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Investigating the Dynamic Impact of FDI Inflows and Economic Growth on Environmental Degradation: Evidence From FMOLS and DOLS for Selected Asian Countries[1]

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Abstract

The study examines the dynamic relationship between foreign direct investment (FDI) inflows, economic growth, and environmental degradation and investigates the long-run validity of the environmental Kuznets curve (EKC) and the pollution haven hypothesis (PHH) for selected Asian countries over the period 1990–2019. Additionally, this study aims to discover the long-run impact of energy consumption, globalization, and population density on environmental degradation by employing a panel cointegration approach, fully modified ordinary least squares (FMOLS), and dynamic ordinary least squares (DOLS). The findings provide clear evidence of the existence of EKC and PHH in Asian countries for the period 1990–2019 in the long run. The findings reveal that economic growth has a highly significant and positive role in depleting environmental quality, but this effect gets reversed in the long run as, after a certain turning point, economic growth increases, and the quality of the environment gets better. Moreover, FDI inflows and energy consumption have a positive long-run impact on CO_2 emissions, thus contributing to environmental degradation. The study recommends that governments and policymakers should strategically devise and implement CO_2 reduction policies, such as carbon pricing, to encourage economic growth and to improve the quality of the environment, with the ultimate goal being to achieve sustainable development. Moreover, the use of cleaner energy should be promoted, and innovations and technological developments should be encouraged for hydropower, wind power, solar energy and other facilities around the world.

Keywords: environmental Kuznets curve, pollution haven hypothesis, environmental degradation, panel cointegration approach, fully modified ordinary least squares (FOLS), dynamic ordinary least squares (DOLS)

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Introduction

One of the biggest concerns among academics, environmentalists, scientists, policymakers, and governments is how to cope with challenges and threats posed by climate change. Greenhouse gases (GHGs) which contribute to global warming, have polluted the environment such that breathable air and drinkable water have become scarce. Climate change poses a great threat to all species and is affecting the planet dreadfully and dangerously at an alarming rate. Some of the proven impacts of climate change are warmer weather, rising temperatures, extreme rainfalls, floods, droughts, rising sea levels, and melting glaciers (directly affecting the freshwater ecosystem, hydropower, agriculture, and sanitation, which are among the necessities of human survival). Thus, the challenge for governments and societies is how to deal with threats posed by climate change in the context of ongoing economic development [Chowdhury, Moran, 2012].

States need economic production to achieve sustainable development, which at present comes through energy consumption and the burning of fossil fuels. This in turn produces significant emissions of GHGs. The most frequently emitted GHGs are carbon dioxide (CO_2, released from burning fossil fuels), methane (CH_4, released from production and transportation of oil, gas and coal), and nitrous oxide (N_2O, released from industrial and agricultural activities). Moreover, gases with a high global warming potential, known as fluorinated gases, are also emitted during industrial processes [IPCC, 2014]. Thus, economic growth comes at the cost of the environment.

In their noteworthy study of the environmental impacts of the North American Free Trade Agreement, G.M. Grossman and A.B. Kruger [1991] developed what became known as the environmental Kuznets curve (EKC) hypothesis to explain the relationship between economic growth and environmental quality. The EKC hypothesis posits that the environment tends to degrade as per capita income rises up to a certain level, after which the environment tends to improve as per capita income further rises, reflecting an inverted U-shaped relationship between economic growth and environmental pollution [Sapkota, Bastola, 2017]. Graphically, the concept of the EKC hypothesis is shown in Figure 1.

