Digitalization And CO2 Emissions In BRICS: What Role Does Education Play In The Green Economy?

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Research Article

Keywords: Digitalization. Education. CO2 emissions. BRICS

Posted Date: October 20th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-930177/v1

Abstract

This paper aims to examine the effects of digitalization and education on environment quality by using a dataset of BRICS economies from 1990 to 2018. Theories predict a positive effect of digitalization and education on environment quality but previous empirical studies on these nexus produced mixed outcomes. While our study has three core findings; mobile has a negative effect on CO2 in only Russia, while the internet has a negative effect on CO2 emissions in BRICS economies except India in long run. Thus digitalization plays a crucial role in fostering environmental quality in BRICS. Similarly, education has also improved the environmental quality in BRICS by reducing CO2. The effects of digitalization and education are significantly observed in mostly BRICS economies in short run. Regarding implications, this study recommends that the BRICS governments should improve digitalization in the economy and also repair the education system to realize significant green economic growth.

Introduction

The most significant threats today's world faces are variations in weather conditions and the heating of the globe (Jafri et al. 2020; Sohail et al. 2021). Literature, in this context, is rising, and empirics are trying to find the factors that can achieve a sustainable environment. Notably, the efforts to control greenhouse gas emissions (GHG) gathered pace after the world leaders signed Kyoto Protocol in 1997. In order to control GHG emissions, renewable energy can prove helpful; hence, it is included as a 17th goal in the sustainable development goals (SDGs) of the united nations (UN). In 2018, the international panel on climate change (IPCC) highlighted that to attain net-zero status, i.e., to maintain the temperature of 1.5°C by 2050, the GHG emissions must be reduced by 45% by 2030 against the 2010 levels. One of the main reasons, pointed out by various studies, behind the global GHG emissions is increased economic activities worldwide. Consistent with this view, the celebrated work of Grossman and Kreuger (1994) stated that at the initial stage of economic growth, the CO2 emissions increase, whereas at the later stage of economic development, CO2 emissions decline. Nevertheless, empirics have yet to reach an agreement on whether the effects of growth on the environmental quality also relied on the use of environmentally friendly technologies and priorities or not.

Meanwhile, digitalization has gained immense momentum in recent decades, and it has transformed the way individuals, consumers and firms act, work and communicate worldwide. This phenomenon is ascribed to the advent of "information and communication technologies (ICT)" mainly internet and mobile phone technologies that produce new products and processes, additional market mechanisms and organizational complexities, together with technological advances. Now ICT is increasingly penetrating the global economy. The use of ICT-related products is influencing all spheres of life including economic, social, political, ecological aspects. The empirical literature has provided substantial evidence to support the hypothesis that ICT use increases economic growth (Habibi & Zabardast 2020; Niebel, 2018; Majeed and Ayub, 2018).

One group of studies argues that the role of digitization for economic prosperity varies depending upon the development level of digitizing economies and the measure of digitization (Habibi & Zabardast 2020; Myovella et al. 2020; Usman et al. 2020). Habibi and Zabardast (2020) for Middle East countries, Myovella et al. (2020) for Sub-Saharan Africa (SSA) countries and Usman et al. 2020 for South Asian economies conclude that the benefits of digitation are dissimilar across countries. Contrary to this, using panel data of 122 developing countries from 2003 to 2015, Majeed (2020) provided robust empirical evidence of favourable role of digitization for the performance of the developing world. These studies, however, frame the importance of digitization for the economic prosperity of developed and developing economies. Whether digitization is a blessing for a green economy, or it hinders the management of the green economy? The answer to this question has received little attention. Moreover, the extant empirical studies provide conflicting results.

