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The Implications of Ecological Footprint for EKC Hypothesis by Considering Cross-section Dependence and Heterogeneity

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ABSTRACT

"Ecological Footprint" is increasingly being used as a stand-in for environmental deterioration in current energy, environment, and growth literature. By including ecological footprint together with other independent variables such as energy usage, GDP, trade, and urbanization for a few Asian nations between 1990 and 2018, this analysis adds to the body of current work. Findings support panel heterogeneity and cross-sectional dependency. The study established a long run cointegration relationship among variables. The findings of the FMOLS study show that actual income has a favorable effect on ecological footprints. For a few Asian nations, we find no support for the EKC theory. The results of this research provide a clearer understanding of how the economic factors and ecological footprint interact. Energy efficiency initiatives should be implemented in these nations to encourage energy saving and the use of renewable energy to reduce environmental effects. Moreover, plans to boost the economies of the Asian region's nations' revenue-generating industries are advised.

1 Introduction

The Ecological Footprint is a useful tool for measuring the environmental impact of human activities. According to the Global Footprint Network (2021), humanity's ecological footprint exceeds the planet's biocapacity by 56%, indicating an unsustainable rate of resource consumption and waste production. In 2020, Earth Overshoot Day, the date on which humanity had used up its annual allotment of natural resources for the year, fell on August 22, the earliest date ever recorded (Earth Overshoot Day, 2020). The average American's Ecological Footprint is approximately 8.4 global hectares (gha), while the global average is around 1.7 gha. This means that if everyone in the world consumed resources at the same rate as the average American, we would need the resources of over five Earths to sustain us (Global Footprint Network, 2021). A typical household in the United States has an Ecological Footprint of around 28 gha, nearly three times the global average, due to high energy consumption, large homes, and high car usage (Center for Sustainable Economy, 2019). Comparing the Ecological Footprints of different countries shows the stark difference in environmental impact between developed and developing countries (Global Footprint Network, 2021).

These facts and figures highlight the urgent need for sustainability and reducing our ecological footprint to ensure the ability to meet our needs without compromising the ability of future generations to meet their own needs. Economic activities play a significant role in affecting the global environment. Since the mid-20th century, the main contributing factor to increases in the Earth's temperature has been emissions caused by economic activities (IPCC, 2018). Environmental degradation has been considered a major challenge for human survival on Earth due to deforestation, increases in temperature, harmful impacts on agricultural output, and rises in sea level (Nathaniel et al., 2019).

The human demand on the environment is known as the ecological footprint (Yasin et al., 2019; Wackernagel et al., 2019), which can be tracked using an environmental accounting system. This system analyzes how much it costs to create and dispose of the resources we consume, in addition to redefining growth. Moreover, fossil fuel pollution contributes to global warming, which causes floods and other weather catastrophes (Perkins, 2017). The Environmental Kuznets Curve (EKC) hypothesis indicates "an inverted U-shaped relationship between per-capita income and pollution" levels. In the short run, working with the same technology is the main outcome of the falling returns of capital in the manufacturing of industrial goods consumption, and the real divisibility of production and consumption is becoming the main reason for the EKC hypothesis. Hence, further explanation can be found in studies by Andreoni & Levinson (2001), Brock & Taylor (2010), and Plassmann & Khanna (2006).

The proposition of the EKC has been analytically studied by a number of economists and analysts for different economies and regions. Each study has used different measures of pollution, different techniques and methods for analysis, and types of proxies for income. Some studies have taken carbon emissions as an indicator of environmental degradation, such as Friedl & Getzner (2003), De Bruyn et al. (1998), Lindmark (2002), and Zarzoso & Morancho (2004), who have confirmed the EKC hypothesis. However, some studies, such as Anjum et al. (2014), Cole (1997), Lee et al. (2009)

Anjum et al. (2014), Cole (1997), Lee et al. (2009), and Shafik & Bandyopadhyay (1992) have concluded that there is no confirmation of the EKC hypothesis. In panel estimations, we found mixed results. For example, studies conducted for low-income countries (Omri, 2013; Taguchi, 2012) and for BRICS nations (Pao & Tsai, 2010; Tamazian et al., 2009), as well as studies by Stern & Common (2001), have produced different findings. Some studies are of the view that there is a unidirectional causal association between CO2 emissions and income that has no proof of the "inverted U association between income" of the country and environmental degradation studied by Arrow and Berdhai (1995). A number of studies found significant results of causality among the indicators of the environment and per capita income identified by Chen & Huang (2013), Coondoo & Dinda (2002), and Lee et al. (2009). However, both variables CO2 emissions and income, when applying OLS while taking income as a dependent variable, result in biased and insignificant results examined by Stern (2004). Some studies used the technique of simultaneous equations and calculated the hypothesis of EKC by applying a number of statistical tools and proxies while taking income as an endogenous variable (Omri et al., 2014; Liu, 2005; Omri, 2013). Halkos (2003) examined a panel model while taking the lag of the endogenous variable for the short-term equilibrium of CO2 emissions.

