage measures at various levels of aggregation. The main findings are summarized as follows. First, we find that the Oceania becomes more interlinked with the rest of the global economy in the long-run as the business cycles become more synchronized; and that the trade linkage between the Oceania and the rest of the global economy is quite substantial, with the *total trade linkage index* having an average value of 83%. Second, we find that USA, China, Canada, France, Germany and Japan are the influential and/or dominant economies that have the potential to spread trade shocks to the Oceania. The results further indicate that Asia, the Americas, and Europe regional trade blocs play influential roles in the Oceania's trade. Third, we find that the Oceania economies (namely, Australia and New Zealand) are predominantly open but vulnerable to global trade shocks, especially those originating from the aforementioned dominant sources. These findings are particularly consistent with the fact that the Oceania's intra-trade has been relatively low relative to its extra-trade with the rest of the global economy. Interestingly, we also find that China, Canada, Japan, and South Korea are most susceptible to trade shocks originating from the Oceania. On the whole, however, our findings indicate that the Oceania economies are predominantly net receivers of trade shocks rather than net transmitters.

The foregoing findings of this study have several policy implications because, according to Greenwood-Nimmo *et al.* (2015), "globalization makes it impossible for dominant economies to collapse in isolation". First, policymakers in the Oceania are able to see that the stability of the continent depends somewhat on the actions of the rest of the global economy, which are generally outside the control of the continent. In other words, the results of this study constitute an essential wake-up call to policymakers in the Oceania to be mindful of the chances of adverse trade shocks emanating from the aforementioned dominant sources, particularly the Asian trade partners. Policymakers and leaders in the Oceania should therefore coordinate policies towards safeguarding the continent from future crisis. Second, the results of this study provide evidence to assist policymakers in the Oceania and the rest of the global economy in identifying the likely sources of future trade shocks so that appropriate policy responses to such shocks can be designed. Such policies and strategies will in turn assist the Oceania to achieve shared prosperity and enhanced living standards for all its citizens on a sustainable basis. Third, the findings provide evidence that can assist policymakers across the globe in understanding how measurement and evaluation of trade linkages can be used to improve risk measurement and management, and public policy. This underlines the need for policymakers in the Oceania to view the results of this study as part of the much needed early warning signals towards the evolution of well-coordinated policy actions that can safeguard the continent from potential global trade shocks.

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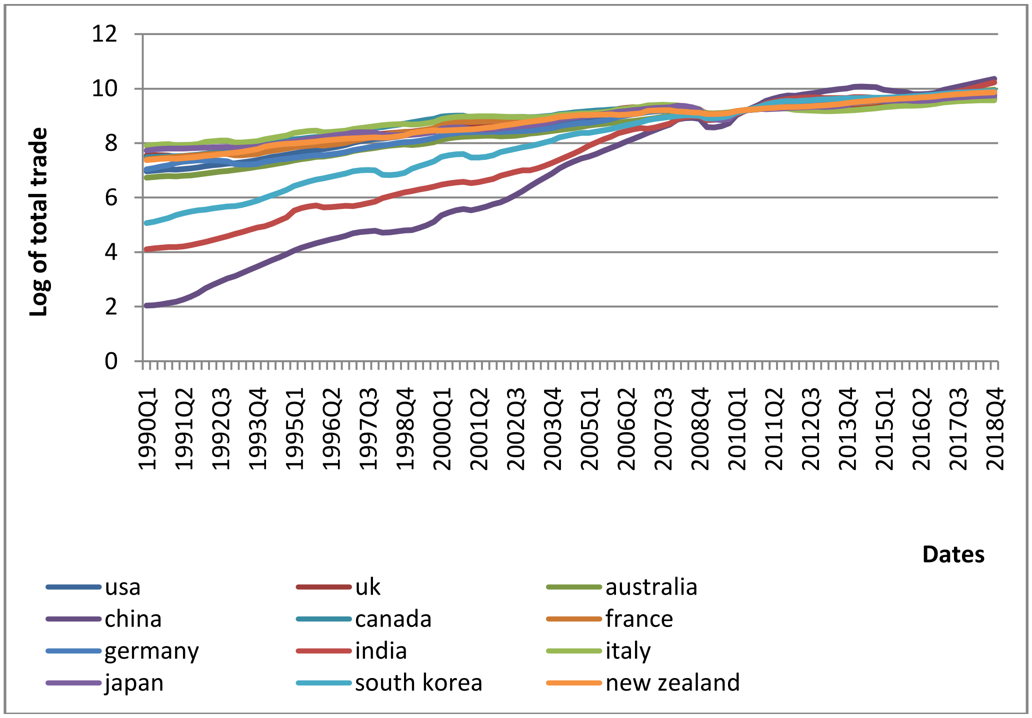
Appendix 1: Descriptive statistics of the data