Theoretically, the nature of the relationship between digitalization and environmental quality is quite complicated and diverse. Two different opinions exist in this context: one argues that digitalization is a hurdle in the way of achieving a clean and green economy, and the other thinks vice versa. Digitalization increases ICT use, which in turn exerts more burden on the environment through a rise in energy consumption due to production, consumption, and disposal of ICT-related products (OECD, 2010; Houghton, 2015; Majeed, 2018). Moreover, digitalization also helps increase production efficiency, reduce the cost of production, and makes the product cheaper. As a result, the overall demand for the products increases which deteriorates the environmental quality (Majeed, 2018; Plepys, 2002).

On the other side, the studies like Plepys, 2002 and Lashkarizadeh and Salatin, 2012 supported the idea that digitalization can help develop environmentally friendly technologies and proved a blessing for the environment. Apart from managing the environmental-related risks digitalization can also anticipate these risks. For instance, simulation machines help in "learning by simulation," which is beneficial for policymaking and supervising critical consequences of trial and error. Similarly, the spillover effects of awareness, knowledge, and information in conserving the environment can also be spread through digitalization appears in the form of "internet network” (Majeed, 2018). Another effect that helps achieve better environmental quality via digitalization is the “ dematerialization effect” which transforms the economy's outlook from physical to information resources. Moreover, as a result of dematerialization, vehicle movement in society lessens because people rely more on e-commercing, online trading, virtual meetings, and distance learning. Further, ICT offers innovative and mechanized answers like power production, digital revolution, and smart cities.

One strand of the literature argues that the impact of digitization on environmental sustainability depends upon the response of energy demand to increasing digitization. The literature suggests both the positive and negative effects of digitization on energy demand (see, for details, Lange et al., 2020). On the one hand, increasing use of the internet and other ICT tools increases the more use of electricity. On the other hand, ICT investments substitute the demand for labour use and energy for production processes, therefore alleviating the burden on the environment (Khayyat et al. 2016). The actual association between digitalization and energy demand stems from four impacts namely “direct effects, changes in energy efficiencies, economic growth and sectoral change” (Lange et al. 2020). Thus, the net effect on energy demand and consequently on environmental sustainability can vary from country to country.

The studies that have tried to explore digitalization-environment nexus can be categorized into three different groups. The first set of studies include the studies which confirm the favorable impact of ICT on environmental quality. For instance, Lashkarizadeh and Salatin (2012) gathered the data for 43 developed and developing economies confirmed that ICT improves the environmental qualities in the selected economies. Further, Zhang and Liu (2015) for China, Ozcan, and Apergis (2018) for emerging markets, and Lu (2018), in the context of 12 Asian countries, found favorable effects of ICT on the environment. The second set of studies include those studies which found that digitalization hurt the environmental quality. These studies, include Liu et al. (2006), and Salahuddin et al. (2016) confirmed that digitalization hurts the environmental quality of China and OECD countries, respectively. Lastly, the third set of studies provided mixed results. For example, using panel data of 132 developed and developing countries over the period 1980–2016, Majeed (2018) found out that digitization mitigates environmental pollution in the developed economies while escalates emissions in the developing world.

The aforementioned discussion suggests that the empirical literature on digitization-environment nexus is not yet conclusive and further research is required. Further, the literature indicates that digitization can have diverse effects across different income groups of countries. Moreover, empirics mainly emphasized a single aspect of digitalization. However, no empirical evidence on the digitalization-environment nexus in the context of BRICS is available to date. BRICS economies are the fastest-growing emerging economies and genuinely striving hard to attain the status of developed economies; hence, exploring the nexus in the BRICS context is pertinent.

Despite increasing research and understanding of environmental problems, ecological disruption is still high. In this scenario, researchers need to go beyond conventional determinants of CO2 emissions and need to think about other avenues such as education and awareness to tackle environmental problems. That is the role of education is fundamental in explaining ecological concerns. Education reflects the quality of human capital in a society. For instance, an increase in human capital helps the economies to conserve energy and resources by decreasing a large amount of wastage (Zen et al., 2014). Moreover, education stimulates people to embrace environmental rules and guidelines, consequently, ecological superiority (Majeed & Mazhar 2020; Desha et al., 2015). Majeed and Mazhar (2020) collected data for developed, middle-income, and low-income nations and strongly supported the notion that human capital improves environmental quality. Similarly, Ahmed et al. (2020) found a similar type of results for G-7 economies.

