

Impact of Socioeconomic Factors and Energy Consumption on Environmental Quality

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Abstract

This paper examines potential factors that affect CO₂ emissions in 40 Asian countries between 1993 and 2022. Using various models with Driscoll-Kraay standard errors, cross-sectional time-series feasible generalized least squares (FGLS) regression, high-dimensional fixed effects (HDFE) linear regression, simultaneous quantile regression, and elastic net regression, the main results show that energy consumption significantly contributes to CO₂ emission in the context of the Impact = Population·Affluence·Technology (IPAT) hypothesis. Ethnic polarization significantly increases CO₂ emission levels, especially in regions with poor governance. At medium and high levels of emissions, foreign direct investment (FDI) helps in decreasing emissions, supporting the pollution halo hypothesis. Institutional quality, which stems from regulatory assurance and adherence to rules, performs an insurance function, reducing levels of environmental pollution in countries with moderate to high emission levels. Asian economies, therefore, should seek sustainable environmental development through renewable energy, improved governance, and eradication of ethnic polarization. Our findings are invaluable for policy making, offering means to navigate the growth-environmental dilemma and indicating the directions that should be taken to achieve sustainable growth.

Keywords: *environmental quality, CO₂ emissions, institutional quality, ethnic polarization, energy consumption*

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1. INTRODUCTION

One of the most critical issues of the modern world for social, economic, and ecological development is environmental pollution and heightened levels of CO₂ emissions. Asia is a significant region in this regard. It has undergone rapid industrialization and shown outstanding economic development, however the increase in its energy needs has made the region one of the world's largest emitters of CO₂. Accordingly, solving Asian environmental issues is not only an Asian problem but an international one, especially since the entire world is striving to achieve international development goals, including the Sustainable Development Goals (SDGs) established by the United Nations. Unpacking the dynamics of environmental quality in Asia requires a nuanced exploration of several key factors such as gross domestic product, energy usage, foreign direct investment (FDI), the institutional environment, and ethnic polarization.

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Previous models of development – particularly industrialization – are associated with environmental degradation, and growing CO₂ emissions are often indicative of early growth. This view is not entirely supportive of the environmental Kuznets curve (EKC) hypothesis that postulates that, as countries grow richer, they tend to lean towards cleaner technologies and, therefore, achieve better environmental results (Riahi et al., 2017). Thus, we test this hypothesis in the context of Asian countries, which include varied economies, in order to identify how advancement and sustainability intersect.

The major source of CO₂ emissions in Asia is energy consumption, sustained by the use of fossil energy such as coal and crude oil. The need for such energy sources surges as economies and populations grow, and this growth may overwhelm efforts to replace energy sources with clean technology. To understand the effects of this rising energy demand, this research employs the Impact = Population·Affluence·Technology (IPAT) formula, within which impact is shaped by population, affluence, and technology. Another issue associated with the Asia region is the environmental aspect of FDI. On the one hand, the pollution halo hypothesis postulates that FDI might be used for technology transfer, which results in lower emissions in the host country, and proposes that FDI can have a crucial purpose in technology transfer as long as the host country's standards are not as strict as those of the home country. On the other hand, the pollution haven hypothesis postulates that industries in countries with less strict statutory requirements become havens for polluting industries and intensify pollution levels. Since the regulatory frameworks differ radically from one country to another in Asia, it is imperative to evaluate the impact of FDI on environmental quality (Skvarciany et al., 2020).

Ethnic polarization seems to be a less investigated but very relevant aspect of the emerging environmental governance in Asia. Ethnic diversity and resulting social tensions can seriously undermine governance and render the enactment and enforcement of environmental standards all but impossible. Ethnic polarization is identified as the main factor contributing to environmental degradation; Judge et al. (2023) study shows how social fragmentation strains policy implementation and governance. Institutional quality, sound rule of law, effective enforcement agencies, and sound political stability all have a role to play in determining environmental status. Zheng et al. (2023) show that even the most noble political efforts targeting the environment may fail in nations where institutions are weak, primarily due to inefficient implementation. In this context, ethnic polarization worsens the situation, which hinders the achievement of governance and sustainable goals.

