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Technological Innovation and Green Growth: Evidence from South Asia

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Annotation: Green growth through technological innovations is the need of the hour for the developing economies of South Asia. Yet these economies suffer from the continued consumption of non-renewable fuel sources, producing tons of CO2 annually. This research analyzes how green growth has been affected by technological innovation in South Asia (Bangladesh, Pakistan, India, Sri Lanka, and Nepal) during 1990 to 2019. Growth related variables such as foreign direct investments (FDI) and gross national product (GDP) are included along with access to green patents while estimation is achieved through FMOLS and DOLS model. Basic econometric tests such as Cross-section dependence test, Panel unit root tests and Wester Lund co-integration test are also applied. The findings show that patent application by residents and renewable energy consumption have negative and statistically significant impacts on CO2 emissions; GDP has positive and statistically significant effect on CO2 emissions and FDI has no effect on CO2 emissions in both the long and short run. The results suggest that governments need to promote sustainable energy related technologies and apply them in their economic functioning.

Keywords: Green growth, CO2 emissions, South Asia, GDP, FMOLS and DOLS.

1. Introduction

Green Growth is a strategy to achieve the sustainable development. (Manzoor & Samad, 2013). It indicates efficiency in resource use while diminishing pollution and greenhouse gas emissions and serving as a means to protecting the natural environment. According to World Bank (2012) green growth is productive in its utilization of regular assets, and clean in a sense that it limits contamination and ecological effects. Technological innovation is one of the important strategies of green growth through suitable innovation policies. Initiated by the developed world, green technologies have quickly made their way to the underdeveloped parts of the world, especially the South Asian countries like India, Pakistan and Sri Lanka. Green growth and technological innovation lead to improved sustainable development which is beneficial for micro and macro level institutions.

To achieve green growth, it is imperative to use low carbon green technologies which can provide required results while being environmentally sustainable. Carbon dioxide (CO_2) is a greenhouse gas (GHG) released due to careless anthropogenic activities such as fossil fuel burning, urbanization and desertification (Dauda *et al.*, 2019). When trade and foreign direct investments (FDI) are done by building contamination concentrated industries, the host faces a rise in CO_2 emanations. This practice

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has long been taking place in the underdeveloped parts of the world, such as South Asia and Africa, and is a proof of the pollution haven hypothesis (PHH) (Rafindadi *et al*., 2018; Zhu *et al*., 2016) (Sun *et al*., 2017). Although foreign direct investments (FDI) are recognized from portfolio benefit in which a financial expert simply buys the values of foreign-based organization, a few investigations state that FDI enhances ecological supremacy (Zhu *et al*. 2016).

To combat this phenomenon, patented green technologies are necessary which can not only improve the environmental condition but will also provide legal protection to the owners. The invention, which is to be ensured by a patent, should be new, valuable, utilitarian, and innovative. After the patent is granted, the patent proprietor has a selective option to keep others from business utilization of the protected innovation. If allowed, the consequences reveal a pattern of growing coordinated efforts in innovative activities across the world in the course of recent many years, which may suggest that the world has started to accept the inchoative phase of "Techno-globalism" (Ma & Lee, 2008).

All these activities collectively come under the umbrella of renewable energy sources and methods. Renewable energy is determined as the amount of the gross inland consumption of energy from infinite sources, which are characterized as inexhaustible non-fossil fuel sources; hydroelectric, solar, geothermal, biomass, nuclear electric power, natural gas, petroleum, and biogas. The United States are one the few nations that have adopted renewable sources for energy production as a growing percentage in their total energy supply and produce 17.95% of energy from such sources (U.S Energy Information Administration, 2019)

However, this is not the case of numerous South Asian countries which still use fossil fuels as their main source of energy production all of which are included in the top 100 countries for CO_2 emissions from energy generation (Rahman, Saidi, & Mbarek, 2020). South Asia has incredible capability to become the next innovation hub. As South Asian countries are mainly dependent on non-fossil fuel energy sources, it is interesting to see the relation between national growth, in terms of GDP, and CO_2 emissions. Considering the effects of technological innovations on green growth in the developing economies can be beneficial in a way that environmental change reduction of the innovations is ceaselessly imagined by these economies.

Since South Asia houses some of the world's robustly growing economies (India and Pakistan), it is intriguing to see that most of the existing literature on green growth in Asia focuses on select few countries, specifically China and Japan. Home to some of the most populous and maturing low-income economies, the lack of scholarly insight on green growth in South Asia is a gaping hole that needs to be filled. The current study deals with this gap by investigating five South Asian countries, namely Bangladesh, Pakistan, India, Nepal, and Sri Lanka, and finding the relations between green patents, renewable energy consumption, foreign direct investment, and GDP per capita on CO2 emissions. The time period under observation is from 1990 – 2019. For statistically support, the study employs new and updated techniques of estimation like cross sectional dependence, CADF and CIPS stationarity tests and Westerlund Cointegration test.

After a detailed discussion of review of literature in section two, section three explores model and methodology while section four discusses data analysis and results. Section five deals with conclusion and offers sound recommendations for future policy implications.

2. Literature Review

Analysis on the effect of technological innovation on green growth for selected South Asian countries is based on the endogenous growth model. Endogenous growth model has significant hypothetical system for understanding the growth cycle. These theories are significant because that they underscore that

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capital collection and innovations can instigate economic growth while diminishing returns can reduce it. This model shows how long-run economic growth can be achieve through spillovers and the scale effect of ideas and research within the economy (Onyimadu, 2015). According to the endogenous growth model, the roles and dynamics of innovation and discovery and all of the variables, Carbon dioxide emission (CO_2), Patent by the resident (PR), Renewable energy consumption (REC), Foreign direct investment (FDI), and GDP per capita (GDPPC). Thus endogenous growth theory investigates the long-run economic growth through technological transfers is provided.

Lee & Min, (2015) inspected that utilization an example of Japanese assembling firms during 2000 to 2010, and finds that the green R&D for Eco development can diminish carbon outflows and increment firm esteem. Amongst different ecological development factors, market management and legislative guideline are progressively considered to diminish carbon emanations.

Zhang & Da, (2015) showed that to locate the effective approaches to diminish carbon outflow power in China, the study used the LMDI method to break down the progressions of Chinas carbon emanations and carbon discharge force from 1996 to 2010, from the viewpoints of vitality sources and mechanical structure individually. At that point, the study acquaints the decoupling record by investigating the decoupling connection between carbon emanations and financial development in China. The outcomes demonstrate that, from one viewpoint, financial development showed up as the primary driver of carbon outflows increment in the previous decades, while the diminishing of vitality power and the cleaning of conclusive vitality utilization structure assumed critical parts in controlling carbon emanations; then, the auxiliary business demonstrated the chief wellspring of carbon discharges decrease among the three enterprises and had generally higher potential. Then again, when the decoupling relationship is thought of, most years during the investigation time frame saw the relative decoupling impact between carbon discharges and monetary development, which showed that the decreasing impact of hindering components of carbon emissions was not exactly the driving impact of financial development, and the economy developed with expanded carbon outflows; there showed up the total decoupling impact in 1997, 2000 and 2001, which suggested that the economy developed while carbon outflows diminished; while no decoupling impact was distinguished in 2003 and 2004.