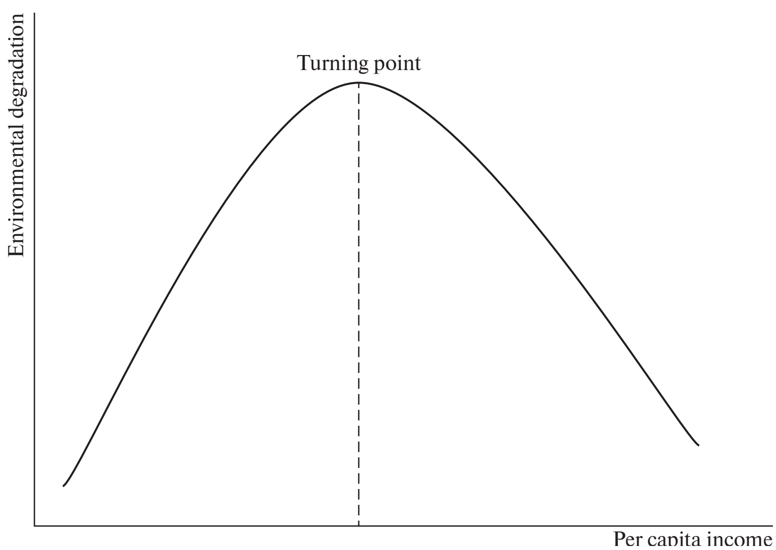

Fig. 1. Environmental Kuznets Curve

Source: Prepared by the authors.

Foreign direct investment (FDI) is an important contributor to sustainable development. FDI inflows are an important source of income that generates employment in developing and emerging economies, and it is welcome as a result. Generally, regulatory costs play a vital role in determining the level of FDI inflows and outflows from developed to developing countries or vice versa [Busse, Groizard, 2006] and these are higher for pollution-intensive firms in developed countries relative to developing countries. As a result, competition among countries to attract FDI can lead to environmental degradation [Bokpin, 2017] as these countries offer more attractive, flexible environmental policies. The lower regulatory costs and flexible environmental policies in developing countries create an incentive for pollution-intensive industries to shift to developing states to avoid higher regulatory costs and stringent environmental regulation. This is known as the Pollution Haven Hypothesis (PHH), developed by B.R. Copeland and M.S. Taylor [1994], which describes the logic of developed states physically investing in developing countries because they tend to have lower environmental standards and weak enforcement.

This study is focused on Asian countries and in this regard, the Carbon Dioxide Information Analysis Centre (CDIAC) reports that Asian countries are among the highest CO_2 emitting countries [Boden, Marland, Andres, 2017]. As developing countries grow, their CO_2 emissions also tend to grow; this is a matter of concern in the context of international environmental agreements such as the Kyoto Protocol,[2] which are working to overcome problems related to GHGs and global warming. Figure 2 shows the CO_2 emissions trends in developing Asian countries.

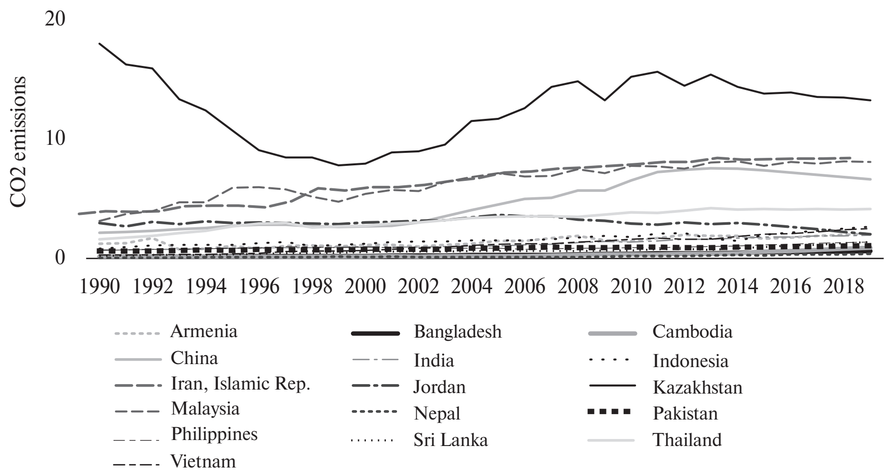

Fig. 2. CO_2 Emission Trends in Asian Countries

Source: Compiled by the authors based on information from the World Bank [2021].

As Figure 2 shows, Kazakhstan is the highest emitter of CO_2 and stood at 12.24 metric tons per capita in 2019, followed by Iran, Malaysia, and China with 8.42, 8.12, and 6.62 metric tons per capita of CO_2 emissions respectively. The high level of CO_2 emissions in Kazakhstan is related to a series of reforms including privatizations, significant changes to its regulatory system, and political reforms to modernize and stabilize the economy. The reforms in Kazakhstan resulted in higher FDI inflows and strong economic growth throughout the 2000s [OECD, 2017].

