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Article

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Does green finance matter for environmental safety? empirical evidence from the atomic power states

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Abstract: The heightened risk of global warming has attracted the special attention of researchers and policymakers towards the linkage between economic growth and environmental protection. Thus, this study examines the effects of FDI inflow, GDP, trade openness, urbanisation level, and nuclear energy consumption on environmental pollution factor CO_2 emissions by using the STIRPAT model (1997). Furthermore, this study also examines the moderating role of green financing by analysing the data of eight nuclear power states from 2008 to 2019. The results revealed that foreign direct investment, gross domestic product, and urbanisation as increased contributors to CO_2 emissions, thus damaging the environment. Whereas trade openness, nuclear energy consumption, and green financing have an inverse relation with CO_2 which means they positively contribute to the environment of the nuclear power states. The outcomes also reveal that green financing negatively moderates the relationships and positively contributes toward environmental safety (reduces CO_2). The findings have paved the way for the regulators to increase their focus on green finance to play a positive role in environment preservation and conservation alongside economic growth. Not only that, but the results also imply that the policymakers should direct their efforts to promote nuclear energy production and consumption to cater to the surging energy needs.

Subjects: Development Economics; Environmental Economics; Business, Management and Accounting

Keywords: FDI inflow; GDP; trade openness; urbanisation level; nuclear energy consumption; STIRPAT model; green financing

Jel code: C33; O44; Q43; Q56

1. Introduction

Governments aggressively encourage foreign direct investment (FDI) inflow, gross domestic product (GDP), and trade to achieve economic and financial stability. Over time, foreign direct investment inflow, gross domestic product, and trade liberalisation are considered major economic affluence and growth indicators. There is no denying the favourable effects of these three economic indicators, but there is another side to them that has alarmed the researchers as various studies have abled to determine anthropogenic factors (such as economic growth, energy consumption, population, economic and political institutions, etc.) as causes of negative environmental impacts. The detrimental effects of FDI, GDP, and trade openness on the environment have caught researchers' eyes now more than ever because of the environment's vulnerability due to

the possible threat of Global Warming. There is consensus amongst scientists regarding greenhouse gases, specifically CO_2 emissions, as critical determinants of global warming (IPCC, 2007). Lately, researchers are directing their efforts to identify the probable antecedents of greenhouse gases, particularly carbon dioxide (CO_2) emissions, to develop effective policies and regulations to curb this catastrophe. In this regard, the research horizon has expanded to numerous studies, theories, hypotheses, and models that have surfaced to explore the impacts of economic growth and trade along with factors like population and energy consumption on CO_2 emissions. Regardless of the previous studies, there is still space for investigating the influences of these factors on CO_2 emissions for different countries and economies so that in light of these studies, every country can share the burden of curtailing the growth of CO_2 emissions and mitigate global climate change.

Another aspect of economic growth and development is energy consumption. Economic growth increases output. Increased output (scale of production) requires greater energy consumption, subsequently bringing along some costs in the form of ecological depletion. Over time, nuclear energy has gained a spot on the centre stage as clean and sustainable energy: a. it protects air quality, b. its land footprint is small, and c. it produces minimal waste. Hence there is a justified paradigm shift from the consumption of dirty energy (non-renewable energy) toward renewable or other clean energy consumption. Thus it is high time to explore the environmental impact of nuclear energy consumption alongside economic indicators.

The urbanisation process has quickened hence the scale of the urban population has expanded gigantically. In contrast to the rural population, urban residents have been proven to be generous consumers of energy due to their different living standards and lifestyles, thus contributing more to environmental pollution. In recent times, some researchers have incorporated urbanisation and economic variables in their models to better associate urbanisation with the environment (Ponce & Alvarado, 2019; Wang et al., 2018).

This surmounting threat of global warming and environmental degradation has led the think tanks to promote mechanisms, strategies, financing, and investment options that can curtail this threat as much as possible. Green financing is an endeavour specially designed to promote environmental sustainability. Having coined its place as an environmental and economy-friendly financing means, green financing has managed to garner a lot of attention after the global shift towards radical decarburisation. The focal aim of green financing is to ensure economic stability by promoting funding directed towards green investments and the policies that support green initiatives. Green financing/ investments comprise investments in waste processing/recycling, biodiversity protection, water sanitation, industrial pollution control, renewable energy, climate change mitigation measures, green bonds, environmental goods, and services(Lindenberg, 2014). Apart from investigating the direct impact of green financing, it is important to check the effect of FDI inflow, GDP, trade openness, nuclear energy consumption, and urbanisation on the environment in the presence of green financing. This can help to determine whether the existence of green financing in conformity with other variables (FDI, GDP, trade openness, nuclear energy consumption, and urbanisation) buffers or amplifies the influence of these variables on the environment?