Ali *et al.*, (2017) analyzed the effect of urbanization on carbon dioxide emission in Singapore during 1970-2015. The autoregressive distributive lags (ARDL) approach is implied inside the examination. This study shows that uncovers a negative and huge effect of urbanization on carbon emanations in Singapore, which implies that metropolitan advancement in Singapore isn't a boundary to the development of ecological quality. In this manner, urbanization improves natural quality by diminishing carbon outflows in the example nation. The outcome likewise featured that financial development has a positive and critical effect on carbon emission, which recommends that monetary development diminishes ecological quality through its immediate impact of expanding carbon discharges in the nation. Notwithstanding the elevated level of urbanization in Singapore, this implies that 100 % of the general population is living in the metropolitan place; it doesn't prompt more natural debasement. Henceforth, urbanization won't be viewed as an impediment while starting approaches that will be utilized to lessen ecological corruption in the nation. Strategy creators ought to consider the nation's degree of financial development rather than urbanization while detailing arrangements to lessen ecological corruption, because of its immediate effect on expanding carbon dioxide emissions.

Zugravu-Soilita, (2017) analyzed that the effect of Foreign direct investments on industrial pollutants (CO_2, SO_2, NOx, and BOD emanations) on an enormous example of exceptionally heterogeneous nations. By utilizing board information on assembling foreign direct investments from France, Germany, Sweden, and the UK, during 1995 to 2008, and by building up an observational model with

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"first" and "second request" cooperation conditions, the study explored the presence and the restriction of the most disputable FDI-instigated impacts on modern discharges, like, contamination refuge, Factor Endowments and contamination Halo speculations. The study has three fundamental discoveries: (1) focal theories connecting pollutant to FDI are found to act at the same time, with restricting impacts; (2) FDIs are related with contamination decrease, i.e., prevailing contamination radiance initiated impact, in nations with low to average cash-flow to-work proportion yet not very remiss natural guideline; (3) foreign direct investments have establish to expand contamination, like, winning contamination shelter and additionally aspect blessings incited impacts, in nations with normal capital enrichments and careless ecological guidelines, just as in all the capital bountiful nations, however with a littler size in nations having exacting natural guidelines as well as a high-gifted work power. Some particular and intriguing discoveries are examined concerning various FDI-beginning nations and FDI-have nation gatherings.

Kwon *et al*., (2017) investigated that both specialized productivity and virtual environmental control (VEC) of 12 European nations during 1990 to 2015. The study utilizes a two-phase information envelopment examination (DEA). In the primary stage, the examination estimated the specialized proficiency of environmentally friendly power vitality advances (GET) related to petroleum derivatives, sustainable power source, and capacity advances of every nation for vitality age as to Carbon dioxide (CO_2) emanations by studying GET-related licenses. Utilizing the logarithmic mean Divisia list (LMDI), the investigation decayed Carbon dioxide (CO_2) outflows into the accompanying mechanical components: vitality power, fuel blend, and Carbon dioxide (CO_2) emanation coefficient. In the subsequent stage, they evaluated the VEC in every nation by examining GET patent changes using innovative work (R&D) venture at given changes in (CO_2) discharges. The outcomes found that various angles for every nation regarding specialized productivity and VEC, recommending possible degrees of both effective Carbon dioxide (CO_2) decreases and attractive GET improvement by utilizing reference nations as a benchmark. The examination results can add to setting up a powerful public innovation strategy and help in calls for normal duty and the dynamic investment of countries intending to environmental change.

Yii and Geetha, *et al.,* (2017) analyzed the connection between the carbon dioxide emission and technological innovation for Malaysia during 1971 to 2013, the contributory relationship between technology innovation and carbon dioxide (CO_2) emission. The result of the VAR model shows that carbon dioxide (CO_2) emission is negatively connected to technology innovation in the short term. The results recommended that policy-makers should promote innovation analysis to help economic growth and ecological sustainability.

Kahouli *et al*., (2018) investigated that the four-route connection among electricity utilization, Carbon dioxide emissions, R&D stocks, and financial growth during 1990 to 2016, by executing a few methods: SUR, 3SLS, and GMM. The empirical methods determine that the four arrangements of conditions (power, CO_2, R&D, and development models) are assessed together with the arrangement of conditions. These methods make it conceivable to assess all the boundaries of the models simultaneously and tackle the issue of endogeneity. Nonetheless, the outcomes uphold the event of unidirectional causality among power and R&D stocks while different connections exist. From one perspective, there is unidirectional causality between R&D stocks and monetary development just as unidirectional causality between R&D stocks and CO_2 outflows, then again.

Mensah *et al*., (2019) showed the technological impact on green growth in (28) Organization for Economic Cooperation and development (OECD) economies during 2000 to 2014. Utilizing STIRPAT and IPAT models, the outcome discovered vehicle connected technology is useful for green growth in

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the Oceania sub-area. OECD Asia's innovations of the creation and preparation of merchandise has been useful for green growth. Environmental change innovations corresponding to age and broadcast of vitality are unfavorable to green growth in the OECD economies yet its effect is noticeable in Asia and Europe sub-boards.

Song *et al.,* (2019) analyzed the effects of financial receptiveness and R&D investment on green economic during 2005 to 2015 in china. The outcomes found that economic openness and green financial growth have a nonlinear negative U-formed connection. Although the R&D positively affects green financial growth. The effect of the R&D scale on green economic growth is positive for quite a while, yet the effect is negative in the eastern and western districts in the recent time frame.

Hasnisah, *et al.,* (2019) studied the relationship among renewable and non-fossil fuel energy, environmental quality and financial growth, in 13 developing countries of Asia during 1980 to 2014 by using the OLS model. The existence of the inverted U-shape Environmental Kuznets Curve hypothesis has been found in 13 Asia countries.

Liobikiene and Butkus, (2019) studied that the economic growth, energy, and urbanizations effect the natural quality 0f environment. The study appeared in their investigation for 147 selected countries during 1990 to 2012 for urban areas. The result shows that gross domestic product and urbanization added to decreasing carbon dioxide discharges. Hence, nations should consider the innovative change of growth and energy effectiveness as they look for sustainable economic growth.

Wang, (2017) and Wang, *et al.* (2018) applied DEA model, pooled board regression and cross sectional edge work separately during 2011 to 2013 in the United State. To investigate the effect of environmental change innovation for picked US producing organization, these examinations got Research and improvement use and development for alleviation technology. Jumper's modern segments were considered in these examinations. Regardless, the experts didn't totally examine the activity environmental change related innovations as per creation and getting ready of production played in advancing green growth.

Bagheri, *et al.* (2018) the study investigates that the used multi-factor energy input output model during 2013 in Canada. It finds out that various factors making green development on different economic policies. These studies measured different pollutant as assess of green growth including carbon dioxide (CO_2) emission in totally. On the other hand, none disaggregated green growth into demand-based and manufacture based emission.