[2] The Kyoto Protocol was adopted on 11 December 1997 in Kyoto, Japan with an aim to reduce GHGs and prevent dangerous climate change.

The validity of the EKC hypothesis has been widely tested, but there is still room for testing. While there is a substantial body of literature supporting the hypothesis, it has not been proven and is subject to criticism due to inconsistent outcomes prior to various adjustments in the econometric model specification [Kaika, Zervas, 2013; Stern, 2014]. The empirical literature on the hypothesis shows contradictory evidence; some studies discovered that economic growth worsens environment quality, thus confirming the EKC hypothesis [Baek, Kim, 2013; Pao, Tsai, 2011] while U. Al-Mulali, B. Saboori and I. Ozturk [2015] found a positive relationship between gross domestic product (GDP) and pollution in both the short and long run. Likewise, the relationship between FDI inflows and environmental degradation is contradictory and in need of further examination. Some studies conclude that FDI inflows are good for the environmental quality of recipient countries as they facilitate the transference of eco-friendly and energy-efficient technologies [Eskeland, Harrison, 2003; Liang, 2008], while a few studies reverse this relationship and conclude that FDI inflows harm the environmental quality of the recipient countries [Lan, Kakinaka, Huang, 2011; Pao, Tsai, 2011].

In light of these arguments, this study investigates the dynamic relationship between FDI inflows, economic growth, and environmental degradation for selected Asian countries over the period 1990–2019. Specifically, the study examines the long-run validity of the EKC and PHH hypotheses. Additionally, the study investigates the impact of energy consumption, globalization, and population density on environmental degradation.

Literature Review

Different pollutants have been used in the literature as a proxy to represent pollution and environmental degradation. The first empirical investigation of the EKC hypothesis by Grossman and Krueger [1991] used sulphur dioxide (SO_2), fine smoke, and suspended particles to investigate the income relationship. T.M. Selden and D. Song [1994] examined the EKC hypothesis using four indicators: SO_2, carbon monoxide, oxides of nitrogen, and suspended particulate matter; the study concluded that the EKC hypothesis holds for all of these. Various studies have used SO_2 for investigation of the EKC hypothesis [Stern, Common, 2001; Taguchi, 2013]. However, because SO_2 has more localized impacts, many studies have used CO_2 emissions, which have global impacts, as the pollution indicator and have explored the relationship between CO_2 and economic growth [Chiu, 2017; Saboori, Sulaiman, Mohd, 2012; Shahbaz et al., 2013]. Further, because it is responsible for approximately 76% of GHG emissions [IPCC, 2014], this study uses CO_2 emissions as a proxy for environmental degradation.

It is generally found in the environmental literature that economic growth leads to a rise in the levels of CO_2 emissions and consequently causes environmental degradation. However, the relationship is still contradictory in the empirical literature and invites further investigation. M. Shahbaz et al. [2013] concluded that economic growth directly leads to an increase in CO_2 emissions. Similarly, T. Li, Y. Wang, and D. Zhao [2016] confirmed the existence of an EKC for pollutants including wastewater, solid waste emissions, and CO_2. The impact of economic growth may also vary by income group. N. Aslanidis and S. Iranzo [2009] examined the validity of the EKC hypothesis and found no evidence for the existence of an EKC; rather, they found two regimes – a low-income regime and middle to high-income regime. They concluded that CO_2 emissions increased with economic growth in the low-income regime, while economic growth was found to slow environmental degradation in middle to high-income regimes. There are studies that found evidence in support of the EKC hypothesis in China [Jalil, Feridun 2011], Pakistan [Ahmed, Long, 2012; Nasir, Ur Rehman, 2011], Italy [Mongelli, Tassielli, Notarnicola, 2006)], and Korea [Baek, Kim, 2013]. P.K. Narayan and S. Narayan [2010] discovered that an increase in income has reduced CO_2 emissions in South Asian and Middle Eastern countries.