The consideration of an indicator of environmental quality to investigate EKC can remain a problem for empirical analysis (Ulucak and Apergis, 2018) as CO2 is mainly used as an ecological indicator. The link is, however, required to be reinvestigated by indicating a comprehensive measure of degradation to capture the entire impact of human actions on the environment in response to an increase in the income level (Gill et al., 2018; Dasgupta et al., 2002; Stern, 2014; Kaika and Zervas, 2013). As a result, "ecological footprint" could be an additional element "of the EKC concept" to consider total ecological loss. "Ecological footprint" incorporates six indicators: carbon footprint, woodland, cropland, fishing grounds, built-up, and grazing land (Lin et al., 2018). While pollution is the main worldwide problem, Asian developing countries are an important case explored for a variety of reasons. In fact, air pollution is a serious issue in Asian developing countries. The World Health Organization states that two-thirds of the worldwide deaths caused by air pollution happen in Asian countries. The World Air Quality Report (2018) shows that Asian developing countries, including China, India, Thailand, Pakistan, and Bangladesh, have the most polluted cities in the world. Fossil fuels burning and outdated vehicles with poor maintenance are the key causes of air pollution in Asian developing countries (Cervero 2000).

The hypothesis of the Environmental Kuznets Curve (EKC) proposes that environmental degradation initially increases with economic growth, but eventually, economic growth leads to an improvement in environmental quality. The relationship between economic growth and ecological footprint has been investigated in several studies. For example, a study examined the relationship between economic growth and ecological footprint in China using ecological footprint analysis. The study found that China's ecological footprint increased with economic growth from 1992 to 2014, but the increase slowed down after 2005, (Dong et al., 2020). Another study used ecological footprint analysis to investigate the relationship between economic growth and ecological footprint in the United States. The study found evidence of an EKC relationship for some ecological footprint indicators (Wu et al., 2020). However, some studies have found limited or mixed evidence for an EKC relationship. For example, a study found no evidence of an EKC relationship between economic growth and ecological footprint in Vietnam (Le & Nguyen, 2021).

In conclusion, while some evidence suggests the existence of an EKC relationship between economic growth and ecological footprint, more research is needed to fully understand the complex interactions between economic growth, environmental quality, and sustainability.

The study is credible in many ways. First, earlier studies related to CO2 emissions were employed as a measure of environmental deterioration in Asia. This study uses EF as a measure of environmental quality, which is better than CO2 since just the atmosphere cannot cover the adverse impacts of social actions (Nathaniel et al., 2019; Bello et al., 2018). Second, to estimate unbiased and efficient results, we use the "cross-sectional dependence (CD) test." We employ traditional and "second-generation unit root" and co-integration tests. Third, we use the "Augmented Mean Group (AMG)" estimation method to address country-specific heterogeneity and CD, which is an addition to previous literature.

The rest of the paper is organized as follows: Section 2 discusses the literature review, section 3 presents the model and methodology, section 4 describes the data analysis and findings, and section 5 reports the conclusion and any policy implications.

2 Literature Review

2.1 Ecological footprint GDP growth and energy use

Recent research has continued to examine the relationship between ecological footprint, GDP growth, and energy use. Many studies have found a strong association between economic growth and higher ecological footprints, as well as between energy consumption and ecological footprint. For instance, Wang et al. (2021) found that economic growth is a significant driver of ecological footprint in China, while Guan et al. (2020) discovered a similar relationship in the United States. While Wang and Zhou (2021) found that energy consumption is positively associated with ecological footprint in China.

However, some research has suggested that there is evidence of decoupling between economic growth and ecological footprint, indicating that economic growth can be achieved without increasing ecological footprint. For example, Miao et al. (2021) found evidence of relative decoupling between economic growth and ecological footprint in China.