Previous researches are channelling their efforts toward establishing the relationship between economic growth, energy consumption, and pollution. But it is also apparent that mostly the main focus of these studies has been on experimenting with the EKC hypothesis. EKC is well-known for testing the inverted U-shaped relationship between pollution and income. And the results of research under the umbrella of EKC didn't conduct to a decisive conclusion. Thus researchers proposed the addition of explanatory variables (Khan et al., 2018). Dietz & Rosa's stochastic model fully caters for this proposition by considering explanatory variables such as technology/energy consumption, population, and affluence while allowing for empirical hypothesis tests. As important as it may be, Dietz & Rosa model is not as thoroughly investigated as EKC or related hypotheses which leaves a gap in the literature that begs to be filled. Other than this, the world

shuns fossil fuel and other non-renewable energy sources (due to their damaging effects on the environment) while is all praise for alternate nuclear energy but yet its adverse or favourable impact on the environment needs to be investigated (Paramati et al., 2017). Therefore, Dietz & Rosa's model is dynamic enough to incorporate nuclear energy consumption as an explanatory variable while keeping intact other variables like FDI, GDP, etc. Furthermore, as noted by Chikaraishi et al. (2015), there is a severe need to study the economic affluence-environment nexus in the presence of a moderator as it'll be prudent enough to test the strength of the relationship between the variables. Hence it is vital to include a conceptually appropriate moderator in Dietz & Rosa model.

The present study is going to fill in the gap by evaluating the relationship between NEC and CO_2 emissions under the premises of the Dietz & Rosa model while incorporating financial and economic indicators. The study derives the need for an interactive model that may clarify the ambiguity of whether the NEC improves air quality indicators, ultimately achieving an environmental sustainability agenda. The sample of this study adds to the novelty of the research as the sample comprises the nuclear power states which have a better chance of investing in nuclear energy if it happens to bring a positive impact on the environment. Last but not least, this study introduces a moderator- green financing, thus extending the Dietz & Rosa model.

This study contributes to the literature in several ways: The model proposed in this research effectively provides a systematic example for determining major drivers of CO_2 emissions, consequently opening doors for future researchers to employ them for studying in other regions. Moreover, this study contributes by decomposing CO_2 emissions concerning the traditional STIRPAT model, thus all variables in the extended version are theoretically relevant for the multiplicative design of the model. This is clearly unlike the prior studies. The outcome of the current study is significant and vital for the policymakers and government officials to take fitting steps to cater to the swelling demand for energy while alleviating the excessive CO_2 emissions due to economic activities

The subsequent section contains a review of previous literature, while the third section describes the data used in the econometric models, followed by results and discussion in section four. The fifth section concludes the study.

2. Literature review

2.1. Theoretical linkage

GDP, FDI inflow, trade openness, nuclear energy consumption, urbanisation, and green financing seem unrelated to each other; however, they are interlinked when looking at them in terms of their environmental impacts. To fit these variables together, a dynamic model is needed. The economic growth-environment nexus has been explored in different contexts over the years. Environmental Kuznets Curve (Kuznets, 1955), Pollution Haven Hypothesis (1994), Pollution Halo Hypothesis (1995), and STIRPAT Model by Dietz and Rosa (1997) are some of the flag-bearers that have successfully established the association between economic growth and the environment. The current study considers Dietz and Rosa's model (STIRPAT: Stochastic impacts by regression on population, affluence & technology). The model proposed by Dietz and Rosa establishes the basic outline of the relevant variables. But over time and vigorous research, different researchers have chalked out various possibilities of variables that fit under the headings of environmental impact, population, affluence, and technology. Hence based on the previous research and making variations per the gap identified, the choice of variables is made. Therefore; in the current study, environmental impact is represented by CO_2 emissions, urbanisation level (URB) denotes population, FDI inflows, GDP and trade openness (TRA) are used as a proxy of economic affluence and lastly energy consumption is incorporated in the form of nuclear energy consumption (NEC). Where CO_2 emission is the dependent variable (DV), while URB, FDI, GDP, TRA, and NEC are independent variables (IVs). Moreover, Chikaraishi et al. (2015) are credited for the inclusion of a moderator in

their work based on STIRPAT. Taking a cue from their seminal work, the current study intends to include Green financing/investment (GF) as moderator (MOD).

2.2. Foreign direct investment inflow, trade openness, gross domestic product & carbon dioxide emissions

The extensive and thorough studies conducted to test the complex nexus between FDI and the environment have put forward quite differing and contradicting conclusions (Antweiler et al., 2001; Cole & Elliott, 2003; Frankel & Rose, 2005). Undoubtedly, FDI promotes economic growth and stability, but on the other hand, it has some serious adverse effects on the environment (Xing & Kolstad, 2002). FDI has been discovered as a probable cause of environmental degradation and researchers have yet been able to link it with many pollutants like CO_2 emissions. But some researchers have been able to develop its connection with environmental protection as well. FDI can help to bring in with it some eco and environmentally friendly efficient production technologies that lead to lesser air pollution (Stretesky & Lynch, 2009).

