



MODELING THE CAUSAL LINKAGES BETWEEN TRADE OPENNESS, INNOVATION, FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH IN ASIAN COUNTRIES

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ABSTRACT

The relationship among innovation, economic growth, trade openness and financial development has been an interesting topic in context of research, and many researchers have done significant work on these relationships. As far as economic growth is concerned, the impact of financial development, trade openness and innovation has been considered to be the most essential. In the similar context, the current study has been designed with the motive to find out and investigate the casual relationships between innovation, financial development, trade openness and economic growth of Asian countries. Based on the context of Asian countries, the data has collected of Asian countries including Bangladesh, Indonesia, Japan, Philippines, Thailand and Turkey, for the time period of 1980 to 2018. The Cobb Douglas production model has been used to get assistance for the achievement of the objectives of the current study. The collected data was analyzed by applying unit root test and panel VAR estimation model in the study. The results have indicated that there is no casual relationship among financial development and innovation. In the same way, no casualty has been found among trade openness and innovation. Contrarily, unidirectional casual relations have been found between economic growth along with financial development and in the same way, between trade openness and financial development. Lastly, this study has found a “bidirectional” casual relationship amid economic growth and trade openness. This study provides different implications especially for the policy makers of the Asian countries who can get assistance from this study to enhance their economic growth.

Contribution/ Originality

This study contributes to existing literature by investigating the casual relationships between innovation, financial development, trade openness and economic growth of Asian countries.

1. INTRODUCTION

In the World Development Bank report, Asia has the capital and population needed to become more than half of the economy of the world by 2050. Within this continent, there are a large number of developing nations named as China, Pakistan, India, Bangladesh, Russia, Afghanistan, Sri Lanka, Nepal, Japan and Myanmar, etc (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018; Shah, 2018). This is considered as the maximum population and area covering continent all over the world like it contains the 17.212 million square miles area with the 4.164 billion people oriented population (Yendamuri & Ingilizian, 2019). The problem statement of this study is to evaluate the influence of trade openness (TO), financial development (FD), and innovation on the economic growth of the Asian states (Bangladesh, Indonesia, Japan, Philippines, Thailand and Turkey). This statement is an informative and productive approach to make firm decisions for the effective economic growth of these nations. The major objectives of this research are; to critically inspect the influence of trade openness (TO) on the economic growth of the Asian Countries; to critically inspect the impact of innovation on the economic growth (EG) of the Asian Countries, and to critically inspect the influence of financial development (FD) on the economic growth of the Asian Countries.

In the previous researches, there was work on considering the dynamics of TO, FD, energy intensity, and technological innovation in the Bangladesh and South Africa perspective (Pan., Uddin, Han, & Pan, 2019; Salahuddin & Gow, 2016). In addition, the previous scholars also worked on Ghana, South Africa, Nigeria and Indian economic perspective by specifically considered the relationship between FD, tourism and EG (Ehigiamusoe & Lean, 2018; Ohlan, 2017). But nobody majorly worked on exploring this economic concept from the Asian countries' perspective, which is specifically focused in this paper. This shows that this is a valid study that covers the previous research gap and also gives a new direction to the future scholars to work on the additional economic factors that impact on the state's economy.

Overall, it's challenging and informative research that will help the Asian state's policymakers, government, the business community and the related financial bodies to work on the enhancement of the TO, innovation and the FD within their state, so that their economic growth becomes enhanced. Also, this informative research will help these states' native to understand the importance of industrialization and foreign trade for the economic welfare of their state. This valid information based statistical data will help the upcoming scholars to utilize its information in their discussion and the other hypothesis selection mechanism. After completing this first section of the introduction, there will be worked on the previous researches on the related topic in the literature review section. This section will review the relevant research theory and relational literature review of the related topic. Section three will present the research methodology where all the research data collection, its analytical test technique will be discussed. After this technical section, the next section four will be based on results and analysis where all the variables' outcomes are statistically analyzed and evaluate this. Last, but not the least, in the discussion and conclusion portion, there will be a consideration of the tested outcomes in the practical Canadian market perspective and also conclude all the research outcomes. In addition, its limitation and future implications will also be discussed in this section.

