DOI: http://doi.org/10.4038/ijabf.v8i1.121

International Journal of Accounting & Business Finance
Vol.8, No.1, June 2022 Issue. pp. 102 - 122

Dynamics of financial development, innovation, trade, and economic growth: evidence from developed and developing nations

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Abstract

The paper empirically explores the interrelationship among financial development, innovation, trade, and economic growth in 20 developing and developed nations. It applies the panel data methodology to give detailed and more efficient information about the study variables. Further to this, Principal component analysis is applied on the panel data to reduce the eighteen dimensions of financial development and six dimensions of innovation into two indices, separately for developed and developing nations. To bring out the best linkage possible between the stated variables, Panel regression is employed such as Dynamic OLS, Fully Modified OLS and Simple OLS. The study's key finding indicates a significant relationship between economic growth (EG), trade (TO) and innovation for developed nations. A significant relationship exists between economic growth (EG) and trade (TO), financial development (FD) and innovation for developing nations. A negative and significant relationship with innovation. Thus, it implies that economic growth (EG) boosts through trade (TO) and financial development (FD) in developed nations while economic growth (EG) boosts through trade (TO), innovation, and financial development (FD) in developing nations. On further employing the vector error correction model, the presence of short-run causality between growth, trade and innovation in developed nations and short term causality only between growth and trade for developing nations further reaffirms the results obtained. Thus, the consistent result across various estimation techniques indicates an insignificant relationship between growth and financial development for developed nations but a significant relationship in developing countries between growth, trade, financial development, and innovation. The implications of the study highlight that in developing nations, to innovate and enhance trade and growth, policies to boost infrastructure for R&D should be implemented, while for developed nations, trade is required to boost financial strength and this growth of the economy in both the long and short run.

Keywords:- *Financial development, Economic growth, Innovation, trade, VECM*

1 Introduction

Studies on determining macroeconomic variables influencing the economic Growth (EG) of a nation have been of great interest among researchers for many decades. Literature highlights some of the dominant macroeconomic variables like Financial Development (FD) (King & Levine, 1993; Hassan, Sanchez & Yu, 2011; Masten, Coricelli & Masten, 2008; Levine, Loayza & Beck, 2000), Foreign Direct Investments (FDI) (Balasubramanyam, 1996; Agarwal, 2001; Wang & Bloomstrom, 1992; Borensztein, De Gregorio & Lee, 1998; Gupta & Singh, 2016), Inflation (Pradhan, 2011; Rousseau & Yilmazkuday, 2009), Innovation (Hasan &

Tucci, 2010; Wong, Ho & Autio, 2005; Fan, 2011), Human Capital (HC) (Ibrahim & Alagidede, 2018), degree of dependency on natural resources like oil (Sachs & Warner, 2001; Mehlum, Moene & Torvik, 2006; Beck, 2011; Nili & Rastad, 2007; Gylfason & Zoega, 2006) having a causal relationship with economic growth. The two most significant sets of studies from the literature highlighted the empirical relationship with economic growth; one is the "financial development-economic growth" nexus, and the other is "innovation-economic growth" nexus. Research concerning the relationship between financial development (FD) and economic growth (EG) stresses that if there is progress in the banking sector and financial markets expansion, it results in mobilization of funds, capital accumulation and raised savings which eventually results in positive economic growth (Levine, 1997; Wachtel, 2001; Pradhan, Arvin, Norman, & Nishigaki, 2014). Researchers also examined the relationship between economic growth (EG) and innovation and suggested that as the number of patents, inventions, and new research increases in a nation, positive economic growth is witnessed (Hasan & Tucci, 2010; Fan, 2011; Wong et al., 2005). Although the findings of earlier studies are not conclusive, some studies highlight unilateral, some state bilateral, and some prove no such nexus.

Given that economic growth is imperative for any economy, it is not surprising to see that examining the contributing factor of economic growth (EG) becomes the topmost priority of the regulators and policymakers. In this line, this paper explores the interrelationship between financial development (FD), innovation, trade, and economic growth (EG) for 20 nations. Literature highlights that studies on these variables have been conducted by applying either of the two econometric approaches. One approach used in earlier studies is the time series regression analysis which examines the relationship between financial development (FD), innovation, economic growth (EG) and trade. Another approach used in earlier studies is the cross country regression, wherein factors of economic growth (EG) are examined. The current study utilises a new approach where panel data of 20 nations is used to empirically analyze the causal relationship between the study variables from 1995 to 2018 to highpoint new evidence. The current paper applied the panel data methodology to give detailed and more efficient information about the study variables. Further to this, Principal component analysis has been applied on the panel data to reduce the components of financial development and innovation into two indices, individually for developed and developing nations. These indices are an adequate measure as PCA helps extract suitable information from the selected parameters and avoid multicollinearity, thus transforming into a single variable. To bring out the best linkage possible between the stated variables, Panel regression is employed such as Dynamic OLS, Fully Modified OLS and Simple OLS. Thus, this study's novel framework makes it interesting and different from the existing studies on similar variables. Another two variables, innovation and trade, have been incorporated in the study wherein the interrelationship between these four variables is examined.