Studies have emphasized the need for sustainable development strategies that promote economic growth while reducing ecological footprint. Wang and Sun (2021) found that energy efficiency and technological innovation are effective ways to decrease ecological footprint in China. Similarly, Ren et al. (2020) suggested that renewable energy development can help to reduce both energy consumption and ecological footprint.

Overall, the latest literature suggests that the relationship between ecological footprint, GDP growth, and energy use is complex and multifaceted. While economic growth and energy consumption are often associated with higher ecological footprints, there is evidence of decoupling and potential for sustainable development strategies to mitigate ecological impact.

2.2 Ecological footprint and urbanization

Urbanization is a significant driver of ecological footprint, with cities responsible for a considerable portion of global energy consumption and greenhouse gas emissions. Recent research has investigated the relationship between urbanization and ecological footprint, emphasizing the need for sustainable development strategies that can mitigate the environmental impact of urban areas.

Studies have consistently found a positive correlation between urbanization and ecological footprint. For example, Wang et al. (2020) found that urbanization is a critical factor driving ecological footprint in China, while Ali et al. (2021) reported similar results in Pakistan.

Despite this, some research suggests that sustainable urban development is possible, and that urban areas can reduce their ecological footprint. For instance, Guo et al. (2020) demonstrated that compact urban form and public transportation can reduce energy consumption and carbon emissions in Chinese cities, while.

Sustainable urban planning and policy are also essential in reducing ecological footprint. Wu et al. (2020) recommended promoting energy efficiency, renewable energy, and green transportation in urban areas, while Shrestha and Rasul (2020) highlighted the importance of integrated land use and transportation planning for sustainable urban development.

Overall, the latest literature indicates that urbanization has a substantial impact on ecological footprint, but sustainable development strategies and policies can reduce this impact and promote a more sustainable urban future.

2.3 Ecological footprint and trade

The ecological footprint of international trade has become an increasingly important area of research, as globalization and international trade have resulted in complex supply chains and increased global resource consumption. The concept of embodied emissions, which considers the environmental impact of producing goods in one country but consuming them in another, has emerged as a key aspect of the relationship between ecological footprint and trade.

Studies have shown that trade can have a significant impact on the ecological footprint of countries. For example, Zou et al. (2020) found that trade was a major contributor to China's ecological footprint, with the country's carbon footprint being significantly influenced by its exports. Similarly, Lenzen et al. (2018) found that international trade accounted for over a quarter of global greenhouse gas emissions, with emissions embodied in international trade growing faster than those from domestic production.

However, some research suggests that trade can also have positive environmental effects. For instance, Zhang et al. (2020) argued that international trade can facilitate the transfer of green technologies and promote sustainable development in developing countries. Similarly, Wang and Li (2019) found that trade can lead to environmental upgrading in China's manufacturing sector, as firms are incentivized to adopt cleaner production technologies to meet the environmental standards of export markets.

The latest literature on ecological footprint and trade emphasizes the need for policy interventions to ensure that trade is environmentally sustainable. For example, Zhang et al. (2020) recommended promoting green trade policies, such as eco-labelling and green procurement, to encourage sustainable production and consumption. Similarly, Lenzen et al. (2018) suggested implementing carbon tariffs to address the environmental impact of embodied emissions in trade.

Overall, the latest literature indicates that trade has a significant impact on the ecological footprint of countries, with embodied emissions playing a critical role in this relationship. While trade can promote sustainable development, policy interventions are necessary to ensure that trade is environmentally sustainable.

3 Model and Methodology

For the study of EKC theory, our model is based on (Bilgili et al., 2016; Álvarez-Herránz et al., 2017; Li & Lin, 2015; Lin et al., 2016). The econometric model is given as:

$$EF_{it} = b_0 + b_1 EC_{it} + b_2 GDP_{it} + b_3 GDP_{it}2 + b_4 UR_{it} + b_5 TO_{it} + \mathcal{E}_{it} \qquad \ldots\text{(i)}$$

In the above equation (1) terms b0 & $\mathcal{E}_t$ show the constant and error term while the EF, EC, GDP, UR and TO show "ecological footprint, energy use, economic growth", urbanization, and openness of trade, respectively. While the "b0, b1, b2, b3, b4 and b5" are the parameters of the variables. We take the data from 1990 to 2019, as most of the data are available since 1990, and it is collected from WDI and the Global footprint network. Natural log is applied to interpret the parameters in terms of elasticities. The data in log form is given as.

$$\ln(EF)_{it} = b_0 + b_1 lnEC_{it} + b_2 lnGDP_{it} + b_3 lnGDP_{it}2 + b_4 lnUR_{it} + b_5 lnTO_{it} + \mathcal{E}_{it} \qquad \ldots\text{(ii)}$$

The main reasons of the of the "environmental degradation in Asian countries" are the increase in economic and developmental activities which are alarming and the gap among both the factors i.e. biocapacity and ecological footprint become wider and wider. Therefore, the study intends to examine EKC theory "using ecological footprint as dependent variable."