2. HYPOTHESES DEVELOPMENT

2.1. Economic Growth Theory

A Mercantilism theory is such a type of economic growth theory which stated that the wealth of a nation is usually determined based on the accumulation of gold and running trade surplus with the other states (Magnusson, 2019). This theoretical approach in the business is considered as the

pioneer of the industrial revolution which majorly advocates the state's regulatory authorities to promote the international trade openness mechanism in order to generate wealth and strengthen the national power (Vaggi & Groenewegen, 2016). This theoretical approach is utilized by the previous scholars in the critical evaluation of the perfect economic performance of a developing nation like Marcel Schroger studied this mercantilist motive to yield higher GDP and per capita income within a state (Schröder, 2017). Another related theory to generate major financial development within a developing state is an endogenous growth theory which stated that the economic growth of a state is majorly influenced by technological innovation and human capital. This approach is excessively utilized by the business community of the Asian states who utilize their young human capital in their advanced entrepreneurial projects, and China and India are the best examples of this theory implication. The researchers used this endogenous growth theory in order to explore the regional performance of a state by considering their special economic zones (Pan & Ngo, 2016), and also to understand the long term GDP growth rate of the populated size country whose management majorly used human power as a real asset of a state who work for the development of a state (Cozzi, 2017; He, Zhang, Zheng, & Wan, 2019).

2.2. Trade Openness and Economic Growth

In order to explore the relationship between TO and EG, a research was conducted by Silajdzic and Mehic (2018), where they majorly studied the empirical and theoretical perspective in their critical analysis. According to them, the trade openness majorly leads to greater differences in technology, economic efficiency, market imperfection and the endowments that may result in the diverse impact on the trade liberalization. They stated that trade liberalization leads to a positive economic outcome, especially in the less advanced transition economies. This shows that sometimes, there is a positive impact of trade barriers on the internal GDP growth of a state beyond its context of transition (Silajdzic and Mehic (2018). Well, Keho (2017) also majorly worked on considering the case study of Cote d'Ivoire in its TO and EG based relationship. According to him, capital stock and labor act as regressors in enhancing the favorable EG due to the strong relationship between TO and capital formation in the EG development (Keho, 2017). In the openness measurement issue-based informative research, the researchers majorly conducted empirical research between these two variables in the long-run economic growth (Albashabsheh, Alhroob, Irbihat, & Javed, 2018; Amir, Rehman, & Khan, 2020). According to these scholars, there are two major dimensions of trade integration within two states named as export quality and export variety that help to measure the trade openness. In the end, they concluded that there is a linear pattern between the export ratio and the export basket's quality, and such openness to trade results in the positive growth of a developing state (Huchet-Bourdon, Le Mouël, & Vijil, 2018). After critically analyzed the previous researches, the following hypothesis has been proposed;

H1: *There is a significant relationship between TO and EG*

2.3. Innovation and Economic Growth

In the Behavioral and Experimental Economics based informative journal, Thompson (2018) majorly stated that social capital networks facilitate the information and sharing and cooperation between the economic agents for the innovative activities, because innovation is a major driver of the economic cycle of a state. According to her, this innovation-based growth model is such social capital that is exclusively utilized by the majority of the developing states where the social capital stimulates the innovative activities and lead to higher monopolistic profits. In the end, she concluded that collective social capital generated and boost the EG through innovation (Thompson, 2018). In 2017, there was research by business scholars whose major aim to consider the influence of the innovation on the smart economic growth of a state in a long-run relationship. In that research, the scholars majorly worked on six major indicators of innovation named as R&D expenditure, patents-residents, patent-non-residents, high technology exports, technology and scientific knowledge (Kamalu, Wan Ibrahim, Ahmad, & Mustapha, 2019). According to them, all the innovation factors are directly linked with the per capita EG of a state. They suggested that this innovation and per capita economic growth play a significant role to maintain a sustainable growth of a state. In addition, the other researchers majorly worked on the Asian states and the financial innovation in

their economic growth. The major aim of this researches was to provide evidence of financial innovation in the efficient economic stability of a developing nation. Their test of coo-integration satisfied the occurrence of long term association between these two major factors where the gross domestic product and the board-to-narrow money is considered as a gross domestic product. According to these scholars, the co-efficient of the financial proxy variables is positive and significant in both the short and long run (Qamruzzaman & Jianguo, 2017; Shukla, 2017). This shows that in the economic status, there is a strong relationship between the innovation and economic development of a state. Hence, the following hypothesis has been proposed for this research study;

