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Trade Openness, Knowledge Spillovers and Economic Growth: An Empirical Study of Pakistan, India and Sri Lanka

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Abstract---This study investigates the linkages between trade openness, R&D spending and economic growth in the three SAARC countries, namely; India, Pakistan and Sri Lanka. The simultaneous model based on two equations is constructed. In one of the equations public R&D is used as a dependent variable and in the other equation it is used as an independent variable to explain the growth rate which is taken as a dependent variable. The study then employs 2SLS technique to capture the fixed and the random effects. Later, the choice of either the test is done statistically through the Hausman test making a conclusion. The data is taken from 1991-2022. The study aimed to investigate the chain effect starting from trade integration that generates new knowledge and innovation and later that to what extent this innovation (proxied by public R&D expenditure) boosts the economic growth. Beside these endogenous variables, some of the control variables are also used to explain the variation in the regression equations. From the results of the empirical analysis the study draws three main conclusions. One that trade openness holds a positive relationship with public R&D spending. Second, public R&D spending also fosters economic growth, hence a bi-directional causal link is found between the two variables. Third, human capital and physical capital are significant and positively linked to the public research and development investments, while labor force participation, manufacturing (value added production) sector and physical capital are positive and significantly impact the GDP growth rate.

Index Terms----- Economic Growth, R&D, Trade Openness

Introduction

Economists have endeavored to explain the determinants of economic growth. In 1957 and 1994 Solow, Hicks and Wheeler conversed the role of free market mechanisms, significance of open economies and privatization in achieving sufficient economic growth. But it was not until the emergence of giant economies like USA, Japan, Korea and Singapore, that focus was diverted from the physical factors that partially contributed towards economic growth that these economies experienced, rather to a different dimension that actually led to the growth of such economies. Denson in 1962 came up with this dimension that only one third of the economic growth experienced by USA could be attributed to these physical inputs, hence, there was something still missing that acted as the silent ingredient. Later, research came up with the New Growth Theory that provided evidence that trade or the openness of the economies were responsible for such rapid developments. According to National Bureau of Economic Research (Grossman and Helpman,1990), Lucas (1988) and Romer (1986; 1990) advocated that openness in trade was an integral part in achieving economic growth. This is also asserted in Economic Journal (Winters,2004) that liberalised trade stimulates growth but at the same time some other factors like investment and institutions respond positively to trade liberalisation are also important in explaining economic growth.

This growing literature on trade has examined the benefits of trade through production input-output linkages. Amidst of this notion, the emerging concept of knowledge complementarities is introduced and in this world of inter connected countries and sectors, with changing trade patterns and economic compositions, the knowledge compositions are also altered which latter conditions the economic growth. The fact that this increase in knowledge is ultimately reflected in higher productivity, it must be known that the aggregate investment in R&D by a certain economy is not just enough unless it trickled down across various sectors. Both the conditions are important for growth to take place.

Trade exhibits great dynamic gains that come in the form of technological innovation and new knowledge. Also exhibited in the Economic Journal (Cohen and Levinthal,1989:99; Aghion and Jaravel,2015:125) the discussion on knowledge diffusion can be found as one much talked about conduit of gain as a result of increased trade. They introduced the concept of absorptive capacity that is enhanced when an economy invests in R&D activities. The studies provided a critical insight on R&D as a complementarity of knowledge spillovers. The studies conclude that R&D has a dual role of not only introducing novelties but also to expand the broader capabilities of the economy to adapt to the information available externally. And the extent to which the expenditure on R&D is conducted depends on the ease and character of learning.

Study Objectives

Objectives of the present study are listed below:

- To quantify the impact of trade openness on knowledge spillovers.
- To examine the impact of Innovation on economic growth.
- To testify the inter relationship of new knowledge and Economic Growth by forming a system of equations
- To investigate the effect of factors other than this knowledge diffusion and trade openness on economic growth. (Control Variables)
- Which of the channels is more effective to foster growth, endogenous variables or the exogenous ones?

Literature Review

This segment of the paper examines a portion of the critical bits of work with respect to the topic. Many researchers venture forward to add to the effectively extensive accessible literature. This part of the paper will mainly critically discuss the empirical studies conducted for this relevant topic and variables under discussion.