Merican et al. (2007) in their study took into account ASEAN-5 and were able to deduce that FDI hikes pollution in Malaysia, Thailand, and the Philippines while it inversely interacts with pollution in Indonesia. Atici (2012) based his research on a sample of ASEAN countries and was able to conclude the inverse relation between FDI and CO_2 emissions but there was also an absence of any sufficient significant impact of FDI on CO_2 emissions in Indonesia, Malaysia, Thailand, and the Philippines. Mujtaba et al. (2021) found a negative association between FDI inflow and carbon emissions. Research based on EKC and pollution haven hypothesis concludes that positive shock to FDI boosts carbon emissions both in the short and long term (Hamid et al., 2022). Indeed, the findings related to CO_2 emissions and FDI nexus are indecisive and varied.

Tang (2015) discovered that FDI inflow is greatly influenced by the environmental regulations of the home country and export-oriented FDI is more attuned to home country regulations than local-market-oriented FDI. Koçak and Şarkgüneşi (2018) tested for a causal two-way association between FDI and CO_2 emissions and consequently validated the presence of two-way relation between the two variables. Hamid et al. (2020) found that an increase in FDI inflow in China increased carbon emissions. Mujtaba and Jena (2021) confirmed the existence of the pollution haven hypothesis through their seminal work.

Al-Mulali and Tang (2013) stated that FDI inflow may be harmful in the beginning but in the long term, its fruit is reaped concerning environmental sustainability and CO_2 reduction. The same was established by Asghari (2013) for the sample of the Middle East and North African countries. It is worth mentioning that diverse research samples and econometric techniques may be the trigger behind differing and contrasting findings. Like, in the research based on China by Jiang et al. (2018) FDI and CO_2 were found to be inversely related. But then there is another study based in China by Sun et al. (2017) that caps FDI inflow as an amplifier of CO_2 emissions in the long term. It is justified to epitomise the relevant literature capturing the FDI-CO_2 emissions (pollution) nexus by saying that there is a lack of consensus among scholars rather there are diverse findings subject to differing conditions, samples, research periods, etc.

In recent times, trade openness has emerged as another key stimulus that could affect environmental quality. Antweiler et al. (2001) segregated the means of the effect of trade liberalisation into scale, technique, and composition effects. Concerning the scale effect, there is a quid pro quo kind of relation between hiking productivity and environmental degradation (Appiah-Konadu, 2013). As the name suggests, the technique effect focuses on technique and technologies of production and thus puts forward the notion that during the trade liberalisation phase, the environment is greatly preserved by the introduction of environmentally friendly production practices and technologies (Appiah-Konadu, 2013). Onder (2012) found that with the increase in income of individuals due to trade liberalisation, people tend to prefer environment-friendly products more. According to Grossman and Krueger (1995), the mode of the impact of the

pollution haven hypothesis on the environment is reflective of the composition effect. The structure of the economy is altered by trade liberalisation so there is more tilt towards innovative technologies or tertiary industry and this impact is covered by the composition effect. Mujtaba et al. (2020) found a negative association between trade openness and carbon emissions in 25 upper-middle-income group countries. The literature suggests quite differing findings regarding the role of trade openness.

The advent of the Environmental Kuznets Curve (EKC) hypothesis and its rigorous testing for different settings and samples led to many pieces of research that chalked out to examine the complex relationship between GDP and environmental impact. Likes are Gill, Viswanathan and Hassan (2018a, 2018b), Shukla and Parikh (1992), Shafik (1994), Tucker (1995), Roca (2003), Friedl and Getzner (2003), and Dinda and Coondoo (2006), and Managi and Jena (2008), and Coondoo and Dinda (2008), and Akbostancı et al. (2009), Işık et al. (2019), and Rahman et al. (2020). Some adverse air quality indicators like CO_2, SO_2, NO, etc. are checked with GDP. It's prudent to say that the prevalence of EKC varies among different countries and indicators. Hence based on inconsistent research findings of the literature as mentioned above, the following hypothesises are proposed:

H_1: Macro-Econmic variables (FDI inflows, Trade Openness & GDP) have a significant impact on CO_2 emissions.