The remaining paper is organized in the following manner: Section two discusses literature, and section three highlights the data and methodology, followed by section four, which highlights on the empirical results. Lastly, the paper provides the conclusion and policy implications in section five.

2 Literature review

A combined interdependence between financial development, innovation, trade, and economic growth is studied in the current paper. Brief literature on this interlinkage has been discussed in this section. Many studies indicate the innovation-EG nexus, FD-EG nexus, innovation-FD nexus, and trade-EG nexus. Each strand has been discussed separately. It has been witnessed that within each strand of literature, there are again four types of hypotheses, "demand leading hypothesis", "supply leading hypothesis", "feedback hypothesis", and "neutral hypothesis".

The first aspect of the literature highlights the causal relationship between financial development (FD) and growth. In some earlier studies, it has been witnessed that there is a significant impact of financial development (FD) on economic growth (EG) and supports the supply leading hypothesis (Christopoulos & Tsionas, 2004; Schumpeter, 1912; Gurley & Shaw, 1955; Kar, Nazlıoğlu & Ağır, 2011; Chaiechi, 2012; Rioja & Valev, 2004). In a study, financial development (FD) and EG highlighted a positive relationship (Levine et al., 2000). In another study where 43 nations are considered to explore the relationship, the results highlight that financial development (FD) is positively impacting economic growth(EG) if a nation's financial development(FD) level is more than its cross-sectional averages (Mishra & Narayan, 2015). In some studies, it is also discussed that for developing nations, the effect of financial development on EG is greater as compared to the developed nations (Masten et al., 2008; Calderón & Liu, 2003). These studies stress that the policymakers should focus on developing and refining the financial system as it results in enhancing economic growth (EG) (Gurley & Shaw, 1955; Bencivenga & Smith, 1991; Pagano, 1993).

The other body of literature present on financial development-economic growth nexus supports the "demand following hypothesis" that states that it is the economic growth (EG) that has a significant impact on the financial development (FD) (Lucas, 1988; Jung, 1986; Chandavarkar, 1992; Stiglitz, 1994; Xu, 2000; Levine, 1997). In contrast to the research mentioned above, some studies throw light on a new angle and suggest that two economic variables indicate that these studies support the neutrality hypothesis (Pradhan et al., 2014). Studies showcased the bilateral relationship between financial development (FD) and economic growth (EG) (Abu-Bader & Abu-Qarn, 2008). A new variable, investment, was introduced, and a tri-variate model VAR model was applied in a study on Egypt. The findings supported a reciprocated relationship between these variables (Abu-Bader & Abu-Qarn, 2008). Other studies also confirm this feedback hypothesis (Apergis, Filippidis & Economidou, 2007).

Another strand of literature discussed the interlinkage between economic growth (EG) and innovation. A robust association is

witnessed between technical innovation and growth (Nadiri, 1993; Romer, 1986; Mansfield, 1972). One body of literature stresses a strong empirical effect of innovation on economic growth (EG) (Romer, 1986; Romer, 1990; Stokey, 1995; Cetin, 2013; Fan 2011; Pradhan, Arvin, Hall & Nair, 2016; Yang, 2006). Technological advancements and innovation lead to improved production, leading to long-term economic growth (EG), going along with the "supply-leading hypothesis" (Grossman & Helpman, 1994; Mansfield, 1980; Griliches & Mairesse 1983). In contrast, evidence of the "demand following hypothesis" highlights that economic growth (EG) impacts innovation (Sinha, 2008; Cetin, 2013; Pradhan et al., 2016). Another body of literature throws light on the bilateral link between innovation and economic growth (EG) and supports the feedback hypothesis (Cetin, 2013; Pradhan et al., 2016). These studies witnessed that both innovation and economic growth influence each other. Some research supports the "neutrality hypothesis" and indicate no linkage between the two variables (Pradhan et al., 2016; Cetin, 2013).

Some research also suggests that trade, including both i.e., imports and exports are the engine of growth of a country and has a positive effect on it. Simultaneously, innovation also fuels trade and supports economic growth (EG) as it increases the competitiveness of a country and establishes a new business environment. Also, countries determine ways to enhance their foreign trade competitiveness and adopt innovation (Sener & Delican, 2019). In developed countries, technological developments have positively impacted international trade (Sener & Delican, 2019).