In the Journal of Economic Surveys (Joshua J. Lewer,2003:17) states that organized free trade has an intensifying impact on development as human welfare. The study uncovers that a one percent point increment in the growth of exports is related with a one fifth percentage point increment in economic growth. The author investigates the empirical relationship between economic development and export growth in an example of 55 middle income developing economies utilizing between nation cross segment examination. The outcomes uncover a solid positive and a significant link between export growth and economic growth.

Musleh-ud Din et al. (2003:42) conducted a study on Pakistan from 1960-2001 using real exports, real imports and real GDP. Inside a bivariate vector auto-regression (VAR) structure, Granger causality is utilized to look at the association between trade openness and economic development. An error correction model is evaluated to examine the short-keep running and additionally long-run causal configurations. The outcomes demonstrate the absence of causality among trade openness and economic growth in the short run. This recommends short-run variations in trade openness and GDP growth rates might be ruled by business cycle vacillations with no reasonable causal example in the short run.

In another study (Kraay and Dollar, 2004:114) an interesting comparison was drawn between countries that supported the argument that economies which were more open to trade experienced faster growth, however another factor that is mentioned is that of the geographical situation (whether the coutry is landlocked, its size, its proximity to major markets etc).

In a World Bank study by Welch and Wacziarg (2008:22) it was concluded that for the period 1950-1980, the economies that practiced liberalised trade regimes tended to observe the annual growth figures that were actually 1.5 percentage points in compariosn to the pre liberalised trade regimes.

Empirical studies have discovered a conceivable two-way causality in the trade– development connect, whereby nations that exchange more may have higher per capita incomes, while countries with higher per capita incomes tends to provide favorable infrastructural facilities that are needed to absorb and facilitate increased trade volume. Thy may also have more resources with which to incapicitate the information search costs related with trade, or may demand more traded goods.
(Kim and Lin, 2009:45).

Zeren and Ari (2013:3) also observed a positive bidirectional causal links between trade openness and economic growth for G7 countries. The effects of openness to trade is analysed in the case of South East European (SSE) countries. A 16 year panel data of 10 SEE countries is taken for the time 1996 to 2012. The system GMM is used for the estimation, where the development rate of the sample countries is taken as the reliant variable on trade openness and some other control factors like initial level of GDP per capita , human capital, FDI and work drive. The investigation finds out that the positive effects of open trade are only backed by the initial per capita income and other control variables.

Semancikova (2016:13) tested this hypothesis that developing countries that practiced export oriented trade regimes were more prone to economic growth rather than those economies who were relatively more inclined towards the import substitituion regimes. With an open economy , the high vulnerability that is induced by negative imports is balanced by a significant benefit of productivity and competetiveness. Instead of using any specific technique, the author uses a despcritive and comparative analysis of significant empirical studies conducted during that decade. the author found out that trade liberalisation boosted up economic growth. In drawing comparisons of various prominent studies the author present a summary of the few eminent studies done in this regard.

Kim et.al (2016:45) presents the trade-development connect with refernce to the development unpredictability, utilizing the cross-sectionally autoregressive distributed lag(CS-ARDL)panel data approach. This paper inspects whether there is a noteworthy long-run growth gain from trade and whether this gain is achieved at the expense of gretaer vulnerabilty that a country experiences as being exposed to the external shocks.. A panel of 73 developed and developing countries over the period 1970-2011 is taken in the examination to uncover that trade boosts economic growth over the long haul and in the short keep running with bigger effects in the short keep running than over the long haul. As such, more noteworthy trade enhances long-run economic growth to the detriment of higher growth instability, the finding is by all

accounts more pertinent for non-OECD nations or nations with less developed finanacial frameworks, low human capital, higher inflation, more noteworthy defilement, or less unbending labor regulations.

Another study was conducted on South African countries by Wijeweera and Manwa (2016:51). They used an ARDL approach in the bound testing cointegration process.Two models were established to look at the impact of open trade on economic growth. . Model one took the average tariff rate as a proxy of trade liberalisation and the other model took the trade ratio as another proxy of unrestricted trade. In either of the model testing it was found that South African countries have clearly benfited from these trade liberalisation policies both in the short and the long run.