The aim of this research is to analyse the influence of ethnic polarization on environmental management in Asian countries, especially in relation to globalization. It looks at how the harmonization of ethnic differences compounded by growing globalization leads to inept environmental management in the region. This paper also discusses the impacts of social inclusion and social exclusion on the capability of Asian countries to have sustainable economic growth and development alongside the management of environmental issues. Drawing from a cross-sectional dataset gathered from multiple relevant sources, this research constructs a theoretical framework of ethnic polarization, institutional quality, and economic factors in relation to environmental governance. It explores possible socio-political and economic factors for environmental decision-making, so that socially just environmental

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policies can be implemented in the region. Accordingly, several policy recommendations are made to assist in reducing the levels of ethnic polarization, improve the quality of governance and call for better environmental management practices in the future.

Unlike previous studies, this research employs ethnic polarization and environmental governance as two interrelated concepts, extending the existing literature which mostly disregards the interaction between ethnic polarization and environmental governance. For example, Montalvo & Reynal-Querol (2005) and Bharathi et al. (2023) explore how ethnic diversity hampers economic growth and governance but do not investigate how ethnic divisions affect environmental management. Other researches such as Cole (2003) and Churchill (2019), explore the relationship between globalization and environmental policy, however few studies observe or take into consideration social factors such as ethnic polarization that can potentially worsen the situation of poor environmental governance. Some more contemporary works (Ahmed et al., 2025; Nodehi et al., 2022) explore the effects of globalization on Asian environmental policies, but do not include ethnic polarization as a social aspect. Our research differentiates ethnic polarization as one factor and institutional quality as another, and, in this way, provides a multi-faceted approach to exploring how these factors affect environmental policy. Unlike most studies, which operationalize social factors mainly in terms of economic indicators (Yasin et al., 2023), this research investigates ethnic polarization as a social factor that influences environmental reform, thus enhancing the understanding of social aspects of governance. This research paper is relevant and useful for both the theoretical development of the subject and the provision of practical recommendations for policymakers and researchers interested in sustainable development in one of the fastest-growing and environmentally vulnerable regions of the world (Zheng et al., 2023).

To conduct our empirical analysis, we use Driscoll-Kraay standard errors, cross-sectional time-series feasible generalized least squares (FGLS) regression, high-dimensional fixed effects (HDFE) linear regression, simultaneous quantile regression, and elastic net regression, which are advanced methods covering both static and dynamic analysis.

The study is organized as follows. Section 2 reviews the literature. Section 3 presents the data and methodology. Section 4 presents and discusses the empirical results. Section 5 concludes the study with policy implications.

2. THEORETICAL BACKGROUND

The link between economic development and environmental degradation is of key interest to studies focusing on environmental economics. The most common applicable concept is the environmental Kuznets curve (EKC) hypothesis, developed by Grossman & Krueger (1991), which indicates that with an increase in a country's income, pollution increases, but, after a point, it begins to decline. The rationale is that, as economies progress, governments put in place better policies to control environmental degradation, and the technologies used by industries become cleaner. Such a relationship has much empirical evidence, especially in high and middle-income countries. Grossman & Krueger (1995) illustrate this relationship using sulphur dioxide emission records of 71 nations, while other studies (Hochman & Timilsina, 2017; Kharazishvili et al., 2021; Werth et al., 2021) report similar findings from nations

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including Malaysia and China. Nevertheless, the EKC hypothesis cannot be generalized. In their respective papers, Rasoulinezhad & Taghizadeh-Hesary (2022) and Zhang et al. (2022) find non-linear relationships between economic growth and environmental quality, with environmental quality being worst in the parts of Sub-Saharan Africa that have the most regulatory systems in place. Furthermore, studies on the EKC hypothesis often use cross-sectional data, which may mask the socio-political preconditions for environmental change in divergent countries. Such subtleties only indicate the importance of additional research into the relationship between economic growth and environmental sustainability, specifically in the developing economies of Asia.