At the firm level, the literature suggests a theoretical consensus that innovation positively impacts a firm's exports; however, empirical studies show mixed results (Wu, Wei & Wang, 2020). The innovation capability of a firm (Rasiah, Shahrivar, & Yap, 2016) and innovation positively impacts the exporting activity (Rodil, Vence & del Carmen Sánchez, 2016; Wu et al., 2020) and business performance of a firm (Golovko & Valentini, 2011). It is also evident that innovation-intensive firms demonstrate different behaviour of entering and exiting the export markets like that of firms enrolled in low-intensity innovation (Love & Ganotakis, 2013). Innovation contributes to the export of firms in both ways, i.e. directly and indirectly. Past research establishes that knowledge creation of a firm and export-related activities are linked as the firm's export orientation and its capacity to create internal knowledge are endogenously related (Love & Ganotakis, 2013). This implies that the firms that conduct R&D activities self-select foreign markets (Gkypali, Arvanitis & Tsekouras, 2018). For innovative firms, there is a positive effect of exposure to international markets as it allows them to sell more of their products on entering international markets (Love & Ganotakis, 2013).

Various innovation types like technological innovations, product innovations and organizational innovations foster marketing innovations of a firm and impact its export growth positively (Bodlaj, Kadic-Maglajlic & Vida, 2020). In the case of firms from developing markets such as Nigeria, it is

evident that process innovation and marketing innovation exerts increased export performance (Edeh, Obodoechi & Ramos-Hidalgo, 2020). Product innovation affects a firm's productivity and stimulates firms to export (Cassiman, Golovko & Martínez-Ros 2010). Organizational innovation also plays an essential part in enhancing a firm's export performance; both ways are directly and indirectly. Technological innovation as well performs a mediating role (Azar & Ciabuschi, 2017). It brings closeness to the global world and increases trade relations between countries (Sener & Delican, 2019). The other view in the literature also states that trade and FDI significantly affect technology and product innovation by local organizations in developing nations (Gorodnichenko, Svejnar & Terrell, 2020). In the case of Chinese firms, export activities increase the R&D intensity of an importing firm. Also, importing firms' R&D intensity is increased by importing intermediates (Chen, Zhang & Zheng, 2017).

Very few researches discuss the relationship between innovation and FD, and the results are mixed (Pradhan et al., 2016; Hsu, Tian & Xu, 2014). A few points can be highlighted here after discussing the literature on the nexus between these four variables. Firstly, the findings of all these strands are not conclusive. Within each relationship, mixed outcomes are presented with the change of time and countries of study. Secondly, the interlinkage between innovation and financial development (FD) has not been explored exhaustively. Thirdly, no literature is available that has discussed the joint interdependence between the variables, i.e. innovation, financial development (FD), trade, and economic growth (EG). One study has been found so far (Pradhan et al., 2018) that has tried to overcome the issues to some extent and attempts to analyze the combined interdependence between three variables, innovation, financial development (FD) and economic growth (EG). A fourth variable, namely trade, is added to discuss the economy's holistic model in the current study.

Based on the review of literature and theory, the following hypotheses have been formulated:

H1a: Financial development has a significant impact on economic growth

H1b: Economic growth has a significant impact on financial development

H1c: There is a bilateral relation between financial development and economic growth

H1d: There is no linkage between financial development and economic growth

H2a: Economic growth has a significant impact on innovation.

H2b: Innovation has a significant impact on economic growth.

H2c: There is a bilateral relation between economic growth and innovation

H2d: There is no linkage between economic growth and innovation.

H3a: Trade has a significant impact on economic growth

H3b: Economic growth has a significant impact on trade

H4a: Innovation has a significant impact on trade

H4b: Trade has a significant impact on innovation

H5: Financial Development has a significant impact on innovation

3 Material and methods

Data

The paper intends to assess the association between Economic Growth (EG) and innovation, trade openness (TO), and Financial Development (FD). The sample selected for the study comprises of developed and developing nations as there is a possibility of variation in the significance of the relationship between the selected variables and to further assess the implementation of policy measures in each of the areas. Based on the existing literature, the framework of interaction between the selected variables may help in drawing a comparative picture and further emulate the learnings of developed nations in developing nations over the selected period of time. The countries have been selected based on their scale of development and share in global trade. The selected developed nations are Australia, Canada, France, Germany, Italy, Japan, New Zealand, Spain, United Kingdom and United States of America. While the developing nations selected are Brazil, China, Hong Kong, India, Korea, Malaysia, Mexico, Russia, Singapore and South Africa.

Data is connected annually, which is time series in nature. The source of data is the World Development Indicators and International Financial Statistics. These indicators are provided by the 'World Bank and International Monetary Fund'. This data is collected for both developing (10) and developed (10) nations. The time period of the study is 1995-2018 (Singh and Siddiqui, 2021).