H2: *There is a significant relationship between Innovation and EG*

2.4. Financial Development and Economic Growth

It's true that FD cause a productive influence on EG within a state because its development results in the enhancement of cash flow within the state. Like in the Journal of Policy Modeling, business scholars stated that FD plays a major role in enhancing the economic growth of a state. According to their panel data analyses based outcome, efficient financial performance has a positive long term effect on the steady-state level of the per capita based GDP and result in the substantial involvement of the credit market (Durusu-Ciftci, Ispir, & Yetkiner, 2017). In the same research, another study was made by Muazu Ibrahim and Paul Alagidede, where they examined the overall EG impacts when the real and finance sector growth is majorly relying on the panel data specifically for the 29 African countries. According to their generalized method, it becomes clear that FD directly supports the EG and helps the state to efficiently grow in the real and financial sectors. They concluded that growth elasticity is changed in either real size or financial sector, is much higher under balanced sectorial growth (Ibrahim & Alagidede, 2018a). Well, in the Future Business Journal, Ramphul Ohlan stated that tourism led growth developed such econometric techniques that result in the influence of the Indian's state economic growth. According to them, there is a need of effective policies for the development of international tourism-based financial development within the state (Ohlan, 2017). Well, in the Sub-Saharan African perspective, (Ibrahim & Alagidede, 2018a) stated that financial development results in the enhancement of human capital, income per capita and financial development. According to their results, the financial performance enhances the overall economic performance of a state to actively participate in economic development (Ibrahim & Alagidede, 2018b). These researches' data has been proposed the following hypothesis;

H3: *There is a significant relationship between FD and EG*

3. METHODS

The current study has been designed with the motive to find out and investigate the impact that is casted by three independent variables i.e. innovation, financial development and trade openness on the dependent variable, economic growth for Asian countries. Based on the context of Asian countries, the researcher has collected panel data from Bangladesh, Indonesia, Japan, Philippines, Thailand and Turkey for the time period of 27 years. The Cobb Douglas production model might provide assistance for the achievement of the objectives of the current study i.e. to explore the relationships amid innovation, trade openness, financial development and economic growth. The Cobb Douglas Model can be represented as follows;

$$Y = AL^{\beta}K^{\alpha}e^{\varepsilon}$$

In this equation, Y is representing the economic growth, A shows the "total factor productivity", K is denoting the "capital", L represents the labor and finally ε is the error idiom. In addition, α and β are in the equation showing the output elasticity associated with capital and labor respectively. In the current study, the technology aspect has been determined through the use of three factors i.e. innovation, trade openness and financial development. Therefore, the Cobb Douglas model will take the following form;

$$Y = \theta FD^{\sigma} INN^{\gamma} T^{\omega} L^{\beta} K^{\alpha} e^{\varepsilon}$$

This model will then be distorted into the linear function which is presented as;

$$\log(Y)_{it} = a + \gamma_{1i}g(INN)_{it} + \sigma_{2i}g(FD)_{it} + \alpha_{3i}g(K)_{it} + \omega_{4i}g(T)_{it} + \varepsilon_{it}$$

In addition to this, we will consider four VAR models which will be given as follows;

Model 1:

$$g(Y)_{it} = \beta_0 + \sum_{j=1}^P \beta_{1,t} g(Y)_{i,t-k} + \sum_{j=1}^P \beta_{2,t} g(INN)_{i,t-k} + \sum_{j=1}^P \beta_{3,t} g(FD)_{i,t-k} \\ + \sum_{t=1}^P \beta_{4,t} g(T)_{i,t-k} + \sum_{t=1}^P \beta_{5,t} g(K)_{i,t} + \varepsilon_{i,t}$$

Model 2:

$$g(INN)_{it} = \gamma_0 + \sum_{j=1}^P \gamma_{1,t} g(INN)_{i,t-k} + \sum_{j=1}^P \gamma_{2,t} g(Y)_{i,t-k} + \sum_{j=1}^P \gamma_{3,t} g(FD)_{i,t-k} \\ + \sum_{t=1}^P \gamma_{4,t} g(T)_{i,t-k} + \sum_{t=1}^P \gamma_{5,t} g(KH)_{i,t} + \sum_{t=1}^P \gamma_{6,t} g(ENT)_{i,t} + \varepsilon_{i,t}$$