Cao *et al.* (2019) explored the multitude of apparent direct impacts on industrialization. Environmental and green growth is both carrying out positively as compared to industries. With the usage of industrialization, they are using the advanced level opportunity for a different condition. Ecological contamination issues pose a potential threat in China, and the size of its changes makes its planned arrangements of widespread intrigue. China has asked to separate some ecological weight from financial development, and an advancement driven methodology is proposed to manage the synergic improvement between the economy and condition. Taking into consideration both negative and negative effects of the advancement driven system on a green monetary turn of events, the theme of this examination is to investigate the effect and component of arrangements and proportions of the advancement technique on the green financial turn of events, through the exact examination of board information of 47 pilot savvy urban communities in China during 2009-2017. The outcomes show that the technology-driven technique has positive impacts on the green turn of events, while some technology-driven pointers assume various functions in the advancement of the financial green turn of

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events. This examination gives a dynamic indication to supportable improvement strategy plan in creating nations, particularly in rising economies.

Lin and Zhu, (2019) showed that they used linear regression model and china provincial panel data during 2000 to 2015.The result show that green growth has gotten unexpected consideration as global chase for economic success pursue for monetary achievement frequently prompts environmental degradation. Environmental impacts in green technologies reduce demands investing by decoupling growth which lower the human potential pose risk climate change.

Khan, et al. (2020) examined the effect of public and private alliance of power enhancement and modern growth on the average of consumption of carbon reduction which has derived for China while 1990 to 2017. The research followed the customized ordinary least square and Maki cointegration test and generalized least square as well as based unit root test, canonical cointergration regression and domain causality frequency test and dynamic ordinary least square. The analysis leads that cointegration connection with public private corporation interest in energy, renewable energy consumption, technologies growth, imports and exports which is based on utilization of carbon emission is demonstrated along trades and environmentally near power connection and inventive which a pivotal lead down demand base on carbon emission in both sector public private corporation for investment in energy, gross domestic product and imports for leading to increase the consumption of carbon outflow. While, long term conditions of public and private organization investment and innovative growth source development for the cleaner creation measure to public private association investment environmentally sustainable power source.

Hao *et al.*, (2020) investigated the green growth in technological a sustainable climate for G7 countries during 1991-2017. The analysis employed second generation panel data method(s), for example, Cross-Sectionals Augmented Dickey-Fuller Distributive slack (CS-ARDL) model. The results found that theoretical and observational discoveries demonstrate that both straight and non-direct period for green growth diminishes carbon dioxide discharges. Additionally, ecological degradation, human resources and sustainable energy use are found to diminish carbon dioxide discharges.

Yasmeen *et al*., (2020) studied the function of technological innovations, natural guidelines, and urbanization in ecological cost during 2008 to 2018 in China. The study followed the GMM method to utilize the effect of technological growth, environmental system, and urbanization on environment. The outcomes showed that urbanization is negatively affects environmental proficiency at a public level.

Li *et al*., (2020) used a panel threshold model to consider the effect systems of natural guideline on technological innovation. Thinking about industry heterogeneity, the study further investigates whether such instruments contrast in industry. The fundamental findings are: (1) the effect systems of ecological guideline on technological innovation is significant. (2) Apart from innovations balance, additionally the study found that ecological guideline can advance GTFP through increasing market focus and building green market passage boundaries in high-pollution discharge industries. (3) Such an upper hand is just successful for the time being as technological innovation investigates a positive impact in the long-run.

Yuan *et al*., (2020) used panel data for 30 provinces in china during 2006 to 2015 and the study sys-GMM method for estimation. The results show that: (1) adaptable ecological arrangement can essentially encourage modern economical change. (2) Flexible ecological strategy has an altogether certain effect on mechanical development. (3) Environment administrative implementation directs the connection between adaptable natural strategy and mechanical development.

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Extensive research has been done on CO_2 emissions. But up till now, no study has been found to use empirically CO_2 emissions for green growth in the south Asian countries. Additionally, there is a gap of study on the effect of technological innovation on green growth the countries. Hence, this investigation empirically seeks to make most important contributions to existing literature.

3. Model and Methodology

3.1 Theoretical Framework

Section 3.1 illustrates the theoretical background that connects the CO_2 to renewable energy consumption and technological innovation combined with income and FDI variables. The Cobb–Douglas production function connects output to the factors of production: labor, capital and energy through the technology as given below:

$$Y = AL^{\alpha}K^{\beta}E^{\gamma} \quad 1$$

where, α, β, and γ are the elasticities of output regarding labor, capital, and energy, respectively. A generally is called total factor productivity (TFP). Taking the natural logarithmic of 1 can be given as:

$$lnY = lnTFP + \alpha lnL + \beta lnK + \gamma lnE \quad 2$$

It is assumed that over time TFP is not constant (Solow, 1957). This is because of the innovation, technological developments, and know-how related activities mostly associated to trade, FDI, international competitiveness, and convergences among the economies over the world.

Now we follow standard assumption by Beenstock and Dalziel (1986) and Nordhaus (1975). We know that 1) The cost function is acting as a dual function of the production function; 2) Average cost and fixed markup are the basis of factor pricing 3) Demand for goods and services are the basis of preference function in the economy which is further a function of price and income; 4) all the functions are based on Cobb–Douglas type of specification; and 5) Assuming cost minimization, first-order conditions are derived. Based on these assumptions, we can derive energy demand equation as:

$$lnE = \omega_0 + \omega_1 lnp_k + \omega_2 lnp_1 + \omega_3 lnp_e - \omega_4 lnTFP + \omega_2 lnI \quad 3$$

where, p_k, p_1, p_e are the prices of capital, labor, energy and income.

Following Hasanov and Mikayilov (2020), Nordhaus (1975) and Beenstock and Dalziel (1986), Equation 3 can be reduced to Equation 4, where based on some assumptions, prices of factors other than energy are dropped given below.

$$lnE = \varphi_0 + \varphi_1 lnI - \varphi_2 lnTFP + \varphi_3 lnp_e \quad 4$$

Assuming that energy is the combination of fossil fuels energy and renewable energy, equation 4 can be described as:

$$\ln(FE + RE) = \varphi_0 + \varphi_1 lnI - \varphi_2 lnTFP + \varphi_3 lnp_e \quad 5$$

Applying Taylor expansion to the left-hand side of equation 5 the following expression will be found:

$$\ln(FE + RE) \approx FE + RE$$

Now equation 5 takes the form.

$$FE = \varphi_0 + \varphi_1 lnI - \varphi_2 lnTFP - \varphi_3 lnp_e - RE \quad 6$$

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CO_2 is produced when fossil fuels are burned, and there are conversion scalars called emission factors for each fuel type. Using this association, it can be stated that total CO_2 emissions is related to total fossil fuels energy: Based on this relationship, equation 6 can be written as:

$$CO_2 = \theta_0 + \theta_1 lnI - \theta_2 lnTFP - \theta_3 lnp_e - \theta_4 RE$$

The secondary data is collected from World Development Indicators (WDI 2020) for South Asian countries that are; Bangladesh, Pakistan, India, Nepal, and Sri Lanka during 1990 to 2019. The carbon dioxide (CO_2) emission is measure in (metric tons per capita) that act as dependent variable while patent by resident (resident), Renewable energy consumption (%of total final energy consumption), foreign direct investment (% of GDP), and GDP per capita (constant 2010USS) are independent variable.