The effect of FDI on the quality of the environment has also attracted an immense amount of scholarly attention. On the one hand, the pollution haven hypothesis claims that multinational corporations open affiliate companies in countries with low environmental standards, which results in high pollution. Evidence for this is reported in numerous Asian economies, with Belaïd et al. (2023) and Dogan et al. (2022) pointing out that increased FDI is associated with increased pollution in South and Southeast Asia. On the other hand, the pollution halo hypothesis postulates that the FDI can introduce technologically superior and cleaner technologies to host countries, especially middle-income countries. Sharvini et al. (2018) and Zhao et al. (2024) show similar findings, suggesting that an appropriate institutional setting can help FDI promote a sustainable environment. These perspectives highlight the need to undertake an empirical examination of the FDI-environment relationship in Asia, where institutional environments vary significantly. The IPAT model (Rehman et al., 2022; Yi et al., 2021) is another theoretical model that gives a background to environmental deterioration. It indicates that the rate of population increase, economic development, and technological advancement define the impacts on the environment. For example, in the Asian environment, several studies (Mayer et al., 2020; Zhang et al., 2019) reveal that with population growth and economic growth, CO₂ emissions rise. In contrast, technological improvement frequently does not mitigate these pressures. This calls for an exhaustive assessment of a host of socio-economic factors in order to gain an accurate picture of what is determining the quality of the environment in Asia.

Institutional quality is another variable that significantly affects environmental impacts. Selvakkumaran & Limmeechokchai (2016) demonstrate that improved political institutionalism is essential for environmental management and the implementation of rules to effectively moderate CO₂ emissions. Some factors, such as low institutional quality, political instability, or high levels of corruption, may hinder the ability of a country to enforce or sustain policies that protect the environment. Due to a lack of necessary institutional structures, development, and enforcement, policies aimed at regulating environmental conditions may need to be more effectively implemented and monitored, therefore creating less strict environmental policies and increasing pollution. Countries may also be inclined to develop their economies in the short run rather than focus on consequences such as pollution. This pattern is most evident in Asia, where government systems differ significantly across Asian economies and where institutional development considerably determines the efficacy of environmental regulations.

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An overlooked but emerging issue in environmental management is ethnic polarization. Ahmad & Amin (2020) state that ethnic polarizations destabilize governance and hinder the ability of a country to adopt proper environmental policies. Analysing multi-ethnic countries such as India, Fankhauser & Jotzo (2018) conclude that intergroup competition leads to the ignoring of numerous environmental issues, which in turn stimulates ecological deterioration. Hence, it is necessary to grasp the manifestations of ethnic polarization in environmental governance so that specific interventions can be tailored to the social as well as environmental problems affecting ethnically divided countries.

The energy-induced CO₂ emission hypothesis reveals the direct impact of energy utilization on increased CO₂ emissions, particularly in rapidly industrializing Asian economies. The booming energy demands of fossil fuel-dependent countries such as China and India have prompted the emergence of CO₂ emissions. Though increased energy consumption results in the enhancement of new generation capacity and the application of efficiency technologies and systems, the first consequences of the energy utilization process are normally more visible. Existing studies (Rehman et al., 2022, Wang et al., 2024) demonstrate that increases in the size of economies coincide with increased energy needs and, thus, increased emissions, most of which come from coal and crude oil. Policies to reduce CO₂ emissions differ in their performance throughout the region as a result of differences in governance quality and institutional support. Asian countries focus on political stability and the efficiency of the regulatory environment, with many achieving considerable progress in the transition to renewable energy and the prevention of negative impacts, with fluctuating but overall decreasing emissions levels.

Conversely, Asian countries with relatively poor governance, especially in the Southeast Asia region, generally face failure in implementing the right environmental policies, potentially enhancing pollution. The involvement of population growth in forecasting and formulating energy consumption, according to the IPAT framework, justifies the complexity of the social/contextual dynamic that determines energy demand and use, hence there is a need for the development of more holistic strategies that address the energy demand issue as well as sustainable utilization of energy resources. It is important to grasp these dynamics in order to provide the right CO₂ emission reduction policies and enhance environmental quality in Asian economies. Based on this theoretical foundation and previous empirical studies, this paper posits several hypotheses concerning the association between socioeconomic factors and the environmental quality of Asian countries. These hypotheses explore the links between economic development, FDI, the institutional environment, and energy consumption which determine environmental conditions in this diverse and dynamically growing area.

