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Sustainable Development: Financial development a curse or boon for environment: With Special reference to CO_2 emission

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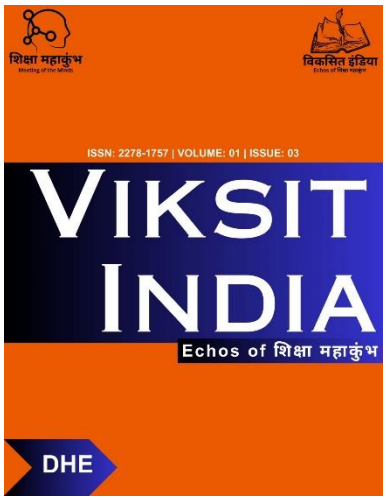

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Abstract

Purpose: This study examines the effects of financial development on CO_2 emissions in ten particular nations between the years of 2001 and 2021. Investigating whether financial development increases or decreases CO_2 emissions is the main goal of this study. This study observes the causal relationships between financial development and emissions of CO_2 in order to assess the implications for sustainable development.

Design and methodology: The present study is conducted on secondary data. we concentrate on air pollution in this work and use carbon dioxide (CO_2) emissions per capita as the primary indicator for the state of environmental pollution. As indicators of financial development, GDP, net foreign direct investment inflow and outflow, and bank credit to the private sector are used. In addition to this population is taken as control variable. It employs panel data of the top ten CO_2 emitter countries (China, Canada, India, Italy, Japan, United States, U.K, Korea Rep, France, Germany) from 2001 to 2021. Fixed effect and first difference model are used to analyse the data of the study.

Findings: Results from the use of an econometric technique infer without a doubt that financial development will have a favourable long-term influence on CO_2 emissions. Furthermore, according to a fixed effect model, empirical evidence suggests that the effect of domestic credit given by banks to the private sector has a positive relationship with *CO2* emissions. With the increase in GDP per capita *CO2* emission decreases so the study supports EKC hypothesis.

Research implications: The collected results suggest that economic policy measures should focus on encouraging loans to finance the following: (i) Switching to low-emission engines and later to gas-powered automobiles, as well as hybrid and electric vehicles; (ii) Financial commitments to more energy-efficient technology that facilitates the switch to cleaner energy sources, particularly in the energy, manufacturing, and transportation sectors; and (iii) Research and development initiatives that should facilitate CO_2 reduction. Implications of present study are Credit funding should be wisely distributed and directed towards low-carbon businesses and projects. In order to encourage financial institutions to engage in green credit activity, appropriate fiscal and taxing mechanisms should be implemented. In addition, organisations should be set up to monitor the financial impact of carbon, measure the effectiveness of credit funds. Several fiscal mechanisms, including as taxes, subsidies, and incentives, can be used by policymakers to encourage the gradual transition into green economy.

Originality/value: The study is original in work and studied the link of financial development with environment upgradation/ degradation. The work suggested various measures to deal with problems of *CO2* emission. Various policy implications are suggested for environment sustainability.

Keywords: CO_2 emission, financial development, carbon taxes, green economy, GDP, FDI.

Introduction

The effects of climate change on the world are already visible in the rise in the frequency of extreme weather events, changes in precipitation patterns, and intensification of storms. sea level rise and reversing ocean currents. In turn, these modifications may have a big effect on how ecosystems work, how long species can survive, and how well humans can live. The largest portion of greenhouse gas emissions that are still a concern in regard to climate change and global warming are carbon dioxide (CO2) emissions. Economies engage in anti- environmental actions that contribute to climate change and CO2 emissions out of a quest for economic prosperity. Globally, there is a severe concern from high CO2 emissions, particularly in developing nations. Regardless of who is to blame for this accumulation, gases (GHGs) on the earth's surface are now negatively harming both developing and developed countries around the world. It's more complex than simple to understand how the environment and growth are related. The analysis of the impacts of global trade and capital flows, as well as the focus on the

environment-growth relationship, are necessary to solve environmental challenges in the open, liberalised, and interconnected world economy of today. The impact of financial development on environmental conditions has gained increasing attention in the recent literature.