Analyzing the connection between technological innovations related to green growth, econometric model takes the form.

$CO_2 = f$ (PR, REC, FDI, GDPPC)

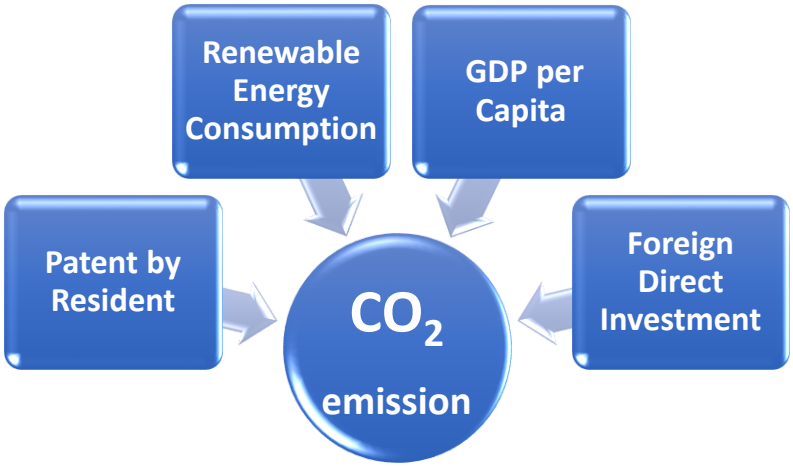

Figure: 1

The figure 1 shows the association moving from independent variables patent by resident (PR), Renewable energy consumption (REC), foreign direct investment (FDI), GDP per capita (GDPPC) and carbon dioxide emission (CO_2) are dependent variable.

The econometric model state that carbon dioxide (CO_2) emissions, PR represent patent by resident, REC represent the renewable energy consumption, FDI represent the foreign direct investment, GDPPC represent the GDP per capita (constant 2010USS). The technology is well-organized utilizing of commodities to reduce unused in pollution. We have followed different studies like Orubu and Omotor (2011) Shahbaz *et al*. (2012) and Sabaori and Sulaiman (2012), for final model.

$$lnCO_2 = \beta_o + \beta_1 lnPR_{it} + \beta_2 lnREC_{it} + \beta_3 lnFDI_{it} + \beta_4 lnGDP_{it} + \varepsilon_{it}$$

All the variables are given in logarithmic form and show the percent change. Dependent variable is the carbon dioxide (CO_2), β1 to β4 represent the coefficient values for the predictors. In which "i" signifies the country and t represent time.

3.2 Econometrics Methodology

The following econometric techniques are applied on the panel data.

1. Panel Unit Root test

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2. Cross Sectional Dependency

3. Wester Lund co-integration

When we analyze panel data, the unit root is used to detect the stationary properties of the data. However, we test for cross-section dependence (Pesaran 2004) to be able to choose a suitable "unit root and cointegration tests that can reduce cross-sectional dependence" issues.

Cross-sectional augmented Dickey-Fuller (CADF) panel unit root tests (Pesaran 2007) are appropriate in the presence of cross-section dependence, because they are robust in the presence of cross-section impacts. Westerlund panel cointegration Cointegration tests are required to establish long-run relationship among variables. In the series, If the presence of cross sectional dependency is verified, common cointegration tests (Johansen 1988; Kao 1999) have some biases which can give ambiguous results. we used (Westerlund 2007) cointegration test to overcome such shortcomings, because it can remove "cross-section dependence effects among the variables by the bootstrap method than other cointegration such as Johansen (1988) and Kao (1999) with no such properties. The cointegration test statistics are Gt (between groups), Ga (among groups), Pt (between panels), and Pa (among panels). Gt, Ga statistics test null hypothesis of no cointegration in whole panel against existence of cointegration in one cross-sectional units at least. Pt, Pa test null of no cointegration in the whole panel, against evidence of cointegration in the whole panel."

Cross sectional dependence test does not require large sample, and this is the advantage of the test (Barbieri, 2006). However, even for small samples, the test is considered as oversized for moderate conditions of cross-sectional dependence.

There are different advantages of using Westerlund cointegration test. 1. In case of cointegration test, according to Westerlund (2008), the panel cointegration test performs well than the time series cointegration test given that it allows researchers to get more observations by pooling the time-series and across section data. 2. "Westerlund (2007) cointegration is also robust to slope homogeneity and cross-section dependence." 3. Without influencing asymptotic null distributions, with doing the testing, it produces more powerful tests

4. Data Analysis and Results

This section presents data analysis and results. Table 1 indicates descriptive analysis of the variables. The mean value of CO_2 emissions is 0.63 while standard deviation that shows deviation from the mean is 0.44. The average value of foreign direct investment is 0.88 whereas standard deviation that reveals deviation from the mean is 0.74. The mean value of economic growth is 1132.6 while the value of standard deviation is 812.6 which indicate deviation from the average. The average value of patent by residents is 1292.5, though the standard deviation that reveals deviation from the mean is 3282.7. The mean value of the last variable i.e. renewable energy consumption is 59.78 whilst the value of standard deviation is 17.60 which indicate deviation from the mean. The jarque bera shows that the residual of the entire variable is normally distributed. All the variables are positively skewed. Kurtosis statistic of the variables shows that the entire variable is palty-kurtic except patent application by resident.

Table 1: Descriptive Statistic Analysis

	CO2	FDI	GDP	PAR	REC
Mean	0.630	0.889	1132.573	1292.518	59.785
Median	0.609	0.775	840.173	68.000	55.020
Maximum	1.930	3.668	4011.682	16289.00	95.119
Minimum	0.041	-0.098	354.257	1.000	30.130

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Std. Dev.	0.444	0.743	812.599	3282.727	17.603
Skewness	0.869	1.240	1.878	3.109	0.554
Kurtosis	3.446	5.046	6.220	12.106	2.252
Jarque-Bera	20.160	64.617	153.003	759.929	11.160
Probability	0.000	0.000	0.000	0.000	0.003
Sum	94.62172	133.3751	169886.0	193877.7	8967.880
Sum Sq. Dev.	29.40893	82.33062	98387466	1.61E+09	46171.31
Observations	**150**	**150**	**150**	**150**	**150**

Note: Author's self-estimation

Table 2 reveals the correlation matrix among the study variables. Correlation matrix has two functions, one is shows relationship between the variables and the second is indicate multicollinearity problem. If the correlation coefficient between the variables is 0.8% or 80% or more than this then there exist multicollinearity. Multicollinearity is an issue when one or more than one variable related each other's. And it is difficult to tell that which variable is affect the dependent variable (Koop, 2004). In our model no variable is reveals multicollinearity. And this suggesting no-multicollinearity problem exists in the proposed variables in the model. The outcome of our estimation is according to the previous literature. The variable of renewable energy consumption is negative relationship with CO_2 emissions. While the remaining variables have a positive relationship with CO_2 emissions.

