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RESEARCH ARTICLE

Innovations, energy consumption and carbon dioxide emissions in the global world countries: An empirical investigation

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Abstract
Technological innovations are the important sources of economic growth of a country and it is inter associated with other factors such as energy consumption, economic growth and carbon dioxide emission. A change in these factors affect the capability of technological innovation and thus the effect of these factors on innovations need to be explored. This study investigates the effect of carbon dioxide, energy consumption and economic growth on innovations proxies by different innovations indicators. The sample data is collected from 1980 to 2019 of the world 181 countries and OLS, fixed effect, two step Generalized method of moments and panel quantile regression models were employed for data analysis. The results reveal that carbon dioxide and economic growth increase technological innovations while the inflow of FDI decrease innovations output. Energy consumption also negatively affects innovation indicators except for research and development. In the case of quantile regression, energy consumption is positive while carbon dioxide and foreign direct investment are negative across different quantiles for research and development. Energy consumption and foreign direct investment reduce technological innovations proxy by patent application residents while carbon dioxide and economic growth increase it. The findings of this study have considerable policy suggestions for the global countries.

Keywords: Innovations; carbon dioxide emission; energy consumption; economic growth

Introduction

Improved level of innovations help acquiring the sources of renewable energy, rise energy efficiency in production and reduce carbon emissions which can leads to sustainable development. Innovations improvement is important to increase economic growth (Aghion & Howitt, 1990), however the innovations determinants such as such as energy consumption, economic growth, foreign direct investment and carbon dioxide emission need investigation to identify its role in innovation output as a change in these factors affect the capability of technological innovation. Due to the importance of innovations in economic growth, researchers have focused to investigate the determinants of innovations which indicate that an increase in research and development cannot be the only source to enhance technological innovation while technology transfer and spillovers, international trade, education, institutions and foreign direct investment (Chunying, 2011); (Varsakelis, 2006); (Furman, Porter, & Stern, 2002), however, some other researchers believes that there is no association between foreign direct investment and technological innovation (Yang & Qi, 2001); (Haddad & Harrison, 1993). However, several others argue that technological innovation negatively affects foreign direct investment when it is below the level threshold while positive when it is above the threshold level (Loukil, 2016). The empirical literature has not considered carbon emission and energy consumption in such a case however, it is commonly believed that technological innovation affects energy consumption, economic growth, foreign direct investment and environmental quality. Such investigation has not been done which investigated the effect of carbon dioxide, energy and foreign direct investment on technological innovation. Both foreign direct investment and technological innovations are linked such as innovation facilitates foreign direct investment while foreign direct investment brings new management skills, new technology and capital that affect

the level of innovation. Energy is used for production and other economic activities such as foreign direct investment which in turn boosts economic growth thus a rise in the use of energy, foreign direct investment and economic growth increase carbon dioxide emission. However, this effect can be varied in different countries due to different environmental regulations, the level of energy use and foreign direct investment. Innovations are required in these activities such as a rise in innovation level facilitated foreign direct investment, raising energy efficiency and increasing economic growth while these factors in turn influence technological innovations. Consequently, it is important to study the effect of foreign direct investment, carbon emission and economic growth on technological innovation. Based on the above discussion and statements, we believe that such a complex study has not been done in prevailing literature however, some studies have only considered the effect of foreign direct investment or economic growth on technological innovations. Likewise, commonly used proxies of innovations such as patent application residents or high technology export are used however this study used four indicators to proxy for technological innovations. Similarly, carbon dioxide, energy consumption, and foreign direct investment have not been taken in the same study to examine their impact on technological innovation as these factors are very important to each other. By considering all these factors this study, it will deeply examine the effect of these variables on each indicator of technological innovations which has not been attempted before. Consequently, this study examines the effect of carbon dioxide, energy consumption and foreign direct investment on technological innovation indicators by considering other most important factors in a sample of 179 global countries. Dynamic panel models and panel quantile regression were used to investigate this association both in a dynamic way and its effect on technological innovation across different quantiles to achieve the most efficient results. The findings confirm that all proxies of innovation are negatively affected by foreign direct investment while it's been increased by carbon emission and economic growth. Energy consumption is also negatively related with all proxies except research and development while trade is negatively related with patent applications nonresidents and positive with all other proxies of innovation. The quantile regression results indicate that foreign direct investment negatively affects patent applications nonresidents in the first quantiles while insignificant at the highest quantile whereas carbon dioxide emission and financial development are strongly positive and increase innovations proxy by patent applications nonresidents. Energy consumption and trade are negative while economic growth is positive across quantiles for patent applications nonresidents. Foreign direct investment and carbon dioxide are negative across different quantiles for research and development while financial development and energy consumption are positive. Trade is also negatively related to research and development while economic growth is insignificant. Foreign direct investment, trade and energy consumption are negatively related to patent applications residents while carbon dioxide and financial development are positive. Likewise, economic growth is positively related to patent applications residents in the middle quantiles. In the case of technology, foreign direct investment, financial development, energy consumption, and trade are positive while carbon dioxide is negative in the first few quantiles and positive in the highest quantile for technology. Such analysis in the previous studies has not been done while our findings are very beneficial for the sample countries regarding technology, innovation, enhancing economic growth and environmental policies as well foreign direct investment attraction.

The remaining parts of the study are structured as follows; section 2 is composed of a literature review, part 3 present the variables and methods, section 4 presents discussions and results while section 5 gives recommendation, suggestions and conclude the study.