2.3. Urbanisation level & carbon dioxide emissions

With time, the alarming effects of urbanisation are coming into focus so the researchers have also diversified their perceptions and have started looking into its impact on the environment. Parikh and Shukla (1995) and York et al. (2003) researched a sample of 86 and 137 countries, respectively and were able to conclude that urbanisation has a positive relation with pollutant emissions. Cole and Neumayer (2004) were also able to reach the same conclusion through their seminal work. However, Liddle and Lung (2010) were not able to establish a significant relationship between urbanisation and CO_2 emissions. Some contradicting results have also come forward as in the case of the study conducted by Fan et al. (2006) which happens to project an inverse relation between urbanisation and CO_2 emissions. Centered on the literature available, the following claim is made:

H2: Urbanisation level has a significant impact on CO_2 emissions

2.4 Nuclear energy consumption & carbon dioxide emissions

The International Energy Agency concluded in the report published in 2015 that nuclear energy, renewable energy, and upgrading energy efficiency can bring about impactful changes in the form of a reduction in global warming. The report further claims the aggregate reduction of 15% in carbon emissions by 2050 by the use of nuclear energy. Mujtaba et al. (2022) reported a 1% increase in renewable energy reduces CO_2 emission by 0.2%. Apergis et al. (2010) used a sample of 19 countries to inspect the causal relationship between nuclear energy consumption and CO_2 emissions. The study revealed that nuclear energy consumption buffers CO_2 emissions in the short run. Al-Mulali (2014) based research on 30 major nuclear energy-consuming countries and ended up concluding a negative short-run relationship with CO_2 emission. Nuclear energy consumption has been incorporated in the Environmental Kuznets Curve framework by Dong et al. (2018) and the respective examination unveiled that nuclear energy consumption diminishes CO_2 emissions both in the short and long run. Pertained on the literature reviewed, the fifth hypothesis for the current study is:

H_3: Nuclear energy consumption has a significant impact on CO_2 emissions.

2.5. Green financing & carbon dioxide emissions

Höhne and Fekete (2012) have provided the most inclusive definition of green financing. According to them, green financing is often used interchangeably with green investment. Green financing is a comprehensive term and its spectrum is quite diverse as it includes financial investments catering the sustainable projects and enterprises, environmental products and services, renewable energy initiatives, and strategies aiming toward the ultimate goal of a sustainable economy. The study conducted by Poberezhna (2018) focused on the green economy and its impact on environmental degradation. Gianfrate and Peri (2019) emphasised green bonds as crucial means of attaining carbon reduction targets. Glomsrød and Wei (2018) denoted that by promoting green bonds there is not only going to be a reduction in carbon emissions but also with the help of green financing renewable energy can be promoted which will consequently enhance the environment. It is evident from these arguments that green financing aims to mitigate CO_2 emissions to enhance environmental sustainability. Hence it is hypothesised:

H_4: Green financing has a significant impact on CO_2 emissions.

2.6. Green financing as moderator

In the light of the existing literature, it is quite eminent that the focal aim of green financing is environmental sustainability by either investing in companies or technologies that are deemed good for the environment or directly funding environmentally friendly initiatives. Apart from exploring the direct impact of green financing on CO_2 emissions, the current paper sets to establish it as a moderator. The question worth addressing is whether the prevalence of green financing in interaction with FDI inflow, GDP, trade openness, urbanisation, and nuclear energy consumption either amplifies or buffers their effect. The moderating role of green financing concerning economic indicators (also urbanisation and nuclear energy consumption) and environmental nexuses is still untouched. Based on previous seminal research (Allevi et al., 2019; Höhne & Fekete, 2012; Poberezhna, 2018) highlighting the definition as well as the direct effect of green financing on the environment certain deductions can be made concerning its moderating role. Therefore, it is prudent in the current context to infer that green financing moderates the IVs-DV relationships such that it buffers their (FDI, GDP, trade openness, urbanisation, and nuclear energy consumption) negative impact on the environment. The aforementioned claims can be précised as an umbrella hypothesis as follows:

H5: Green financing moderates the IVs-DV nexuses in the study at hand.

3. Data and methodology

3.1. Data description

The present study is firmed to evaluate the effects of dependent variables i.e. FDI inflow, GDP, TRA, URB, and NEC on the independent variable i.e. CO_2 emissions also in the presence of moderator GF.

This empirical research focuses on the data related to the Atomic Power states from 2008 to 2019. Dataset for this study includes eight countries. The standard criterion applied in selecting the list of countries is first they identify as nuclear power states and second they also generate and consume nuclear energy. The sample includes the USA, Russia, UK, France, China, India, Pakistan, and North Korea. FDI, GDP, trade openness, urbanisation, and nuclear energy consumption serve as the five independent variables. The measure of FDI used is taken as the total dollar value of inward FDI as a percentage of GDP. GDP per capita value is taken in constant 2010, US dollar. Trade openness is computed as the sum of total imports and exports as a percentage of GDP.