Table No 2 Correlation Matrixes

	CO_2	**PAR**	**REC**	**FDI**	**GDP**
CO_2	1				
PAR	0.764	1			
REC	-0.726	-0.421	1		
FDI	0.593	0.382	-0.549	1	
GDP	0.490	0.198	-0.294	0.477	1

Note: Author's self estimation

Table 3 shows the results of cross-sectional dependence test (Pesaran 2004) and it clearly supports the presence of the cross-sectional dependence among the variable in Panel level. The results rejected the null hypothesis at a 1% sig nificance level, and accept the alternative of cross-sectional dependence, considering the confirmation of cross-area reliance during action, we imply panel unit root test (Pesaran 2007), which is solid inside seeing cross sectional dependence. Cross sectional dependence test discovers effect of shock in one country on another country.

Table 3 Cross-section Dependence test

Variables	**Breusch-pagan LM**	**Pesaran LM**	**Bias-corrected scaled LM**	**Pesaran CD**
CO_2	259.53(0.00)***	55.79(0.00)***	55.71(0.00)***	16.08(0.00)***
PAR	167.17(0.00)***	35.14(0.00)***	35.05(0.00)***	12.23(0.00)***
REC	238.40(0.00)***	51.07(0.00)***	50.98(0.00)***	15.41(0.00)***
FDI	38.26(0.00)***	6.32(0.00)***	6.23(0.00)***	4.28(0.00)***
GDP	292.30(0.00)***	63.12(0.00)***	63.03(0.00)***	17.09(0.00)***

Note: author self-estimations

Before estimation, stationarity of the data is check by the applied of panel unit root tests at level and first difference. We applied Im, Pesaran (2007) and Shin W-stat (Im *et al*, 2003), Fisher Augmented

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Dickey Fuller (FADF, 1979). We apply the second-generation unit root test which includes CADF and CIPS test. Table 4 reveals that at level 1(0) no one variable is stationary, but at a 1st difference i.e..1(1), all the variables are stationary leading to rejection of the null hypothesis of presence of unit root.

Table 4 Panel Unit Root test

Variables	IPS		FADF		CIPS		CADF	
	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
CO_2	6.67	-4.20***	0.49	36.56***	4.18	-4.08***	0.29	97.85***
PAR	3.57	-8.92***	8.95	82.88***	3.61	-7.14***	16.58	113.93***
REC	0.47	-4.61***	8.66	40.23***	-1.38	-1.92**	4.74	100.53***
FDI	-1.01	-7.03***	11.08	63.63**	0.25	-5.78***	31.59	109.92***
GDP	8.79	3.50***	0.10	12.43***	7.64	2.74**	0.01	22.02***

Note: author self estimations

If the existence of cross-sectional dependence is verified, normal co-integration tests (Johansen 1988, Kao 1999) have few prejudices that could produce invalid results. In this situation (Westerlund, 2007) co-integration test apply as it would eliminate cross-section dependence changes between the variable with the help of bootstrap skills than other co-integration would (Johansen, 1988 and Kao, 1999) not have those properties. Yet, co-integration test statistic is Ga, (among, categories) Gt, (between, groups), Pa (among, panels), Pt (among, panels). The results indicate cointegration. The results are given in table 5.

Table 5: Westerlund panel Co-integration test

Statistic	Value	z-value	P-value
Gt	-3.323	-2.055	0.020
Ga	-8.476	1.307	0.905
Pt	-5.112	-0.284	0.038
Pa	-7.643	0.490	0.688

Note: Author's self estimation

Table 6 reveals the results of FMOLS. The coefficients of all the variables are significant except FDI. The coefficient of the patent application (PAR) is negative and statistically significant. According to our results the patent application by residents used as a proxy of technological innovation increases by one percent then the CO_2 emissions used as a proxy for Green growth is decreased by 40%, which indicate that as the technological innovation increases it will lead to increases the green growth in the panel of countries during the studied period. This finding is the same as the past studies of (Mensah *et al*., 2018).

Renewable energy consumption has a negative and statistically significant impact on CO_2 emissions. This means that a one-unit increase the renewable energy consumption lead to reduce the CO_2 emissions by 0.007%. This results are similar with the findings of (Dogan & Seker, 2016, Chiu & Chang, 2009, and Al-Mulali *et al*., 2015).

Foreign direct investment has a positive but statistically insignificant effect on CO_2 emissions. These findings are in line with the results of (Dauda *et al*., 2019).

The coefficient of GDP is positive and statistically significant. A 1% increase in economic growth increases the CO_2 emissions by 0.0002%. Our results are similar with the findings of (Mensah *et al*., 2018).

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Table 6: Fully Modified Ordinary Least Square (FMOLS)

Dependent Variable: CO_2 emission				
Variable	**Coefficient**	**St. Error**	**t-Statistic**	**Prob**
PAR	-0.000404	0.00000388	10.41444	0.0000
REC	-0.007560	0.001449	-5.215374	0.0000
FDI	0.014428	0.013898	1.038135	0.3010
GDP	0.000259	0.0000216	11.98614	0.0000
R-squared	0.985950			

Note: Author's self-estimation

Results of dynamic ordinary least squares are reported in table 7. The results of DOLS are the same as the findings of FMOLS. According to DOLS findings, a patent application by residents (PAR) is a negative and statistically significant effect on CO_2 emissions. Similarly, renewable energy consumption has a negative coefficient and a statistically significant effect on CO_2 emissions. Like the result of FMOLS, FDI has a positive coefficient but insignificant. It means that CO_2 emissions are independent of FDI. In the last GDP has a positive sign and statistically significant.

Table 7: Dynamic Ordinary Least Square (DOLS)

Dependent Variable: CO_2 emissions				
Variable	**Coefficient**	**St. Error**	**t-Statistic**	**Prob**
PAR	-0.000	0.000	7.067	0.0000
REC	-0.008	0.001	-4.624	0.0000
FDI	0.022	0.014069	1.569	0.1214
GDP	0.000	0.000	15.817	0.0000
R-squared	0.997			

Note: Author's self-estimation

Granger Causality test is applied to illustrate the direction of the relationship between the variables. The results given in table 8 show that there is a bidirectional correlation between a patent application by residents (PAR) and CO_2 emissions. This implies that patent application by residents (used as a proxy for technological innovation) causes CO_2 emissions i.e. green growth; in turn CO_2 emissions causes' patent application by residents. Similarly, a bidirectional connection exists between renewable energy consumption and CO_2 emissions. This implies that renewable energy consumption causes CO_2 emissions, and in turn, CO_2 emissions cause renewable energy consumption. A bidirectional association is found between economic growth and renewable energy consumption. This implies that economic growth causes renewable energy consumption, and in turn, renewable energy consumption causes economic growth. A unidirectional relationship exists between FDI and CO_2 emissions. This implies that CO_2 emission causes FDI. Similarly, a unidirectional relationship exists between economic growth and CO_2 emissions. This means that economic growth causes CO_2 emissions. Also, the unidirectional relationship is found between patent application by residents and renewable energy consumption means a patent application by residents causes renewable energy consumption. Additionally, unidirectional causation exists from the patent application by residents to FDI. Unidirectional causation exists from the patent application by residents to GDP. The same causation exists from renewable energy consumption to FDI. In the last, unidirectional causation exists from economic growth to FDI.

