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RESEARCH ARTICLE

The effect of Foreign direct investment and carbon dioxide on technological Innovations: Worldwide evidence from 180 countries

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Abstract

This study examines the effect of carbon dioxide, energy consumption and foreign direct investment on technological innovations in 180 countries of the world from 1980 to 2019. By employing panel quantile regression, the results indicates that foreign direct investment reduce innovation proxy by patent application residents in the first quantile however this effect is insignificant at the highest quantiles start from 60th quantile. Carbon dioxide emission significantly increase innovations in all quantiles while the effect of economic growth is positive in first few quantiles that's increase innovations. The effect of financial development is positive while energy consumption and international trade significantly and negatively affect innovation proxy by patent applications residents. Likewise, the effect of FDI on high technology export is positive across quantiles indicates that its increase technology innovations. The effect of carbon dioxide exerts negative effect on technology in the first few quantiles while it's become positive at the highest quantiles. Financial development, energy consumption and international trade significantly increase technology while the effect of GDP on technology is positive only in the 70th quantile. These findings have considerable policy implications for the sample countries regarding economic growth, foreign direct investment inflow, energy consumption and technological innovations.

Keywords: Technological innovations; carbon dioxide emission; energy consumption; economic growth; foreign direct investment

1. Introduction

Rising the capability of technological innovations in today's modern era is considered important to enhance energy efficiency, acquire renewable energy sources, lower carbon dioxide emissions and achieve long term economic growth. Theoretical literature shows that innovations enhance economic growth (Aghion & Howitt, 1990), and it's also indicated by empirical studies such as (Fagerberg, Srholec, & Knell, 2007). 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 and foreign direct investment on technological innovation indicators by considering other most important factors in a sample of 180 global countries. Panel quantile regression were used to investigate this association across different quantiles to achieve the most efficient results. the results indicates that foreign direct investment reduce innovation proxy by patent application residents in the first quantile however this effect is insignificant at the highest quantiles start from 60^{th} quantile. Carbon dioxide emission significantly increase innovations in all quantiles while the effect of economic growth is positive in first few quantiles that's increase innovations. The effect of financial development is positive while energy consumption and international trade significantly and negatively affect innovation proxy by patent applications residents. Likewise, the effect of FDI on high technology export is positive across quanities indicates that its increase technology innovations. The effect of carbon dioxide exerts negative effect on technology in the first few quantiles while it's become positive at the highest quantiles. Financial development, energy consumption and international trade significantly increase technology while the effect of GDP on technology is positive only in the 70^{th} quantile. 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.

2. Literature review

Several factors such as energy consumption, economic growth, foreign direct investment and international trade affect technological innovations. 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. A similar study on the effect of foreign direct investment on technological innovation in Chinese provincial data from 2009 to 2018 is conducted 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. 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. 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. 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. (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.

3. Methodology

This study examines the effect of foreign direct investment, carbon emission, and economic growth on technological innovation in the global panel of 180 countries from the period of 1980 to 2019. The study use panel quantile regression for analysis where the baseline regression model is as follows;

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

In equation 1, TIN represents technological innovation proxy by patent application residents (number per thousand population) (Wusiman & Ndzembanteh, 2020); (Rodríguez-Pose & Wilkie, 2019) and high-technology exports (percentage of real gross domestic product). 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. Descriptive statistics and variables are shown in Table 1 while the correlation matrix is given in Table 2.

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
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	Technology	CO2	GDP	FND	ENR	TO
FDI	1.000							
PT1	-0.058	1.000						
TECHNOLOGY	0.253	0.224	1.000					
CO2	0.043	0.221	0.199	1.000				
GDP	-0.042	0.093	-0.029	-0.165	1.000			
FND	0.246	0.152	0.455	0.289	-0.273	1.000		
ENR	-0.004	0.098	0.257	0.680	-0.177	0.354	1.000	
TO	0.269	-0.2004	0.349	0.264	0.034	0.126	0.193	1.000

The study use OLS and panel quantile regression for data analysis. We use 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;

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

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

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;

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

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:

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

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

4. Results and Discussions

Table 3 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 3. Quantile regression results

Variables	ENR	FND		GDP		CO_2		FDI	
OLS	-0.837**	(11.11)	39.59***	(97.37)	449.5***	(157.4)	2,254***	(25.66)	-6.220
5th	0.0700***	(0.837)	8.543***	(7.358)	17.21**	(11.80)	101.2***	(2.083)	-7.076***
10th	-0.0106**	(0.115)	1.033***	(1.015)	1.608	(1.627)	9.558***	(0.287)	-1.001***
20th	-0.0270**	(0.454)	3.557***	(3.987)	4.838	(6.392)	57.21***	(1.129)	-3.709***
30th	-0.00786	(0.478)	5.753***	(4.198)	11.41***	(6.730)	88.23***	(1.188)	-6.143***
40th	0.0512***	(0.478)	6.883***	(4.199)	11.98***	(6.731)	89.87***	(1.189)	-7.236***
50th	0.0700***	(0.837)	8.543***	(7.358)	17.21**	(11.80)	101.2***	(2.083)	-7.076***
60th	0.0960**	(1.439)	12.19***	(12.65)	24.42*	(20.28)	161.5***	(3.581)	-5.336
70th	-0.0180	(7.007)	18.27***	(61.59)	39.86	(98.73)	352.2***	(17.44)	-5.749
80th	-0.709	(20.08)	65.79***	(176.5)	165.0	(283.0)	1,678***	(49.97)	-22.59
90th	-3.005	(116.1)	332.6***	(1,021)	515.0	(1,636)	5,593***	(288.9)	-65.53
95th	-9.759**	(151.6)	1,545***	(1,333)	1,069	(2,136)	10,002***	(377.3)	-262.8