Economic growth is indicated by an index of Gross Domestic Product with the base as 1995, while for Innovation and Financial Development. These indices are formulated by using Principal Component Analysis. The sum of export and import volumes of each nation is taken as the value of trade openness of a nation. To overcome the issue of heteroskedasticity, it is advised to consider the log of the values of the variables selected (Singh and Siddiqui, 2021). 6 measures of innovation and Financial Development comprising 18 measures as depicted in table- 1 are considered for defining the variables for the present study. These variables have been selected based on existing literature and it has been seen that to create indices the technique usually used is PCA (Singh and Siddiqui, 2021; Pradhan et al. 2014).

Table 1. Parameters included in constructing Financial Development Index Innovation Index

Financial Development Index			Innovation Index
Broad money (% of GDP)	Gross domestic savings (% of GDP)	Private credit by deposit money banks and other financial institutions to GDP (%)	High-technology exports (% of manufactured exports)
Central bank assets to GDP (%)	Liquid liabilities to GDP (%)	Public-private partnerships investment in ICT (current US$)	Patent applications, nonresidents

Credit to government and state-owned enterprises to GDP (%)	Outstanding domestic private debt securities to GDP (%)	Remittance inflows to GDP (%)	Patent applications, residents
Deposit money banks" assets to GDP (%)	Outstanding domestic public debt securities to GDP (%)	Stock market capitalization to GDP (%)	Research and development expenditure (% of GDP)
Domestic credit to the private sector (% of GDP)	Personal remittances received (% of GDP)	Stock market total value traded to GDP (%)	Researchers in R&D (per million people)
Financial system deposits to GDP (%)	Personal remittances received (current US$)	Total reserves (includes gold, current US$)	Scientific and technical journal articles

Source: Authors' Compilation based on definitions as given by World Development Indicators, World Bank and International Financial Statistics by International Monetary Fund

PCA has been applied to develop a single measure for selected dimensions of financial development and selected dimensions of innovation. Two indices for each are developed for separate set of countries. For the innovation variable, developed nations' eigenvalues reflect that the first result of PCA supports 54.2 percent variance and on rotation, 41.4 percent. In case of developing nations, the first result of PCA indicates 51.3 percent variance and on rotation 47.4 percent (Singh and Siddiqui, 2021). In case of financial development index, developed nations' eigenvalues suggest that the first result of PCA explains 36.4 percent variance and on rotation 24.7 percent (Singh and Siddiqui, 2021). In case of developing nations, the first result of PCA describes 41.14 percent variance and on rotation 37.31 percent (Singh and Siddiqui, 2021). Thus, the result of PCA is most appropriate as it describes the variation. The KMO and Bartlett's Test for sampling adequacy in the analysis is more than 65 percent in the innovation index and more than 72 percent for the financial development index (Singh and Siddiqui, 2021). Thus, the indices are now applied as an independent variable to understand the interlinkages.

Methodology

Once the indices for innovation and financial development have been formulated based on PCA, to examine the interaction between the chosen variables, the following equations are formed:

To evaluate the objective of the paper, the equations which are formulated are

$$\ln Growth = \beta 0 + \beta 1 \ln FD + \beta 2 \ln TO + \beta 3 \ln Inn + \varepsilon \text{ ---- (1)}$$

$$\ln TO = \beta 0 + \beta 1 \ln FD + \beta 2 \ln Growth + \beta 3 \ln Inn + \varepsilon \text{ ---- (2)}$$

where, growth is referred to as the yearly data for GDP at constant prices, FD is the Financial Development Index, TO is Trade, and Inn is Innovation Index. To

overcome the problem of heteroskedasticity, the selected variables have been converted into log. Further stationarity of the data series is checked as non stationarity may lead to biased results. If the data series is non stationary at level but stationary at first difference level and cointegrated, regression can be performed. Hence, the next step is to assess the cointegration of the series by employing Pedroni's cointegration test. To bring out the best linkage possible between the stated variables, Panel regression is employed such as Dynamic OLS, Fully Modified OLS and Simple OLS. This is undertaken as the time period is short and the shocks may lead to unreliable results.

Cross-sectional dependency tests are then employed as a shock wave which disturbs a nation may also impact other nations. Since the nations are highly integrated, cross-sectional dependency is important in identifying interlinkages among the series and can be tested using a Lagrange test (Breusch and Pagan, 1980; (Singh and Siddiqui, 2021). The building of the statistic of the test relies upon the evaluation of the model, which is as follows:

$$y_{it} = \alpha_i + \beta_i^{'} x_{it} + \varepsilon_{it} \quad (3)$$

for i = 1,2,…,N t = 1,2,…,T

In the above panel data model, i represents the 'cross-section dimension', t represents the 'time dimension', y_{it} represents the 'dependent variable', and x_{it} is the 'k×1 vector' of illustrative variables. α_i is the intercept and β_i is the slope, and these two coefficients are permitted to differ among the nations. ε_{it} represents the 'identical and independently distributed error terms' for each i. However, these could be cross-sectionally correlated for all t.