Model 3:

$$g(FD)_{it} = \theta_0 + \sum_{j=1}^P \theta_{1,t} g(FD)_{i,t-k} + \sum_{j=1}^P \theta_{2,t} g(Y)_{i,t-k} + \sum_{j=1}^P \theta_{3,t} g(INN)_{i,t-k} \\ + \sum_{t=1}^P \theta_{4,t} g(T)_{i,t} + \sum_{t=1}^P \theta_{5,t} g(INF)_{i,t} + \varepsilon_{i,t}$$

Model 4:

$$g(T)_{it} = \alpha_0 + \sum_{j=1}^P \alpha_{1,t} g(T)_{i,t-k} + \sum_{j=1}^P \alpha_{2,t} g(Y)_{i,t-k} + \sum_{j=1}^P \alpha_{3,t} g(INN)_{i,t-k} \\ + \sum_{j=1}^P \alpha_{4,t} g(FD)_{i,t-k} + \sum_{i=1}^P \alpha_{5,t} g(FDI)_{i,t} + \varepsilon_{i,t}$$

In these models, *i* represents the countries while *t* represents the time period of data and *k* represents the lag numbers of the variables. The data regarding these variables has been collected from the reliable databases such as World Development Indicators and Global Economy etc. The first variable, economic growth has been measured through the GDP per capita of the country. Similarly, the second variable capital stock (K) has been measured through gross fixed capital formation. In the similar fashion, the financial development denoted by (FD) of a country has been measured through the share of domestic credit in private segment as the percentage of GDP. Moreover, trade openness denoted by (T) has been measured with the percentage of GDP share of the total trade of the country. In addition, foreign direct investment FDI has been measured through the incoming FDI as the % of GDP. The next variable, inflation (INF) has been measured through the consumer price index CPI. Another variable, human capital HC has been measured as the share of graduates in the population as the percentage. In the last, the variable, entrepreneurship has been measured in the context of the share of population which is entrepreneur or the owner of a new business. In this way, all the variables of the study, in addition to the control variables have been measured.

3.1. Unit Root Test

The first step in the estimation procedure after the collection of data is to apply the unit root test on the collected data in order to make sure that there is no unit root in the gathered data and it is stationary. The stochastic properties of the variables of the study are examined through the unit root

test. The researcher has applied two types of unit root tests. These types include LLC and IPS unit root tests (Im, Pesaran, & Shin, 2003; Levin & Lin, 1993). These tests are having the foundation that the null hypothesis and alternate hypothesis. The null hypothesis of this tool indicates the presence of unit root in the collected data and the data is non stationary. On the contrary, the alternate hypothesis indicates that there is no unit root in the collected data and the data is stationary. In case the null hypothesis gets rejected as per the results of the study, then it is accepted that there has been no unit root found in the collected data and the data is ready to be used for further analysis and estimation techniques. These tests have been used on the basis of the following equation;

$$\Delta y_{i,t} = a_i + \rho y_{i,t} - 1 + \sum_{j=1}^{pi} a_j \Delta y_{i,t-j} + \varepsilon_{i,t}$$

In this equation, $\Delta y_{i,t}$ shows the difference of the term $y_{i,t}$ which is specific for i^{th} country and the time period of t .

3.2. The Estimation of VAR Model

After the confirmation of the stationarity of the collected data, the next step is to apply the major estimation technique of the study i.e. VAR model estimation technique. For the application of this technique, it is necessary that the optimal lag number must be determined. This lag number k has been found by using the “Schwarz criterion” SC as well as “Akaike information criterion” AIC. The lag number obtained by using these criteria is 1. This model not only provides the information about the direct impacts of different variables on each other but it also assist to determine the various casual relationships present among the variables of the study.

4. RESULTS ANALYSIS

As the first step of estimation of the collected data, the researcher applied the LLC and IPS unit root tests so that the stationary characteristics of the variables can be examined and investigated. The results have been presented vividly in the [Table 1](#) of the study. As per the results regarding LLC unit root test, it is clear that in level series; only one variable i.e. foreign direct investment has rejected the null hypothesis which means that at level series the collected data is non stationary. This issue has been resolved by the application of first difference on the data and after this application, all the variables can be seen rejecting null hypothesis. In the exact similar way, in case of IPS unit root test, only two variables i.e. capital and entrepreneurship are rejecting the null hypothesis but in the first difference series all the variables have rejected the null hypothesis. This means that at the first difference, the collected data is free of the unit roots and is totally stationary. The detailed results along with the probability values for each variable can be viewed in the [Table 1](#).