The analysis is conducted in three steps, first we use the panel unit root test to check the stationary of the data. Panel unit root tests are used to address the problem of the spurious regression. If the variable is not stationary at level, we take first difference of the data. Cointegration analysis is used to examine the long-run relationship between variables. (K ao, 1999; Pedroni, 1999, 2004). It is assumed that there is no cointegration. The test is formulated as follows.

$$Y_{it} = \alpha_{it} + \delta_{it} t + \beta_i X_{it} + e_{it} \qquad \ldots\text{(iii)}$$

$$Y_{it} = \beta \Delta X_{it} + \acute{\eta}_{it} \qquad \ldots\text{(iv)}$$

In equation (iii) Y is explanatory variable, X is independent variable, α is constant effect, e is the error terms' and t shows trend of the variable. While the equation (iv) represents the linear regression from where the residuals are estimated.

Another test is applying 2nd cointegration test developed by (Kao, 1999) are also conducted to evaluate the (Pedroni, 2004, 1999) cointegration test. For this purpose, the generalize Dickey-Fuller test we applied which are given in equation (v) where μ's are the residuals, σ and C are coefficients of Unit root test. The ADF tests' formula is given in equation (vi).

$$\mu_{i,t} = \sigma\, \mu_{i,t} + \sum_{i=1}^{n} \mathrm{C} j\, \Delta\mu_{i,t-1} + \epsilon_{it} \qquad \ldots\text{(v)}$$

$$ADF = \frac{\left(t_{ADF} + \sqrt{\frac{6N\theta_v}{2\theta_{0v}}}\right)}{\sqrt{\left(\frac{\theta_{0v}^2}{2\theta_v^2}\right) + \left(\frac{3\theta_v^2}{10\theta_{0v}^2}\right)}} \qquad \ldots\text{(vi)}$$

In 3rd step we analyse cointegration coefficients empirically. For most precise results, the two popular tests are used in panel data analysis to address the problems of endogeneity and autocorrelation amongst error term and independent variables. These are formulated in equation (vii) and (viii), based on (Pedroni, 2000, 2001) called the "Fully Modified Ordinary Least Square and Dynamic Ordinary Least Square". Each estimator is formed for the justification of EKC theory and use to examine the effect of energy use, GDP, urbanization, and openness of trade on the ecological footprint.

$$\hat{\beta}_{FMOLS} = \left[\frac{1}{N}\sum_{i=1}^{N}\{\sum_{t=1}^{T}(\mathcal{X}_{it} - \bar{\mathcal{X}}_i)^2\}\right] \times \left[\{\sum_{t=1}^{T}(\mathcal{X}_{it} - \bar{\mathcal{X}}_i)\widehat{EF}_{it} - T\hat{\Delta}_{\epsilon\mu}\}\right] \qquad \ldots\text{(vii)}$$

$$\hat{\beta}_{DOLS} = \left[\frac{1}{N}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\mathcal{X}_{it}\acute{\mathcal{X}}_{it}\right)^{-1}\left(\sum_{t=1}^{T}\mathcal{X}_{it}\widetilde{EF}_{it}\right)\right] \qquad \ldots\text{(viii)}$$

In the above equation EF is dependent variable while X are the independent variables. Due to the very rigorous methods of (FMOLS) and (DOLS) it might not be the good decision to formulate any good results while dealing with panel data. That is the reason for cross-sectional data analysis the newly modified technique is used by (Bond & Eberhardt, 2013; Eberhardt & Teal, 2010) called Augmented Mean Group (AMG), which has two approaches for the regression analysis given in the following equations;

$$\Delta EF_{it} = \acute{b}\Delta\mathcal{X}_{it} + \sum_{t=2}^{T} C_t \Delta D_t + \mu_{it} \qquad \rightarrow \qquad \hat{C}_t \equiv \hat{\mu}_t$$

$$EF_{it} = a_i + \acute{b}_i\mathcal{X}_{it} + C_i t + d_i\hat{\mu}_t + \mu_{it} \quad \hat{b}_{AMG} = N^{-1}\sum_i \hat{b}_i \qquad \ldots\text{(ix)}$$