H0: Cov(εit,εjt)=0; no-cross sectional dependency for all t and i≠j

H1: $Cov(\varepsilon_{it},\varepsilon_{jt})\neq 0$; cross-sectional dependency for at least one pair of $i\neq j$

The hypothesis is tested, and the following Lagrange multiplier statistic test was developed by Breusch and Pagan (1980).

$$LM = T\sum_{i=1}^{N-1} \quad \sum_{j=i+1}^{N} \quad \hat{\rho}_{ij}^{2} \quad (4)$$

where ρˆij, for each i, is the "sample estimate of the pair-wise correlation of the residuals from ordinary least squares (OLS) estimation of equation 1".

A careful treatment is needed while examining Granger causality in the case of panel data. One of the concerns in this regard is to regulate for a probable cross-sectional dependency among the nations. In the current study, distress impinging on one nation may also affect other nations because of the high level of international trade, globalization, and financial integration. The significance of examining it was emphasized by Pesaran (2006) in the Monte Carlo experiment. This also demonstrates the considerable preference and size misrepresentations when such relation

is overlooked (Pesaran, 2006). The other concern is to determine whether the slope coefficients are considered homogenous and heterogeneous to enforce the causality constraint on the estimated parameters. By enforcing the joint restriction for the panel, the causality caused from one variable to another is the null hypothesis (Granger, 2003). Considering this, the empirical analysis begins with checking for cross-sectional dependency, and then by slope homogeneity throughout nations. Post this; there is a need to determine the panel causality method that should be used to ascertain the path of causality between trade openness, innovation, financial development (FD) and growth.

The Granger causality implies that the understanding of the previous values of one variable (X) enhance the predictions of another variable (Y) (Granger, 1969). In the case of cross-sectional dependency and heterogeneity among the countries, the adopted technique should check for these characteristics. There is the presence of numerous panel causality methods (Kar et al., 2011). The vector error-correction models (VECMs) to examine and analyze the paths of causality between the selected variables are as follows:

$$\Delta Growth_{it} = \eta_{11j} + \sum_{k=1}^{p1} \alpha_{11ik}\, \Delta Growth_{it-k} + \sum_{k=1}^{p2} \beta_{11ik}\, \Delta Financial\ Development_{it-k} + \sum_{k=1}^{p3} \gamma_{11ik}\, \Delta Innovation_{it-k} + \sum_{k=1}^{p4} \delta_{11ik}\, \Delta Trade\ Openness_{it-k} + \omega_{11i} ECT_{11it-1} + \varepsilon_{11it} \quad (5)$$

$$\Delta Trade\ Openess_{it} = \eta_{22j} + \sum_{k=1}^{p1} \alpha_{22ik}\, \Delta Trade\ Openess_{it-k} + \sum_{k=1}^{p2} \beta_{22ik}\, \Delta Financial\ Development_{it-k} + \sum_{k=1}^{p3} \gamma_{22ik}\, \Delta Innovation_{it-k} + \sum_{k=1}^{p4} \delta_{22ik}\, \Delta Growth_{it-k} + \omega_{22i} ECT_{22it-1} + \varepsilon_{22it} \quad (6)$$

$$\Delta Financial\ Development_{it} = \eta_{33j} + \sum_{k=1}^{p1} \alpha_{33ik}\, \Delta Financial\ Development_{it-k} + \sum_{k=1}^{p2} \beta_{33ik}\, \Delta Growth_{it-k} + \sum_{k=1}^{p3} \gamma_{33ik}\, \Delta Innovation_{it-k} + \sum_{k=1}^{p4} \delta_{33ik}\, \Delta Trade\ Openness_{it-k} + \omega_{33i} ECT_{33it-1} + \varepsilon_{33it} \quad (7)$$

$$\Delta Innovation_{it} = \eta_{44j} + \sum_{k=1}^{p1} \alpha_{44ik}\, \Delta Innovation_{it-k} + \sum_{k=1}^{p2} \beta_{44ik}\, \Delta Financial\ Development_{it-k} + \sum_{k=1}^{p3} \gamma_{44ik}\, \Delta Growth_{it-k} + \sum_{k=1}^{p4} \delta_{44ik}\, \Delta Trade\ Openness_{it-k} + \omega_{44i} ECT_{44it-1} + \varepsilon_{44it} \quad (8)$$

Where Δ is the first difference operator, i is the country, t is the time period, and ε is the error term. ECT is the lagged error correction term which indicates long-run dynamics, and the differenced variables explain the short-run dynamics. For the suggested models to give strong findings, the study parameters have to be stationary at level and cointegrated.