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Table 8: Results of Granger Causality Tests

Pairwise Granger Causality Tests				
Null Hypothesis	**Obs**	**F-statistic**	**Prob**	**Outcomes**
PAR does not Granger Cause CO2	140	0.61602	0.0416	
CO2 does not Granger Cause PAR		2.33962	0.0013	Bidirectional
REC does not Granger Cause CO2	140	3.56880	0.0309	
CO2 does not Granger Cause REC		4.35049	0.0148	Bidirectional
FDI does not Granger Cause CO2	140	1.18981	0.3074	
CO2 does not Granger Cause FDI		5.10356	0.0073	Unidirectional
GDP does not Granger Cause CO2	140	8.62656	0.0003	
CO2 does not Granger Cause GDP		0.04499	0.9560	Unidirectional
REC does not Granger Cause PAR	140	0.29258	0.7468	
PAR does not Granger Cause REC		0.05750	0.0441	Unidirectional
FDI does not Granger Cause PAR	140	0.87107	0.4208	
PAR does not Granger Cause FDI		3.91973	0.0221	Unidirectional
GDP does not Granger Cause PAR	140	0.20671	0.8135	
PAR does not Granger Cause GDP		1.45684	0.0366	Unidirectional
FDI does not Granger Cause REC	140	0.12583	0.8819	
REC does not Granger Cause FDI		4.72715	0.0104	Unidirectional
GDP does not Granger Cause REC	140	0.07152	0.0310	
REC does not Granger Cause GDP		1.98259	0.0417	Bidirectional
GDP does not Granger Cause FDI	140	2.70261	0.0707	
FDI does not Granger Cause GDP		0.20196	0.8174	Unidirectional

Note: Author's self-estimation

In the last GDP has a positive sign and statistically significant. This shows that GDP growth has a positive statistically significant effect on CO_2 emissions. 1% increases in GDP growth lead to escalating CO_2 emissions by 2% ((Mensah *et al*., 2018).

Discussion

South Asia is among the world's regions most subjected to household air pollution. In Bangladesh, India and Pakistan almost 79, 60 and 52 percent of the population are exposed to pollution from burning of fossil fuel. Moreover, one of the very heavily populated territories on earth is South Asia. As labor is used as an input in production process, therefore population is a part of growth. Moreover, for the goods and services, population is considered big market, but increased population implies increased human activities and extra use of energy that cause an increase in CO2 emissions.

Our findings showed that output growth raises CO2 emissions and worsens the ecosystem. The South Asian economies are known as a main contributor to CO2 emissions. For example, India is among the main emitters of global CO2 emissions due to reasons stated. The results here is thus a sign that environmental protection and energy regulations and policies are producing positive results.

Moreover, innovation decreases CO2 emissions in South Asian countries, and promote environmental quality. Raiser et al. (2017) most inventors strictly protect their technological ideas spreading to third parties. Based on this contraction of global access to available technologies could be the reason for our findings. It is also believed that transitioning to technology innovation is a long-term process.

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Energy use has been recognized by several studies as the main cause of CO2 emissions. Our study shows that renewable energy decreases co2 emission. This is due to fact that wind, solar, and hydroelectric processes produce electricity with no related air pollution emissions. This is opposite of the concept that fossil fuel energy leads primary energy use in many countries.

Foreign direct investment has a contribution to economic growth. However, these capital flows into economies have advantages and costs. When trade and FDI are carried out by pollution intensive industries the host country practices rise in CO2 emissions. This is called pollution haven hypothesis. Our results verified the theory (Sun et al. 2017).

5. Conclusion and Policy Implications

This study examines the effect of technological innovation on green growth in South Asian countries during 1990 to 2019. Secondary data has been collected from the World Development Indicator (WDI 2020). The dependent variable CO_2 emissions is used as a proxy for green growth and the independent variables used in our model are patent applications by residents, renewable energy consumption, foreign direct investment, GDP per capita. This study used panel data techniques such as cross sectional dependence, panel unit root, Wester Lund co-integration fully modified ordinary least square (FMOLS) and dynamic ordinary least square regressions (DOLS) to examine the long-run relationship. The outcome of our estimation is according to the previous literature. The results of all panel unit root tests reveal that all the variables are stationary at a 1^{st} difference. Westerlund panel co-integration test confirmed the long-run relationship. The findings of the study show that Patent application by residents and renewable energy consumption has a negative and statistically significant impact on CO_2 emissions in both the model's FMOLS and DOLS. While GDP is a positive and statistically significant effect on CO_2 emissions and FDI does not affect CO_2 emissions in both the models' FMOLS and DOLS.

Policymakers must join the technological innovation into mitigation of carbon dioxide emissions which could allow waste reuse ongoing system to diminish pollution. Countries necessary evaluate the impact of environmental cost of FDI before authorizing them into their economy. Incorporate and assimilate cutting advance technology from FDI that permit the capability of moderating CO_2 emissions.

Economic growth adds carbon dioxide emissions, and it increases the use of energy. Accordingly, government needs to take sustainable energy related source, for instance, renewable energy consumption which are beneficial to ecosystem as it increases green economy.

The findings of this study may offer valuable insights for government in the formation of technological, energy use, and FDI associated programs for CO_2 emissions. It is general understanding that technological improvement and additional use of renewable energy use are environmentally friendly. Thus, the officials should continue their helpful actions for the expansion of both factors. Additionally, they should apply these policies as corresponding to each other rather than separate policies. For example, renewable energy and technological innovations are the key components of clean energy changes. Results show that is both innovation and renewable energy use decrease CO_2 and are statistically significantly. It would encourage decision makers to consider these two components as key factors of the clean energy transition in these economies. We found that a rise in the income level or economic activity will bring more pollution. Therefore, officials may need to set up some regulations. In this respect, carbon price (CP) is one of the most applicable emission reduction measures as it has numerous advantages over other measures. Hence, international organizations recommend this measure to the authorities of countries. India introduced a nationwide carbon tax of USD1.07/t of CO_2 for coal both produced and imported and increased it to USD1.60/t of CO_2 in 2014. Since half of India's electricity generation is produced from coal, it is considerably difficult for the Indian policymakers to

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implement CP measures. Therefore, our major policy suggestions would be the applications of the methods, policies, and formation of the statutory frameworks that help the shift toward renewable energy with technical improvements.

There are certain limitations of the study that could inspire future research. It can cover the most recent changes such as COVID-19 recession and oil price decrease would be worth considering. Moreover, as a measure of technological innovations, we use data on the patent by residents, one of the key measures of the innovative activities that can decrease CO_2 through improving production technologies to make them less energy intensive. One can consider other approaches like research and development expenditures.