Literature review

In preceding literature, a large number of researchers explore the effect of technological innovations, foreign direct investment, energy consumption and related factors on carbon emission however the effect of these factors on technological innovation is limited. Even in some studies conducted in the preceding literature on the impact of these factors on innovation or technology but with little accord such as the previous studies have used some commonly used indicators of innovation or have to find the effect of single factor on innovation such as foreign direct investment. For example, a study conducted by (Adikari, Liu, & Marasinghe, 2021) examine the relationship between foreign direct investment and innovation in Sri Lanka for the period 1990 to 2019 using the ARDL model. The authors illustrate that there was a negative effect of foreign direct investment on innovations however education and research and development were positive. The authors claim that research and development are vital factors that effectively explain technological innovation. Similarly, (Chunying, 2011) investigated the technological from and foreign direct investment nexus in China from 1987 to 2009 by using the quantile regression method. The results of their study show that foreign direct investment positively affects technological innovation in China at the bottom distribution while this effect was found negative at the top conditional distribution. They further indicate the low-level effect of foreign direct investment on only low-level innovations while the negative role of foreign direct investment on high-level technological innovation. In the case of developing and emerging countries, financial development has also been considered as (Loukil, 2020) examined the financial development effect on innovation in developing and emerging countries from 1980 to 2009. The author found that there is a nonlinear effect between innovation and

financial development. They found that there is a threshold value of economic growth below, the effect of financial development on innovation was insignificant, while the effect is positive of financial development on economic growth above the threshold value. Their findings suggest that financial institutions can promote innovations in presence of healthy economic development. The effect of foreign direct investment on technological innovation in Chinese provincial data from 2009 to 2018 is studied by (W. Li, 2021). The authors used a threshold regression model where the results show that regional innovation capability intellectual property intensity is significantly affected by foreign direct investment. They further indicate that foreign direct investment maximizes regional innovations capability when the intellectual property protection intensity is maintained near the level threshold. Likewise, another study also considered the effect of foreign direct investment on innovation. (Loukil, 2016) studied the developing countries' foreign direct investment and innovations from 1980 to 2009. The study also uses the threshold model and found that foreign direct investment has a negative effect on innovation below the threshold while positive when the value is above the threshold value. They indicate that such a level of innovation is not enough for economic policy to attract foreign direct investment. (Wang, Liu, & Wang, 2021) studied the technological innovation effect in China enterprises produced by Foreign direct investment from 2015 to 2017. They found that improvement in Foreign direct investment activities in Chinese enterprises promotes the level of technological innovations. They further indicate that the research and development-related activities of Foreign direct investment perform a very active role in promoting the enterprises' technological innovation ability. Likewise, economic growth has also been added to such associations as (Pala, 2019) studied economic growth and technological innovation in 25 developing countries and employed a random coefficient model to the data for analysis. The authors found that economic growth is affected negatively by research and development in some of the sample countries while positive in a group of some countries. On the other hand, several studies indicate that there is an association between carbon dioxide, foreign direct investment, economic growth and technological innovation as a study on the linkage between foreign direct investment, technological innovation and economic growth is conducted by (Sheng Yin & Hussain, 2021). The study findings reveal that these indicators positively affect economic growth and foreign direct investment. They also argue that economic growth, foreign direct investment and tourism were also the positive factors contributing to the ecological footprint. They further confirm the two-way casual association between tourism and ecological footprint, technological innovation and ecological footprint, and a one-way casual association between technological innovation, foreign direct investment inflow, and tourism. A similar study is conducted by (Sheng, Miao, Song, & Shen, 2019) who examined the linkage between innovation, carbon emission, and urbanization in 48 cities in China from 2001 to 2015 using a spatial econometric model. They found a U-shaped and N-shaped curve across different cities and found that innovation positively affects the carbon dioxide reduction in some of the cities while this effect is insignificant in some of the sample cities however they confirm that innovation play moderating role between carbon emission and urbanization. (Uddin, Pan, Saima, & Zhang, 2021) considered the changes in socio-economic factors and examine the effect of energy intensity and technological innovations in 23 countries of Europe. By using threshold regression, the authors found that both stock and banks affect energy intensity and rely on the level of technological innovations. Likewise, (Hu et al., 2021) studied the effect of innovation and economic openness on the environment for the period 1990 to 2014 in Asian countries. By using dynamic and fully modified OLS estimators, the authors found that energy consumption and trade openness increase the level of emission while GDP, foreign direct investment, and patents depress carbon dioxide emission in Asian countries. Likewise, different proxies for innovation have been used and found its impact on economic growth as (Pece, Simona, & Salisteanu, 2015) studied the long-term effect of innovation on economic growth. They used multiple regression models and investigated such associations in CEE countries. The authors found that innovation and economic growth were positively linked. The effect of technology innovation on carbon emission was also studied by (R. Li, Lin, Jiang, Liu, & Lee, 2021) in 66 countries considering economic development in this association. The authors show that the relationship between technological innovations and carbon dioxide was U-shaped and this relationship was positively and negatively affected by economic development cases when economic growth crosses the threshold level. The authors found both N and U-shape correction in the sample of OECD and High-income countries and argue that technological innovations and advancement have a dynamic influence on carbon emission in a different sample of countries.

Methodology

This study examines the effect of foreign direct investment, carbon emission, and economic growth on technological innovation in the global panel of 179 countries from the period of 1980 to 2019. The baseline model is as follows;

$$TIN_{it} = \beta_0 + \beta_1 TIN_{it-1} + \beta_2 FDI_{it} + \beta_3 CO2_{it} + \beta_4 GDP_{it} + \beta_5 FND_{it} + \beta_6 ENR_{it} + \beta_7 TO_{it} + \varepsilon_{it} \quad (1)$$

In equation 1 given above, TIN represents technological innovation proxy by four innovation indicators, FDI represent the inflow of foreign direct investment taken as a

percent of GDP, CO2 is carbon dioxide emission (metric tons per capita), GDP is per capita gross domestic product used to represent economic growth, FND is financial development proxy by domestic credit to the private sector by the bank as % of GDP, and TO represents international trade. Four indicators are used to proxy innovations that include patent application residents (number per thousand population) (Wusiman & Ndzembanteh, 2020); (Rodríguez-Pose & Wilkie, 2019). The second indicator of innovation is patent application nonresidents (number per thousand population). This proxy is used by (Qamruzzaman, Tayachi, Mehta, & Ali, 2021). Likewise, the third proxy is research and development expenditure (percentage of real gross domestic product). This proxy is recently used by (Coluccia, Dabić, Del Giudice, Fontana, & Solimene, 2020); (Knott & Vieregger, 2018) ; (Chunying, 2011; Maradana et al., 2017). The fourth indicator of innovation in our study is high-technology exports (percentage of real gross domestic product). Descriptive statistics and variables are shown in Table 1 while the correlation matrix is given in Table 2.