Empirical literature

Using the ARDL technique, Jayantha Kumaran et al. (2012) examined the connections between carbon emissions, economic growth, trade, energy consumption, and structural breaks when comparing China and India. In the Chinese economy, wealth, structural changes, and energy use all have an impact on CO2 emissions. The authors validated the validity of the EKC hypothesis in India, however they found little evidence of a significant relationship between structural changes and CO2 emissions and economic growth. A study by Hossain (2011) examined the relationships between CO2 emissions per person, energy use, economic growth, trade openness, and urbanisation in newly industrialised nations, including Turkey. The Granger causality test results indicate that there is no long-term "Ganger-causal" link between the variables, but that there is evidence for short-term unidirectional Granger causality. In their work, (Dogan and Turkekul,2015) used ARDL to construct relationships between carbon dioxide (CO2) emissions, energy consumption, real output (GDP), GDP2 (squared real output), trade openness, urbanisation, and financial development in the USA between 1960 and 2010. According to what he revealed, environmental degradation is accelerated by urbanisation and energy use over time, but not by financial development. The enhancement of the environment has also been linked to trade, according to research. The environmental Kuznets curve (EKC) theory for the USA was also not supported by this study since actual output improves the environment while GDP2 raises gas emissions. According to different periods of their investigation, Say and Yucel [2006] and Fodha M, Zaghdoud [2010], and others have demonstrated that there is a positive association between CO2 emissions and economic growth. Time series data from 1971 to 2011 were used in a study by Rafindadi Abdualrashid Abd [2016] in which the ARDL bounds testing, the Zivot-Andrew structural break test, and the Bayer- Hanck combine cointegration analysis were applied. Using the VECM model, the causality analysis was verified. The study's conclusions showed that while financial development raises energy demand, it also reduces CO2 emissions. Economic expansion reduces energy demand but boosts CO2 emissions. Also, the study found that trade openness raises energy consumption while enhancing environmental quality by reducing CO2 emissions. However, it was discovered that there had been a considerable rise in CO2 emissions due to energy use. Financial development and energy use are shown to be causally related in both directions, and the similar conclusion Kumaran et al (2012) (Grossman & Krueger, n.d.; Kunnas & Myllyntaus, 2007)

Data and methodology

Data Description

The present study is conducted on secondary data. Like in other earlier studies (e.g., Hossain (2011), Rafindadi Abdualrashid Abd (2016)), we concentrate on air pollution in this work and use carbon dioxide (CO2) emissions per capita as the primary indicator for the state of environmental pollution. As indicators of financial development, GDP, net foreign direct investment inflow and outflow, and bank credit to the private sector are used. In addition to this population is was drawn for financial development and CO2 emissions. In Another study (Ali et al., 2015) the effects of energy consumption, economic growth, financial development, and economic globalisation on carbon emissions in the Pakistani economy assessed. The results of the study reported a long-term equilibrium relationship between carbon emissions and the regressors in the carbon emission model. The factors have been found to be causally related in both the long and short terms. A positive correlation between sustainable economic development and energy emissions was found by Xepapadeas [2005] in an empirical investigation. (Kayani et al., 2020) examined the causal connections between urbanisation, financial development, consumption of renewable energy, and CO2 emissions in order to evaluate the consequences for sustainable development. It makes use of panel data for the top 10 CO2 emitters from 1990 to 2016 (Japan, USA, South Korea, Germany, Iran, Canada, Saudi Arabia, China, India, and Russia). In order to analyse the study's data, tests such as panel co- integration, panel fully modified least squares (PFMOLS), and panel vector error correction model (VECM) are used. The panel VECM test's empirical finding of a long-term, unidirectional causal relationship between CO2 and financial development (FD) and globalisation (GLOB) and urban population (URB) (UP). The PFMOLS test results indicate that there are significant long-term positive correlations between FD and UP.

Theoretical framework

Several researchers from the early 1990s assumed that each economy should concentrate on its expansion and that any environmental issues will eventually be resolved by the process of economic growth as a result of the EKC concept. The EKC hypothesis states that after an economy reaches an appropriate level of economic growth, additional economic growth can reduce environmental deterioration. There is a surplus of natural resource stock and little waste generation during the early stages of economic development, when primary production predominates. Natural resources are significantly depleted throughout development and industrialisation, and wastes build up as a result. In this stage, environmental degradation and income or economic growth (per capita) are positively correlated (per capita). Services, better technology, and information dissemination restrict an economy's reliance on its material base and prevent environmental damage as a result of continued economic growth. There are a few EKC studies that address CO2 emissions. There appear to be conflicting results depending on the type of analysis employed (cross-country or time-series) and the time frame being looked. Some researchers reported U shape application of EKC (Ali et al., 2015; Hao et al., 2016; Yao et al., 2019) (Haug & Ucal, 2019) some researchers report no U-shaped impact of EKC (Dogan & Turkekul, 2016) Jayantha

taken as control variable. This study observes the causal relationships between financial development and emissions of CO2 in order to assess the implications for sustainable development. It employs panel data of the top ten CO2 emitter countries (China, Canada, India, Italy, Japan, United States, U.k, Korea Rep, France, Germany) from 2001 to 2021 which are Richest countries in the world as per statistics of the International Monetary Fund, updated as of October 2020. Fixed effect and first difference model are used to analyse the data of the study.