Against this backdrop, in this study, our primary focus is to investigate the effects of digitalization and education on the CO2 emissions in BRICS economies by collecting data from 1990–2018. To the best of our knowledge, no previous studies have explored the dynamic relationship between digitalization, education, and CO2 emissions in the BRICS economies. Therefore, this is the first-ever study that has tried to explore the impact of digitalization and education on CO2 emission in the BRICS economies.

The analysis has chosen the BRICS economies, which is based on the rationale that BRICS economies truly represent the developing and emerging economies, and their role on the world stage is increasing with every passing day. Moreover, these economies have become the most significant contributors to CO2 emissions at a global level. Therefore, selecting these economies will provide a clear picture of how digitalization and education will affect CO2 emission in emerging and developing economies, which will help policymakers in the emerging markets and developing economies achieve a better environment.

The contribution of this study in the current literature is multi-dimensional. Firstly, the analysis investigates the dynamic impact of digitalization and education on the CO2 emissions in the BRICS economies. Secondly, the results for each country is provided in a comparative setting. Thirdly, the analysis employs two different measures of digitalization. Fourthly, researchers lack agreement on the impacts of digitalization on CO2 emissions, i.e., positive, negative, or inconclusive, and this analysis will help solve this puzzle (Majeed, 2018). Fifthly, this analysis also includes education in the carbon emission function of BRICS economies because CO2 emissions increase due to social and economic activities of men, and education (human capital) can help control the CO2 emissions. Lastly, this study relies on the ARDL technique that will be helpful in getting both short and long-run estimates in the context of BRICS economies.

This is a novel study for BRICS economies that trace short and long-run dynamics of digitization for environmental degradation using ARDL approach over the period 1990–2018. The findings of this study are supportive for helpful academicians, development practitioners, environmentalists, telecommunication authorities, ICT industries, and international organizations. This study endeavors policy suggestions for preserving the environment in the present digitizing world. The findings of this research are helpful for those economies which are deploying digital infrastructure and for economies that are prioritizing human capital investment.

The rest of the paper is organized in the following manner. A short explanation of the “model, data, and methodology” is provided in Sect. 2. The empirical results and their discussion are reported in Sect. 3. Finally, Sect. 4 provides a conclusion of the paper and suggests some suitable policy implications.

Model And Method

The Solow model noted that only technological evolution can explain the persistent increase of living standards (Solow, 1994). While new growth theories observed technological progress as a key factor of economic growth (Barro et al. 1991; Barro and Sala-i-Martin, 1992; Mankiw and Romer, 1992) and criticized the Solow growth model because it is considered technology variables as exogenous. Endogenous growth theories are taken technology progress and human capital variables as non-exogenous. Additionally, it is reasoned that digitization and human capital have robustly affect green economic growth, but also outcomes such as health outcomes, poverty rates, clean energy consumption, and environmental quality (Lange et al. 2020 and Usman et al. 2021). Based on endogenous growth theory we develop the CO2 emissions model and function form is:

--------- (1)

Where CO2 is CO2 emissions, digitization consist of two variable named mobile cellular and internet users, and education represents years of schooling, GDP represents the GDP growth, and FDI is financial development index. Based on empirical literature studies, e.g., Habibi and Zabardast (2020), Lange et al. (2020), and Usman et al. (2021) we have extended the CO2 emissions model. The functional form is rewritten as the equation form as:

------ (2)

