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Energy Economics

Connecting the Carbon Ecological Footprint, Economic Globalization, Population Density, Financial Sector Development, and Economic Growth of Five South Asian Countries

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We investigate the connection between the carbon ecological footprint, economic globalization, population density, financial sector development, and economic growth in five South Asian nations from 1971 to 2019. Using a panel autoregressive distributed lag model, we find that population density, economic growth, and economic globalization positively affect the carbon ecological footprint in the long run. However, financial development is inversely related to the carbon ecological footprint at a 10% statistical level of significance.

I. INTRODUCTION

Resource utilization on a larger scale can degrade the environmental quality and increase CO2 emissions, which create challenges for policymakers. Therefore, in recent years the global economy has been facing the dual challenge of achieving higher economic growth and low environmental degradation. Previous studies have investigated the causes of environmental degradation by considering CO2 emissions as a proxy. However, recently researchers have shifted their priority to the ecological footprint, since it is proved to be an authentic and inclusive perspective for assessing environmental degradation, as opposed to CO2 emissions, which disclose only partial information (Ahmed et al., 2021; Sarkodie, 2021).

To measure globalization, contemporary researchers have shifted their focus to economic globalization as developed by Dreher (2006). Economic globalization is measured in terms of the volumes and receipts of exports and imports, the net inflow of foreign direct investment (FDI) and foreign institutional investors, and several restrictions such as tariff rates, import barriers, taxes on exports and imports, and capital account restrictions. Theoretically, economic globalization can impact the ecological environment both positively and negatively. Economic globalization enhances environmental quality through the favorable effects of trade by transferring eco-friendly technology and FDI. On the contrary, when host countries seek FDI, they relax their environmental laws and regulations, and developed countries take these advantages and transfer energy-intensive technologies to low-income and developing countries and degrade the host countries' environment (Destek & Okumus, 2019).

The impact of financial development on environmental quality can be positive, negative, and independent, depending upon the nature of financing in the specific country. A well-developed financial system facilitates loans at a low margin to those companies that are judiciously following the environmental laws and regulations and contributing toward eco-friendly projects to reduce environmental degradation (Capelle-Blancard & Laguna, 2010). Further, an efficient financial system attracts more FDI inflow into the renewable energy sector to enhance the environmental quality in the host country. On the contrary, Sadorsky (2010) believes that financial development provides easy financing to industries. As a result, there is an increase in industrial activities, which increases carbon emissions and pollutions and diminishes the environmental quality. Zakaria and Bibi (2019) observe that environmental degradation is due to financial development in South Asian countries. Population density enhances ecological imbalances by raising traffic congestion, pollution, and excessive energy use. Bongers (2020) indicates that efforts should be put into developing environmental policies fostering emission efficiency, and not energy efficiency.

The impact of globalization and financial development on the carbon ecological footprint of South Asian countries by controlling the population density and energy consumption has critical implications for environmental sustainability. Therefore, this study investigates the dynamic short- and long-run impacts of economic globalization, financial development, population density, and economic

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growth on the carbon ecological footprint. Besides this, previous literature is based on CO2 emissions as a proxy for environmental degradation, which is a significant limitation. However, we use the carbon ecological footprint as a comprehensive indicator for environmental degradation (Dogan et al., 2020). This is the first paper that examines this relation in the context of South Asian countries, to the best of our knowledge.

II. DATA, METHODOLOGY, AND RESULTS

A. Data

The study uses data from 1971–2019 for five South Asian countries: India, Pakistan, Sri Lanka, Bangladesh, and Nepal. The variables used are the carbon ecological footprint of carbon consumption (in global hectares per capita), financial development, which is proxied by domestic credits to the private sector (*DCPS*, as a percentage of the gross domestic product, or GDP); population density (*POP*, defined as the number of people residing per square kilometer of land)' economic growth, which is a proxy of the GDP per capita (in constant 2010 US dollars); and economic globalization, measured by the KOF index of globalization (*ECGI*). Data on the carbon ecological footprint consumption per capita (*EFCCP*) are extracted from the global footprint network. The GDP per capita, financial development, and population density are sourced from World Development Indicators. All the variables are used after logarithmic transformation, to obtain consistent estimates and avoid the problem of heteroskedasticity.

We also use the ecological footprint consumption per capita total (*EFCPT*) and the total globalization index (*GI*), which consists of economic, social, and political globalization. The *EFCPT* data are collected from the global footprint network, and the *GI* is extracted from the KOF index of globalization.

B. Methodology

The rationale behind employing a panel estimation is to control for individual heterogeneity and identify unobservable characteristics (Baltagi, 2014). The data cover five countries of South Asia over 49 years, resulting in 245 observations. Since the panel of countries (N = 5) is much smaller than the number of years considered (T = 49), the generalized method of moments estimator might not be appropriate for our analysis. However, the autoregressive distributed lag (ARDL) approach is more appropriate here (since T > N in our case). To examine the short- and long-run relations, we employ a panel ARDL model (Pesaran et al., 1999). Despite the underlying regressors exhibiting I(0), I(1), or a combination of both, ARDL is superior (Pesaran & Shin, 1998).