Declarations:

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REFERENCES

1. Adeel Farooq, R. M., Abu Bakr, N. A., & Raji, J. O. (2018). Green field investment and environmental performance: A case of selected nine developing countries of Asia. *Environmental Progress and Sustainable Energy*. Retrieved from https://doi.org/10.1002/ep.12740
2. Bank, W. (2016). *World Bank Database*. Retrieved from https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?locations=8S
3. Bank, W. (2019). *World Development Indicators*. Retrieved from http:/ /www.worldbank.org/data/onlinedatabases
4. CBS. (2021). *Centraal Bureau voor de Statistiek*. Retrieved from https://www.cbs.nl/en-gb/society/nature-and-environment/green-growth/economic-opportunities/indicatoren/green-patents
5. Chen, F., Jiang, G., & Kitila, G. M. (2021). Trade Openness and CO2 Emissions: The Heterogeneous and Mediating Effects for the Belt and Road Countries. *Sustainability*. Retrieved from https://doi.org/10.3390/su13041958
6. Economic, S. (2019). *Finance Division*. Retrieved from Government of Pakistan: http://www.finance.gov.pk/survey_1819.html
7. Erdoğan, S., Yıldırım, D. Ç., & Gedikli, A. (2019). INVESTIGATION OF CAUSALITY ANALYSIS BETWEEN ECONOMIC GROWTH AND CO2 EMISSIONS: THE CASE OF BRICS

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM

– T COUNTRIES. *International Journal of Energy Economics and Policy*. Retrieved from https://www.econjournals.com/index.php/ijeep/article/view/8546

8. Fabrizi, A., Guarini, G., & Meliciani, V. (2018). Green patents, regulatory policies and research network policies. *Research Policy*. Retrieved from https://www.researchgate.net/publication/323818882_Green_patents_regulatory_policies_and_research_network_policies
9. Ganda, F. (2019). The impact of innovation and technology investments on carbon emissions in selected organisation for economic Co-operation and development countries. *Journal of Cleaner Production*.
10. Hanif, I., Faraz Raza, S. M., Gago-de-Santos, P., & Abbas, Q. (2019). Fossil fuels, foreign direct investment, and economic growth have triggered CO2 emissions in emerging Asian economies: Some empirical evidence. *Energy, 171*(C), 493-501. doi:10.1016/j.energy.2019.01.011
11. Hao, L.-N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: How critical the network of enviornmental taxes, renewable energy and human capital is? *Science of the Total Environment*. doi:10.1016/j.scitotenv.2020.141853
12. Haq, A. U., Jalal, M., Sindi, H. F., & Ahmed, S. (2020). Energy Scenario in South Asia: Analytical Assessment and Policy Implications. *IEEE Access*. doi:10.1109/ACCESS.2020.3019648
13. Hu, S., Zeng, G., Cao, X., Yuan, H., & Chen, B. (2021). Does Technological Innovation Promote Green Development? A Case Study of the Yangtze River Economic Belt in China. *Enviroenmental Research and Public Health*.
14. Huang, Y., Chen, X., Zhu, H., Huang, C., & Tian, Z. (2019). The Heterogeneous Effects of FDI and Foreign Trade on CO2 Emissions: Evidence from China. *Hindawi: Mathematical Problems in Engineering*, 14. Retrieved from https://doi.org/10.1155/2019/9612492
15. Intepat. (2020). Can Patents Help Save The Environment? Retrieved from https://www.intepat.com/blog/patent/green-patents-environments/
16. Jamal, S. (2019). Green Growth in Pakistan: A Necessary Paradigm Shift. *The Asia Foundation*. Retrieved from https://asiafoundation.org/2019/08/28/green-growth-in-pakistan-a-necessary-paradigm-shift/
17. Khan, M. K., Teng, J.-Z., Khan, M. I., & Khan, M. O. (2019). Impact of globalization, economic factors and energy consumption on. *Science of the Total Environment, 688*, 424-436. Retrieved from sci-hub.se/10.1016/j.scitotenv.2019.06.065
18. Kwon, D. S., Cho, J. H., & Sohn, S. Y. (2017). Comparison of technology efficiency for CO2 emissions reduction among European countries based on DEA with decomposed factors. *Journal of Cleaner Production*. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0959652617305000
19. Manzoor, R., & Samad, G. (2013). The Sustainable Green Growth Perspective of Pakistan: In the Context of Environment Friendly Technologies. *Pakistan Development Review*.
20. Muhammad, B., & Khan, S. (2019). Effect of bilateral FDI, energy consumption, CO2 emission and capital on economic growth of Asia countries. *Energy Reports, 5*, 1305-1315. Retrieved from https://www.sciencedirect.com/science/article/pii/S2352484719302495

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM

21. Pangestu, M., & Armstrong, S. (2018). Asian economic integration: The state of play. In *Asain Economic Integration in an Era of Global Uncertainty* . ANU Press.

22. Rahman, M. M., Saidi, K., & Mbarek, M. B. (2020). Economic growth in South Asia: the role of CO2 emissions, population density and trade openness. *Heliyon*(6). doi:10.1016/j.heliyon.2020.e03903

23. Sandberg, M., Klockars, K., & Wilen, K. (2019). Green growth or degrowth? Assessing the normative justifications for environmental sustainability and economic growth through critical social theory. *Journal of Cleaner Production, 206*, 133-141. doi:https://doi.org/10.1016/j.jclepro.2018.09.175

24. Sapkota, J. B. (2020). Integrating South Asia into Asia: Evidence from Trade Statistics. *Munich Personal RePEc Archive (MPRA)*. Retrieved from https://mpra.ub.uni-muenchen.de/106097/1/MPRA_paper_106097.pdf

25. Su, C.-W., Naqvi, B., Shao, X.-F., Li, J.-P., & Jiao, Z. (2020). Trade and technological innovation: The catalysts for climate change and way forward for COP21. *Journal of Environmental Management, 269*. Retrieved from https://doi.org/10.1016/j.jenvman.2020.110774

26. Sun, H., Clottey, S. A., Geng, Y., Fang, K., & Amissah, J. C. (2019). Trade Openness and Carbon Emissions: Evidence from Belt and Road Countries. *Sustainability, MDPI*. Retrieved from https://ideas.repec.org/a/gam/jsusta/v11y2019i9p2682-d230156.html

27. Survey, E. (2019). Retrieved from Government of India: https://www.indiabudget.gov.in/economicsurvey/

28. UNCTAD. (2020). Retrieved from United Nations Conference on Trade and Development: https://unctad.org/news/investment-flows-developing-countries-asia-could-fall-45-2020

29. Yasmeen, H., Wang, Y., Zameer, H., & Solangi, Y. A. (2019). Decomposing factors affecting CO2 emissions in Pakistan: insights from LMDI decomposition approach. *Environmental Science and Pollution Research*.

30. Zameer, H., Yasmeen, H., Zafar, M. W., Waheed, A., & Sinha, A. (2020). Analyzing the association between innovation, economic growth, and environment: divulging the importance of FDI and trade openness in India. *Environmental Science and Pollution Research*.

31. Aitken, B. J., & Harrison, A. E. (1999). Do domestic firms benefit from direct foreign investment? Evidence from Venezuela. American economic review, 89(3), 605-618.

32. Albino, V., Ardito, L., Dangelico, R. M., & Petruzzelli, A. M. (2014). Understanding the development trends of low-carbon energy technologies: A patent analysis. Applied Energy, 135, 836-854.