The study use OLS, Fixed effect, Generalized method of moments (GMM) and panel quantile regression for data analysis. The reason for using several estimators is to compare our results with previous studies while the main focus of this study will be based on system GMM and quantile regression. We use the OLS estimator as a basic econometric technique and compare its results with quantile regression and the system GMM model. Static models that induced OLS and fixed effect t may lead to several econometric issues and thus may give inefficient results. (Arellano & Bond, 1991) developed two steps Generalized method of moments estimator and further developed by (Blundell & Bond, 1998) is finally considered for analysis to control for endogeneity in our regression model. two-step model is considered more efficient compared to a one-step GMM(Law & Azman-Saini, 2012) and thus we focus on a two-step estimator. The system GMM estimator is based on additional conditions as it adds equations in level to the equation of first difference and the explanatory variables lagged difference as instruments (Bond, Hoeffler, & Temple, 2001). The system GMM works to combine the set of all previous equations into levels. (Blundell & Bond, 1998) present that difference estimators have persistence in the lagged dependent variables and that's why they may perform not well. (Arellano & Bover, 1995) proposed a system GMM estimator which has been considered to perform better than the first difference estimator (Blundell, Bond, & Windmeijer, 2001). It's also explained the time-series variation and accounts for individual unobserved country-specific effects. It's also included the dependent variable as independent and better control endogeneity of independent variables (Beck et al. 2007). The method is recently used by (Johansson & Wang, 2012), (Khan, Weili, Khan, & Khamphengxay, 2021); (Seven & Coskun, 2016); (and Khan, Weili, & Khan, 2021). In addition, to validate our instruments, we use the standard Hansen/Sargan test. The null hypothesis states that the instrumental variables do not correlate with residuals. Moreover, we conduct the serial correlation test (AR2), whose null hypothesis states that there is no second-order serial correlation between error terms.

The baseline model for system GMM can be stated as follows;

$$TIN = \beta_0 + \beta_1 TINV_{it-1} + \beta_2 Y_{it} + \beta_3 X_{it} + \varepsilon_{it} \dots\dots\dots\dots\dots\dots (2)$$

Where TIN is innovation, TINit-1 is the lag dependent variable, Y represents explanatory variables, X represent control variables *and* ε is the error term.

Table.1. Descriptive statistics

Variable	Description	Mean	Std. Dev	Min	Max
FDI	Foreign direct investment	5.095	38.537	-1275.19	1282.633
GDP	Economic growth	1.842	6.006	-64.992	140.367
PT1	Patent application residents	10691.75	64078.21	1.000	1393
PT2	Patent application nonresidents	4926.64	21020.49	1.000	336
RD	Research and development	0.938	0.946	0.005	4.952
TECHNOLOGY	High technology export	10.706	11.492	0.0001	78.476
CO2	Carbon dioxide emission	4.488	7.914	0.0001	266.483
FND	Financial development	38.904	35.27	0.001	304.575
ENR	Energy consumption	2404.708	2951.99	9.548	28902.85
TO	International trade	81.98762	49.836	0.02	437.326

Table.2. Correlation matrix

Variables	FDI	PT1	PT2	RD	Technology	CO2	GDP	FND	ENR	TO
FDI	1.0000									
PT1	-0.0585	1.0000								
PT2	-0.0567	0.7242	1.0000							
RD	-0.0872	0.3385	0.2916	1.0000						
Technology	0.2534	0.2249	0.1976	0.3599	1.0000					
CO2	0.0436	0.2215	0.3236	0.4597	0.1996	1.0000				
GDP	-0.0428	0.0932	0.0409	-0.1999	-0.0294	-0.1658	1.0000			
FND	0.2462	0.1522	0.0258	0.5001	0.4556	0.2897	-0.2730	1.0000		
ENR	-0.0040	0.0987	0.1861	0.5044	0.2579	0.6802	-0.1773	0.3545	1.0000	
TO	0.2693	-0.2004	-0.2099	0.0160	0.3495	0.2649	0.0343	0.1268	0.1931	1.0000

In addition, we used quantile regression to evaluate the concomitant relationship in the conditional distribution. (Balsvik & Haller, 2011) also used quantile regression to investigate the effect of foreign direct investment on innovation. The choice of quantile regression methods is also inspired by existing non-contemporary and contemporary studies that show the importance of using empirical strategies to clarify countries with different levels of outcome variables (Roger Koenker & Gilbert Bassett Jr, 1978); (Tchamyou & Asongu, 2017). Compared with alternative techniques based on the average of outcome variables, these studies acknowledge that the methods are also consistent in their robustness in providing conditional survey results. These alternative methods provide survey results with comprehensive policy implications (Koenker & Ng, 2005); (Okada & Samreth, 2012); (Hao & Naiman, 2007); (Asongu & Odhiambo, 2019). Using traditional regression methods may result in overestimation or underestimation of correlation coefficients, or may fail to successfully detect important relationships because these techniques focus on average effects (Binder & Coad, 2011). Panel quantile regression was introduced by (R Koenker & G Bassett Jr, 1978) in their seminal work. Quantile regression in redistribution is more robust, but it cannot deal with heterogeneity that is not observed in a country. Therefore, the current paper uses panel quantile fixed effects to examine conditional heterogeneity and unobserved individual heterogeneity. (Lamarche, 2010) and (Galvao Jr, 2011) have considered econometric theory to apply quantitative regression to panel data. The generalized form of the median regression analysis for other quantiles can be expressed in the following form in equation 3, while the fixed effect panel quantile regression can be explained as in equation 4;

$$Q_{yi}(\tau \mid x_i) = x_i^T{}_{\beta_\tau} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$Q_{yi}(\tau_k \mid \alpha_i x_{it}) = \alpha_i + x'_{it}(\tau_k) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

There is a major problem with fixed-effect panel quantile regression. The existence of a large number of fixed-effects is due to incidental parameter problems (Lancaster, 2000); (Neyman & Scott, 1948). When individuals tend to infinity, there will be inconsistencies, but each cross-section has a fixed observation value. The purpose of the fixed effect is to eliminate the unobserved effects of the fixed effect. These methods are expected to be linear and its not the reason of conditional quantiles (Canay, 2011). In order to overcome with these problems, (Koenker, 2004) proposed a method which deals with the unobserved fixed effects. The author fixes this with parameters and estimates them collectively with the covariate effects of different quantiles. Penalty term is used in this problem of calculation is minimized of estimated parameter. The calculation meted of parameter estimation is as follows;

$$\min_{(\alpha,\beta)} \sum_{\mathrm{k}=1}^{K} \sum_{t=1}^{T} \sum_{i=1}^{N} w_k P_{\tau k}\left(y_{it} - \alpha_i - x_{it}^T \beta(\tau_k)\right) + \lambda \sum_{I}^{N} \mid \alpha_I \mid, \dots\dots\dots\dots (5)$$