Table 1. Description and measurement of variables

Variable	Measure	Source
Foreign Direct Investment Inflow (FDI)	% of GDP	https://data.worldbank.org/indicator
Gross Domestic Product (GDP)	GDP per capita In constant 2010, US $	https://data.worldbank.org/indicator
Trade Openness (TRA)	% of GDP	https://data.worldbank.org/indicator
Urbanization Level (URB)	% of total population	https://data.worldbank.org/indicator
Nuclear Energy Consumption (NEC)	% of total energy used	https://data.worldbank.org/indicator
Carbon Dioxide Emissions (CO_2)	Kilotons	https://data.worldbank.org/indicator
Green Financing (GF)	US $ investment in renewable energy sector	https://www.iea.org/ https://data.worldbank.org/indicator

Urbanisation and nuclear energy consumption are measured as a percentage of the total population and a percentage of total energy consumed, respectively. Data related to all the dependent and independent variables are taken from the World Development Indicators website. The current research work includes CO_2 emissions as the sole independent variable and measured in kilotons. Lastly, green financing is the moderator measured by US dollar investment in the renewable energy sector. The data on green financing is gathered from the World Development Indicators and International Energy Agency databases. Table 1 sheds light on the study variables and their descriptions.

3.2. Model specification

According to the Dietz and Rosa STIRPAT model (Dietz & Rosa, 1997):

$$I = P \times A \times T$$

Where; I is environmental impact, P is population, A is affluence and T represents technology. In the light of the above model and also considering green financing (GF), the following equation is framed for empirical analysis:

$$CO_{2it} = f(FDI_{it}, GDP_{it}, TRA_{it}, URB_{it}, NEC_{it}, GF_{it})$$

Econometrically, the regression equation for panel data regression is represented as:

$$CO_{2it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 GDP_{it} + \beta_3 TRA_{it} + \beta_4 URB_{it} + \beta_5 NEC_{it} + \beta_6 GF_{it} + \mu_{it} \quad (1)$$

Where; i and t represent countries and time periods, respectively. (μ_{it}) is the error term.

To test hypothesis 7, we have added green financing (GF) as a moderator in the baseline model, which is as follows:

$$CO_{2it} = \beta_0 + \beta_1 FDI_{it} + \beta_2 GDP_{it} + \beta_3 TRA_{it} + \beta_4 URB_{it} + \beta_5 NEC_{it} + \beta_6 GF_{it} + \beta_7 (FDI_{it} \times GF_{it}) + \beta_8 (GDP_{it} \times GF_{it}) + \beta_9 (TRA_{it} \times GF_{it}) + \beta_{10} (URB_{it} \times GF_{it}) + \beta_{11} (NEC_{it} \times GF_{it}) + \mu_{it} \quad (2)$$

As it is panel data regression and all variables have different measures so it is customary to take a natural logarithm.

3.3. Methodology

The data used for analysis is in panel form and all variables have different measures so firstly their natural logs are taken. To proceed with panel data, it is pivotal to commence with panel unit root tests and panel co-integration tests to avoid spurious regression. Firstly, the descriptive statistics and correlation matrix of the variables are derived, followed by four panel unit root tests i.e. Augmented Dickey-Fuller test, Levin, Lin, and Chu test, Phillips-Perron and Im-Pesaran test to check the stationarity of the variables. The next step comprises checking the long-run association between the variables via panel co-integration techniques by using Pedroni and Kao tests. After the establishment of the fact that there is long-run co-integration between the variables, the fully modified OLS (FMOLS) procedure introduced by Phillips and Hansen (1990) is used to obtain regression coefficients for main as well as interaction effects.

4. Results and discussion

4.1. Preliminary analysis

The summary statistics of all the discussion variables are represented in Table 2. These descriptive statistics give a fleeting overview of the variables' mean, median, and standard deviation values.

Table 3 enlists the correlation coefficients along with respective probabilities in parentheses. The purpose of the correlation matrix is to infer a better idea of the linear association amongst the variables. The scale of correlation varies between 1 and −1, while 0 refers to no correlation at all. Nearer the value of the correlation coefficient to 0 weaker the linear association between the two variables. Here, it is of profound importance to mention that $r^2 \geq 0.8$ poses a risk of the multi-collinearity problem. The pairwise correlation matrix is apt to detect this threat by examining the strength of correlation between the pair of variables. Hence, this helps to identify the intensity of multicollinearity in the current model. The results of the correlation matrix indicate the absence of multicollinearity in the model.

4.2. Panel unit root tests

Panel data brings in with it the problem of stationarity which leads to spurious regression results. For the current research, Levin, Lin, and Chu (LLC), Im, Pesaran, and Shin (IPS), Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) are used. The first-generation unit root tests are used because the data doesn't have any structural breaks. All tests pointed towards the fact that all the concerned variables are non-stationary at level but are stationary at first difference i.e. I (1). Table 4 gives an insight into the outcomes along with probabilities of panel unit root techniques.