The empirical literature on the relationship between FDI inflows and pollution contains contradictory findings. Some empirical studies found a positive relationship between FDI and pollution while others discovered a negative relationship between the two variables. F.H. Liang [2008] found a positive association between FDI and the environmental quality in China as the recipient country, due to the transfer of eco-friendly technology. Likewise, J. Acharyya [2009] found a positive impact of FDI inflows on economic growth and CO_2 emissions in India. Moreover, the study also discovered that the impact on CO_2 is larger and that, in the 1990s, FDI inflows had a larger positive impact on CO_2 emissions via economic growth. In contrast, H.-T. Pao and C.-M. Tsai [2011] concluded that FDI inflows worsen environmental quality in a study that confirmed the PHH. The study by Al-Mulali, Saboori and Ozturk [2015] concluded that capital increases pollution and confirmed the PHH in Vietnam, while L.-S. Lau, C.-K. Choon and Y.-K. Eng [2014] also discovered that FDI deteriorates environmental quality as it promotes economic growth. Li, Wang, and Zhao [2016] concluded that FDI inflows increase CO_2 emissions, thus deteriorating environmental quality. However, the study also suggested that this impact may be minimal. Likewise, other studies, such as those by G.A. Bokpin [2017] and J. Baek [2016] found harmful impacts of FDI inflows on environmental quality, thus confirming the PHH, and concluded that FDI inflows lead to a rise in CO_2 emissions.

Energy consumption has long been associated with an increase in CO_2 emissions and climate change. On the relationship between energy consumption and environmental pollution, M. Shahbaz et al. [2013] discovered that energy consumption has a positive impact on CO_2 emissions. Besides CO_2 emissions, energy consumption also positively impacts other pollutants such as wastewater and solid waste emissions [Li, Wang, Zhao, 2016]. Other studies that found a positive relationship between energy consumption and CO_2 emissions were undertaken by K. Ahmed and W. Long [2012] and N.C. Leitão [2013]. Therefore, energy consumption is one of the main determinants of CO_2 emissions that lead to environmental degradation [Jalil, Feridun, 2011].

On the relationship between globalization and pollution, M. Liu et al. [2020] found that globalization and CO_2 emission reflect an inverted U-shaped curve which supports the EKC hypothesis for Group of 7 (G7) countries. With respect to Vietnam, T.C.V. Nguyen and Q.H. Le [2020] found that globalization is harmful to the economy and as globalization increases over time, so too will CO_2 emissions in Vietnam. Shahbaz et al. [2019] also investigated globalization-driven CO_2 emissions and examined the EKC of 87 low- to high-income countries. Surprisingly, some countries confirmed the U-shaped and inverted U-shape curves, while some had neither U-shaped nor inverted U-shaped curves. The study concluded that, in some countries, increased globalization tends to decrease carbon emissions while globalization damages environmental health in others. A. AhAtil et al. [2019] investigated the nexus between CO_2 emissions and four dimensions of globalization, namely: economic globalization, social globalization, political globalization, and overall globalization. They found that economic globalization has no effect on CO_2 emissions in the short run, but that it significantly affects CO_2 emissions in the long run.

On population density's impact on environmental degradation, Ahmed and Long [2012] concluded that population density is positively related to environmental degradation in Pakistan. H. Saleem et al. [2018] discovered a positive relationship between population density and CO_2 emissions, indicating that population density increases CO_2 emissions. Similarly, P. Sapkota and U. Bastola [2017] found a significant and positive impact of population density on CO_2 emissions. According to the study, the more densely inhabited a region is, the less obvious the pollution is and, as a result, the less opposition to polluted planted areas. Similarly, M.A. Cole, R.J.R. Elliot, and S. Wu [2008] discovered that industries located in areas with high population density tend to have higher pollution. The study concluded that population density and SO_2 emissions are positively related to each other.