In the given equation, the country (N) index is represented by I where T, *K* represent the number of country observation in the quantile index. Likewise, x represents the explanatory variables matrix and P_{tk} is the quantile of the loss function. W_k given in the equation is the *k-th*, the weight of the quantile is used to control the contribution of the *k-th* quantile to the fixed effect estimate. Equal weight quantile in this research is focused which is given by (Alexander, Harding, & Lamarche, 2011). In addition, λ represents the tuning parameter which is used to improve the β estimation and reduce individual effects to zero. When λ becomes zero, the penalty term will disappear, and then the usual fixed effect estimator can be obtained. However, if the λ term tends to infinity, we will get model estimates without individual influence. The current paper λ has been set equal to 1 (Damette & Delacote, 2012). The specification of the τ quantile function of the baseline model variables in the current research can be as follows:

$$Q_{yi}(\tau \mid \alpha_i, \xi_t, x_{it}) = \alpha_i + \xi_t + \beta_{i\tau} TINV_{it} + \beta_{2\tau} fdi_{it} + \beta_{3\tau} CO2_{it} + \beta_{4\tau} GDPPC_{it} + \beta_{5\tau} FND_{it} + \beta_{6\tau} ENR_{it} + \beta_{7\tau} TO_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where *i* represent countries, time is t, y_{it} is the indicator TIN, the description of all other symbols is given above.

Results and Discussions

Results of OLS and fixed effect models

Table 3 present the results of OLS and fixed effect models. We don't explain the results of OLS and FE in detail because we use these two estimators just for comparison purposes with our targeted econometric models and compare our results with previous studies. As discussed in the methodology section that OLS or fixed-effect models may lead to several econometric problems and may give unreliable and inefficient results. That's why our main focus is system GMM and Quantile regression models and we consider the findings of these estimators.

The effect of foreign direct investment on patent applications nonresidents in both models is significant while carbon dioxide is positive only in OLS model. The estimated coefficient of financial development and economic growth are significant and positive in OLS model while the coefficient are insignificant in fixed effect estimator. The effect of energy consumption and international trade exert significant but negative effect on patent application shown by their estimated coefficients in OLS model however the sign in the fixed effect model is positive. The estimated coefficient of foreign direct investment in OLS and fixed effect are negative significant indicates that foreign direct investment reduces research and development while the effect of carbon dioxide on research and development in both models are positive which shows that carbon dioxide increases research and development. Economic growth is negative in fixed effect while positive in OLS, financial development is positive significant both in OLS and fixed effect model which indicates that financial development significantly and positively affects research and development. Energy consumption positively affects research and development in the OLS model while trade positively affects research and development in fixed effect and negatively and significantly in the OLS model.

Table 3: OLS and FE results

	PT2		RD		PT1		Technology	
VARIABLES	OLS	FE	OLS	FE	OLS	FE	OLS	FE
FDI	-6.220	5.352	-0.004***	-0.000***	-175.0**	-30.82*	0.032**	0.007*
	(25.66)	(19.79)	(0.000)	(0.000)	(69.31)	(49.33)	(0.014)	(0.008)
CO2	2,254***	375.6	0.004***	0.028***	4,131***	6.485***	-0.147	1.310***
	(157.4)	(299.5)	(0.006)	(0.007)	(392.5)	(709.9)	(0.105)	(0.322)
GDP	449.5***	-82.35	0.000**	-0.006***	1,093***	-184.5	0.188**	0.010
	(97.37)	(66.13)	(0.005)	(0.001)	(244.8)	(155.9)	(0.091)	(0.049)
FND	39.59***	8.734	0.009***	0.002***	382.8***	133.6***	0.109***	0.040**
	(11.11)	(12.75)	(0.000)	(0.000)	(27.85)	(29.75)	(0.008)	(0.016)
ENR	-0.837**	1.267**	0.000***	-1.380	-4.024***	3.607***	0.000**	-0.002***
	(0.334)	(0.580)	(1.480)	(1.300)	(0.826)	(1.356)	(0.000)	(0.000)
TO	-116.6***	77.72***	-0.001***	0.004***	-274.7***	65.19	0.042***	-0.008
	(8.324)	(17.34)	(0.000)	(0.000)	(20.78)	(40.90)	(0.006)	(0.016)
Constant	2,444***	5,20***	0.143***	0.312***	-525.2	40,512***	-0.458	10.04***
	(852.3)	(1,847)	(0.0499)	(0.064)	(2,158)	(4,413)	(0.824)	(2.801)
Obs	2,339	2,339	1,318	1,318	2,242	2,242	819	819
R-squared	0.211	0.019	0.437	0.162	0.194	0.084	0.314	0.059
N.ID		120		117		116		119

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The effect of foreign direct investment on patent applications residents is negative significant both in OLS and fixed effect model while the effect of carbon dioxide is positive significant both in OLS and fixed effect model which indicates that foreign direct investment reduces and carbon dioxide increases patent applications, residents. Economic growth and financial development significantly and positively affect patent applications residents in the OLS model while economic growth is insignificant in the fixed-effect model. Energy consumption and trade are positively significant in fixed effect while negative significant in OLS. The coefficients of foreign direct investment and financial development are positive significant both in OLS and fixed effect indicating that these

two variables significantly increase technology while carbon dioxide is positively significant in fixed effect and insignificant in OLS. Economic growth positively and significantly increases technology in OLS while the coefficients are insignificant in fixed effect. Energy consumption is positive and negative in OLS and fixed effect respectively while trade is positive in OLS and insignificant in the fixed-effect model.