Another recent study (Zahonogo, 2016:3), research is conducted for sub-Saharan Afriac (SSA) in which 42 countries are taken as a sample. The unusual finding of the study reveals an inverted U-shaped response of growth to trade openness. The investigation shows that trade limit exists underneath which increased trade volume has benefial ramifications for economic growth or past which the exchange affect on development rots. The effect of trade advancement on development depends upon the progression level. An income threshold exists above which greater trade openness affects economic growth and underneath which expanded trade volume has adverse outcomes. (International Economics and Economic Policy [Agénor], 2004)

There is also rich body of literature available which establishes the innovation resulting from R&D has an impact on economic growth. Innovation and novelty are something that are considered potent for the development and sustainability of economic growth. In this world of competing economies, only those can stay which invest in research and development to bring upon new ideas, skills, product varieties, processes, technique es etc. that contribute to the overall productivity gains. Research and Development breeds two types of spillovers, namely; new information or innovation or the idea of learning by doing. Economists have largely argued that R&D means generation of new information, but Cohen and Levinthal (1989:99) in their study suggested that R&D not only means new information but it helps to embrace and exploit exisiting information. And this assimilation is often referred to as "Absoptive Capacity". The term "absorptive capacity" is defined "as the ability of the country to adopt and implement new technologies developed in the advanced nations and made available through free trade"(Kebede, 2002). However, the study provides the view that with increased productivity provided by increased trade, the element of "learning by doing" is automatically generated, given firms get more practiced in whatever they are already doing by becoming efficient in that, while on the other side with absorptive capacity firms are only able to do things differntly by simply acquiring outside knowledge. The study concludes that both the technological opportunity and appropriability determines the ease of learning through R&D.

Helpman and Grossman (1990:34) advocated that open trade stimulates economic growth through the mechanism of endogenous technological progress. Productivity in the research lab depends upon the "stock of knowledge capital", a variable that is defined as the engineering and industrial know-how in the local economy. Advocates of the Endogenous Growth theory suggest that new stock of knowledge can be obtained from the outside world and it appears to be sensible that the degree of the overflows between two nations will increment with the volume of increased bilateral trade.

In another study by Young (1991:106), the interaction of developed and developing countries through free trade is examined and it is revealed that the consumer welfare is automaticaly improved. And since both the countries benefit from the usual static gains generated from free trade, technical innovation and GDP growth is experienced simultaneously.

Lichtenberg (1993:4) finds a connection between the proportion of private R&D consumptions to GDP and the development rate of output per person from 1964 to 1989 in an example of 74 high income countries.However, the relationship between government R&D and the development rate was zero or even negative in a few details.

Madden and Savage (2001:8) examines the empirical results from the sample of OECD and Asian countries from 1980-1995 for the role of R&D activity on technological development. The study employs A sample of G7,Non G-7 and some Asian economies is taken . The study uses TFP index to represent economic growth, while the dependent variables are the domestic R&D, trade openess (taken as imports as a share of GDP), a catch up variable is also taken (country I TFP dividd by US TFP), and the growth rate of real GDP. There are some interaction terms as well that maesures the elasticity of

TFP as for domestic and foreign R&D. At the point when the level of interface of trade with overseas R&D capital stock is positive, at that point the impact of outside R&D on household TFP is bigger the more open the economy is to foreign trade.Domestic R&D positively affects TFP, and the effect is higher in Asian nations. Nine of the 21 outside R&D coefficients are noteworthy, showing overflows from foreign R&D through trade. The main finishes of the examination is that household R&D has a generally extensive effect on TFP development in the NICs and LICs

Teixera and Fortuna (2004:3) tried to find a relationship between output, human capital and innovation. The link is tested for Portugal from 1960-2001. The innovation capability is measured by the R&D spending . an unrestricted VAR model is used to establish the link byy using the cointegration technique it was established that R&D has a positive impact on TFP which is taken as a proxy for growth. When R&D goes up by 1%, total factor productivity increases by 0.4%, hence knowing that innovation capability is potent for Portugal's economy.

Yanyun et.al (2004) investigates the long run association between R&D and economic growth using a panel data set of 8 Asian countries, from 1994-2003. The study is established on the basic Cobb Douglas production function, where the main focus remains on the contribution of R&D .