Eq. (2) is a CO2 model in selected BRICS economies is predictors by mobile cellular subscriptions per 100 people (ICT), individual internet users (% of population), average years of schooling variable is taken for education, while most of the macro variables are a mixture of I(1) and I (0) so we can apply the error correction modeling approach or bounds cointegration approach proposed by Pesaran et al. (2001). The key edge of the ARDL approach, which gives us long-run and short-run cointegration estimates in a single step. While Pesaran et al. (2001) noted that the ARDL method is more suitable for a small sample and reported robust and consistent short and long estimates in a small data sample. The ARDL method is free from the problems of autocorrelation and endogeneity is addressed through the selection of lag length. So we modify the specifications (2) in error correction format as given below:

$$\Delta CO_{2,t} = \gamma + \sum_{p=1}^{n1} \gamma_{1p}\, \Delta CO_{2,t-p} + \sum_{p=0}^{n2} \gamma_{2p}\, \Delta Mobile_{t-p} + \sum_{p=0}^{n3} \gamma_{3p}\, \Delta Internet_{t-p} + \sum_{p=0}^{n4} \gamma_{4p}\, \Delta Education_{t-p} + \sum_{p=0}^{n5} \gamma_{5p}\, \Delta GDP_{t-p} + \sum_{p=0}^{n5} \gamma_{6p}\, \Delta FDI_{t-p} + \pi_1 CO_{2,t-1} + \pi_2 Mobile_{t-1} + \pi_3 Internet_{t-1} + \pi_4 Education_{t-1} + \pi_5 GDP_{t-1} + \pi_6 FDI_{t-1} + \mu_t \quad \text{---------} \; (3)$$

Specifications (3) are ARDL forms of CO2 model and give long and short-term estimates through one equation. The coefficients represent with “delta” indicators signify short-run results and coefficients - normalized on depict estimates of long-run. The soundness of long-run results is confirmed through the F test offered by Pesaran et al. (2001). Pesaran et al. (2001) developed new critical values for F-test that are more suitable for large samples. As our sample is not large, thus, we follow the new critical values of F test given by Narayan (2005). The alternative procedure of cointegration is assessed through the ECM or t-test, if the value is negative and significant it confirms the cointegration.

The empirical analysis is based on yearly data ranging from 1990 to 2018 for a group of BRICS countries. The carbon dioxide emissions (CO2) is used as the dependent variable. Moreover, we have used the two proxies for digitization named mobile cellular and internet users, while education is also used as the independent variable. Control variables used in our empirical analysis are GDP per capita growth (GDP) and financial development index (FDI). In the model, only the CO2 variable is transformed to logarithmic form. All dataset is extracted from the World Bank, while FDI is taken from IMF. The details of variables and descriptive statistics are presented in Tables (1) and (2).

Table 1
Definitions and sources

Variables	Abbreviations	Definitions	Sources
Carbon dioxide emissions	CO2	Carbon dioxide emissions (kilotons)	World Bank
Mobile cellular	Mobile	Mobile cellular subscriptions (per 100 people)	World Bank
Internet users	Internet	Individual Internet users (% of population)	World Bank
Average years of schooling	education	Average years of schooling	World Bank
GDP growth	GDP	GDP per capita growth (annual %)	World Bank
Financial development index	FDI	An index that captures financial markets development.	IMF