Two-step system GMM results

Table 4 presents the two-step system GMM results on the effect of explanatory variables on technological innovation. The results indicate that the estimated coefficient of foreign direct investment is negative and significant for all dependent variables. The results indicate that foreign direct investment reduces innovations in the sample countries. More specifically, the findings show that if there is a percent increase in foreign direct investment will reduce patent application nonresidents by 0.515, patent application residents by 1.04, research and development by 0.01 and high technology export by 0.011 percent. Our results are reinforced by the findings of (Loukil, 2016). (Adikari et al., 2021) also found the negative effect of foreign direct investment on innovation in Sri Lanka which is similar to our findings. Foreign direct investment can bring advanced technology and spillover effects which can enhance innovations however it may still be below the desired level in some countries in the panel that reduces innovation levels such as low income or developing countries. These countries' innovations are negatively affected by foreign direct investment as these countries are forced only on rising economic growth to enhance their living standard thus they are not yet in a position to focus on advanced level technology transfer of foreign direct investment to rise innovations. (Berger & Diez, 2008) argues that foreign direct investment affects technological advancement through strategic impact, human resource development and forward and brain-led information diffusion. Our sample countries, there include lower-income and developing countries that may still attract foreign direct investment to enhance economic growth to attain higher living standards and they may not focus to rise innovation capability. There may be the transfer of obsolete technology by multinational corporations to the host countries because they may afraid to transfer advanced technology which can reduce the future competition and loss of intellectual property. Low-income countries even try to attract such foreign direct investment to raise economic growth. Domestic companies of these countries may work with foreign investors as a joint venture to get advanced technology from abroad which can create an innovative atmosphere and thus can raise the level of innovations.

Likewise, the estimated coefficient of carbon dioxide is positive significant for innovations proxy by patent applications nonresidents and technology while negative and significant for research and development and patent applications residents. This result shows that an increase in carbon dioxide emission significantly increases patent applications for nonresidents and technology while reducing research and development and patent applications for residents. Carbon dioxide discharge can be the reason for higher economic growth in developing countries as these countries are rising economic growth through production, industrialization and other economic activities such as foreign direct investment and trade. An increase in these activities, in turn, raises energy demand thus rising carbon dioxide emissions. Thus, higher economic growth may raise the level of innovations. Thus, the findings reveal that carbon dioxide in the sample countries rise technological innovations proxy by patents nonresidents and high technology export however its effect on patent application residents and research and development expenditure is negative. The country's carbon emission in turn degrades environmental quality and increases economic growth however the innovations capability may be raised due to economic activities. Thus, the findings further illustrate that developing and low-income countries may have a high level of environmental degradation due to high carbon emission discharge through economic activities however a rise in innovation may reduce environmental pollution and a rise in economic growth in future after the countries reach a certain level of development. This phenomenon is termed is innovation Claudia curve in the previous studies however we have not used it in this study as this study only focuses on the effect of these factors on technological innovations.

The estimated coefficient of economic growth for patent applications nonresidents, patent applications residents, and technology is highly significant and positive while negative significant for research and development. The results show that an increase in economic growth significantly increases the level of innovation, patent applications nonresidents, patent applications residents, and technology while reducing research and development. The findings suggest that economic growth is increased through economic activities such as foreign direct investment and production, and industrialization and thus these activities rise carbon emissions. We found that carbon emission and economic growth both are positively related to rise in innovations as the countries going to be developed, innovations might be increased. However, economic growth and carbon emission have environmental consequences. (Loukil, 2020) also found similar results which reinforce our findings.

The coefficient of financial development is highly significant and the sign is positive for research and development and technology which indicates that an increase in financial development increases these two factors of innovation. More specifically, the results indicate that if there is a percent increase in financial development will increase research and development and technology by 0.001 and 0.014 percent respectively in the sample countries. The results suggest that the countries' financial institutions

have an important role in countries' innovation level. A well functional financial system facilitates projects related to economic activities and raises the level of innovation. (Hsu, Tian, & Xu, 2014)) also argues that well-established and effective financial markets overcome moral hazards and reduce the external costs of firms which in turn enhance innovation. Likewise, (Aristizabal-Ramirez, Botero-Franco, & Canavire-Bacarreza, 2017) shows that the soundness of innovations depends on a well-established and well-functioning financial market which improves resource allocation and investment in strategic sectors and enhances technology.

Table 4: System GMM results

Variables	PT2	RD	PT1	Technology
FDI	-0.515***	-0.000***	-1.041*	-0.011***
	(0.166)	(4.750)	(0.611)	(0.000)
CO2	8.242***	-0.001***	-28.35***	0.052***
	(2.111)	(0.000)	(7.019)	(0.018)
GDP	36.39***	-0.001***	151.5***	0.007**
	(0.458)	(8.860)	(4.607)	(0.003)
FND	0.0341	0.0001***	0.700	0.014***
	(0.172)	(3.420)	(0.451)	(0.000)
ENR	-0.017***	3.030***	-0.083***	-0.000***
	(0.002)	(4.420)	(0.012)	(2.100)
TO	-0.423***	3.920***	5.619***	0.008***
	(0.087)	(6.740)	(0.330)	(0.000)
$PT2_{it-1}$	1.041***			
	(0.000)			
$R\&D_{it-1}$		0.998***		
		(0.004)		
$PT1_{it-1}$			1.064***	
			(0.000437)	
$Technology_{it-1}$				0.834***
				(0.004)
Constant	-40.45***	0.008**	-667.6***	0.562***
	(10.97)	(0.003)	(46.47)	(0.079)
Observations	2,136	1,118	2,051	693
Number of id	117	101	110	115
AR2	0.45	-1.62	-0.05	0.59
	(0.649)	(0.105)	(0.959)	(0.022)
Sargan test	1986.70	1364.56	8049.11	0.59
	(0.207)	(0.000)	(0.000)	(0.769)

Note. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Our findings regarding technology and research and development show that financial markets play important role in rising research and development and technology in the sample countries. Financial markets have improved resource allocation and reduced the external costs of firms that have contributed to technology improvement. On the other hand, financial development does not affect patent applications nonresidents and patent applications, for residents. (Loukil, 2020) found that when the economic development threshold values are below, the financial development does not affect innovation while above the level of the threshold has a positive effect of financial development on innovation. They indicate that a healthy economic environment is essential for financial institutions to provide high-quality financial services and promote more innovation.