4. Results

a. Empirical results

The first step is to assess the descriptive statistics to understand the data for the developed and developing nations. the descriptive statistics are as enumerated in Table 2.

The descriptive statistics for developed and developing nations clearly indicates the difference in growth levels. It can also be seen that trade openness is more for developed as compared to developing nations. it can also be seen that innovation is positive for developed nations while financial development is better for developing nations. Thus the selected sample, will help in drawing a comparative inference between the selected variables.

The variables are chosen on the basis of existing literature and are checked by applying the Second Generation panel unit root test and Panel Cointegrations Test (Pedroni 2004). The findings suggest that the

variables are stationary at the first difference level as depicted in Table-3 and cointegrated, as depicted in Table-4. Hence, there exists a long-run relationship between innovation, financial development (FD), growth, and trade (TO).

The Pedroni test will make a priori assumption of a unique cointegration equation/vector. In the Pedroni test, we regress this equation with FMOLS to get the residual. The residual/error term will be tested whether it is stationary. The result below shows that this cointegration equation does not result in a stationary error term since all P-values are higher than the 10% significance level (there is no cointegration from this equation). This is undertaken for both developed and developing nations, and results are enumerated in Table-5. Thus it can be concluded that cointegration is present in variables for developed nations while not in the case of developing nations.

Table 2. Descriptive Statistics

	Developing Nations				Developed Nations			
	Innovation	Financial Development	Trade Openness	Growth	Innovation	Financial Development	Trade Openness	Growth
Mean	-1.66	-4.166	0.493	131.39	0.41	-0.001	1.152	184.23
Median	-0.264	-0.032	0.521	125.45	-0.269	-0.0703	0.560	160.14
S.D	1	0.999	0.159	1.978	1	1	1.258	1.399
Kurtosis	7.750	0.986	-0.175	-0.099	19.013	6.097	0.229	9.909
Skewness	2.783	-0.415	0.065	0.759	4.170	2.233	1.293	2.817
Minimum	-0.826	-2.754	0.189	100	-0.680	-1.34466	0	92.419
Maximum	4.471	2.491	0.945	206.34	6.416	4.15389	4.344	731.63

Note:- S.D=Standard Deviation

Table 3. Second Generation Panel Unit Root Test

	Developed Nations					Developing Nations				
	Moon Perron		Choi	Pesaran	Chang (2002)	Moon Perron		Choi	Pesaran	Chang (2002)
	ta Tb	tab tbB	Pm	CIPS	Average IV t-ratio	ta Tb	tab tbB	Pm	CIPS	Average IV t-ratio
Growth	0.40 (-0.23) 0.41(-0.21)	0.40 (-0.25) 0.40 (-0.24)	0.57 (-0.18)	0.53 (-2.25)	0.99 (2.55)	0.24 (-0.66) 0.22 (-0.77)	0.21 (-0.77) 0.21 (-0.79)	0.86 (-1.09)	0.89 (-1.86)	0.05 (-1.57)
Trade Openness	0.00 (-3.88) 0.00 (-3.64)	0.00 (-4.14) 0.00 (-3.73)	0.02 (2.06)	0.96 (-1.66)	0.92 (1.43)	0.07 (-1.41) 0.06 (-1.53)	0.06 (-1.51) 0.07 (-1.46)	0.06 (1.5)	0.12 (-2.71)	0.71 (0.57)

Innovation	0.00(-17.67) 0.00 (-18.327)	0.00 (-18.65) 0.00 (-19.38)	0.00 (6.95)	0.91 (-1.72)	0.75 (0.67)	0.00 (-2.77) 0.00 (-3.30)	0.00 (-3.02) 0.00 (-3.49)	0.02 (1.90)	0.8 (-1.99)	0.48 (-0.045)
Financial Development	0.59 (0.25) 0.58 (0.21)	0.60 (0.26) 0.59 (0.24)	0.16 (0.96)	0.95 (-1.72)	0.75 (0.67)	0.00 (-2.35) 0.01 (-2.30)	0.00 (-2.53) 0.01 (-2.13)	0.25 (0.65)	0.93 (-1.77)	0.53 (0.09)

*P value, ( ) statistics, * 1 % level of significance, ** 5 % level of significance, *** 10% level of significance.*