Data and Methodology

Data and Descriptive Statistics

To estimate model (1), panel data for 16 Asian countries is used for the period 1990–2019. The choice of countries is based on the availability of the data and the list of countries is given in Appendix A. The data for CO_2 emissions, GDP per capita, FDI net inflows, energy consumption, and population density were collected from world development indicators (WDI), while data on globalization was taken from the KOF index (for details on the KOF index see S. Gygli et al. [2019]). Summary statistics of the data are presented in Table 1, which shows that the total number of countries (n) used in the study is 16 ($n = 16$), time (T) span is 30 years ($t = 30$), and overall observations are 480 ($N = 480$). As also shown in Table 1, the highest overall mean value is 15,200,000.0 for squared GDP per capita, while the lowest overall mean value is 2.80 for CO_2 emissions. Similarly, CO_2 emissions range from 0.04 to 18.01 metric tons per capita and GDP per capita ranges from $321.30 to $12,478.20. Energy consumption ranges from 118.9 to 4,796.1 kilograms of oil equivalent per capita. FDI net inflows range from –2.76 to 23.21% of GDP, and population density ranges from 5.50 to 1,252.60 people per square kilometres of land area; globalization has a minimum range value of 11.10 and maximum range value of 90.30.

Table 1. Descriptive Statistics

Variable	Analysis	Mean	Std. Dev.	Min	Max	Observations
CO_2 emissions	overall	2.800	3.39	0.04	18.01	$N = 480$
	between		3.32	0.16	12.57	$n = 16$
	within		1.08	–1.97	8.23	$T = 30$
GDP per capita	overall	2915.0	2583.6	321.3	12478.2	$N = 480$
	between		2352.3	536.9	8148.3	$n = 16$
	within		1215.3	–696.3	7742.0	$T = 30$
Squared GDP per capita	overall	15200000.0	25900000.0	103221.6	156000000.0	N= 480
	between		21600000.0	308808.7	71100000.0	$n = 16$
	within		15200000.0	–35400000.0	99700000.0	T= 30
Energy consumption	overall	1082.8	1047.6	118.9	4796.1	$N = 480$
	between		1004.9	176.6	3823.4	$n = 16$
	within		385.8	–416.1	2398.8	$T = 30$
FDI	overall	2.945	3.25	–2.76	23.21	$N = 480$
	between		2.29	0.19	7.10	$N = 16$
	within		2.37	–3.28	20.71	$T = 30$
Population density	overall	214.366	240.67	5.50	1252.60	$N = 480$
	between		244.47	5.99	1041.97	$n = 16$
	within		42.17	–35.01	425.00	$T = 30$

Variable	Analysis	Mean	Std. Dev.	Min	Max	Observations
Globalization	overall	51.572	23.38	11.10	90.30	$N = 480$
	between		21.30	25.54	87.23	$n = 16$
	within		10.98	4.73	84.74	$T = 30$

Source: Authors' calculations.

This study investigates the dynamic relationships between CO_2 emissions, FDI inflows, economic growth, energy consumption, globalization, and population density. Additionally, the study attempts to validate the existence of the EKC and PHH hypotheses. Thus, the study includes the most relevant variables based on the empirical literature related to the EKC and PHH [Acharyya, 2009; Dinda, 2004; Sapkota, Bastola, 2017] and considers the following equation:

$$lnCO2_{it} = \beta_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{it}^2 + \beta_3 lnFDI_{it} + \beta_4 lnEC_{it} + \beta_5 lnGBZ_{it} + \beta_6 lnPD_{it} + \varepsilon_{it},$$

where *i* indicates cross-section, while *t* in subscript stands for time series. β_0 is constant while ($\beta_1 ... \beta_6$) are coefficients and ε_{it} is the error term. ln represents the natural log of variables. $CO2_{it}$ is carbon dioxide emissions used as a proxy to represent environmental degradation, thus it is the dependent variable and measured in metric tons per capita. Moreover, GDP_{it} is the gross domestic product (GDP) per capita measured in Constant 2010 US$, and squared *GDP* per capita is denoted by GDP_{it}^2. FDI_{it} is the foreign direct investment (FDI) net inflows measured as a per cent of *GDP*. EC_{it} is energy consumption that is measured in kilograms of oil equivalent per capita. GBZ_{it} symbolizes globalization on a KOF index scale ranging from 1 (lowest level of globalization) to 100 (highest level of globalization). The KOF index reflects multiple aspects of globalization. However, this study uses only the economic globalization aspect of the index. PD_{it} shows population density measured in people per square kilometre of land area. ε_{it} is a disturbance term. The existence of an EKC, that is, an inverted U-shaped relationship between CO_2 emissions and economic growth, depends on the estimated values of coefficients of GDP and GDP^2 (β_1, β_2). There will be a level relationship if both coefficients equal zero ($\beta_1 = \beta_2 = 0$). Likewise, a monotonically decreasing linear relationship is present if $\beta_1 < 0$ and $\beta_2 = 0$. A U-shaped relationship is present with the estimated coefficients $\beta_1 < 0$ and $\beta_2 > 0$, while an inverted U-shaped relationship or EKC will hold if $\beta_1 > 0$ and $\beta_2 < 1$. The expected sign for EC is positive, while expected signs for FDI, GZB, and PD can either be positive or negative since the empirical literature has contradictory and mixed results of each variable.