4.1. Results of Panel VAR Model

The results of panel VAR model have been presented in the [Table 2](#) of the study in which the results associated with all the four models of the study have been distinctly given. As per the results of the model 1, it is quite clear that the first lagged value of GDP and capital have positive along with significant impact on the GDP. In other words, the GDP is supposed to enhance by 23.7% and 14.8% with the increase in one percent of first lagged GDP and capital respectively. Alternatively, trade openness has shown the significant and negative impact on GDP. In other words, the GDP will decrease by 2.5% with one percent increase in trade openness. Innovation and financial development have shown insignificant impact on GDP. In case of model 2, it is clear that first lagged value of innovation and human capital have significant and positive impacts on innovation. It can be stated in this way that innovation will enhance by 34.3% and 7.4% with the increase in first lagged innovation and human capital respectively. All the remaining variables have shown insignificant impact on innovation. As far as the third model is concerned, it can be seen in the results that first lagged value of GDP and financial development along with inflation has significant impacts on the financial development. The financial development will increase by 67.5%, 33.7% and 44.9% with the one percent increase in first lagged GDP and financial development and inflation respectively. However, trade openness has shown negative along with significant impact on financial development and this

impact is of 12.7%. It can also be stated in this way that with the increase in trade openness of 1%, the financial development might decrease by 12.7%. The first lagged innovation has shown no shock on FD. The VAR model results of the last model of the study indicate that first lagged innovation has positive along with significant impact on trade openness and it will increase by 96.7% with the increase in innovation. On the other hand, the first lagged GDP also has significant impact over trade openness but this impact is negative. With the one percent increase in GDP, the trade openness is supposed to decrease by 36.6%. The remaining variables have posed no impact over the trade openness. In this way, the results associated with panel VAR model for the four developed models of the study can be interpreted and understood.

Table-1. Unit root test.

Variable	LLC Test		IPS Test	
	Level	1 st Difference	Level	1 st Difference
Economic Growth	-3.2746 (0.735)	-8.8264*** (0.000)	-2.7524 (0.424)	-10.0356*** (0.000)
Innovation	-3.2753 (0.263)	-6.2644** (0.000)	-1.6322 (0.312)	-8.0372** (0.000)
Financial Development	-4.3764 (0.384)	-11.7235*** (0.000)	-2.7346 (0.721)	-13.1356*** (0.000)
Trade Openness	-4.3544 (0.472)	-8.8343*** (0.000)	-2.2631 (0.294)	-10.5342*** (0.000)
Inflation	-5.8264 (0.426)	-10.2642** (0.000)	-3.7254 (0.245)	-12.1532** (0.000)
Foreign Direct Investment	-4.2354** (0.002)	-9.8263*** (0.000)	-2.7134 (0.244)	-13.8173*** (0.000)
Capital	-4.8432 (0.826)	-8.8163*** (0.000)	-5.8642** (0.001)	-11.7235*** (0.000)
Human Capital Investment	-6.2462 (0.724)	-9.7233*** (0.000)	-1.2342 (0.532)	-9.1342*** (0.000)
Entrepreneurship	-7.4823 (0.242)	-7.1375*** (0.000)	-4.8163** (0.003)	-11.4224*** (0.000)

Note: *, ** and *** depicts 0.10, 0.05 and 0.01 levels of significant respectively.

Table-2. Panel VAR model.

Variables	Model 1 (GDP)	Model 2 (INN)	Model 3 (FD)	Model 4 (T)
GDP (-1)	0.237*	0.026	0.675*	-0.363***
INN (-1)	0.053	0.343*	0.626	0.967*
FD (-1)	-0.072	-0.054	0.337*	-0.023
T (-1)	-0.025***	-0.026	-0.127***	0.073
K	0.148*	-	-	-
HC	-	0.074*	-	-
FDI	-	-	-	-0.025
INF	-	-	0.449***	-
ENT	-	0.025	-	-

Note: *, ** and *** depicts 0.10, 0.05 and 0.01 levels of significant respectively.