Table 4. Panel Cointegration Test Results

	Developed Nations		Developing Nations	
	Fisher Stat.* (from trace test)	Fisher Stat.* (from max-eigen test)	Fisher Stat.* (from trace test)	Fisher Stat.* (from max-eigen test)
None	0.0000 (82.05)	0.0000 (70.29)	0.0000 (101.0)	0.0000 (69.68)
At most 1	0.0577 (30.81)	0.2570 (23.67)	0.0005 (47.62)	0.0160 (35.85)
At most 2	0.4095 (20.79)	0.4921 (19.46)	0.1406 (26.81)	0.4837 (19.59)
At most 3	0.3392 (22.02)	0.3392 (22.02)	0.0101 (37.53)	0.0101 (37.53)
Inference	Not Cointegrated	Not Cointegrated	Cointegrated	Cointegrated

*P value, ( ) statistics, * 1 % level of significance, ** 5 % level of significance, *** 10% level of significance*

Table 5. Cross Dependency Test

	Developed Nations				Developing Nations			
Variable	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD

Growth	0.00 (894.37)	0.00 (89.53)	0.00 (89.31)	0.00 (29.53)	0.00 (1015.55)	0.00 (102.30)	0.00 (102.08)	0.00 (31.85)
Trade Openness	0.00 (803.16)	0.00 (79.91)	0.00 (79.69)	0.00 (24.67)	0.00 (539.47)	0.00 (52.12)	0.00 (51.90)	0.00 (18.63)
Innovation	0.00 (677.88)	0.00 (66.71)	0.00 (66.49)	0.00 (25.01)	0.00 (556.24)	0.00 (53.88)	0.00 (53.67)	0.00 (14.03)
Financial Development	0.00 (360.86)	0.00 (33.29)	0.00 (33.07)	0.17 (1.36)	0.00 (483.52)	0.00 (46.22)	0.00 (46.00)	0.00 (20.32)

*P value, ( ) statistics, * 1 % level of significance, ** 5 % level of significance, *** 10% level of significance*

As discussed in the methodology section, cross-sectional dependency is tested in the case of panel causality. This is required as represent empirical analysis consists of a number of countries. To check the existence of cross-section dependence, tests are carried out as represented in Table-5. The results indicate no cross-section dependency across nations implying that regression is an appropriate estimation method.

On identifying presence of cointegration between variables, parameters are estimated through dynamic and fully modified OLS. The results are indicated in Table-6. In this step, we estimate a long-run relationship between innovation, trade (TO), Growth, and financial development (FD). We regress the equation, which results in a stationary error term (regressing with dynamic OLS). Hence, we can estimate a long-run relationship only from this equation.

The study's key finding indicates a significant and positive relationship between economic growth (EG) and trade (TO) and innovation for developed nations. Financial development (FD) does not have a significant relationship with EG in the case of developed nations. A significant and positive relationship exists between economic growth (EG) and trade (TO), financial development (FD), and innovation for developing nations. On examining the impact of various variables on trade (TO), it is seen that a significant and positive relationship is present between trade (TO) and economic growth (EG) and financial development (FD) in the case of developed nations. In case of developing nations, a significant and positive relationship exists between trade (TO) and economic growth (EG) and financial development (FD) but a negative and significant relationship with innovation.

Therefore, economic growth (EG) supplements trade (TO) and financial development (FD) in developed nations while EG boosts through trade (TO), innovation, and financial development (FD) in developing nations. In terms of trade promotion, trade boosts through economic growth (EG) and FD in both the cases. Innovation is significant but

negatively related to trade promotion. Granger causality test was applied after VECM and the results are indicated in Table-7. There is a presence of short-run causality between economic growth (EG), trade (TO), and innovation in developed nations and only between economic growth (EG) and trade (TO) for developing nations. The trade-led growth hypothesis holds for the present study as also proven by past literature. Trade (TO) and innovation for developed nations indicate short run causality, while for developing nations, the causality runs from trade (TO) to economic growth (EG), financial development (FD) and innovation. Thus, the result is as per the innovation-led growth hypothesis. While there is no causality between financial development (FD) and innovation (Singh and Siddiqui, 2021; Pradhan et al., 2016; Yang 2006).