In a case study conducted on Canada regarding the increased export participation, the researchers Baldwin and Gu (2004) found out that the productivity growth that the manufacturers experienced due to this increased trade came through

three main mechanisms. These mechanisms are highlighted as learning that comes with greater volume of export transactions;exposure to increased competition from foreign firms; and increase in product specialization that is accompanied by gretaer economies of scale. The evidence in the study states that firms through free trade participation tends to invest increasingly into R&D and training to develop capacities to absorb foreign technology. Hence through increased exports, the technological advancements are improved and improvised through a better understanding of coping up with the oddity and novelty of innovations taking place in an economy.

In an another interesting study conducted by Osorio (2004) a two tier analysis is made to first identify the impact of R&D investment on innovation , and later how and to what extent this innovation is reciprocated in the form of increased economic growth. In the study the level of innovation is proxied by patent application, in order to catch the innovation capacity in a given region and assesses the profitability of interests in R&D. It plans to demonstrate the speculation that private, public, and higher R&D ventures yield diverse outcomes as far as innovation genaeration and resulting economic development in peripheral and non-peripheral locales. These normal distinctive outcomes depend on the presence of some particular financial qualities, which impact the creative capability and capacity of a region.

In a study by Cameron, Proudman and Redding (2005:49), a case of 14 UK manufacturing industries since 1970. The study examines innovation and technology transfer are the main drivers of growth in productivity. Technology transfer is significant and statistically important while R&D increases innovation. The study reveals that the productivity growth in UK are observed by the increased level of innovaton that is generated through R&D, while international trade facilitates the transfer of technology.

Wong et al (2005:24) present a Cobb-pDouglas fuction in the study to explore firm formation and technologocal advancement as discrete drivers of economic development. The investigation utilizes a cross-sectional study on 37 nations. Two theories are set up in the examination, first that the higher the technological advancement, higher would be the development rates. The second theory was that the nations with higher TEA (Total Enterpreneur Activity) delighted in increasingly economic development. Here advancement was taken as licenses to GDP proportion. The last outcomes demonstrated that development is decidedly and altogether positively connected with economic development, while the second theory was simply dismissed.

Schneider (2005:78) examines the role of high-technology trade, IPRs and FDI in determining a country's rate of innovation and economic growth. A panel data set of 47 countries is considered, including both developed and developing countries. Innovation is measured in the form of patent applications . the findings show that technology transfers had a positive and significant effect on innovation.

Falatoon and Safarzadeh (2006:53) uses a univariate decomposition of per capia GDP into permanent and irregular components. The two reference centuries are 19^{th} and 20^{th} century. The study examines the sway of the major technological innovations of the past two centuries on per capita GDP. The study scrutinize the two centuries in accordance with the innovatuons that steam engine, rail industry, oil industry, aerospace, computers, internet brought along. The geometric mean of the results state that the average growth rate was 1.69% as compared to the growth rate of 2.20% in the centuries if innovatons were to take place. The data shoed that rail industry gae a major boost to the real GDP per capita figures.

Torun and Ciceki (2007:29) measures empirically the relationship between innovation and economic growth. The study draws three main conclusions, first that innovation does play a significant part in boosting economic growth, second that there are significant spillovers between countries, and lastly, that these spillovers are mainly localised.

Economic Modelling

Endogenous Growth theory suggests that there is positive relationship between innovation and trade and innovation and economic growth. Osorio and Pose (2004:35) and Torun et al (2007) all tested empirically the link between innovation and economic growth. While various other studies, Soto and Flores (2010) pursue the same argument and found a positive relationship between trade and innovations emerging as a result of knowledge spillovers (due to increase imports) and domestic innovation (as a result of increased R&D activities taken place with an intention to compete in the international markets) (Ramos and Zarzoso,2009). In this study we attempt to visit these relationships in the context of three large South Asian economies i.e., India, Pakistan and Sri Lanka and examine that to what extent these relationships hold true in the South Asian region.

Simultaneous Equations Model

In this system two endogenous variables are accounted for their inter relationship with each other (Arne and Hamann, 2015). Where one endogenous variable is a dependent variable in one equation and becomes the independent variable in the second one. It is generally the back-and-forth relationship that these two endogenous variables share. This technique is further elaborated in the econometrics books. Gujrati in his book of Basic Econometrics states the simultaneous equation model. SEM becomes more meaningful if there's a two-way relationship between the endogenous variables and the model becomes relevant as the equation may not estimate the parameters of a single equation without taking into account, the variables included in the other equation in the model. (Gujrati, 2004)

Fixed Effect

The Fixed Effect Model (FEM) are a class of statistical model that hold the hypothesis that the coefficients are systematic. It incorporates the country specific effects that are deterministic. The intercept term is permitted to fluctuate and vary across the sample countries while arbitrary varieties are thought to be independent across countries. FE models control for the impacts of time-invariant factors with time-invariant impacts.