The coefficient of energy consumption is highly significant for all dependent variables while the effect is negative on patent applications nonresidents, patent applications residents, and technology while positively affecting research and development. The results show that an increase in energy consumption significantly reduces innovation except for research and development in which energy consumption exerts a positive effect. The estimated coefficient of trade openness is highly significant in all models while the effect is negative while positive on other dependent variables. The results show that an increase in trade openness significantly reduces patent applications for nonresidents while increasing other innovation indicators.

Results of Panel Quantile regression

We use panel quantile regression as a robust check to the system GMM model as well to examine the effect of the explanatory variables on each innovation indicator across different quantiles. Table 5 presents the results of Quantile regression on the impact of explanatory variables on innovations (patent nonresidents) where the effect of foreign direct investment on patent applications nonresidents is negative significant from the 5th quantile to the 60th higher quantile while it becomes insignificant at the highest quantile from 70th to 95th quantile. The results are almost similar to the system GMM model however, the quantile regression results show that this effect becomes insignificant in the highest quantiles. The results indicate that foreign direct investment significantly reduces innovations in the first quantiles till 60th while this effect becomes insignificant when reaches the higher quantile after the 70th. The coefficients of carbon dioxide from the 5th quantile to the last quantile 95th are highly significant and positive which indicates that carbon dioxide emission significantly increases patent applications for nonresidents. The estimated coefficients of economic growth are insignificant in the first two quantiles while it's become positive and significant in the 20th and 30th quantiles while again becomes insignificant in the 40th and 50th quantiles. Again, the effect is positive and significant when reaches the 60th and 70th while in the highest quantiles the effect becomes insignificant.

The coefficient of financial development is positive and significant in all quantiles from the 5th to the 95th quantile which indicates that financial development significantly increases patent applications for nonresidents.

The coefficient of energy consumption is negative significant mostly in all quantiles except 10th, and highest 80th, 90th while again it becomes negative significant at the

Table 5: Results of Quantile regression

Dependent variable: Patent Nonresidents											
Variables	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
FDI	-21.24***	-1.093***	-1.885***	-2.973***	-7.313*	-21.24***	-14.91**	-10.64	-12.59	-30.45	-26.43
	(6.962)	(0.361)	(0.528)	(1.071)	(4.085)	(6.962)	(6.150)	(10.41)	(29.75)	(62.52)	(96.14)
CO2	368.9***	7.247***	18.14***	35.10***	103.5***	368.9***	590.2***	763.4***	1,277***	3,523***	5,795***
	(42.69)	(2.214)	(3.237)	(6.568)	(25.05)	(42.69)	(37.71)	(63.83)	(182.4)	(383.4)	(589.5)
GDP	41.50	1.039	3.313*	7.586*	19.95	41.50	61.43***	87.92**	119.6	178.8	347.4
	(26.42)	(1.370)	(2.003)	(4.064)	(15.50)	(26.42)	(23.33)	(39.49)	(112.9)	(237.2)	(364.8)
FND	23.27***	0.534***	1.593***	3.481***	8.476***	23.27***	32.67***	44.75***	52.39***	49.16*	93.51**
	(3.015)	(0.156)	(0.229)	(0.464)	(1.769)	(3.015)	(2.663)	(4.508)	(12.88)	(27.07)	(41.63)
ENR	-0.305***	-0.00530	-0.0135**	-0.0295**	-0.0990*	-0.305***	-0.454***	-0.573***	-0.609	-1.288	-2.228*
	(0.0906)	(0.00470)	(0.00687)	(0.0139)	(0.0532)	(0.0906)	(0.0801)	(0.135)	(0.387)	(0.814)	(1.251)
TO	-17.24***	-0.802***	-1.694***	-3.163***	-6.607***	-17.24***	-22.96***	-28.01***	-33.39***	-61.37***	-111.0***
	(2.258)	(0.117)	(0.171)	(0.347)	(1.325)	(2.258)	(1.995)	(3.377)	(9.649)	(20.28)	(31.18)
Constant	606.4***	59.36***	122.5***	205.3***	334.7**	606.4***	705.1***	820.0**	1,007	2,994	6,206*
	(231.2)	(11.99)	(17.53)	(35.57)	(135.7)	(231.2)	(204.2)	(345.7)	(987.9)	(2,076)	(3,193)
Obs	2,339	2,339	2,339	2,339	2,339	2,339	2,339	2,339	2,339	2,339	2,339

Note. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

highest quantile 95th. This result indicates that energy consumption significantly reduces patent applications' nonresidents. The effect of international trade in all quantiles is highly significant and negative which indicates that it significantly reduces patent applications for nonresidents.

Table 6 presents the results of Quantile regression on the impact of explanatory variables on research and development where the effect of foreign direct investment on research and development is negative significant which is almost similar to the impact of foreign direct investment on patent applications nonresidents however the coefficient is insignificant at the top highest quantiles 90th and 95th. The results are also similar to the dynamic model results given in the above tables. The results indicate that the inflow of foreign direct investment significantly reduces research and development in the 1st quantile while when it reaches the top, then exerts an insignificant impact on research and development. This means that foreign direct investment reduces innovation proxies by research and development. The coefficient of carbon dioxide is also negative mostly in all quantiles however the effect of carbon dioxide in the 5th quantile is insignificant and then it is negative significant at the 10th. Again from 20th to the 50th quantile the coefficients are insignificant and from 60th to the 80th are negative significant while at the top highest quantile, 95th, it becomes positive. The results indicate that carbon dioxide significantly reduces research and development until it reaches the highest quantile.