Econometric Technique

To estimate the model, it is necessary to check unit root in panel series. Several panel unit roots are developed to test unit root in panel data and the tests are widely used in the analysis of dynamic panel estimations. The panel unit root tests are categorized into two types, namely first and second generations. Both first-generation and second-generation unit root tests are dependent on the assumption of cross-sectional independence in the panel data. The first-generation panel unit root tests are independent of an assumption of cross-sectional dependence: these include the LLC test [Levin, Lin, Chu, 2002], the Breitung test [Breitung, 2001], the IPS test [Im, Pesaran, Shin, 2003], the Fisher ADF, and PP-Fisher tests [Choi, 2001; Maddala, Wu, 1999]. This study will make use of the LLC, IPS, and Fisher tests to check panel unit root in the data.

In addition to panel unit root tests, panel cointegration tests are also popularly used in literature; this study adopts residual-based cointegration tests. Residual-based tests are aimed at observing unit root in the residuals by modelling a cointegration equation. The presence of unit root in residuals indicates there is no cointegration among variables; cointegration exists when unit root in residuals remains absent. The commonly known residual-based tests are the Pedroni tests [Pedroni, 1999; 2004], the Kao tests [Kao, 1999; McCoskey, Kao, 1998] and the Westerlund tests [Westerlund, 2007]. If the presence of cointegration is confirmed by residual-based tests, that is, Pedroni and Kao, the next step is to select an estimator for panel cointegration estimation. Since the conventional OLS estimator is second-order asymptotically biased with invalid standard errors [Kao, Chen, 1995], this study adopts Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) to for panel cointegration estimation. The aim of FMOLS and DOLS estimators is to estimate the long-run equilibrium association amongst the variables after being identified by cointegration tests. The advantage of FMOLS lies in its ability to correct for serial correlation and endogeneity bias. FMOLS also has the advantage of dealing with heterogeneous cointegration [Khan et al., 2019], and M. Hamit-Haggar [2012] considered it to be the most suitable technique for the panel. Likewise, DOLS also takes into account serial correlation and endogeneity presented in standard OLS by incorporating cross-section specific lags and leads along with a panel cointegrating equation [Othman, Masih, 2015].

Results and Discussion

The panel unit root tests indicated in this study include individual effects and user-specified lag 1 is used. The results of the panel unit root tests are presented in Table 2. The study used Levin-Lin-Chu (LLC), Im Pesaran Shin (IPS), and Fisher unit root tests to inspect the order of integration. Table 2 reports the results of these three unit root tests, at a level and 1st difference. The results indicate no such stationarity issue at the first difference for all of the variables with a 1% level of significance. Consequently, a mix of I (0) and I (1) order of integration processes was found, and the study proceeded to examine the presence of cointegration between the dependent variable (CO_2 emissions) and independent variables (GDP, squared GDP, FDI, energy consumption, globalization, and population density).