Random Effect

In Random Effect Model the country specific impacts are taken as arbitrary when contrasted with FEM that view them as deterministic. This depends on the presumption that random variety in different cross sections come from overlapping not from the same sample. In an REM, the unobserved variables are assumed to be uncorrelated with all the observed variables. RE gives you a chance to assess impacts for time invariant factors.

Hausman Test

The Hausman particular test serves to approve the adequacy of both of the two tests mentioned previously. The real distinction between the two models is that the FEM detailing is seen as one where scientists make inductions contingent on the settled impacts in the example. The Hausman test is in some cases portrayed as a test for model misspecification. Basically, the test hopes to check whether there is a connection between the unique errors and the regressors in the model. The invalid theory is that there is no relationship between the two. Deciphering the outcome from a Hausman test is genuinely clear: The null hypothesis is that there is no correlation between the two. Interpreting the result from a Hausman test is fairly straightforward: if the p-value is small (less than 0.05), reject the null hypothesis.

Model Specification

Model One: Impact of economic Growth and Trade Openness on R&D Expenditure

Y=∫ (economic growth, Trade openness, Human development Index, Growth of Gross Fixed Capital Formation)
Y=∫ (GDP GROWTH, TOPEN, GFCFG, HDI)

$$\mathbf{ERD} = \gamma\mathbf{0} + \gamma\mathbf{1GDPG} + \gamma\mathbf{2TOPEN_{it}} + \gamma\mathbf{4GFCFG} + \gamma\mathbf{5HDI} + \mu\mathbf{3}$$

Given:
ERD= Expenditure on Research & Development as a percentage of GDP
GDPG= Growth rate of GDP
TOPEN= Trade Openness (Imports plus Exports as a percentage of GDP)
GFCFG= Growth of Fixed Capital Formation Capital as a %age of GDP
HDI= Human Development Index

Model Two: Impact of R&D Expenditure on Economic Growth

Growth=∫ (R&D Expenditure, Gross Fixed Capital Formation, Labor Force Participation Rate, Manufacturing share as a percentage of GDP, Foreign Direct Investment)
Y= ∫ (ERD, GFCFG, LNLB, MAN. LNFDI)

$$\mathbf{GDPG} = \boldsymbol{\beta}\mathbf{0} + \boldsymbol{\beta}\mathbf{1ERD_{it}} + \boldsymbol{\beta}\mathbf{2GFCFG_{it}} + \boldsymbol{\beta}\mathbf{4\ LNLB_{it}} + \boldsymbol{\beta}\mathbf{4\ MAN_{it}} + \boldsymbol{\beta}\mathbf{4LNFDI} + +\mu\mathbf{2}$$

Where,
GDPG=Percentage growth rate of GDP
ERD= Expenditure on Research and Development
GFCFG= Growth of Fixed Capital Formation Capital (proxy of physical capital)
LB= Labor Force Participation rate (% of population)
MAN= Manufacturing share (Value Added) as a percentage of GDP
LNFDI= Natural Logarithm of Foreign Direct Investment

Empirical Analysis

Identification of the model
Endogenous Variables=2 (ERD and GDPG)
Exogenous Variables in the Model = 6 (TOPEN, HDI, GFCFG, MAN, LNLB, FDIG)
Exogenous Variables in Equation 1= 3 (TOPEN, HDI, GFCFG)
Exogenous Variables in equation 2= 4 (GFCFG, MAN, LNLB, FDI)

MODEL 1
6-3 > 2-1
3>1……. Over Identified

MODEL 2
6-4> 2-1
2> 1……. Over Identified
Since the model in this study is identified a 2SLS technique is relevant and applicable in this case. The tables below show the empirical results derived from applying this technique.