B1. Model Specification

This study examines the connection between the ecological footprint and four exogenous variables for five South Asian countries, using different variables in four specifications. The first two specifications are in the context of two different variables, namely, the ecological footprint of consumption per capita total and the ecological footprint consumption per capita carbon. The other two specifications include different representations of the globalization index and economic globalization. However, only significant results are reported in the results section.

The general specification of the panel ARDL approach is as follows:

$$\begin{aligned} y_{it} = \alpha_i + \sum_{\tau=1}^{P} \beta_0 y_{i,t-\tau} + \sum_{\tau=0}^{q} \beta_1 \varphi_{i,t-\tau} \\ + \sum_{\tau=0}^{q} \beta_2 x_{i,t-\tau} + \sum_{\tau=0}^{q} \beta_3 \vartheta_{i,t-\tau} + \varepsilon_{it} \end{aligned} \tag{1}$$

By reparametrizing this equation, we obtain

$$\begin{aligned} \Delta y_{it} = \alpha_i + \theta_i (y_{i,t-\tau} - \mu_1 \varphi_{i,t-\tau} - \mu_2 x_{i,t-\tau} \\ - \mu_3 \vartheta_{i,t-\tau}) + \sum_{\tau=1}^{p-1} \delta'_{i\tau} \Delta y_{i,t-\tau} \\ + \sum_{\tau=0}^{q-1} \delta''_{i\tau} \Delta \varphi_{i,t-\tau} + \sum_{\tau=0}^{q-1} \delta'''_{i\tau} x_{i,t-\tau} \\ + \sum_{\tau=0}^{q-1} \delta''''_{i\tau} \vartheta_{i,t-\tau} + \varepsilon_{it} \end{aligned} \tag{2}$$

where *i* and *t* represents the country and time, respectively; *y* is the carbon ecological footprint; φ is the economic growth (GDP per capita); *x* is the economic globalization; and φ is a set of variables such as financial development and population density. The terms δ', δ'', δ''', and δ'''' are the short-run coefficients of the lagged dependent variable and other set of explanatory variables. The long-run coefficients are μ_1, μ_2, and μ_3 for the corresponding explanatory variables, as defined above. Lastly, θ_i represents the speed of adjustment.

C. Results and Discussions

C1. Preliminary Tests

The study finds the descriptive statistics and correlation matrix and runs the structural breakpoint test, panel unit root test, and cross-sectional panel dependency test.

Table 1 reports the descriptive statistics of the variables, where the coefficient of skewness is negatively skewed for the carbon ecological footprint, the domestic credit to the private sector, and economic globalization, and the rest of the variables are positively skewed. The kurtosis coefficient is high for the GDP, and financial development (FD) indicates heavier tails than a normal distribution. This result is further strengthened by the Jarque–Bera (JB) test for normal distribution. The JB test rejects the null hypothesis of normality for all the variables.

A pairwise highly positive association is found between the carbon ecological footprint and financial development, the carbon ecological footprint and economic growth, the carbon ecological footprint and economic globalization, and, finally, between economic globalization and economic growth (Table 2).

A panel unit root test is used to check the unit root properties of the variables and their corresponding order of integration. The Im–Pesaran–Shin (IPS) and Levin–Lin–Chu

Table 1. Descriptive Statistics

	EFCCP	FD	POP	GDP	ECGI
Mean	-1.80	3.04	5.62	6.57	3.29
Median	-1.74	3.17	5.55	6.53	3.36
Max.	-0.35	4.17	7.12	8.29	4.02
Min.	-3.89	0.65	4.35	5.60	2.42
S. D	0.84	0.70	0.69	0.62	0.41
Skewness	-0.52	-1.05	0.44	0.69	-0.31
Kurtosis	2.46	4.62	2.56	3.04	2.03
JB	14.29	72.55	9.93	19.66	13.46
Prob.	0.00	0.00	0.00	0.00	0.00

Notes: This table shows the descriptive statistics. None of the variables follow the normal distribution.

Table 2. Correlation Matrix

Variables	EFCCP	FD	POP	GDP	ECGI
EFCCP	_				
FD	0.77 (0.00)	_			
POP	0.15 (0.01)	0.14 (0.02)	_		
GDP	0.84 (0.00)	0.58 (0.00)	0.22 (0.00)	_	
ECGI	0.77 (0.00)	0.64 (0.00)	0.15 (0.01)	0.85 (0.00)	_

Notes: This table shows a high positive correlation between (a) carbon ecological footprint and financial development, and (b) economic growth and economic globalization. ( ) indicates *p*-values.