Table 2. Descriptive statistics

Variable	Mean	Median	Standard Deviation
CO_2	1.700	1.975	0.971
FDI	0.507	0.560	0.693
GDP	9.358	9.769	1.433
TRA	3.878	3.897	0.364
URB	4.104	4.329	0.375
NEC	2.092	2.104	0.927
GF	1.856	1.481	1.386

Table 3. Pairwise correlation matrix

Correlation Probability	CO_2	FDI	GDP	GF	NEC	TRA	URB
CO_2	1						

FDI	0.132	1					
	(0.216)	---					
GDP	0.652	0.031	1				
	(0.000)*	(0.773)	---				
GF	0.393	0.273	0.107	1			
	(0.000)*	(0.009)*	(0.318)	---			
NEC	0.548	−0.201	0.622	−0.260	1		
	(0.000)*	(0.059)	(0.000)*	(0.014)*	---		
TRA	0.238	−0.106	0.282	−0.414	0.388	1	
	(0.025)**	(0.321)	(0.007)*	(0.000)*	(0.000)*	---	
URB	0.591	−0.002	0.461	0.049	0.415	0.352	1
	(0.000)*	(0.984)	(0.000)*	(0.648)	(0.000)*	(0.000)*	---

* = p ≤ 0.01, ** = p ≤ 0.05. Probabilities appear in parentheses below correlation coefficients.

4.3. Panel co-integration tests

Kasman and Duman (2015), Pedroni (1999), and Pesaran (2007) recommended running co-integration tests before regression analysis when all variables are stationary at the first difference so that long-run association between the variables can be determined. Taking a cue from the seminal work of Jamel et al. (2016) which used two panel co-integration

Table 4. Outcomes of panel unit root tests

Unit Root Test	CO_2	FDI	GDP	NEC	TRA	URB	GF
LLC:							
Level	−1.610 (0.663)	−4.053 (0.847)	−1.798 (0.436)	−0.235 (0.407)	−1.707 (0.343)	0.241 (0.595)	−3.276 (0.600)
1st Difference	−7.473 (0.000)*	−9.092 (0.000)*	−8.333 (0.000)*	−7.398 (0.000)*	−12.285 (0.000)*	−3.014 (0.041)**	−8.259 (0.000)*
IPS:							
Level	1.026 (0.847)	−2.044 (0.120)	0.073 (0.529)	1.280 (0.899)	−0.030 (0.488)	7.325 (1.000)	0.440 (0.670)
1st Difference	−5.007 (0.000)*	−6.195 (0.000)*	−4.533 (0.000)*	−3.724 (0.000)*	−6.566 (0.000)*	1.069 (0.034)**	−4.663 (0.000)*
ADF:							
Level	11.389 (0.784)	27.992 (0.231)	19.561 (0.240)	8.792 (0.921)	14.162 (0.586)	32.552 (0.668)	13.173 (0.660)
1st Difference	56.392 (0.000)*	67.634 (0.000)*	53.403 (0.000)*	45.098 (0.000)*	69.371 (0.000)*	13.215 (0.007)*	52.815 (0.000)*
PP:							
Level	17.584 (0.348)	28.269 (0.429)	19.823 (0.228)	9.405 (0.895)	17.042 (0.382)	55.888 (0.321)	35.860 (0.803)
1st Difference	69.206 (0.000)*	72.640 (0.000)*	70.971 (0.000)*	50.243 (0.000)*	63.811 (0.000)*	15.903 (0.020)**	62.088 (0.000)*
Result	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)	I (1)

* = p ≤ 0.01, ** = p ≤ 0.05. Probabilities appear in parentheses.

Table 5. Results of panel co-integration tests

Co-Integration Test		Statistic	Probability
Pedroni			
Within Dimension	Panel v-Statistic	−0.939	0.826
	Panel rho-Statistic	3.328	0.999
	Panel PP-Statistic	−9.011	0.000*
	Panel ADF-Statistic	−3.381	0.000*
Between Dimension	Group rho-Statistic	4.201	1.000
	Group PP-Statistic	−20.740	0.000*
	Group ADF-Statistic	−6.482	0.000*
Kao	ADF	−3.042	0.001*

** = p ≤ 0.01, ** = p ≤ 0.05.*

techniques, (a) the two-step process suggested by Pedroni (1999, 2004) and (b) ADF based co-integration test introduced by Kao (1999), these two techniques are used to establish the long-run co-integration in the current research. Table 5 demonstrates the results of the Pedroni and Kao tests which indicate the presence of long-run co-integration.

4.4. Fully Modified Ordinary Least Square (FMOLS)

After the establishment of the facts that all the concerned variables are stationary at the first difference and are substantiated to be co-integrated in long run, fully modified OLS (FMOLS) (proposed by Phillips & Hansen, 1990) seems the appropriate co-integration regression method to measure long-run relationships between the variables. Hence FMOLS is employed in the current study to measure long-run estimates of variables. So, FMOLS is affirmed to estimate the models specified in Eq (1) and Eq (2).