Empirical Results of Model One

Fixed Effect

Dependent Variable=ERD (%age of GDP)

Table I
The Fixed Effect Model (ERD the dependent Variable)

	Coefficient	standard errors	Probability
gdpg	**0.0235562***	**0.011054**	**0.033**
topen	**0.2401491***	**0.119579**	**0.045**
gfcfg	**0.3798079***	**0.285095**	**0.025**
hdi	**0.7122352***	**0.247022**	**0.004**
c2	**-0.43005**	**0.057871**	**0**
c3	**-0.75974**	**0.072509**	**0**
constant	**0.661453**	**0.338374**	**0.051**

Source: Stata
Note: * denotes significance of the coefficients at 5%

The results above displayed in Table 3 display the fixed effect model where the coefficients are significant at the 5% significance level. The probabilities of all the variables are less than 0.05 that makes them significant. The link that we are trying to establish is that trade openness brings upon new knowledge and innovation that is reflected in the level of R&D activity taking place in an economy. Hence in this model we consider the fixed effect in case of ERD being affected by a set of variables shown above.

The results reveal that there is a positive link between ERD and GDP growth rate. The results are consistent to what the empirical studies reveal that a positive significant link is found between R&D activity conducted and economic growth

The coefficient of GDP growth shows the elasticity that when the growth rate changes by one percent, the ERD ratio goes up by 2.3 percentage points. This suggests that when GDP growth is altered by one percent it positively boosts the research and development expenditure that is incurred by the government. The results are consistent with the theoretical and empirical studies presented in the literature review. This implies that when the GDP grows, the expenditure on R&D is altered by a relatively greater margin as compared to the growth rate of GDP, that ultimately increases the ERD ratio. Given here, the ERD variable denotes R&D expenditure as a percentage of GDP.

The next variable is trade openness that shows a positive sign with ERD. This means that 1% change in trade volume as a percentage of GDP, the ERD ratio will go up by 24 percentage points, which sufficiently satisfies the empirical research that says that the two variables hold a positive and a significant relationship between the two, given the causality runs from trade openness towards ERD. The coefficient result is statistically significant since the probability is 0.045 which is less than 0.05. So we can conclude that the variable of trade openness is significant at the 5% significance level. The studies presented in the literature review in this study presents that trade openness exposes a country to increased knowledge flows that are reciprocated in the form of R&D activity undertaken in an economy. Whenever the trade volume will rise with countries being more liberalized and open the R&D activity will go up in the respective countries. Same conclusion can be drawn from table 3 that both the variables of trade openness ratio and ERD ratio share a positive link (Jie Cai et al ,2017; Girma et al ,2008).

Endogenous growth models with increased trade assimilation , as in Romer and Rivera-Batiz (1991), credit a focal job to global innovation spillovers. In their hypothetical set-up knowledge spillovers from abroad add to national learning

and in this way increment the information stock to influence R&D expenditure incurred in an economy and this channel is generated from increased trade globalization and increased economic integration.

than 0.05. GFCFG is a proxy used for fixed capital (physical) investments that is taking place in an economy. In this model, the results reveal that for every 1 unit change in the growth of gross fixed capital formation, ERD ratio correspondingly increases by 37 percentage points at p-value less than 0.05. The coefficient is significant and positive in relation with the dependent variable of ERD. Piva and Marco (2017) conclude in the study that there is a positive significant relationship between R&D spending and capital formation. However, the study further reveals that these capital formations must be done in high tech sectors. The relationship also holds true theoretically, given that when the capital investment rises, it facilitates the ease with which the R&D activities are held. Physical Capital is needed to accommodate the growing R&D undertakings in an economy. This link is hence found to be coherent and consistent with the theory and empirics in the case of South Asian countries under discussion.

The fourth independent variable is of Human Development Index. The variable is a proxy to measure human capital. Human capital is a central prerequisite for innovation activity as set out in Romer (1990). Second, human capital influences the capacity to adapt technological advances from abroad. The scope and assimilation process of increased innovation and new knowledge that is born in an economy depends heavily on human capital. Human capital in the straggling economy is important. Here in table 1 the HDI coefficient is positive and significant at 5% significance level at p-value to be less than 0.05. It suggests that a change in the index by 1 point, the ERD ratio goes up by 0.71 units.

The human development index has a positive yet a significant relationship with ERD ratio, the result that is consistent with the empirical studies that proves and establish this positive link.