Table 3. Panel Unit Root Test Results

Variables	LCC		IPS		Fisher-ADF		Fisher-PP	
	Level	First Difference	Level	First Difference	Level	First Difference	Level	First Difference
FD	-2.42* (0.00)	-7.53* (0.00)	-0.58 (0.28)	-8.09* (0.00)	-0.15 (0.28)	-7.50* (0.00)	-0.38 (0.34)	-10.72* (0.00)
EFCCP	0.37 (0.64)	-4.46* (0.00)	2.82 (0.99)	-8.25* (0.00)	2.81 (0.99)	-7.43* (0.00)	2.95 (0.99)	-10.13* (0.00)
GDP	6.64 (1.00)	-1.68** (0.04)	10.19 (1.00)	-6.50* (0.00)	8.57 (1.00)	-6.23* (0.00)	9.67 (1.00)	-10.78* (0.00)
ECGI	-1.59** (0.05)	-8.50* (0.00)	-2.20 (0.41)	-8.43* (0.00)	-0.16 (0.43)	-7.56* (0.00)	-0.01 (0.49)	-9.45* (0.00)
POP	-3.79* (0.00)	6.43 (1.00)	-0.39 (0.34)	5.34 (1.00)	-1.88** (0.02)	4.94 (1.00)	-8.13* (0.00)	4.89 (1.00)

Notes: This table shows the panel unit root test results. All the variables are stationary at different orders of integration. Parenthesis ( ) indicates the *p*-values, * and ** indicate the variables are significant at the 1% and 5% level of significance.

(LCC) unit root tests assume cross-sectional independence. Table 3 reports that the variables of interest have both non-stationary and stationary characteristics. However, based upon unanimous results, it can be concluded that all the variables achieve stationarity for different orders of integration, such as I(0) and I(1), making the case stronger for applying the panel ARDL model.

The structural breakpoint test is conducted by creating five structural dummies for the five respective countries, which are then introduced into the panel ARDL equation. Since the dummies turn out to be statistically nonsignificant, we do not tabulate the results here. Panel A of Table 4 presents the long- and short-run results of the panel ARDL model. The coefficients are estimated by using the pooled mean group method. The pooled mean group test restricts

Table 4. Panel ARDL Results

Part A: Long-run Result				
Variables (in log)	Coefficient	S. E	t-stat.	Prob.
FD	-0.24	0.12	-1.87	0.06
POP	1.79	0.38	4.70	0.00*
GDP	0.67	0.13	4.96	0.00*
ECGI	0.91	0.26	3.42	0.00*
Short-run Result				
Variables	Coefficient	S. E	t-stat.	Prob.
ECM	-0.19	0.07	-2.68	0.00*
D(EFCCP (-1))	-0.05	0.04	-1.15	0.24
D(FD)	0.01	0.04	0.36	0.71
D(FD (-1))	0.03	0.04	0.75	0.45
D(POP)	6.62	4.46	1.48	0.13
D(POP (-1))	-2.65	5.20	-0.51	0.61
D(GDP)	0.13	0.65	0.21	0.83
D(GDP (-1))	-0.25	0.33	-0.76	0.44
D(ECGI)	0.05	0.11	0.44	0.65
D(ECGI (-1))	-0.07	0.04	-1.68	0.09
C	-3.86	1.52	-2.52	0.01

Part B: Cross-Sectional Dependency Test: No cross-sectional dependency found over the study period		
	Statistics	Prob.
Pesaran CD Test	1.90	0.06
Residual (Normality) JB Test	60.33	0.00

Note: This table shows the panel ARDL results. These results indicate convergence in the long run. The dependent variable is EFPCC. * denotes the level of significance at 1%.

long-run equilibrium to be homogeneous across countries while allowing heterogeneity for the short-run relation (Asteriou et al., 2021).

We find that population density, economic growth, economic globalization, and financial sector development positively and statistically impact the carbon ecological footprint in the long run. However, none of the variables turns to be statistically significant in the short run. The error correction term is negative and statistically significant at the 1% level, which indicates convergence in the long run. The coefficient of the error correction term indicates that about 19% of adjustment toward the long-run equilibrium occurs within one year. In the short run, economic globalization harms the carbon ecological footprint at the 10% level of significance.

C2. Diagnostic Statistics

The ARDL method neglects contemporaneous correlation across countries caused by unobserved factors. However, ignoring these factors can lead to less consistent parametric and non-parametric estimators (Baltagi, 2014). This is shown from the CD test (Pesaran) result, reported in Panel B of Table 4. The results assume that there is no cross-sectional dependency among the nations over the study period. The diagnostic test results from the JB test of the residual confirms that the model is free from normality and other omitted variables bias. Therefore, the model is well suited for our analysis.

III. CONCLUSION

We attempt to connect the carbon ecological footprint, economic globalization, population density, financial sector development, and economic growth in five South Asian countries from 1971 to 2019. By using a panel ARDL model, we find that population density, economic growth, and economic globalization have a positive and statistically significant impact on the carbon ecological footprint in the long run, whereas, in the short run, economic globalization harms the carbon ecological footprint at the 10% level of significance. Future studies could explore asymmetric methodologies to provide better estimates of the driving factors of the carbon ecological footprint of South Asian countries.

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