33. Al-Mulali, U., Ozturk, I., & Lean, H. H. (2015). The influence of economic growth, urbanization, trade openness, financial development, and renewable energy on pollution in Europe. Natural Hazards, 79(1), 621-644.

34. Bai, J., & Ng, S. (2004). A PANIC attack on unit roots and cointegration. Econometrica, 72(4), 1127-1177.

35. Baul, T. K., Datta, D., & Alam, A. (2018). A comparative study on household level energy consumption and related emissions from renewable (biomass) and non-renewable energy sources in Bangladesh. Energy Policy, 114, 598-608.

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM

36. Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. Applied Energy, 162, 733-741.

37. Change, I. C. (2014). Mitigation of climate change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 1454.

38. Chiu, C. L., & Chang, T. H. (2009). What proportion of renewable energy supplies is needed to initially mitigate CO2 emissions in OECD member countries? Renewable and Sustainable Energy Reviews, 13(6-7), 1669-1674.

39. Chiu, C. L., & Chang, T. H. (2009). What proportion of renewable energy supplies is needed to initially mitigate CO2 emissions in OECD member countries? Renewable and Sustainable Energy Reviews, 13(6-7), 1669-1674.

40. Dauda, L., Long, X., Mensah, C. N., & Salman, M. (2019). The effects of economic growth and innovation on CO 2 emissions in different regions. Environmental Science and Pollution Research, 26(15), 15028-15038.

41. Dogan, E., &Seker, F. (2016). The influence of real output, renewable and non-renewable energy, trade and financial development on carbon emissions in the top renewable energy countries. Renewable and Sustainable Energy Reviews, 60, 1074-1085.

42. Dong, K., Sun, R., & Hochman, G. (2017). Do natural gas and renewable energy consumption lead to less CO2 emission? Empirical evidence from a panel of BRICS countries. Energy, 141, 1466-1478.

43. Duarte, R., Mainar, A., & Sánchez-Chóliz, J. (2013). The role of consumption patterns, demand and technological factors on the recent evolution of CO2 emissions in a group of advanced economies. Ecological Economics, 96, 1-13.

44. Galende, J. (2006). Analysis of technological innovation from business economics and management. Technovation, 26(3), 300-311.

45. Hao, L. N., Umar, M., Khan, Z., & Ali, W. (2021). Green growth and low carbon emission in G7 countries: How critical the network of environmental taxes, renewable energy and human capital is?. Science of the Total Environment, 752, 141853.

46. Hoffman, A. J. (2011). Talking past each other? Cultural framing of skeptical and convinced logics in the climate change debate. Organization & Environment, 24(1), 3-33.

47. Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. Journal of econometrics, 115(1), 53-74.

48. Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of economic dynamics and control, 12(2-3), 231-254.

49. Kao, C. (1999). Spurious regression and residual-based tests for cointegration in panel data. Journal of econometrics, 90(1), 1-44.

50. Khan, Z., Hussain, M., Shahbaz, M., Yang, S., & Jiao, Z. (2020). Natural resource abundance, technological innovation, and human capital nexus with financial development: a case study of China. Resources Policy, 65, 101585.

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM

51. Koop, G., & Poirier, D. J. (2004). Bayesian variants of some classical semiparametric regression techniques. Journal of Econometrics, 123(2), 259-282.
52. Lin, B., & Zhu, J. (2019). The role of renewable energy technological innovation on climate change: empirical evidence from China. Science of the Total Environment, 659, 1505-1512.
53. Liobikienė, G., &Butkus, M. (2019). Scale, composition, and technique effects through which the economic growth, foreign direct investment, urbanization, and trade affect greenhouse gas emissions. Renewable energy, 132, 1310-1322.
54. Lipsey, R. (2002). Home and host country effects of FDI ', NBER Working Paper No. 9293.
55. Mensah, C. N., Long, X., Boamah, K. B., Bediako, I. A., Dauda, L., & Salman, M. (2018). The effect of innovation on CO2 emissions of OCED countries from 1990 to 2014. Environmental Science and Pollution Research, 25(29), 29678-29698.
56. Mihci, H., Cagatay, S., &Koska, O. (2005). The impact of environmental stringency on the foreign direct investments of the OECD countries. Journal of Environmental Assessment Policy and Management, 7(04), 679-704.
57. Nosheen M, Iqbal J, Hassan SA (2019) Economic growth, financial development, and trade in nexuses of CO 2 emissions for Southeast Asia. Environ Sci Pollut Res 26(36):36274–36286.7.
58. Nosheen, M., Iqbal, J., & Khan, H. (2021). Analyzing the linkage among CO2 emissions, economic growth, tourism, and energy consumption in the Asian economies. Environmental Science and Pollution Research International, 1 - 13.
59. Orubu, C. O., & Omotor, D. G. (2011). Environmental quality and economic growth: Searching for environmental Kuznets curves for air and water pollutants in Africa. Energy Policy, 39(7), 4178-4188.
60. Pesaran, M. H. (2004). General diagnostic tests for cross-sectional dependence in panels. Empirical Economics, 1-38.
61. Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross- section dependence. Journal of applied econometrics, 22(2), 265-312.
62. Rafindadi, A. A., Muye, I. M., &Kaita, R. A. (2018). The effects of FDI and energy consumption on environmental pollution in predominantly resource-based economies of the GCC. Sustainable Energy Technologies and Assessments, 25, 126-137.
63. Raiser, K., Naims, H., & Bruhn, T. (2017). Corporatization of the climate? Innovation, intellectual property rights, and patents for climate change mitigation. Energy research & social science, 27, 1-8.
64. Shahbaz, M., Lean, H. H., & Shabbir, M. S. (2012). Environmental Kuznets curve hypothesis in Pakistan: cointegration and Granger causality. Renewable and Sustainable Energy Reviews, 16(5), 2947-2953.
65. Shahbaz, M., Shahzad, S. J. H., &Mahalik, M. K. (2018). Is globalization detrimental to CO2 emissions in Japan? New threshold analysis. Environmental Modeling & Assessment, 23(5), 557-568.
66. Wang, D. D. (2017). Do United States manufacturing companies benefit from climate change mitigation technologies? Journal of cleaner production, 161, 821-830.

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM

67. Wang, D. D., Li, S., &Sueyoshi, T. (2018). Determinants of climate change mitigation technology portfolio: An empirical study of major US firms. Journal of Cleaner Production, 196, 202-215.

68. Wang, S., Zeng, J., & Liu, X. (2019). Examining the multiple impacts of technological progress on CO2 emissions in China: a panel quantile regression approach. Renewable and Sustainable Energy Reviews, 103, 140-150.

69. Westerlund, J. (2007). Testing for error correction in panel data. Oxford Bulletin of Economics and statistics, 69(6), 709-748.

70. Zhu, H., Duan, L., Guo, Y., & Yu, K. (2016). The effects of FDI, economic growth and energy consumption on carbon emissions in ASEAN-5: evidence from panel quantile regression. Economic Modelling, 58

ISSN 2576-5973 (online), Published by "Global Research Network LLC"
under Volume: 5 Issue: 7 in Jul-2022 https://www.grnjournals.us/index.php/AJEBM