Table 1 indicates the various variables used for study with their symbol, measurement and explanation as dependent and independent. Co2 emission metric tons per capita which is proxy of environment degradation and financial Development as independent variable which is indicated through GDP per capita (current US$), Net inflow Foreign direct investment (%age of GDP), Net outflow Foreign direct investment (%age of GDP), Credit to Private non-financial sector from Banks total at Market value (Percentage of GDP).

Statistical results in Table 2, suggest that the average value of CO2 emissions of the ten countries is 8.9096 per capita metric tons with a standard deviation of 4.7075 per capita metric tons. In addition, the, the overall mean value of GDP per capita and its standard deviation stand at 31844 and 16864 billion US dollars respectively. Total population of the sampled countries has a mean value of 3.3923e+008 million people with a standard deviation of 4.8929e+008 million people. Foreign direct investment net inflow of the sampled countries on the other hand has a mean value of 1.9227 with a standard deviation of 1.7017, Foreign direct investment net outflow mean value and its standard deviation stand at 2.1932 and 1.9552respectively. Credit to Private non-financial sector from Banks has a mean value of 88.840 with a standard deviation value of 28.490, a ratio of GDP. This shows that large variances exist in the data of the analyzed variables except FDI and CO2 that has a minimum variance.

Table no 1: List of variables

Symbol	Variables	Measurement	Explanation
CO2	CO2 emissions	metric tons per capita	Dependent
GDP	GDP per capita	current US$	Independent
FDI I	Net inflow Foreign direct investment	%age of GDP	Independent
FDI O	Net outflow Foreign direct investment	%age of GDP	Independent
Credit	Credit to Private non-financial sector from Banks	total at Market value (Percentage of GDP)	Independent
POP	Population	Total	Control

Ho1: There is no significant impact of GDP on CO2 emission.

Ho2: There is no significant impact of FDI Inflow on CO2 emission. Ho3: There is no significant impact of FDI outflow on CO2 emission.

Ho4: There is no significant impact of Credit to Private sector on CO2 emission. Ho5: There is no significant impact of Population on CO2 emission.

Table no 2: Statistical description of variables

Variable	Mean	Standard dev.	Maximum	Minimum	Obs.
CO2 emission	8.9096	4.7075	20.172	0.88375	210
GDP	31844	16864	70249	449.91	210
FDI in	1.9227	1.7017	12.000	-1.2000	210
FDI out	2.1932	1.9552	12.200	-3.7000	210
credit	88.840	28.490	183.40	31.800	210
PoP	3.3923e+008	4.8929e+008	1.4124e+009	3.1021e+007	210

Empirical Models

Regression equation: $CO2it = Bo\ it + B1GDPit + B2FDIINit + B3FDIO\ it + B4CR\ it + B5P\ it + \varepsilon\ it$

Co2 it is carbon emission the dependent variable with cross sectional unit i and time t. bo it is constant b1, b2, b3, b4, b5 are intercept of independent variables GDP, FDI net inflow, FDI net outflow, credit to private sector by banks and control variable population respectively. E is error term.

Table 3 explains the results of various tests conducted for understanding the nature of panel data to run appropriate econometric model. Test for differing group intercepts with Ho: The groups have a common intercept rejected at p value 1.77014e-111p<0.005 which means that data is not poolable due to which one cannot use poolable method. Thereafter individual/cross-sectional effect and time effect tested by applying Pesaran CD and Wald joint tests are applied and both Ho could not be accepted with p-value= 9.42772e-09 and 6.82763e- 13 respectively. These tests indicated that data is having both cross sectional and time effect. Hausman test indicated the non-suitability of random effect and joint test on named regressors ensured fixed effect model is enough here to explain regressors. So fixed effect model is run to draw the results from panel data of 10 richest countries from 2001 to 2021.