Table 2
Descriptive statistics

	Variable	CO2	Mobile	Internet	Education	GDP	FDI
Brazil	Mean	12.77	54.39	25.05	13.95	1.209	0.483
	Std. Dev.	0.267	51.13	24.22	0.827	2.572	0.122
	Min	12.29	0.004	0.003	12.40	-4.351	0.250
	Max	13.18	138.4	67.47	15.40	6.524	0.630
Russia	Mean	14.35	74.63	26.46	13.51	0.982	0.448
	Std. Dev.	0.156	71.54	29.72	1.267	6.640	0.108
	Min	14.21	0.000	0.000	11.80	-14.61	0.000
	Max	15.06	165.6	80.86	15.50	10.46	0.560
India	Mean	14.06	28.61	7.134	9.771	4.690	0.399
	Std. Dev.	0.419	34.55	10.16	1.625	2.038	0.056
	Min	13.39	0.000	0.000	7.700	-0.984	0.280
	Max	14.69	87.31	34.45	12.37	7.083	0.490
China	Mean	15.51	39.11	18.95	11.19	8.856	0.708
	Std. Dev.	0.520	38.99	21.02	1.978	2.159	0.071
	Min	14.75	0.004	0.000	8.800	6.264	0.520
	Max	16.23	114.9	54.30	14.37	13.63	0.790
South Africa	Mean	12.93	66.24	17.81	12.92	0.755	0.498
	Std. Dev.	0.151	59.52	20.75	0.306	2.163	0.103
	Min	12.61	0.019	0.013	11.90	-4.550	0.320
	Max	13.15	158.8	56.16	13.50	4.278	0.650

Results And Discussion

The first and foremost thing before applying the ARDL model is to check the stationarity of the variables because ARDL can't accommodate I(2) variables. Two-unit root tests are applied, i.e., Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). The results of both the tests have confirmed that the variables included in the models are either I (0) or I (1) in Table 3. These findings confirm that we can proceed with the ARDL model as it can take care of the integrating properties of the variables. Hence, we can use the mixture of variables with I(0) and I(1). To check the dynamic impact of the variables, ARDL also requires to select an appropriate number of lags.

Table 3
Unit root tests

		ADF			**PP**		
		I(0)	**I(1)**	**Decesion**	**I(0)**	**I(1)**	**Decesion**
Brazil	CO2	-1.112	-4.947***	I(1)	-1.121	-4.946***	I(1)
	Mobile	-0.926	-2.850**	I(1)	-0.744	-2.891**	I(1)
	Internet	2.241	-3.754***	I(1)	1.875	-3.770***	I(1)
	Education	-1.577	-3.962***	I(1)	-1.635	-3.964***	I(1)
	GDP	-3.762***		I(0)	-3.742***		I(0)
	FDI	-1.626	-4.680***	I(1)	-1.631	-4.733***	I(1)
Russia	CO2	-12.29***		I(0)	-10.01***		I(0)
	Mobile	-0.232	-2.737*	I(1)	-0.455	-2.721*	I(1)
	Internet	1.852	-3.341**	I(1)	1.326	-3.360**	I(1)
	Education	0.753	-3.070**	I(1)	0.284	-2.975**	I(1)
	GDP	-2.421	-7.772***	I(1)	-2.275	-8.177***	I(1)
	FDI	-7.018***		I(0)	-5.899***		I(0)
India	CO2	-0.791	-4.379***	I(1)	-0.773	-4.368***	I(1)
	Mobile	1.216	-2.946**	I(1)	0.618	-2.925**	I(1)
	Internet	2.079	-4.664***	I(1)	4.535	-4.647***	I(1)
	Education	0.716	-4.089***	I(1)	0.612	-4.094***	I(1)
	GDP	-4.909***		I(0)	-4.990***		I(0)
	FDI	-1.751	-4.184***	I(1)	-1.762	-4.152***	I(1)
China	CO2	-0.497	-3.114**	I(1)	-0.542	-3.162**	I(1)
	Mobile	-1.183	-2.884**	I(1)	-1.744	-2.742*	I(1)
	Internet	-1.994	-2.735*	I(1)	-1.062	-2.681*	I(1)
	Education	-1.145	-2.731*	I(1)	-0.717	-2.832*	I(1)
	GDP	-1.848	-6.035***	I(1)	-2.042	-6.119***	I(1)
	FDI	-2.851*		I(0)	-3.198**		I(0)
South Africa	CO2	-1.038	-5.973***	I(1)	-0.922	-6.052***	I(1)
	Mobile	0.375	-4.682***	I(1)	0.271	-4.727***	I(1)
	Internet	1.356	-2.282	I(1)	0.686	-2.327	I(1)
	Education	-3.822***		I(0)	-3.364**		I(0)
	GDP	-2.890**		I(0)	-2.811*		I(0)
	FDI	-0.945	-5.014***	I(1)	-0.957	-5.029***	I(1)