The study employs pooled data, therefore cross-sectional dummies are created for the sample countries to make the analysis more elaborated. To avoid the dummy variable trap, two dummies are created while the constant value demonstrates the reference (benchmark country). C2 and C3 denotes the dummies for Pakistan and Sri Lanka, respectively, while the reference country is India. Now to make comparison we can infer that Pakistan expenditure on R&D is 43% lower than what India is spending as a percentage of GDP. Similarly, to interpret the coefficient of C2, we imply that Sri Lanka is spending 76% lower than what India's expenditure is on R&D. This is a useful comparison since India is the most influential country in the region and is also growing globally on a much faster pace.

Hausman Test

Ho: difference in coefficients not systematic
H1: difference in coefficients are systematic

Table II

Hausman Test Criterion

Probability	0.000

The above table shows the hausman results generated by stata software. The result will suggest that considering our first model either the fixed effects are better reflection of the model or the random effect. The null hypothesis states that the cofficients are not systematic and we accept the hypothesis if the given probability is greater than 0.05. and in that case we accept the Random effect Model. While if the probability hold significance at 5% significance level being less than 0.05 we reject the null hypothesis and accept the alternate hypothesis that is the coefficients are systematic with in the sample data. The probability shown in table 2 is 0.000 which is less than 0.05 meaning that we consider the Fixed Effect Model in case of Model one. Hence the values of the independent variables are assumed to be fixed and constant. It also suggests that only the dependent variable is altered in reponse to the changes in the independent variables.

Empirical Results of Model Two

Random Effect
Dependent Variable=GDP Growth Rate

Table III
The Random Effect Model (GDP Growth rate dependent variable)

	Coefficient	**Standard errors**	**Probability**
erd	**9.135581***	**3.984702**	**0.022**
man	**0.2677496***	**0.1083589**	**0.013**

Gfcfg	**11.14632***	**2.656467**	**0.000**
Lnlb	**-3.096816***	**1.169565**	**0.008**
Lnfdi	**0.9250067**	**0.5264732**	**0.079**
Constant	**12.74422**	**10.35459**	**0.218**

Note: * denotes significance of the coefficients at 5% significance level

The extensive research that is mentioned in chapter 2 of this study states that when innovation and new knowledge is created, it ultimately shifts the economy to a new steady state path. Investment expenditures in R&D, especially in the fields of science and technology are viewed as one of the basic criteria for a country to assess its economic growth and strength to survive and face the cutthroat global competition. Investment in R&D affects growth through three main channels; innovation, capital and knowledge accumulation and development of human capital. New growth theory laid great emphasis on R&D, human capital accumulation in determining long term economic growth. And the tools that R&D provides that help altering the GDP growth rate are; greater product variety, reduced costs in the form of better cost-effective production processes and improved product quality (Kim, 2011:16). The author conducted a study in 2009 where he analyzed the effect of R&D activities undertaken in Korea, in which it was concluded that R&D contribution in economic growth approximately accounted to 35%. Peng (2010) also made a conclusion in the study that if R&D expenditures increase by 1%, GDP growth rate will be altered by 9.2 percentage points. Keeping this theoretical and empirical findings and linkages in mind, the empirical results presented in table 5 also reveal somewhat the same consistent results which the majority of empirical studies establish. With a p-value less than 0.05, the coefficient is significant and positive, showing that a 1-point increase in ERD variable, GDP growth rate will correspondingly be increasing by 9.13 percentage points. Hence in this case the South Asian countries tends to reveal this significant and a positive interactive relationship between R&D and economic growth variants in the long run.

The next variable is the manufactured output as a percentage of GDP. Tsoku et.al. (2017:11) examined the relationship between manufacturing growth and economic growth in South Africa. The Johansen cointegration technique used to find the results revealed that there is a positive significant long run relationship between GDP and manufacturing. The Kaldorian growth laws advocate that manufacturing growth fosters economic growth. The results in table 5 shows that the manufacturing share as a percentage of GDP is positively related to GDP growth rate. With a probability less than 0.05, the coefficient is demonstrating that a unit change in this ratio with cause the GDP growth rate to increase by 26 percentage points.