2.1 Hypothesis Development

The link between economic performance and environmental quality attracts a lot of research interest, and conclusions differ from one setting or approach to another. The EKC hypothesis posits an inverted U-shaped relationship between economic performance and environmental quality; however, empirical efforts to validate this relationship produce mixed evidence. Grossman & Krueger (1991) postulate this hypothesis based on a study of sulphur dioxide emissions in 71 countries, and other studies support the hypothesis in many countries (e.g. Song

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et al., 2018). The EKC hypothesis is evidenced by previous studies (Aziz et al., 2020; Cialani, 2007) which show a positive inverted U-shape in some countries in the Asia-Pacific region, including Malaysia and China. However, several systematic research investigations reveal a negative or zero correlation between economic progress and environmental degradation (Asghar et al., 2024; Kolcava et al., 2019). The EKC hypothesis is dismissed for certain regions, such as Sub-Saharan Africa (Arslan et al., 2022) or specific environmental quality indicators, for example, air quality (Abdouli & Hammami, 2017). Of particular interest is that the majority of studies claiming evidence for the EKC hypothesis employ cross-sectional data, which does no justice to the socio-political environment of Asian countries. Therefore, our first hypothesis is:

H1: There is an inverted U-shaped relationship between CO₂ emissions and per capita income in Asian countries.

FDI activities impact the environment not only due to their positive relationship with CO₂ emissions but also through the indicators of technology transfer, industrial development, and policy environments. They can either contribute to minimizing or aggravating environmental consequences. On the one hand, industries tend to move to countries with looser environmental laws, aggravating existing environmental problems in those countries, which supports the pollution haven hypothesis. Evidence for this is found in the Asia-Pacific region (Cioccolanti et al., 2019; Zheng et al., 2023). On the other hand, the pollution halo hypothesis asserts that FDI brings about technology transfers, which may lead to environmentally friendly practices. Some research suggests that FDI has a positive effect on environmental quality if a transfer of technology comes along with it (Albrizio et al., 2017; Jahanger et al., 2022); however, more evidence is required to explain the findings and its effects on low- or middle-income countries (LMICs). Thus, we formulate our second hypothesis:

H2: FDI inflows increase CO₂ emissions in Asia.

According to the IPAT hypothesis, population, affluence, and technology lead to environmental deterioration and CO₂ emissions. Some studies confirm this, pointing to population growth density as one cause of CO₂ emissions, although the correlation is not universally constant (Swanepoel et al., 2019; Vural-Yavaş, 2021). There is a positive correlation between the growth of population and the emission of CO₂, and countries such as India illustrate this. Population leads to higher energy consumption and emissions and is influenced by population density. Despite having a large populace, this factor is insignificant in countries such as China and Indonesia (Yuan & Zhang, 2020). Therefore, we formulate our third hypothesis:

H3: Rapid population growth is significantly associated with increasing CO₂ emissions.

The correlation between energy consumption and the quality of the environment has a significant amount of evidence (Yu et al., 2020). Studies show that when energy use grows, CO₂ emissions grow too, which points to the importance of rational energy use (Quinche-Martín & Cabrera-Narváez, 2020; Wang et al., 2024). Therefore, our fourth hypothesis is:

H4: Higher energy consumption increases CO₂ emissions in Asia.

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The political systems of countries, including political stability, democracy, and the rule of law, affect environmental standards and compliance. Policies entrenching political institutions that are more responsible, transparent, and capable of effectively providing governance lead to environmental laws that are stronger and more capable of meeting the concerns of citizens regarding pollutants. However, disorder and embezzlement hamper the enforcement of standards and policies, facilitating environmental decay (Iqbal et al., 2021; Robertson & Barling, 2013). This is because, in areas with sound political structures, governments can enforce environmental policy and compel industries to undertake activities within stipulated environmental norms, reducing the emission of gases including CO₂. Institutions able to induce stability in the governance structure support sustainable development in areas such as green technologies. At the same time, countries with fragile institutions, inadequate legal frameworks, and high levels of corruption are unable to solve environmental problems. In conclusion, this paper proposes a negative association between political institutional quality and CO₂ emissions in Asia. Thus, we hypothesize:

H5: Higher political institution quality reduces CO₂ emissions in Asia.

Ethnic polarization is the tendency of society to split along ethnic lines, which results in the formation of enmity. Ethnic divisions lead to a lack of unity and, hence, the rise of political instability in regions that experience them. If several ethnicities are split, government capacity is reduced and integrated environmental policies are hampered. The sides struggle for resources and control, causing environmental problems almost without attention. The competition may encourage policies and interventions to develop the economy to cover the costs of conserving the environment, hence economic activity that enhances the high emission of CO₂. Also, when ethnically polarized societies exist, such groups usually exercise little political power, and are thus unable to force authorities to enact sustainable methods and environmental laws. Since ethnic communities may not have a central government to work for, these groups of people may lack the proper enforcement of existing laws concerning the environment. Ethnic polarization deepens environmental depletion, which in turn increases the emission of CO₂. Therefore, the next hypothesis is:

H6: Ethnic polarization increases CO₂ emissions in Asia.