Table 6: Quantile regression

Dependent variable: research and development											
Variables	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
FDI	-0.002***	-0.001	-0.003***	-0.003***	-0.004***	-0.002***	-0.001	-0.001*	-0.001*	-0.002	-0.003
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.002)
CO2	-0.0039	-0.039**	-0.001	-0.002	-2.050	-0.003	-0.041***	-0.079***	-0.081***	-0.005	0.066***
	(0.0070)	(0.006)	(0.009)	(0.005)	(0.005)	(0.007)	(0.009)	(0.006)	(0.007)	(0.0157)	(0.017)
GDP	0.0012	0.006	0.006	0.005	0.003	0.001	0.003	0.0040	-0.001	-0.008	-0.015
	(0.0053)	(0.004)	(0.007)	(0.004)	(0.003)	(0.005)	(0.007)	(0.005)	(0.006)	(0.0120)	(0.013)
FND	0.006***	0.003***	0.005***	0.005***	0.005***	0.006***	0.006***	0.009***	0.010***	0.0118***	0.0135***
	(0.0005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.0013)
ENR	0.0002***	0.000***	0.000***	0.000***	0.0001***	0.000***	0.0003***	0.000***	0.000***	0.000***	0.0002***
	(1.480)	(1.330)	(2.050)	(1.240)	(1.110)	(1.480)	(1.980)	(1.470)	(1.680)	(3.320)	(3.760)
TO	-0.000**	-0.001**	-0.000	-0.000**	-0.000*	-0.000**	-0.001**	-0.001***	-0.002***	-0.002***	-0.002**
	(0.0003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.0003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0244	0.0274	-0.046	-0.035	-0.009	0.024	0.0010	0.078	0.135**	0.237**	0.344***
	(0.0500)	(0.044)	(0.0691)	(0.0416)	(0.037)	(0.0500)	(0.066)	(0.0497)	(0.0567)	(0.112)	(0.127)
Obser	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318	1,318

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The effect of financial development in all quantiles is positively significant which indicates that financial development significantly increases research and development in the panel countries. This result is similar to the System GMM results which confirm that financial development strongly affects research and development and an increase in financial development by the bank will enhance research and development. Likewise, energy consumption and trade are highly significant while the sign for energy consumption is positive and negative for trade which indicates that energy consumption significantly increases research and development while trade lowers it.

Table 7 present the results of Quantile regression on the impact of explanatory variables on patent applications nonresidents where the estimated coefficient of foreign direct investment is most significant and negative in the first quantiles from 5th to 50th while insignificant at the highest quantiles. The results indicate that foreign direct investment reduces patent applications, and residents, in the beginning until it reaches the highest quantiles. Likewise, the coefficients of carbon dioxide and financial development are positive and highly significant in all quantiles which indicates that carbon emission and financial development significantly increase patent applications for residents in the sample countries. the results indicate that if there is a rise in these two variables will raise the level of patent applications residents in the global panel. similarly, the trade coefficients is highly significant in all quantile while the sign is negative which indicates that an increase in trade significantly reduce patent applications residents while the effect of energy consumption on patent applications residents is positive and negative significant across different quantiles which indicates that it reduces or increase patent applications residents across different quantiles. The coefficient of economic growth is positive in a few quantiles while insignificant at the highest quantiles indicating that its increases patent applications residents.

Table 7: Quantile regression results

Dependent variable: patent applications residents											
Variables	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
FDI	-7.076***	-1.001***	-3.709***	-6.143***	-7.236***	-7.076***	-5.336	-5.749	-22.59	-65.53	-262.8
	(2.083)	(0.287)	(1.129)	(1.188)	(1.189)	(2.083)	(3.581)	(17.44)	(49.97)	(288.9)	(377.3)
CO2	101.2***	9.558***	57.21***	88.23***	89.87***	101.2***	161.5***	352.2***	1,678**	5,593***	10,002***
	(11.80)	(1.627)	(6.392)	(6.730)	(6.731)	(11.80)	(20.28)	(98.73)	(283.0)	(1,636)	(2,136)
GDP	17.21**	1.608	4.838	11.41***	11.98***	17.21**	24.42*	39.86	165.0	515.0	1,069
	(7.358)	(1.015)	(3.987)	(4.198)	(4.199)	(7.358)	(12.65)	(61.59)	(176.5)	(1,021)	(1,333)
FND	8.543***	1.033***	3.557***	5.753***	6.883***	8.543***	12.19***	18.27***	65.79**	332.6***	1,545***
	(0.837)	(0.115)	(0.454)	(0.478)	(0.478)	(0.837)	(1.439)	(7.007)	(20.08)	(116.1)	(151.6)
ENR	0.0700**	-0.0106***	-0.0270**	-0.00786	0.0512**	0.0700**	0.0960**	-0.0179	-0.709	-3.005	-9.759**
	(0.0248)	(0.00342)	(0.0135)	(0.0142)	(0.0142)	(0.0248)	(0.0427)	(0.208)	(0.596)	(3.443)	(4.496)
TO	-5.937***	-0.696***	-2.928***	-4.461***	-5.062***	-5.937***	-8.589***	-14.94***	50.14**	-164.0*	-428.4***
	(0.624)	(0.0861)	(0.338)	(0.356)	(0.356)	(0.624)	(1.074)	(5.227)	(14.98)	(86.61)	(113.1)
Constant	73.80	21.46**	33.34	13.99	39.60	73.80	126.7	373.0	903.5	3,373	12,702
	(64.84)	(8.944)	(35.14)	(37.00)	(37.00)	(64.84)	(111.5)	(542.8)	(1,556)	(8,994)	(11,745)
Obser	2,242	2,242	2,242	2,242	2,242	2,242	2,242	2,242	2,242	2,242	2,242

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table.8: Quantile regression