	AUS	CAN	CHN	FRA	GER	IND
Mean	8.4750	8.8705	6.8578	8.7602	8.5775	7.4791
Median	8.5311	9.0111	7.2636	8.9418	8.6806	7.5637
Maximum	9.9505	9.6955	10.3475	9.7666	9.8561	10.2293
Minimum	6.7292	7.4790	2.0396	7.4037	7.0394	4.1022
Std. Dev.	0.9719	0.6482	2.6701	0.7243	0.8685	1.9452
Skewness	-0.2692	-0.8298	-0.2525	-0.4987	-0.2372	-0.2338
Kurtosis	1.8459	2.4902	1.6562	1.9331	1.6993	1.6402
Jarque-Bera	7.8389	14.5688	9.9606	10.3102	9.2652	9.9936
Probability	0.0199	0.0007	0.0069	0.0058	0.0097	0.0068
Observations	116	116	116	116	116	116

	ITL	JPN	NZL	KOR	UK	USA
Mean	8.8939	8.7894	8.7504	8.0072	8.7698	8.6226
Median	8.9869	8.8586	8.9959	8.2945	8.9383	8.7757
Maximum	9.5711	9.7464	9.8604	9.9035	9.6781	9.7888
Minimum	7.9015	7.7320	7.3716	5.0681	7.4945	6.9622
Std. Dev.	0.4903	0.6210	0.7201	1.4847	0.6793	0.8449
Skewness	-0.6845	-0.1836	-0.3471	-0.3921	-0.5366	-0.5113
Kurtosis	2.2515	1.7047	1.9847	1.8683	1.9869	2.0628
Jarque-Bera	11.7669	8.7612	7.3111	9.1620	10.5272	9.3009
Probability	0.0028	0.0125	0.0258	0.0102	0.0052	0.0096
Observations	116	116	116	116	116	116

Appendix 2: Time series plots of the data



Source: Authors. **Notes**: These graphs plot the data over the full sample.

Appendix 3: Phillips-Perron Unit Root Test Results

Variables	PP Test stat at level	Critical value at 5%	PP Test stat at 1st Diff	Critical value at 5%	Order of Integration
Australia	-0.928777	-3.449365	-5.008164	-3.449716	I(1)
Canada	-1.479847	-3.449365	-4.975387	-3.449716	I(1)
China	-0.456595	-3.449365	-4.960574	-3.449716	I(1)
France	-1.227194	-3.449365	-5.127537	-3.449716	I(1)
Germany	-1.985788	-3.449365	-4.876611	-3.449716	I(1)
India	-0.917026	-3.449365	-4.932506	-3.449716	I(1)
Italy	-1.607359	-3.449365	-5.101454	-3.449716	I(1)
Japan	-2.769257	-3.449365	-5.755559	-3.449716	I(1)
New Zealand	-1.649572	-3.449365	-4.939878	-3.449716	I(1)
South Korea	-0.724908	-3.449365	-4.941351	-3.449716	I(1)
UK	-0.848875	-3.449365	-4.507043	-3.449716	I(1)
USA	-1.377988	-3.449365	-4.981174	-3.449716	I(1)

Source: Authors.

Appendix 4: Johansen system cointegration test results

Panel 1: Trace test

Hypothesized No. of CE(s)	Eigenvalue	Trace Stat	0.05 Critical Value	Prob.**
None *	0.9895	2377.8360	374.9076	0.0000
At most 1 *	0.9738	1872.4530	322.0692	0.0000
At most 2 *	0.9626	1468.1320	273.1889	0.0000
At most 3 *	0.9000	1103.3520	228.2979	0.0001
At most 4 *	0.8778	847.8165	187.4701	0.0001
At most 5 *	0.7581	614.5175	150.5585	0.0001
At most 6 *	0.7214	456.9637	117.7082	0.0000
At most 7 *	0.5919	315.1084	88.8038	0.0000
At most 8 *	0.5552	215.6133	63.8761	0.0000
At most 9 *	0.4816	125.6867	42.9153	0.0000
At most 10 *	0.2858	52.7692	25.8721	0.0000
At most 11 *	0.1296	15.4131	12.5180	0.0159

Panel 2: Max-Eigenvalue test

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Stat	0.05 Critical Value	Prob.**
None *	0.9895	505.3826	80.8703	0.0001
At most 1 *	0.9738	404.3208	74.8375	0.0001
At most 2 *	0.9626	364.7798	68.8121	0.0000
At most 3 *	0.9000	255.5359	62.7522	0.0001
At most 4 *	0.8778	233.2989	56.7052	0.0001
At most 5 *	0.7581	157.5538	50.5999	0.0000
At most 6 *	0.7214	141.8553	44.4972	0.0000
At most 7 *	0.5919	99.4951	38.3310	0.0000
At most 8 *	0.5552	89.9266	32.1183	0.0000
At most 9 *	0.4816	72.9175	25.8232	0.0000
At most 10 *	0.2858	37.3562	19.3870	0.0001
At most 11 *	0.1296	15.4131	12.5180	0.0159

Source: Authors.