Table 4 presents both short and long-run ARDL estimates. Besides, Panel A offered the short-run outcomes for the specified model. Our model takes CO2 emissions as the dependent variable. The focused independent variable digitization is proxied using two measures namely mobile cellular and internet users. The remaining control variables are GDP growth, average years of schooling, and financial development index. The short-run estimates suggest that mobile cellular has a mixed effect on CO2 emissions across BRICS economies. It has a negative and significant effect on emissions for Russia and South Africa while it has a positive impact in Brazil, India and China, respectively. The positive effect, however, is insignificant. The short-run estimates for internet users reveal that it has a negative and significant influence on CO2 emissions in all BRICS economies except South Africa. These findings suggest that the favourable effect of digitization mainly comes from the measure of internet users in the short run.

The short-run estimates for other focused variable education also show a mixed picture across BRICS economies. Education influences CO2 emissions negatively and significantly in Russia, China and South Africa while it has an insignificant impact on emissions in Brazil and India. Moreover, the empirical findings suggest that economic growth escalates CO2 emissions in Russia, Brazil, and South Africa. On contrary, the findings reveal an insignificant effect of growth on emissions for India and China. Finally, the financial development index mitigates CO2 emissions in Russia and South Africa while escalates CO2 emissions in India. In the case of Brazil and China, it has a positive but insignificant impact on CO2 emissions.

Panel B of Table 4 demonstrates the long-run estimates for the BRICS economies. The digitization in terms of mobile significantly mitigates emissions only in Russia. The ARDL estimates suggest that digitization in terms of the internet is negatively associated with CO2 emissions in the long run for Brazil, Russia, China, and South Africa while in the case of India has an insignificant result. The CO2 mitigating effect of digitization is consistent with the prior studies (Ozcan & Apergis 2018; Lu 2018; Lashkarizadeh & Salatin 2012).

Furthermore, our outcomes indicate that education leads to a decrease in CO2 emissions and results also indicate that education shows a statistically significant and negative impact on CO2 emissions for Russia, Brazil, India, South Africa, and China in the long run. An increase in educated people in society helps the economies to conserve energy, resources and decrease the amount of waste in landfills following recycling practices and using green energy products. Besides, education motivates individuals to adopt environmental laws and regulations, thus, environmental quality. This finding is consistent with the existing empirical studies (Ahmed et al. 2020; Majeed & Mazhar 2020; Desha et al., 2015; Zen et al., 2014).

A comparative analysis for BRICS economies reveals that Russia is mainly taking the advantage of digitization in conserving the environment as both measures of digitization significantly lower CO2 emissions both in the short and long-run over the study period. In contrast, India is not benefitting from the increasing digitization. China is also benefitting from digitization in both and short and long-run. However, these favourable effects are limited to the internet as a measure of digitization. Similarly, CO2 emissions are decreasing in Brazil due to an increase in internet users both in the short and long-run. However, the effects for mobile are opposite in the short run while insignificant in the long run. Finally, in contrast to China and Brazil where the internet is the main source of controlling emissions, the effect of the internet in South Africa is insignificant both in the short and long-run, But, interestingly, the effect of mobile on CO2 emissions is negatively significant both in the short and long-run. These findings reveal that overall digitization could serve as a weapon to fight against environmental loss, but individual country experiences are quite diverse.