Dependent variable: Technology											
Variables	5th	10th	20th	30th	40th	50th	60th	70th	80th	90th	95th
FDI	0.0701***	0.0224***	-0.006	0.037***	0.032**	0.070***	0.067***	0.056***	0.073***	0.030	0.022
	(0.016)	(0.009)	(0.012)	(0.010)	(0.012)	(0.0163)	(0.018)	(0.018)	(0.021)	(0.033)	(0.091)
CO2	-0.157	-0.322***	-0.271***	-0.302***	-0.150	-0.157	-0.040	0.239*	0.317**	0.513**	0.452
	(0.120)	(0.072)	(0.091)	(0.076)	(0.093)	(0.120)	(0.133)	(0.137)	(0.160)	(0.249)	(0.673)
GDP	0.126	0.001	0.018	0.029	0.068	0.126	0.165	0.211*	0.218	0.022	0.360
	(0.104)	(0.062)	(0.079)	(0.066)	(0.081)	(0.104)	(0.116)	(0.119)	(0.140)	(0.217)	(0.586)
FND	0.125***	0.044***	0.078***	0.098***	0.111***	0.125***	0.131***	0.115***	0.108***	0.142***	0.074
	(0.009)	(0.005)	(0.007)	(0.006)	(0.007)	(0.009)	(0.010)	(0.0111)	(0.013)	(0.020)	(0.054)
ENR	0.000**	0.000***	0.000***	0.000***	0.000**	0.000**	0.000**	0.000**	0.000**	5.860	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)
TO	0.015**	-0.005	0.005	0.002	0.003	0.015**	0.034***	0.049***	0.077***	0.0710**	0.072*
	(0.007)	(0.004)	(0.005)	(0.004)	(0.005)	(0.007)	(0.007)	(0.008)	(0.009)	(0.014)	(0.040)
Constant	-1.193	-0.402	-0.961	-0.617	-0.632	-1.193	-1.937*	-1.322	-1.079	2.970	11.87**
	(0.936)	(0.563)	(0.717)	(0.597)	(0.729)	(0.936)	(1.040)	(1.073)	(1.255)	(1.948)	(5.264)
Observations	819	819	819	819	819	819	819	819	819	819	819

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 8 present the results of Quantile regression on the impact of explanatory variables on technology where the effect of foreign direct investment on technology is positive mostly in all quantiles while insignificant at the highest quantile. This result on the impact of foreign direct investment on technology differs from the effect of foreign direct investment on other indicators of innovation. This result shows that foreign direct investment increases technology while in other tables, the foreign direct investment effect on other innovation indicators is mostly negative.

The effect of economic growth on technology is insignificant while carbon dioxide is negative significant at the 10^{th}, 20^{th}, and 30^{th} quantiles and then insignificant from 40^{th} to the 60^{th}. At the higher quantiles from 70^{th} to 90^{th}, the effect of carbon dioxide on technology becomes positive while again it's become insignificant the top highest quantile 95^{th}. The results indicate that carbon dioxide both negatively, positively, and insignificantly affect technology. The effect of energy consumption and financial development are positively on technology mostly in all quantiles while its insignificant at the highest quantiles. The results indicate that both financial development and energy consumption significantly increase technology. If there is a rise in these two factors will increase technological innovation. On the other hand, trade is significant and positive at the 5^{th} quantile and insignificant from 10^{th} to 40^{th} quantile however it's become positive significant from 50^{th} to the 95^{th} quantile. The result indicates that trade also increases technology in the global panel countries.

Conclusion

This study investigates the impact of foreign direct investment, carbon dioxide emission, economic growth, and energy consumption on technological innovation in the global panel for the period of 1980-2019. Static models, system Generalized Method of Moments, and panel quantile regression have been used for analysis where the results of system GMM indicate that all proxies of innovation are negatively affected by foreign direct investment while it's been increased by carbon emission and economic growth. Energy consumption is also negatively related with all proxies except research and development while trade is negatively related with patent applications nonresidents and positive with all other proxies of innovation. The quantile regression results indicate that foreign direct investment negatively affects patent applications nonresidents in the first few quantiles while insignificant at the highest quantile however, carbon dioxide and financial development are strongly positive and increase patent applications nonresidents. Energy consumption and trade are negative while economic growth is positive across quantiles for patent applications nonresidents. Foreign direct investment and carbon dioxide are negative across different quantiles for research and development while financial development and energy consumption are positive. Trade is also negatively related to research and development while economic growth is insignificant. Foreign direct investment, trade and energy consumption are negatively related to patent applications residents while carbon dioxide and financial development are positive. Economic growth is positively related to patent applications residents in the middle quantiles. In the case of, technology, foreign direct investment, financial development, energy consumption, and trade are positive while carbon dioxide is negative in the first few quantiles and positive in the highest quantile for technology.

From the findings of this study shown by system GMM, it is concluded that foreign direct investment reduces all kinds of innovations that include research and development, patent applications residents, and technological innovations. The results of quantile regression also confirm the results of the system GMM model which shows that foreign direct investment is negatively related will all the proxies of innovation except technology. The quantile regression shows that foreign direct investment increases technological innovation proxies by high technology export. The effect of energy consumption is negative with all proxies of innovation while the effect of energy consumption on research and development is positive which shows that it increases research and development expenditure explained by system GMM. While the quantile results confirm these results for all indicators except for technology where the energy consumption sign is positive. Financial development is highly significant and positive in all models for all innovations which strongly indicates that financial development increases all types of innovation in the sample countries. Trade is negative mostly in all models for all innovation proxies while it is been found that trade increases technology (technological innovation proxied by high technology export). Our findings indicate that foreign direct investment reduces innovations which can be the reason that countries in the panel still didn't reach the desired level to attract foreign direct investment with advanced technology and foreign direct investment yet didn't contribute to the host countries' innovations however it enhances technological innovation (high technology export). Energy consumption has also not contributed yet to enhancing innovation level however energy consumption has raised research and development innovation. Carbon dioxide, economic growth, and financial development are enhancing innovations which indicates that they have a high contribution to enhancing the level of innovation. The findings also conclude that foreign direct investment should be improved through strong policies which can bring new technologies and new knowledge and in turn this can enhance the level of innovations as well promote economic growth. The energy sector should be improved which is related to innovation and an increase in innovation can in turn enhance energy efficiency by lowering the use of energy use. Innovation can also help acquire renewable

energy sources and thus enhance environmental quality. Its means that innovations are very important in this modern world, as it enhances most of the economic activities such as foreign direct investment, trade, enhance energy efficiency, acquire renewable energy sources and may help reduce carbon emission and enhance environmental quality. In this regard, the factors used in this study should be considered to enhance the level of innovation and an improvement in innovation will raise environmental quality as well economic growth. That's why our study suggests the sample countries consider the weak factors for each indicator of innovation analyzed in our study to enhance innovation level. Our study is limited to the global panel, future studies should conduct such studies on different samples such as developing and developed countries as the level of innovation, foreign direct investment, and other related factors are different in developing and developed countries and thus can get very useful recommendation and policy implication for developing and developed countries. Future studies may also include other closely related factors such as institutions and education level in such study as institutions can be linked with foreign direct investment, financial sectors, and other related factors to find its role in innovation while findings the effect of these factors on innovation.

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