In the above equation Δ' $\mathcal{X}$, and b show difference, independent variables and parameters of independent variable, respectively. While, D_t is dummy variable which covers the gaps in the data, C_t is the parameter of the dummy variables, μ is the error term whereas N and T are the numbers of observation and cross-sections. The estimated AMG technique study the heterogeneity and issue of cross-sectional dependence, the key issue while dealing with panel estimation (Baltagi, 2015; Coakley et al., 2006).

4 Analysis and Results

Section 4 discusses data analysis and results.

Table 1

Correlation Matrix

	EF	EC	GDP	TO	UR
EF	1				
EC	0.17	1			
GDP	0.02	-0.25	1		
TO	0.44	0.84	-0.14	1	
UR	0.13	0.78	-0.21	0.90	1

Correlation matrix shows the strength of the relationship of variables. Table 1 shows the correlation among variables. Results indicate that EC and ecological footprint, are positively correlated.

Now the study utilizes the "cross-sectional dependence test (CD-test) developed by Pesaran". Results in table 2 confirm "cross-sectional dependence for panel data."

Table 2

Cross Sectional Dependence

EF	EC	GDP	TO	UR

CD-test	4.76***	2.00**	17.32***	11.34***	7.32***
p-value	0.000	0.003	0.000	0.000	0.000

** and *** show 5% and 1% significance level.

Moreover, we use “(Hashem Pesaran & Yamagata, 2008)” slope homogeneity test which is based on the estimated “delta and the adjusted delta.” The results suggest that heterogeneity exists across the panel, rejecting the null hypothesis.

Table 3

Homogeneity Test

	EF	EC	GDP	TO	UR
Delta	32.66***	18.68***	37.98***	15.23***	56.56***
Adj Delta	33.26***	20.24***	39.65***	17.56***	58.72***

*** show “1% significance level.”

Table 4 shows the results of the panel unit root test “(LLC, PP-Fisher, and CIPS)”. The “CIPS unit rot test is used when there exist heterogeneity and cross-sectional dependence” across sample countries (Pesaran, 2007).

Table 4

Results of Unit Root Tests

	Level			1st Diff		
	“LLC”	**“PP-Fisher”**	**“CIPS”**	**“LLC”**	**“PP-Fisher”**	**“CIPS”**
EF	-0.32	3.87	-0.65	-12.45***	63.87***	-3.76***
EC	-1.79	5.84	-1.76	-6.43***	67.98***	-4.65***
GDP	3.37	7.32	-2.21	-4.43***	80.22***	-3.43***
TO	1.56	4.87	-1.28	-8.45***	65.12***	-3.34***
UR	-0.98	6.43	-0.43	10.49***	72.65***	-4.87***

*** show 1% significance level.

“Results related to Panel cointegration test are shown in Table 5. The cointegration tests “developed by Kao (1999) and Westerlund (2005)” validates the findings of Pedroni (1999, 2004) cointegration test. The results of the robustness control are shown in Table 5. Cointegration results show the cointegration relationship between analyzed variables.

Table 5

Panel Cointegration

	Stat	P-value	Weighted Stat	P-value
Panel v-stat	-3.45***	0.00	-4.76***	0.00
Panel rho-stat	-4.65***	0.00	-3.45***	0.00
Panel-PP-stat	-4.32***	0.00	-3.78***	0.00
Panel ADF-stat	0.76	0.11	0.83	0.45
Kao (1999)	-3.73***			0.00
Westerlund (2005)	-2.84***			0.00

*** show 1% significance level.

The findings of FMOLS, DOLS and AMG are given in table 6. As we have taken the log of the data so we can interpret long run coefficient in terms of elasticities. We find consistent results in terms of signs of coefficients. However, trade is insignificant in DOLS and AMG results, and FMOLS and DOLS have insignificant results in case of urbanization. Rising real income has a significant effect on Asians' EF, according to FMOLS. So, the EKC hypothesis is not existed for selected Asian economies. As GDP and Square GDP is negative and positive. So, we cannot find EKC hypothesis in Asian countries. Our results are in line with the studies (Al-Mulali & Ozturk, 2016; Pal & Mitra, 2017). EC has positive sign in all estimators, so it indicates negative impact of energy use on environment. (Shafiei & Salim, 2014; Inglesi-Lotz & Dogan, 2018);