Table 3: Basic tests for penal Data

Test for differing group intercepts	Ho: The groups have a common intercept	F (9, 195) = 318.365 p-value = P (F (9, 195) >318.365) = 1.77014e- 111p<0.005	p<0.05 hence groups have different intercept.
Pesaran CD test for cross-sectional dependence	Ho: No cross-sectional dependence	Asymptotic test statistic: z = 5.74072 with p-value= 9.42772e-09	p<0.05 hence here is cross sectional/individual effect in data.
Wald joint test on time dummies	Ho: No time effects	Asymptotic test statistic: Chisquare (20) = 75.4459 with p-value = 2.29536e-08	p<0.05 hence here is time effect in data.

joint test on named regressors	Ho: overall model is not fit. (b1=b2=0)	Test statistic: F (5, 195) = 15.5822 with p-value = P (F (5, 195) > 15.5822)= 6.82763e-13	p<0.05 so Ho is rejected. Hence fixed effect model is enough here to explain regressors.
Hausman test	H0: Random effect model is consistent. Ha: fixed effect model is consistent.	Asymptotic test statistic: Chi-square (5) = 13.8615 with p-value = 0.0165137	p<0.05 so Ho is rejected. Hence random effect model is not enough here to explain regressors

Table 4: Fixed effect model

	P-value	t-ratio	coefficients
GDP	9.15e-010 ***	−6.439*	−7.83913e-05
FDI I	0.5009	−0.6743	−0.0401463
FDI O	4.21e-06 ***	4.735*	0.233919
Credit	0.0010 ***	3.341*	0.0211297
POP	0.0150 **	2.454*	5.12018e-09
Within R-squared S.E of regression Rho Durbin-Watson	0.285482 0.982843 0.813257 (variance in DV due to individual effect) 0.323184		

***** & ** significant at p value 0.05. t-ratio value >1.96 *Ho is rejected**

Fixed effect model considers the heterogeneity of cross section while running the model that's why it is called as within effect model. In table fixed effect model Ho2 is accepted it means FDI net inflow has no impact on co2 emission. Ho, Ho3, Ho4, Ho5 are rejected indicating significant impact on co2 emission where GDP has -ve impact on co2 emission which mean by increase in GDP co2 emission reduced same as reported by environmental Kuznets curve (EKC). Credit to private sector by banks is also contributing towards environment degradation consistent results are reported by (Petrović & Lobanov, 2022)The rejection of Ho4 imply that economic policy measures should be concentrated on encouraging loans to finance the following: (i) switching to low-emission engines and later to gas-powered automobiles, as well as hybrid and electric vehicles; (ii) Financial commitments to more energy-efficient technology that facilitates the switch to cleaner energy sources, particularly in the energy, manufacturing, and transportation sectors; and (iii) Research and development initiatives that should facilitate CO2 reduction. Important to note **If Durbin-Watson value is between 1 to 3 there is no auto correlation here our value is 0.323184 so here is problem of autocorrelation we need to move to first difference method.**

Fixed effect First difference method

To remove unobserved heterogeneity first difference method is used where constant and unobserved error is also removed. Here we run OLS on first difference values.

CO2it- CO2it-1 = B1(GDPit – GDPit-1) + B2 (FDIINit – FDIINit-1) + B3(FDIO it- – FDIO it-1) +B4(CR it– CR it-1) +B5(P it – P it-1) +ε it

In this model CO2it-1 is lag value from first difference. And in the same manner lags are taken also for independent and control variables.

Table 5: fixed effect first difference method

	P-value	t-ratio	coffecients
d_GDP	0.0002 ***	3.797	3.47942e-05
d_FDI I	0.0477 **	1.993	0.0325216
d_FDI O	0.6814	0.4112	0.00625755
d_Credit	0.4261	−0.7975	−0.00433174
d_POP	0.0044 ***	2.879	1.34858e-08
Adjusted R-squared S.E of regression rho		0.116162 0.334725 0.075648 (variance in DV due to individual effect)	

***** & ** significant at p value 0.05. t-ratio value >1.96 *Ho is rejected**

Table 6: Correlation Matrix

CO2emission GDP FDIin FDIout credit POP

CO2emission	1.0000	0.5974	0.0150	0.2873	-0.0571	-0.4732
GDP		1.0000	-0.0178	0.3771	-0.1273	-0.7828
FDIin			1.0000	0.4818	-0.0344	0.101
FDIout				1.0000	0.0213	-0.3852
credit					1.0000	0.0380
POP						1.0000

** 5% critical value (two-tailed) = 0.1354 which is less than t=1.96 so r is significant

Mostly, the variables have positive relationships with the other independent variables, while credit and population have a negative relationship with dependent variable. CO2 has a positive relationship with FDI in, FDI out and GDP.