4.2. Casualty Directions

The direction of casualty of various variables of the study has been obtainable in the [Table 3](#) of the study. It is clear from the table that in case of model 1, T and GDP have unidirectional casualty running in direction as trade openness to GDP. On while no casual relationships have been found in remaining variables of model 1. In case of model 2, no casual relationship has been found at all. In model 3, casualty runs from GDP to FD and also from T to financial development. In the last model, casualty is running from both GDP and innovation towards trade openness.

Table-3. Casualty directions.

Model 1 (GDP)	Model 2 (INN)	Model 3 (FD)	Model 4 (T)
T to GDP	GDP, INN (No)	GDP to FD	GDP to T
FD, GDP (No)	FD, INN (No)	INN, FD (No)	INN to T
INN, GDP (No)	T, INN (No)	T to FD	FD, T (No)

5. DISCUSSION AND CONCLUSION

The current study was aimed at finding the casual relationships between economic growth, innovation, financial development and trade openness in the Asian countries. For this purpose, the researcher applied the Cobb Douglas Productivity model and the data was collected about the variables of the study for 1980 to 2018 years in context of Asian countries including Bangladesh, Indonesia, Japan, Philippines, Thailand and Turkey. The collected data was analyzed by applying unit root test and panel VAR estimation model in the study and the results have been obtained. The results suggest that trade openness has negative impact on the economic growth. In the past studies, there has been a lot of debate on this aspect and studies have indicated that in low financially developed countries, the shock by trade openness is negative towards economic growth but in highly developed countries, it might cast positive impact on economic growth. This result can be confirmed from the past literature (Pradhan, Arvin, Hall, & Nair, 2016; Ulaşan, 2015). In addition, it has been found out in the results that human capital shows significant impact on innovation. As the human capital is measured in the current study as the graduated students of a particular age, therefore it can be stated that educated and skilled people with innovative and creative minds might enhance the innovation in different aspects in the country. This result is in accordance with the past literature (Papalia, Bertarelli, & Filippucci, 2011). In addition, another important result that has been obtained in the results is that the GDP has significant along with positive impact on financial development of a country. These two aspects are very much related to each other and many studies in the past have confirmed this result (Chen & Lei, 2018; Nguyen, Su, & Nguyen, 2018; Rani & Kumar, 2019). As the GDP of a country increases, different sectors of the country get benefited financially from this increase in GDP and thus the FD is increased. In the same way, another result suggests that innovation has significant along with positive impact on trade openness of the country. When industries and different sectors of the country apply different techniques of innovative nature, it enhances the quality of products manufactured and thus the trade is increased in case of exports as well as imports. This result is parallel to the results presented in the studies of similar context conducted in the past (Akinwale, 2018; Pan. et al., 2019). The last significant result of the study is that GDP and trade openness of a country have directional causal relationship between them, which can be confirmed from the other related studies.

The results of research can be accomplished in this way that the first lagged value of GDP and capital has positive along with significant impact on the GDP but trade openness has shown the significant and negative impact on GDP. In addition, innovation and financial development have shown insignificant impact on GDP. First lagged value of innovation and human capital shows significant along with positive impacts on innovation and all the remaining variables have shown insignificant impact on innovation. First lagged value of GDP and financial development along with inflation has significant impacts on the financial development but trade openness has provided negative along with significant impact on financial development. First lagged innovation has positive along with significant impact on trade openness while the first lagged GDP has negatively significant impact towards trade openness. The remaining variables have posed no impact on the trade openness.

6. IMPLICATIONS

The most important implication of the current study for the governments and policy makers is that they must not consider innovation as the most important driver of economic growth. Instead they must make balanced strategies to use innovation for the economic growth of the Asian countries. In this regard, the association between research centers, industries and higher educational institutes must be made stronger along with the improvement of R&D policies. The financial systems must also be improved in order to ensure the financial development. Another important

implication is that the policy makers must consider the human capital by investing in entrepreneurial mindset and capabilities.

7. LIMITATIONS

The researchers may also found this study helpful for their researches and might also consider improving the study. The sample size might be increased and other groups of countries may also be selected for the study. There are various panel data tests and techniques that can also be applied other than VAR model, for estimation purposes

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