Meanwhile, GDP is positively and significantly associated with CO2 emissions in Brazil, Russia, and China. The economic growth of these economies mainly depends upon conventional energy energy sources which dirty the environment. Moreover, these economies are mainly prioritizing the “scale effect” of the development stage where economic growth is achieved at the cost of the environment. This finding is consistent with Ullah et al. (2020). Interestingly in the case of South Africa economic growth has shown a negative and significant impact on CO2 emissions. The likely reason could be the decoupling of economic growth from the environmental loss in this economy by promoting clean energy sources and green growth strategies. Surprisingly, no significant effect is observed for India. This finding is consistent with Zhao et al. (2021) who also found an insignificant impact of economic growth on CO2 emissions for India.

The long-run ARDL estimates for the financial development index (FDI) indicate that it has a negative and significant effect on emissions in Brazil and Russia. Financial development lowers environmental degradation by appealing and fetching more environmental-friendly ventures through research and development. Besides, it can support investment in clean technologies. This finding is consistent with the existing studies (Tahir et al. 2020; Majeed & Mazhar 2019). However, FDI did not exert any significant effect in India and China while it has a positive and significant effect on emissions in South Africa.

The long-run results are considered genuine only if they are cointegrated. From the diagnostic tests reported in Table 4, we gather that the estimates attached to two cointegration tests, i.e., F-test and ECM_{t-1} are significant, confirming that our long-run results are cointegrated in BRICS. Some other diagnostic tests, such as Langrage Multiplier (LM) to see if the residuals are correlated or not, Breusch Pagan (BP) to see if the variance of errors is homoscedastic Ramsey RESET to observe misspecification in the model. Finally, CUSUM and CUSUM-sq tests are used to identify the stability of the parameters. The estimates of these tests confirm that our models are free from the problem of serial correlation, heteroscedasticity, and misspecification. Moreover, the parameters in the models are stable.

Table 4
ARDL short and long-run estimates.

	Brazil		Russia		India		China		South Africa	
Variable	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**
Short-run										
D(MOBILE)	0.003	0.857	-0.002*	1.713	0.000	0.240	0.001	0.177	-0.001*	1.797
D(MOBILE(-1))	0.010***	3.929	0.002	1.410			-0.031**	2.207	-0.001	1.276
D(MOBILE(-2))			-0.003*	1.920			0.013*	1.834		
D(INTERNET)	-0.017**	2.531	-0.004*	1.852	-0.009***	4.684	-0.046***	2.791	-0.002	0.868
D(INTERNET(-1))	-0.030***	2.862	-0.009***	2.770			0.047***	4.206	-0.026***	9.374
D(INTERNET(-2))	-0.010	1.562	0.009***	3.454					0.006***	3.696
D(Education)	0.056	1.303	-0.149***	4.116	-0.034	0.850	-0.131*	1.741	-0.310***	4.893
D(Education(-1))	-0.162***	3.431	0.110**	2.132			0.210	1.214	-0.368***	5.741
D(Education(-2))			-0.132***	3.603			-0.689***	2.926	-0.086*	1.718
D(GDP)	0.017***	2.959	0.005**	2.482	-0.001	0.245	-0.001	0.139	0.006**	2.402
D(GDP(-1))	-0.017**	2.424							0.016***	4.109
D(GDP(-2))	-0.020***	3.304							-0.035***	13.21
D(FDI)	0.201	0.536	-0.989***	2.929	0.446*	1.686	0.224	0.961	-3.295***	11.22
D(FDI(-1))	-0.376	0.786	0.062	0.281			-0.271	0.790	-2.725***	14.91
D(FDI(-2))	1.540***	3.070	0.261**	2.544			-0.796***	3.209	3.056***	11.97
Long-run										
MOBILE	-0.002	1.029	-0.003**	2.449	0.001	0.254	0.012	1.318	-0.003	0.689
INTERNET	-0.025***	2.967	-0.015***	2.617	-0.047	1.541	-0.056*	1.740	-0.052***	3.196
Education	-0.378***	3.899	-0.276***	3.012	-0.519**	2.124	-0.618**	2.007	-2.157***	2.976
GDP	0.093**	2.162	0.008**	2.260	-0.004	0.245	0.039*	1.682	-0.165***	2.901
FDI	-2.792**	2.453	-2.209***	3.261	-0.383	0.281	1.997	1.207	2.151**	2.288
C	8.351***	8.343	11.76***	13.30	9.952***	7.315	7.878***	3.381	-20.23*	1.761
Diagnostic										
F-test	4.012*		4.272*		1.809		14.57***		3.879*	
ECM(-1)	-0.737**	2.206	-0.683**	5.515	-0.189*	1.805	-0.611***	3.049	-0.263**	2.170
LM	5.773		1.811		1.934		1.709		1.934	
Hetro	1.408		0.827		0.704		0.293		0.704	
RESET	0.721		1.235		0.143		0.609		0.143	
CUSUM	US		S		S		S		S	
CUSUM-sq	S		S		S		S		S	