Assumptions

- The mean value of residual/error term is zero

Table 7: Mean value of residual

Fixed effect model	-2.7068e - 016
first difference method 6.5938e	013 p value <0.05 So here mean value in all models is zero.

- The error term is normally distributed.

Table 8: Results of Jarque-Bera test

Fixed effect model	Jarque - Bera test = 2.15488, with p - value 0.340465
First difference method	Jarque - Bera test = 14.5014, with p – value 0.000709689

Ho: Error term is normally distributed (accepted as p>0.05) for model 1 Ho: Error term is normally distributed (rejected as p<0.05) for model 2

- There is no autocorrelation.

Durbin Watson check autocorrelation of lag one only. So, Wooldridge test for autocorrelation in panel data is applied

Table 9: Results of Wooldridge test

Fixed effect model	Test statistic: F (1, 9) = 65.4993 with p-value = P (F (1, 9) > 65.4993) = 2.01767e-05
First difference method	Test statistic (9) = 0.603438 with p-value = P (|t| > 0.603438) = 0.561115

Null hypothesis: No first-order autocorrelation (rho = -0.5) Ho rejected in model 1 and accepted in model 2 so by **applying first difference method problem of autocorrelation is removed.**

- There is homoscedasticity in error term.

Table 10: White's test for heteroskedasticity -

Fixed effect model	Chi-square (10) = 704.514, with p-value = 6.74453e-145
First difference method	Test statistic: LM = 30.6946 with p-value = P (Chi-square (20) > 30.6946) = 0.0593529

Null hypothesis: heteroskedasticity not present rejected for FE model and accepted for FDM.

- There is no multicollinearity. (no high correlation among IDVs)

Result of Belsley-Kuh-Welsch collinearity diagnostics in both models: No evidence of excessive collinearity

- There is no endogeneity. (error term uncorrelated with IDVs)
- Stationarity: (Mean and variance is constant) All variables are stationary in combination of level and first difference by applying unit root.

Findings and Conclusion

- As results of fixed effect model GDP per capita has indirect relation with co2 emission. With the increase in GDP per capita co2 emission decreases so the study supports EKC hypothesis. Here are other studies have also reported the same relation. (Ali et al., 2015) (Yao et al., 2019) But first difference shows a positive relation with GDP per capita; and the same result is reported by (Shah et al., 2022) (Shi et al., 2019).
- The fixed effect model reported direct relation of Credit to Private non-financial sector from Banks with co2 emission. With the increase in Credit to Private non-financial sector from Banks co2 emission increases. Here are other studies have also reported the same relation. But first difference shows a no impact of Credit to Private non-financial sector from Banks on co2 emission; and the same result is reported by (Shah et al., 2022)
- As results of fixed effect model foreign Direct investment net inflow has no impact on co2 emissions reported by (Haug & Ucal, 2019) CO2 emissions per unit of energy, is not influenced by exports and imports, nor by FDI. FDI may involve the transfer of technology from the source country to the host country, which encourages more investments in renewable energy. But first difference shows a positive relation with foreign Direct investment net inflow as reported in (Shah et al., 2022) (Muhammad & Kamran Khan, n.d.) (Jayantha Kumaran et al., 2012) (Sharif Hossain, 2011)
- As results of fixed effect model foreign Direct investment net outflow has positive relation with co2 emission. But first difference shows a no relation with foreign Direct investment net outflow
- Both models are reporting positive relation of population with co2 emission. (Shah et al., 2022) reported the same relation.

Limitations of study

- Sample of study is limited to 10 countries only.
- More efficient and modern econometric methods could be applied. Here fixed and random effects are only run.
- The study solely considers five factors to determine CO2 emissions.

Policy implications

- Credit funding should be wisely distributed and directed towards low-carbon businesses and projects.
- In order to encourage financial institutions to engage in green credit activity, appropriate fiscal and taxing mechanisms should be implemented. In addition, organisations should be set up to monitor the financial impact of carbon, measure the effectiveness of credit funds.
- Several fiscal mechanisms, including as taxes, subsidies, and incentives, can be used by policymakers to encourage the gradual transition into green economy.
- FDIs will be required to bring eco-friendly technologies. Particularly, the governments must announce a reduction in environmental taxes for foreign direct investments that use environmentally responsible practises.
- The government should also inform the populace about the effects of the growing population on the environment.
- The government must update its environmental regulations and promote green economic growth.
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Future research

Future research should take into account additional factors that are inextricably linked to CO2 emissions. Between low-income and high-income nations, a comparison study could be done. Study can be conducted on the environmental regulations in various countries.

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