	Observations	Constant		TO			
	2,339	(852.3)	2,444***	(8.324)	-116.6***	(0.334)	
	2,242	(64.84)	73.80	(0.624)	-5.937***	(0.0248)	
	2,242	(8.944)	21.46**	(0.0861)	-0.696***	(0.00342)	
	2,242	(35.14)	33.34	(0.338)	-2.928***	(0.0135)	
	2,242	(37.00)	13.99	(0.356)	-4.461***	(0.0142)	
	2,242	(37.00)	39.60	(0.356)	-5.062***	(0.0142)	
	2,242	(64.84)	73.80	(0.624)	-5.937***	(0.0248)	
	2,242	(111.5)	126.7	(1.074)	-8.589***	(0.0427)	
	2,242	(542.8)	373.0	(5.227)	-14.94***	(0.208)	
	2,242	(1,556)	903.5	(14.98)	50.14***	(0.596)	
	2,242	(8,994)	3,373	(86.61)	-164.0*	(3.443)	
	2,242	(11,745)	12,702	(113.1)	-428.4***	(4.496)	

Table 4 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.

Table.4: Quantile regression

Dependent variable: Technology Innovations

Variables	ENR		FND		GDP		CO2		FDI
OLS	0.000**	(0.008)	0.109***	(0.091)	0.188**	(0.105)	-0.147	(0.014)	0.032**
5th	0.000**	(0.009)	0.125***	(0.104)	0.126	(0.120)	-0.157	(0.016)	0.0701***
10th	0.000***	(0.005)	0.044***	(0.062)	0.001	(0.072)	-0.322***	(0.009)	0.0224**
20th	0.000***	(0.007)	0.078***	(0.079)	0.018	(0.091)	-0.271***	(0.012)	-0.006
30th	0.000***	(0.006)	0.098***	(0.066)	0.029	(0.076)	-0.302***	(0.010)	0.037***
40th	0.000**	(0.007)	0.111***	(0.081)	0.068	(0.093)	-0.150	(0.012)	0.032**
50th	0.000**	(0.009)	0.125***	(0.104)	0.126	(0.120)	-0.157	(0.0163)	0.070***
60th	0.000**	(0.010)	0.131***	(0.116)	0.165	(0.133)	-0.040	(0.018)	0.067***
70th	0.000**	(0.0111)	0.115***	(0.119)	0.211*	(0.137)	0.239*	(0.018)	0.056***
80th	0.000**	(0.013)	0.108***	(0.140)	0.218	(0.160)	0.317**	(0.021)	0.073***
90th	5.860	(0.020)	0.142***	(0.217)	0.022	(0.249)	0.513**	(0.033)	0.030
95th	0.000	(0.054)	0.074	(0.586)	0.360	(0.673)	0.452	(0.091)	0.022

Observations	Constant		TO	
819	-0.458	(0.006)	0.042***	(0.000)
	(0.824)			
819	-1.193	(0.007)	0.015**	(0.000)
	(0.936)			
819	-0.402	(0.004)	-0.005	(0.000)
	(0.563)			
819	-0.961	(0.005)	0.005	(0.000)
	(0.717)			
819	-0.617	(0.004)	0.002	(0.000)
	(0.597)			
819	-0.632	(0.005)	0.003	(0.000)
	(0.729)			
819	-1.193	(0.007)	0.015**	(0.000)
	(0.936)			
819	-1.937*	(0.007)	0.034***	(0.000)
	(1.040)			
819	-1.322	(0.008)	0.049***	(0.000)
	(1.073)			
819	-1.079	(0.009)	0.077***	(0.000)
	(1.255)			
819	2.970	(0.014)	0.0710***	(0.000)
	(1.948)			
819	11.87**	(0.040)	0.072*	(0.001)
	(5.264)			

5. Conclusion

This study investigates the impact of foreign direct investment and carbon dioxide emission on technological innovation in the global panel for the period of 1980-2019. Panel quantile regression have been used for analysis the results indicates that foreign direct investment reduces innovation proxy by patent application residents in the first quantile however this effect is insignificant at the highest quantiles start from 60th quantile. Carbon dioxide emission significantly increase innovations in all quantiles while the effect of economic growth is positive in first few quantiles that's increase innovations. The effect of financial development is positive while energy consumption and international trade significantly and negatively affect innovation proxy by patent applications residents. Likewise, the effect of FDI on high technology export is positive across quantities indicates that its increase technology innovations. The effect of carbon dioxide exerts negative effect on technology in the first few quantiles while it's become positive at the highest quantiles. Financial development, energy consumption and international trade significantly increase technology while the effect of GDP on technology is positive only in the 70th quantile. The quantile regression shows that foreign direct investment increases technological innovation proxies by high technology export. 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).
The effect of foreign direct investment on innovation gives interesting results as it reduces innovations proxy by patent application residents while its increase high technology export. The results shows that FDI has yet reached due to advancement that rise technology innovation however innovation proxy by patents still not yet the desired level and FDI did not contribute to rise innovations. The inflow of FDI need to be associated with advancement and to contribute to innovation level as raising innovations are important to contribute to economic growth and its also rise environmental quality. Energy consumption has also not contributed yet to enhancing innovation level. 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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