The physical capital proxied by the gross fixed capital formation shares a positive relationship with economic growth. The empirical study presented by Pavelescu (2008:11) gives a demand and a supply side evaluation when intend to reveal the correlation between the gross capital formation and the gross domestic product in countries of the European Union in 2007. The empiric results given in table 5 demonstrates that a 1% increase in the gross fixed capital stock contributes 11% increase in the GDP growth rate. The coefficient is significant and affirms the sign of the coefficient as presented in numerous studies that explains the relationship of gross fixed capital formation and economic growth (Arrow & Kurtz, 1970; Barro 1990, Osuagwu et.al, 2016).

There is a general opinion that increased labor force participation generates greater GDP growth rates. Kragi (2014) presents this paradox of unskilled labor participation rate that retards economic growth especially in developing countries where less attention and expenditures are incurred in training the workforce. Hence in assertion to this, the empirical results presented for labor force participation rate shows that 1% change in the rate of labor participation will bestow a significant and a negative impact on GDP growth rate, causing it to fall by 3.1 percentage points.

The last independent variable in table above is of foreign direct investment. This variable is also taken in growth rate percentage. Rahman. A (2015:7) presents a study in which an insignificant positive relationship is found between FDI and economic growth. The relationship is also tested in the case of Pakistan. The findings indicate that economic growth is negatively affected by FDI (Saqib et.al, 2013, Falki, 2009:5). The empirical results obtained in this study reveal that the sample countries experience a positive but insignificant coefficient (p-value=0.79). Hence this variable being a potent one in determining long run growth must be given attention when designing macroeconomic policies.

Hausman Test

Ho: difference in coefficients not systematic
H1: difference in coefficients is systematic

Table IV
Hausman Test Criterion

Probability	0.9634

The result will suggest that considering our first model either the fixed effects are better reflection of the model or the random effect. The null hypothesis states that the cofficients are not systematic and we accept the hypothesis if the given probability is greater than 0.05. and in that case we accept the Random effect Model. While if the probability hold significance at 5% significance level being less than 0.05 we reject the null hypothesis and accept the alternate hypothesis that is the coefficients are systematic with in the sample data. By looking at the probability that the Hausman test shows which is above 0.05, we fail to reject the null hypothesis and fail to accept the alternate hypothesis stating that the coefficients are systematic. Based on this criterion we chose the Random Effect in the case of Model two.

Conclusion

The study concludes that research and development activities and GDP growth rate shares a bidirectional relationship with each other. The positive and significant signs in both the models signifies the importance and growing impact of the variables on each other. ERD is considered as a function of GDP growth rate and the other way GDP growth is also considered as a function of ERD. A two-way path is recognized when studying the link between R&D expenditure incurred by the government and the GDP growth rate. Public research, however, does generate cross-national knowledge spillovers, so that public research can contribute towards achieving higher productivity growth indirectly by stimulating private R&D capital accumulation.

The study also establishes that human and physical capital both have an impact on R&D investments and economic growth positively, respectively. Human capital is measured by HDI and physical capital is taken as gross fixed capital formation and both the variables are posing a significant relationship with the dependent variables in the model. Human capital is crucially needed to promote and assimilate the new stock of knowledge that is created by the public R&D activity in the country.

One important finding that is affirmed in the study is the concept of innovation and new knowledge that open trade welcomes. But the proxy that measures trade liberalization is trade openness ratio (trade as a percentage of GDP. The positive sign of the Topen coefficient signifies that it shares a strong positive relationship with ERD which adheres to the theory presented in the empirical studies on the subject that increased trade brings in new stock of knowledge. The study concludes primarily that public research and development activities tend to speed up the process that compliments the private research undertaken by firms and businesses. Hence, their productivity gets altered ultimately fostering economic growth.

The second equation in the model advocates the impact of four exogenous variables other than the endogenous variable of ERD. The exogenous variables are extracted from the empirical studies that explains the long run relationship of GDP growth rate with some of the exogenous (control) variables for specification support. In this equation labor force participation rate and FDI are showing a negative (yet a significant) and insignificant (yet positive) coefficient, respectively. This implies that the region needs to give importance to FDI channels that tends to boosts economic growth and also try to increase the participation of skilled and educated labor force. Piling up the unskilled labor force only generates burden for the economy.

Hence the strong positive impact of open trade on domestic R&D in a country demonstrates that the regional empirical results presented in the study are coherent with the endogenous growth theory. Whereas some other exogenous variables are also needed to compliment this two-way relationship, from which FDI is rather insignificant in explaining long run economic growth in the region.

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