Our study is unique given its focus on both the EKC model and Asian institutional and ethnic characteristics when analysing air pollution levels, energy intake, and trade openness. Although the pollution halo hypothesis is receiving increasing attention in the context of CO₂ emissions and ethnic culture in Asia, comparing institutional variables with FDI inflows, validating these hypotheses remains undone due to data realities. Given this background, this study aims to expand the EKC model by considering energy consumption and institutional and ethnic perspectives in the analysis.

3. RESEARCH OBJECTIVE, METHODOLOGY AND DATA

3.1 Model

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The variables employed in the study are described in Table 1. Equation (1) represents the model used to test the EKC hypothesis, which suggests an inverted U-shaped relationship between CO2 emissions per capita (EQ) and GDP per capita (GDP):

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + e_{it} \dots \dots \dots (1)$$

where, EQ represents CO2 emissions per capita, GDP is GDP per capita (constant 2010 US\$), and GDP² is the squared value of GDP per capita (constant 2010 US\$).

Equation (2) is used to test the hypothesis with the addition of FDI net inflows:

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + \alpha_3 FDI_{it} + e_{it} \dots \dots \dots (2)$$

Equation (3) tests the IPAT hypothesis along with the annual percentage of population growth, FDI inflow, GDP per capita, and GDP per capita squared:

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + \alpha_3 FDI_{it} + \alpha_4 POPG + e_{it} \dots \dots \dots (3)$$

Equation (4) includes FDI alongside the other predictors, namely gross domestic product (GDP), energy consumption (EC), and annual population growth (POPG). Countries with high institutional quality would, for example, gain more from FDI because such institutions improve the adoption of appropriate technologies, thus improving environmental returns. This is emphasized in Equation (5), including the pollution halo hypothesis and institutional quality, such as regulatory quality and rule of law, to enable an inherent test of the interaction of FDI with governance. The increase is expected to be highly associated with improved environmental standards in countries with strong institutions, leading to reduced CO2 emissions. If the analysis reveals that FDI is indeed negatively linked with CO2 emissions in countries with better governance, the study gives substantial credence to the pollution halo hypothesis, as it illustrates the need for heuristic institutional quality to maximize the beneficial environmental impact of foreign investment.

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + \alpha_3 FDI_{it} + \alpha_4 POPG + \alpha_5 EC + e_{it} \dots \dots \dots (4)$$

Equation (5) includes the impact of regulatory quality (RQ), rule of law (LO) and political risk (POL):

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + \alpha_3 FDI_{it} + \alpha_4 POPG + \alpha_5 EC + \alpha_6 RQ + \alpha_7 LO + \alpha_8 POL + e_{it} \dots \dots \dots (5)$$

Finally, ethnic power relations (EPR) is added into Equation (6) to test the EPR-induced CO2 emissions in Asian countries:

$$EQ = \alpha_0 + \alpha_1 GDP + \alpha_2 GDP^2 + \alpha_3 FDI_{it} + \alpha_4 POPG + \alpha_5 EC + \alpha_6 RQ + \alpha_7 LO + \alpha_8 POL + \alpha_9 EP + e_{it} \dots \dots \dots (6)$$

3.2 Method

In this study, models with Driscoll-Kraay standard errors, cross-sectional time-series feasible generalized least squares (FGLS) regression, high-dimensional fixed effects (HDFE) linear regression, simultaneous quantile regression, and elastic net regression are considered in the panel data analysis, which offers a reliable means of identifying the determinants of CO2 emissions in Asian economies. Driscoll-Kraay standard errors are appropriate for cross-sectional dependence, autocorrelation and heteroscedasticity, which are characteristic of panel data. FGLS, which makes a model generalized, is an efficient strategy, especially for heteroscedastic and auto-correlated time-series panel data analysis. HDFE regression eliminates auto-correlation and reduces the possibility of omitted variables by including country and time dummies. Quantile regression offers information at various quantiles in the emission distribution, including how the impact of, say, GDP or energy intensity differs between the set of low and high-emitting states. Lastly, elastic net regression can deal with multicollinearity and choosing important predictors combined with penalizing less important ones. In combination, these approaches provide a comprehensive, detailed conception of economic and environmental relations developed in Asian economies in the panel data analysis.