Note: Short and long-run estimates are *** significant at 1%; ** significant at 5 %, and *significant at 10 %

Conclusion And Policy

The hopes set on digitalization reducing environmental pollution have not so far been vindicated. However, digitalization has carried an additional clean energy consumption edge as it eliminates dirty economic activities from the economy. These mechanisms trigger the social and economic factors to green economy and education has also importance for the environment. This study has empirically scrutinized the impact of digitalization and education on CO_2 emissions by analyzing a group of BRICS countries. For empirical analysis, we have employed the ARDL bound testing approach, and from the outcomes of bounds, ECM_{t-1} and F-test statistics have confirmed the cointegration in all CO_2 emissions models except India.

From the estimates of CO_2 models, significant negative short-run effects of mobile are only observed in the case of Russia and South Africa, while the internet has negative significant short-run effects on the CO_2 emissions in BRICS economies except for South Africa. Regarding the short-run results of education, education has a negative sign which is significant in Russia, China, and South Africa. Once again, in long-run, the mobile finding is maintained in only Russia and has significant negative effects on the CO_2. On the other side, the internet also helps in reducing the CO_2 in India in long-run which means that increased use of social media supports in achieving energy efficiency as well as improves the clean environment. The importance of education in the economy cannot reject, because education has also significantly reduced environmental pollution in long run in BRICS economies. Thus, in BRICS, the usage of digitization and education has started to show some fruitful effects on the environmental quality. In light of findings, digitization can also help to reduce dirty energy consumption as well green economy.

These empirical results have some implications for a policy with respect to the BRICS as well developing economies. Digitalization infrastructure especially the internet must be established in order to foster green economic growth. Authorities should also encourage e-commerce, e-business, e-government in the region. The study also concludes that authorities should also build the smart cities through digitization and can control urbanization via technology. Similarly, the government should also initiate green transportation in an economy that is crucial for the promotion of a clean environment. BRICS economies still have very different digitization levels; authorities must allocate more funds for the improvement of digital economies. Our study has few important limitations, some good proxies of the digitalization dataset are not available for the analysis. Upcoming empirical studies should also include a wide range of digital technologies measurements such as mobile web services, cloud computing, robotics, smart devices, e-business, and social media. This data has not available for BRICS economies because digitalization is still at its beginning in these economies. Forthcoming empirical studies may include these variables as they pay more attention to competitiveness, innovation, and green growth. For sustainable direction and suitable channels for other regions are also investigates by authors in future research.

Declarations

Ethical Approval: Not applicable

Consent to Participate: I am free to contact any of the people involved in the research to seek further clarification and information

Consent to Publish: Not applicable

Authors Contributions: This idea was given by Lili Yang. Xiaofeng Wang, Su-Hyeon Kim, Seung-Woo Baek, Zubaria Andlib, and Muhammad Tariq Majeed analyzed the data and wrote the complete paper. While Lili Yang read and approved the final version.

Funding: Not applicable.

Competing interests: The authors declare that they have no conflict of interest.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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