Table 2. Panel Unit Root Tests Results

Variable	**LLC**		**IPS**		**Fisher**			
	level	1st diff.	level	1st diff.	level	1st diff.	level	1st diff.
	t*stat		W-stat		ADF. Chi sq.		PP Chi Sq.	
CO2 emission	–0.35	–6.97***	3.61	–8.68***	16.02	141.84***	33.04	300.77***
GDP	–0.16	–4.28***	6.27	–5.93***	11.24	97.40***	7.90	156.04***
Squared GDP	–0.16	–4.28***	6.27	–5.93***	11.24	97.40***	7.90	156.04***
FDI	–4.00***	–	–7.33***	–	117.12***	–	118.8***	–
Energy Consumption	–0.13	–5.92***	3.31	–7.71***	18.66	124.26***	25.16	280.31***
Globalisation	–5.00***	–	–3.11***	–	64.95***	–	55.06***	–
Population density	–0.41	–7.05***	1.85	–4.00***	38.04	84.92***	297.1***	–

Note: * indicates 10% level of significance, ** indicates 5% level of significance, and *** indicates 1% level of significance.

To analyze the long-run equilibrium among variables of interest, two tests were applied: the Pedroni panel and group statistics and Kao *t*-statistics. Each test considers different assumptions and approaches to calculating the statistics. The tests' null hypothesis is that no cointegration exists against the alternative hypothesis of cointegrated series. Based on the within dimension analysis, the Pedroni panel independently tests sum numerators and denominators along with series and uses the summation to compute the statistics. The panel statistics is divided into four components: panel-v statistic, panel-rho, panel-PP, and panel ADF statistics. In contrast, based on the between dimension analysis, Pedroni group statistics divide the numerator and denominator before summing over cross-sections and compute the statistics. Pedroni group statistics have three computable statistics: group-rho, group-PP, and group ADF statistics. Kao t-statistics assumes the homogeneity in panels and is based on the ADF framework. It is derived from panel least squared dummy variable (LSDV) analysis.

Results of Pedroni and Kao tests are presented in Table 3. For the Pedroni and Kao cointegration tests, the automatic lag length is determined by Schwarz Information Criterion (SIC), and the Bartlett kernel is used for spectral estimation with a determination of bandwidth by Newey and West automatic lag selection. Both tests include individual intercept with no deterministic trend. The results suggest that a long-run relationship among variables exists, that is, variables are cointegrated and tend to move together in the long run.

Table 3. Cointegration Tests' Results

Cointegration Test		Statistics
Padroni	Panel v-Statistic	0.554528
	Panel rho-Statistic	0.733316
	Panel PP-Statistic	–6.787947***
	Panel ADF-Statistic	–2.506911***
	Group rho-Statistic	2.844066
	Group PP-Statistic	–5.722652***
	Group ADF-Statistic	–3.570637***
Kao	t-statistic	–2.909462***

Note: * indicates 10% level of significance, ** indicates 5% level of significance, and *** indicates 1% level of significance.

Table 3 presents evidence of a long-run relationship among variables; the next step was to estimate the relationship among the variables and obtain desired findings. To do so, this study employed two classical long-run estimators – fully modified OLS (FMOLS) and dynamic OLS (DOLS) – to obtain findings.

Table 4 reports FMOLS and DOLS findings; the dynamic OLS performed better relative to the full modified OLS; C. Kao and M.-H. Chiang [2001], using Monte Carlo simulations, reported that DOLS performs better than FMOLS in finite-sample, as finite-sample properties of DOLS are higher relative to FMOLS properties. The findings of both estimators reveal that coefficients of a log of GDP and log of squared GDP are significant at 1% level of significance and are positive and negative, respectively. It is evident that the EKC for selected Asian countries holds in the long run. Long-run coefficient values of GDP and squared GDP for DOLS indicate that 1% increase in GDP per capita will lead to 15.647% increase in CO_2 emissions in long run, and while negative squared GDP per capita shows that 1% increase in squared GDP per capita will decrease CO_2 emissions by –1.122%. A negative log squared GDP per capita coefficient, on the other hand, implies a weak and delayed effect, which could signal a country's failure to keep up with recent discoveries, improve production techniques, or adopt cleaner technology. As a result, environmental regulations may play an important role in enhancing environmental quality. Thus, the EKC hypothesis holds in selected Asian countries, a finding that is consistent with other studies [Baek, Kim, 2013; Jalil, Feridun, 2011; Mongelli, Tassielli, Notarnicola, 2006; Nasir, Rehman, 2011; Shahbaz et al., 2013].