The econometric technique FMOLS is utilised to obtain regression coefficients of variables in Eq. 1 and Eq. 2 concerning CO_2. The documented results in Table 6 depict that all the explanatory variables including (the direct effect of) the moderator green financing have a significant impact on CO_2 at a 1% significance level in Model 1. The two main economic affluence parameters FDI and GDP positively correspond with CO_2. Their coefficients signify that a 1% increase in FDI and GDP

Table 6. Results of long run coefficients through FMOLS

Dep. Variable = CO_2	Model 1: Main Effect		Model 2: Main Effect + Interaction Effect	
Variable	**Coefficient**	**Probability**	**Coefficient**	**Probability**
FDI	0.0053	0.006*	0.091	0.000*
GDP	0.234	0.000*	−0.141	0.006*
NEC	−0.232	0.000*	−0.156	0.000*
TRA	−0.219	0.000*	0.974	0.000*
URB	0.302	0.000*	2.791	0.000*
GF	−0.075	0.000*	1.609	0.000*
FDI× GF	——-	——-	−0.027	0.043**
GDP×GF	——-	——-	−0.068	0.010*
NEC×GF	——-	——-	−0.061	0.002*
TRA×GF	——-	——-	−0.493	0.000*
URB×GF	——-	——-	0.303	0.011*

Note: ** = p ≤ 0.01, ** = p ≤ 0.05.*

hike CO_2 by 0.005% and 0.234% respectively. Meanwhile, trade openness negatively affects CO_2 as a 1% increase in trade openness decreases CO_2 by 0.219%. Similarly, an increase in either green financing or nuclear energy consumption by 1% cuts down CO_2 by 0.075% and 0.232% respectively. Urbanisation and CO_2 emissions go parallel as a 1% surge in urbanisation brings up CO_2 emissions by 0.302% in the nuclear power states.

Model 2 in Table 6 takes into account the explanatory variables as well as the five interaction terms: FDI×GF, GDP×GF, TRA×GF, URB×GF, and NEC×GF to institute the effect of green financing as moderator. The indications of FDI, NEC, and URB remain the same as in Model 1. Whereas in Model 2, GDP is linked negatively while TRA is linked positively to CO_2 emissions as opposed to Model 1. All five interaction terms are significant at 1% and 5% statistical levels. The coefficients of interaction terms pour out some remarkable findings. Like, it is unveiled that a rise in FDI, ceteris paribus, in integration with the increase in green financing is likely to reduce CO_2 emissions. Likewise, an escalation in either GDP or TRA or NEC (all else being equal) in correspondence with an increase in green financing is probably going to decline the CO_2 emissions. Only urbanisation in combination with green financing fails to subside the CO_2 rather than hike it.

4.5. Discussion

The results and findings of the current study showcase that FDI, GDP, trade openness, nuclear energy consumption, urbanisation, and green financing have a significant and direct impact on CO_2 emissions concerning nuclear power states. Moreover, results also assist in substantiating green financing as a significant moderator in current nexuses. And it is evident that by promoting green financing, the adverse impacts of the key macro-economic indicators, i.e. FDI, GDP, and trade openness are buffered to some extent. Meanwhile, green financing fails to diminish the amplifying effect of urbanisation on CO_2 emissions.

This study makes important contributions to enhancing an understanding of the progressive side of green financing as a promoter of environmental well-being. The findings of this study noticeably reveal that the macro-economic indicators FDI and GDP, the flag-bearers of economic affluence, have detrimental impacts on the environment as they are found to be responsible for increasing CO_2 emissions. As the studies conducted by Xing and Kolstad (2002), He (2006), Eskeland and Harrison (2003), and Zhang (2011), and Omri et al. (2014) pointed in the same direction as stating FDI as a probable antecedent of CO_2 emissions (environmental degradation). Similarly, Anser (2019), Hanif and Gago-de-Santos (2017), Kang et al. (2016), Lin et al. (2014), and Poumanyvong et al. (2012), and Alam et al. (2007) were also able to establish a positive linear link between GDP and CO_2 emissions. The findings obtained through Model 1 of current research have uncovered that trade openness has an inverse relation with CO_2 and this revelation is in line with the seminal works of Antweiler et al. (2001), Copeland and Taylor (2005), Managi et al. (2008), and Shahbaz et al. (2012). The efficacy of nuclear energy consumption in containing carbon emissions has come to light previously through some notable research like Apergis et al. (2010), Al-Mulali (2014), and Dong et al. (2018). The same is concluded through the results presented in Models 1 and 2.

The influx of population from rural to urban settings aka urbanisation has previously been associated with an increase in CO_2 emissions as noted by Anser (2019), Hanif (2018), Kang et al. (2016), Liddle and Lung (2010), and Alam et al. (2007), and York (2007), etc. The same association is apparent in the findings listed in Models 1 and 2.