3.3 Data

Data on all the variables used in this study are derived from the World Development Indicators (WDI) database of the World Bank. The dependent variable is CO2 emissions, which measures environmental quality. The independent variables are economic growth incomes or gross domestic product per capita as a proxy for income, FDI, institutional quality energy consumption, and ethics. The sample involves 40 Asian countries from 1993 to 2022, randomly drawn from the World Bank data set, which adopts a stratified sampling approach. The description of variables is provided in Table 1.

A distinctive feature of Asia is that it is considered an area that is rapidly developing economically. Nevertheless, it is characterized by significant differences in its socio-political contexts, which makes it possible to investigate the consequences of environmental impacts. Policies on industrial development and the use of cheap electricity have fuelled the need for energy and a reliance on fossil energy sources, resulting in the release of high levels of CO2.

Tab. 1 - Variable Descriptions. Source: own search

Variables	Abbr.	Description	References
Environmental Quality	CO2	The first dependent variable identified in this study is CO2 emissions expressed in metric tons per capita. The lower the value for this variable, the higher the quality of the environment, based on the amount of CO2 per head of population in a country. Release of CO2 is mainly due to the burning of fossil fuels including coal, oil and natural gas used in the generation of power and heat, in vehicles and for	Aziz et al. (2020)

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		industrial uses. More CO ₂ means an increased rate of destruction of the environment, global warming, climate change and the consequent effects.	
Economic Condition	GDP	Standard of living is expressed through the indicator gross domestic product (GDP) per capita, which is the GDP of the country divided by the number of individuals. This variable defines a country's economic performance in relation to the population, affording an indication of the welfare of the nation's populace.	Asghar et al. (2024)
Foreign Direct Investment	FDI	This is calculated as the net inflow of FDI as a proportion of the country's GDP. It is the capital accumulation through direct or portfolio investment made overseas in domestic firms or assets for enhancing capital formation and economic development.	Abdouli & Hammami (2017)
Population Growth	POP	This is the increase in population size of a country as a percentage in any given year. The variable is informative in measuring the demographic effects of the use of resources and the quality of the environment.	Swanepoel et al., (2019), Vural-Yavaş (2021)
Energy Consumption	EC	This is defined as the total energy utilization in a given country, regardless of whether it is renewable or non-renewable. Fossil energy is non-renewable in the form of coal, oil and natural gas, while renewable energy sources include solar energy, wind energy, hydro power and geothermal energy. This variable is important for determining the effects of energy use on environmental quality, since high energy consumption from fossil energy sources leads to increased emissions of CO ₂ .	Quinche-Martín & Cabrera-Narváez (2020), Wang et al. (2024)
Political Risk Index	POL	This is an indicator of the stability of the political situation in a country as well as the effectiveness of institutions. It includes an index of government stability, regulatory quality, rule of law, and a measure of corruption. Lengthier politico-legal environmental scale values suggest a higher political risk tolerance and superior institutional capability in the enforcement of and compliance with rules regarding environmental standards and policies.	Mehmood (2024)

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Regulatory Quality	RQ	Regulatory quality is quantified based on a regulatory quality index which considers how well the government is formulating and enforcing the right policies and regulations to encourage private business. The higher the value, the better the regulatory environment for business and the environment in the country.	Iqbal et al. (2021), Robertson & Barling (2013)
Rule of Law	LO	The rule of law index assesses the extent to which laws are publicly promulgated, equally enforced, and independently adjudicated, as well as whether the legal framework protects fundamental rights. Higher scores in this index signify stronger legal institutions that support environmental governance.	Iqbal et al. (2021), Robertson & Barling (2013)
Ethnic Power Relations	EPR	EPR indices capture the balance of power between the ethnic groups in a given country. The index measures the balance of power between ethnic groups, with higher scores reflecting ethnic competition or conflict. Where EPR is relatively high, governance may be undermined by social pressures, which makes it difficult to co-ordinate and implement environmental policies.	Fankhauser & Jotzo (2018)

This paper aims to identify possible determinants of CO₂ emissions in 40 Asian countries within the time frame 1993-2022. The parameters adopted for the analysis encompass levels of economic development, quality of governance, the extent of RE solutions, CO₂ emission, and FDI flows. The countries are grouped into three categories: developed countries with extensive formal legal systems and higher RE implementation; middle-income countries with high emission levels due to industrialization and increased urbanization; and developing nation-states with low institutional credibility conducive to sustainable environmental legislation. To analyse the influence of ethnic diversity, political stability, and the strength of regulatory measures on environmental management and performance in the region, the dataset contains corresponding variables.