Table 4. FMOLS and DOLS Results

Variable	DOLS	FMOLS
Log GDP per capita	15.647*** (5.756)	9.320*** (1.561)
Log squared GDP per capita	–1.122*** (0.385)	–0.542*** (0.101)
Log FDI inflows	0.056*** (0.014)	–0.002 (0.006)
Log energy consumption	1.285*** (0.308)	0.752*** (0.082)
Log globalization	–0.575 (0.611)	0.054 (0.045)
Log population density	1.187 (1.077)	–0.130 (0.270)

Note: * indicates 10% level of significance, ** indicates 5% level of significance, and *** indicates 1% level of significance

Similarly, the coefficient of FDI inflows is positive and significant at 1% level of significance, suggesting that a 1% increase in FDI inflows will lead to a 0.056% increase in the level of CO_2 emissions in the long run, and thus degrades environmental quality. The results favour the argument that FDI inflows deteriorate environmental quality; thus, the existence of PHH in selected Asian countries is evident. The result is similar to those of the studies by L.-S. Lau, C.-K. Choong, and Y.-K. Eng [2014], N. A. Neequaye and R. Oladi [2015], and Pao and Tsai [2011]; these studies also found that FDI inflows harm environmental quality by contributing to CO_2 emissions. Energy consumption is significant at 1% level of significance and positively associated with CO_2 emissions. This result is consistent with studies by Shahbaz et al. [2013] and by Li, Wang, and Zhao [2016]. Findings show that a 1% increase in energy consumption will increase CO_2 emissions by 1.285% in the long run. Globalization and population density are positive, but the impact is insignificant on CO_2 emission in the long run.

Conclusion and Policy Implications

This study assessed the relevance of possible determinants that contribute to environmental degradation by examining the dynamic impact of FDI inflows and economic growth on environmental degradation for selected Asian countries. Moreover, the study also assessed the EKC and PHH hypotheses and the impact of energy consumption, globalization, and population density on environmental degradation for these countries for the period 1990–2019. The study used a panel cointegration approach with fully modified OLS (FMOLS) and dynamic OLS (DOLS) to estimate long-run relationships among variables. Findings provide clear evidence of the existence of an EKC and the PHH. Moreover, economic growth has a highly significant and positive role in environmental degradation, but this effect gets reversed in long run after a certain turning point. After that turning point, as economic growth increases, the quality of the environment gets better, thus, confirming the existence of the EKC.

FDI inflows are found to be positively related to CO_2 emissions, and thus, also contribute to environmental degradation. This implies that firms seek safe havens in recipient countries, shifting their pollution-intensive plants to countries with weak environmental regulations. Therefore, there is evidence that the PHH holds in the long run in Asian countries. Additionally, energy consumption linked to economic production highly contributes to CO_2 emissions and causes environmental degradation. Globalization and population density are found to be insignificant in the long run, showing no impact on the environment.

The findings of this study lead to the following policy recommendations: first, to preserve the environment, the governments and policymakers of Asian countries studied herein should act as one, taking a mutual decision on targeting and mitigating CO_2 emissions by devising reduction policies such as carbon pricing. A carbon pricing scheme, which imposes taxes on carbon emissions and polluters, is widely practised across the world and has been proven to reduce CO_2 emissions [Boyce, 2018]. Moreover, policymakers should strategically devise and implement policies to encourage economic growth and environmental protection, with the ultimate goal of achieving sustainable development. Second, since the PHH is confirmed, these Asian countries should seek and encourage eco-friendly FDI inflows and transference of energy-efficient technologies to improve the quality of the environment. A third recommendation relates to the fact that energy consumption contributes to environmental degradation; this concern should be addressed by promoting the use of cleaner energy. Innovations and technological developments should also be encouraged for hydropower, wind power, solar energy, and other facilities within these countries.

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Appendix A

Table A1. List of countries

1	Armenia	9	Kazakhstan
2	Bangladesh	10	Malaysia
3	Cambodia	11	Nepal
4	China	12	Pakistan
5	India	13	Philippines
6	Indonesia	14	Sri Lanka
7	Iran, Islamic Rep.	15	Thailand
8	Jordan	16	Vietnam