Table 6. Panel FMOLS and DOLS Results

Dependent Variable	Independent Variables	FMOLS(Developed Nations)		FMOLS(Developing Nations)		DOLS(Developed Nations)		DOLS(Developing Nations)	
		Coeff	t-Stat	Coeff	t-Stat	Coeff	t-Stat	Coeff	t-Stat
Growth	Trade Openness	92.52	3.80(0.00*)	74.13	3.87(0.00*)	111.26	4.79(0.00*)	79.32	4.07(0.00*)
	Financial Development	-0.82	-0.40(0.68)	16.45	1.60(0.10**)	-0.24	-0.11(0.90)	14.64	1.39(0.10**)
	Innovation	16.16	5.07(0.00*)	98.8	18.47(0.00*)	14.98	4.69(0.00*)	99.71	18.29(0.00*)
Trade Openness	Growth	0.00	3.79(0.00*)	0.00	4.44(0.00*)	0.00	4.83(0.00*)	0.00	2.94(0.00*)
	Financial Development	0.01	2.34(0.02**)	0.27	6.70(0.00*)	0.01	1.87(0.06**)	0.35	8.88(0.00*)
	Innovation	0.02	1.59 (0.11)	-0.23	-4.77(0.00*)	0.01	1.05(0.29)	-0.18	-3.78(0.00*)

*( )P value, * 1 % level of significance, ** 5 % level of significance, *** 10% level of significance*

Table 7. VECM Results

Variables and ECT-1	Developed Nations					Developing Nations				
	ΔGr	ΔTO	ΔFD	ΔInn	ECT-1	ΔGr	ΔTO	ΔFD	ΔInn	ECT-1

ΔGr	--	0.00*(-)	0.82(+)	0.00*(-)	0.11(-)	--	0.02**(-)	0.30(+)	0.74(-)	0.03**(-)
ΔTO	0.67(-)	--	0.71(+)	0.01*(-)	0.04**(-)	0.08***(+)	--	0.06***(+)	0.00*(-)	0.10***(-)
ΔFD	0.00*(+)	0.00*(-)	--	0.36(+)	0.00*(-)	0.95(-)	0.66(-)	--	0.31(+)	0.53(+)
ΔInn	0.10***(+)	0.61(+)	0.81(+)	--	0.78(+)	0.01***(+)	0.79(-)	0.64(+)	--	0.00*(-)

*P value, ( ) statistics, * 1 % level of significance, ** 5 % level of significance, *** 10% level of significance*

Results indicate that growth leads to trade openness, thus affirming the growth led trade hypothesis. Similarly, innovation in both countries leads to growth, thus affirming the innovation-led growth hypothesis. In the case of the sample nations, trade openness also leads to innovation, while financial development has no such impact on innovation. This can be explained by saying that growth in an economy leads to innovation, further leading to growth by attracting more investments and trade openness facilitated by growth, further promoting innovation. As to trade, innovation may be required for building a comparative advantage of products abroad, and the innovation-led growth hypothesis affirms this particular result. To conclude, the result of Panel VECM is basically in line with our theoretical expectation.

4 Discussion

There is an insignificant relationship between economic growth (EG) and trade(TO), financial development(FD), and innovation for developed countries but a significant relationship in the case of developing countries in the long run. The results of the study are in contrast to the "demand following hypothesis" that states that it is the economic growth(EG) that has a significant impact on the financial development(FD) for developed nations (Lucas, 1988; Romer, 1990; Jung, 1986; Chandavarkar, 1992; Stiglitz, 1994; Xu, 2000; Levine, 1997). Thus, in the long run there is a relationship between growth and its determinants for developing nations but no such relationship in developed nations. The findings go hand in hand with some of the earlier studies (Singh and Siddiqui, 2021; Masten et al., 2008; Calderón & Liu, 2003). The error correction term's sign is negative, thus indicating the response of variables to change in growth in the long run. The speed of adjustment, in this case, is 97% between innovation, economic growth (EG), trade (TO) and financial development (FD).

While with trade as the dependent variable, in case of both the groups of nations, there exists a negative but significant relationship in the long run. Thus, indicating the speed of adjustment in developed nations as 96% and developing nations at 90%. On similar lines, the current study witnesses that financial development(FD) has a significant long-run equilibrium with growth

(Christopoulos & Tsionas, 2004; Schumpeter, 1912; Gurley & Shaw, 1955; Kar et al., 2011; Chaiechi, 2012; Rioja & Valev, 2004), trade, and innovation in developed nations' only and innovation has a significant long-run equilibrium in developing nations with growth, trade, and financial development.

5 Conclusion

The present paper assesses the association between growth, trade, innovation, and financial development in 20 nations, ten developed and ten developing nations, from 1995-2018.

Developed nations have treaded the learning curve and the growth curve successfully over a long time. In developing nations, the stages of development are varied, and so is the state of various macroeconomic indicators. Financial development indicates the strength of an economy emerges out to be significant only for developing nations as developed nations are fundamentally strong. Innovation is also a result of growth and trade as when countries interact, they learn and innovate, and it is developing nations mainly where innovation flows in from developed nations while for trading and innovation, a strong financial base is required. Hence to innovate and enhance trade and growth policies to boost infrastructure for R&D should be implemented in developing nations, while for developed nations, trade is required to boost financial strength and this growth of the economy in both the long and short run.

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