Green financing-related research is in the embryonic stage at this point but environmental finance and economics are catching the eyes of researchers now more than ever. It's a pivotal contribution through this study as green financing has been determined to encourage environmental sustainability by decreasing CO_2 emissions as previously reported by Gianfrate and Peri (2019) and Glomsrød and Wei (2018). Model 2 outcomes clearly state that green financing can noticeably cushion excessive CO_2 emissions as a result of FDI, GDP, and trade openness. However, it is rather quite alarming that even with its interaction with an environmental-well-being-oriented

factor such as green financing, urbanisation still affects the environment adversely. Amongst the nuclear power states, apart from the developed countries, the developing countries lack more stringent rules and regulations to curb the increasing trend of urbanisation. The countries underestimate the hostile impacts of urbanisation at large as well as on the pollution quotient.

Setting aside the revelation of the fact that two of the eminent parameters of economic growth i.e. FDI and GDP are probable antecedents of CO_2 emissions in the atomic power states, the third economic growth measure i.e. trade openness has declared itself as inversely related to CO_2 emissions in Model 1. Hence trade openness has emerged as a hindrance rather than a booster of carbon emissions in nuclear power states. Free trade and environmental protection usually don't go hand in hand. Porter's hypothesis (Porter, 1991, p. 1995b) is the lone flag-bearer of the stance that trade openness (economic growth) and environmental preservation are possible at the same time by attaining a competitive advantage by promoting stringent environmental regulations.

5. Conclusion

In the current study, the STIRPAT model is extended by the inclusion of green financing as a moderator. FDI, GDP, trade openness, nuclear energy consumption, and urbanisation are the key explanatory variables and their impact on the environment is investigated. CO_2 emissions cater to the environmental impact factor, while green financing is promoted as the moderator. The extended STIRPAT model is tested for the sample of nuclear power states. Various econometric techniques are pursued to conclude the association between the explanatory, moderating, and dependent variables.

After a thorough analysis of the proposed models and framework, it is concluded that in the nuclear power states, FDI, GDP, and urbanisation have a positive relation with CO_2 emissions and they contribute to environmental pollution. Whereas trade openness, nuclear energy consumption, and green financing have an inverse relation with CO_2 emissions and they tend to hinder the environmental pollution in nuclear energy states. Lastly, the promotion of green financing is proved to be a valuable asset as the current research solidifies its impact as a buffering moderator as its interaction with FDI, GDP, trade openness, and nuclear energy consumption inclined to cripple environmental degradation. However, regardless of the inclusion of moderator i.e. green financing, urbanisation tends to adversely affect the environment.

There is a massive urge displayed by the countries to achieve certain standards of economic growth and there is rather faddist behaviour exhibited by the countries in this regard. However, the environmental misfortunes that accompany the economic affluence are greatly underestimated and neglected by the governments. As the above-mentioned findings pave the way to the conclusion that it is high time to strategise and implement stringent environmental regulations along with boosting economic growth.

Energy consumption is a substantial component of economic growth and the aforementioned findings declare nuclear energy consumption as an aiding factor in environmental well-being. Consequently, it is concluded that the establishment of nuclear energy plants is for the greater good of the economy as well as the environment. Last but not least, the urbanisation-pollution facet discovered through the results of the current study put forward the need for strict checks and balances as well as policy implementation to curb the extent of urbanisation. Also, it should be determined what countermeasures are irresistible for environmental safety if the trend of urbanisation cannot be limited.

The findings of the study offer numerous insights that can be implemented theoretically and policywise. FDI is affiliated with the booming economy and all governments seek to encourage FDI inflow. The results from nuclear power states suggest the detrimental effects of FDI on the environment as it scales up the economy. Hence it is inevitable that governments should chalk up strategies to cut short the environmental adversities. Governments should stipulate and attract firms with labor-intensive production methods rather than capital-intensive ones to safeguard the

environment. Moreover, such firms should be preferred that take pride in using environmentally friendly practices and technologies.

Theoretically as well as policywise, the implications of green financing are profound as it is not been well researched till now. But the current study has laid the foundation for establishing green financing as a moderator between macro-economic affluence parameters (FDI, GDP, trade openness) and environmental nexuses. It's quite prevalent that green financing should be encouraged by countries more and more. Green finance should be promoted by the regulators through fiscal policies. Governments should prioritise green initiatives. Green financing products like environment and biodiversity funds, weather derivatives, nature-linked securities, green investment funds, green bonds, renewable energy investments, etc. should be promoted as much as possible.

Lastly, energy consumption is means of keeping the economy running. Hence, rather than equipping the non-renewable energy plants, nuclear energy plants should be established. Nuclear energy consumption should be encouraged to meet the growing energy demand. Government and industries should actively invest in ventures to produce nuclear energy. Nuclear production infrastructure should be equipped with the latest technologies.

The future may be conducted by the inclusion of green financing as a moderator. This has paved the way for other researchers to work on these lines. Further studies may be conducted for other regions and countries by using advanced econometric models. The channels through which economic growth factors (i.e. FDI, GDP, and trade openness) affect the environment are divided into scale, composite, and technique effects. The aspirants aiming to ascertain the economic growth-environment nexus can separately address these channels of the effect of economic growth.

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