Table 6

Long Run Results

	"FMOLS"		**"DOLS"**		**"AMG"**	
	Coeff	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**
EC	0.76***	3.76	0.65***	5.72	0.45***	2.76
GDP	-0.23***	-15.43	-0.18***	-11.43	-0.45***	-3.45
GDP^2	0.03***	4.32	0.05***	4.43	0.21***	4.43
TO	0.76	1.72	0.32***	2.34	0.65	0.98
UR	-0.32	-1.43	-0.21	-1.45	-0.43***	-2.65

*** shows 1% significance level.

The causality granger test was employed in this work to determine the causal link between variables. Table 7 shows the results of the panel granger causality test and the two-way causal relationship between TROP and GDP. The findings show a "one-way causal relationship between ecological footprint and GDP", EC and GDP, energy consumption and GDP, urbanisation and energy consumption, and urbanisation and TROP.

Table 7

Pairwise Dumitrescu Hurlin Panel Causality Tests

Hypothesis	**W-Stat**	**P-value**	**Decision**
EC→ EF	0.5911	0.1305	No
EF →EC	2.2743	0.8901	No
GDP →EF	1.0703	0.2973	No
EF →GDP	4.7652	0.0099	Yes
TO →EF	0.5448	0.1194	No
EF →TO	6.1248	0.000	Yes
UR →EF	2.1149	0.9856	No
EF →UR	0.9323	0.2390	No
GDP →EC	1.2917	0.4093	No
EC →GDP	5.4137	0.0013	Yes
TO →EC	5.1797	0.0028	Yes
EC →TO	2.3991	0.7944	No
UR →EC	4.4752	0.0217	Yes
EC →UR	3.1391	0.3241	No
TO →GDP	5.1931	0.0027	Yes
GDP →TO	3.8801	0.0868	Yes
UR →GDP	7.0211	0.000	Yes
GDP →UR	2.1807	0.9630	No

UR →TO	10.6965	0.0000	Yes
TO →UR	3.0150	0.3873	No

"

5 Conclusion and Commendations

CO2 emissions are often used as a proxy for environmental degradation in the energy and environment literature. However, the present study uses ecological footprint to measure environmental quality, thereby filling a gap in the existing literature. This study extends previous research by examining the Environmental Kuznets Curve (EKC) proposition for selected Asian countries (China, India, Japan, Pakistan, Bangladesh, Philippines, Vietnam, Turkey, Indonesia, and Malaysia) from 1990 to 2018, using ecological footprint as well as various independent variables such as energy use, GDP, trade, and urbanization.

The results indicate a positive correlation between energy consumption and ecological footprint, which is consistent with previous research (Fang et al., 2015; Yamamoto et al., 2016; Silva et al., 2016). We used the cross-sectional dependence test (CD-test) developed by Pesaran and found evidence of cross-sectional dependence for panel data. Additionally, we used the homogeneity test from Pesaran and Yamagata (2008) and found heterogeneity between panels. The cointegration link between the variables under study is further supported by cointegration findings. However, the FMOLS and DOLS tests provide statistically insignificant findings for commerce and urbanization, respectively.

According to the FMOLS findings, an increase in GDP has a statistically significant effect on ecological footprint. Thus, the EKC theory does not apply to several Asian nations. The Granger Causality Test showed a two-way causal relationship between TROP and GDP, which was confirmed by a panel Granger causality test. The results also show a unidirectional causal link between ecological footprint and GDP, EC (ENC) and GDP, urbanization and energy use, and urbanization and TROP.

The study's findings suggest launching energy efficiency initiatives in these nations to increase energy efficiency, particularly with regard to petroleum energy, and to promote the use of renewable energy sources to reduce environmental impact. It is also recommended that policies be adopted to boost the GDP of the Asian region's nations by expanding their revenue-generating industries. The results suggest that urbanization decreases the ecological footprints of regions; hence, policymakers should support urbanization plans that can help reduce environmental degradation.

However, the essential political and social awareness variable was not considered in this study's estimation procedure. Therefore, it is suggested that future research should take into account these economic variables and estimate the ecological impact. The results of this study may help in better understanding how ecological footprint and economic variables combine to cause overall environmental degradation.

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