4. RESULTS AND DISCUSSION

4.1 Results

The descriptive statistics of the variables of the study are presented in Table 2. The mean value of CO₂ emissions is 4.23, and its standard deviation is 108.88. This implies that the Asian economies in the sample exhibit significant differences in terms of CO₂ emissions. The mean value of EPR is 0.1654, suggesting that ethnic heterogeneity exists in the Asian countries under consideration. The mean GDP per capita is equal to 0.057, and its standard deviation is 0.075.

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For POL, the mean value is 0.5679 and its standard deviation is 0.17. Thus, a moderate to high mean of POL suggests a moderate to high level of political risk in the sample. The mean value of RQ is 0.49, and the standard deviation is 0.64, implying that there is relatively high variability in the quality of institutions in the Asian economies under consideration. The mean POPG is equal to 0.4663, and the standard deviation is equal to 0.1696, implying moderate growth of the population in the sample. FDI has a mean value of 0.3134 and a standard deviation of 0.2261, which indicates that the Asian economies under study have a large variation of FDI inflows.

Unreported results show that CO₂ emissions and GDP are positively related, suggesting that as economic performance elevates, CO₂ emissions also increase. This supports Grossman and Krueger's EKC hypothesis, which states that as a country develops from a lesser level of income, there is an increase in emissions.

Tab. 2 - Descriptive Statistics of the Variables. Source: own search

Variable	Observation	Mean	Median	Q1	Q3	Maximum	Minimum	Std. dev
CO ₂	1044	4.2302	4.3698	1.5778	4.789	6.3873	0.1496	108.88
GDP	1126	0.0569	0.0318	0.2249	0.6640	0.8823	0.001	0.075
FDI	1101	0.3134	0.2969	-0.0135	1.930	2.7722	-0.974	0.2261
POPG	1184	0.4663	0.4339	0.2156	0.8824	1.0167	0.0697	0.1696
EC	963	-0.491	-0.383	-0.9933	0.6734	0.9421	-1.999	0.6418
POL	623	0.5679	0.576	0.3245	0.6358	0.792	0.1650	0.1701
RQ	609	-0.491	-0.383	-0.9963	0.4563	0.9260	-1.6043	0.6418
LO	609	0.2979	0.276	0.2014	0.3806	0.4592	0.165	0.1701
EPR	1187	0.1654	0.1532	0.0935	0.8340	0.9765	0.0108	0.0749

Note: Per capita carbon emission (CO₂), per capita energy consumption (EC), ethnic powers relations (EPR), regulatory quality of institutions (RQ), law and order (LO), per capita gross domestic product (GDP), population growth (POPG), foreign direct investment net inflows (FDI), political risk index (POL).

Furthermore, the correlation between CO₂ emissions and each of population and energy is highly positive, indicating that an increase in population density and energy intensity is associated with an increase in emissions. However, CO₂ emissions and regulatory quality are negatively correlated, implying that institutions have a positive impact on reduced emissions. This observation supports the pollution halo hypothesis which states that FDI can improve environmental performance, given that the host countries have appropriate institutions. Figure 1 visualizes the correlation matrix.

The results of the regression analysis should help the global community understand the dynamics of the indicators that determine the levels of CO₂ emissions in the countries of the developing world in order to improve their assessment of the links between economic growth and sustainable development. Among the results reported in Table 3, the most notable is the relationship between the economic indicators, particularly GDP, and its second-order (GDP²), which is favourable to the EKC hypothesis. The relationship is also shown in Figure 2. This implies that when developing their economies, countries experience a downward trend of CO₂

emissions until a certain income level is achieved, beyond which emissions rise again, indicating further interaction of development and pollution in the environment.

Energy consumption has a strong positive correlation with CO₂ emissions in all models, which is statistically significant. This establishes that the continued use of non-renewable energy sources in developing countries is to blame for increased emissions. Implicit in these results, therefore, is the need to address the energy policy agenda, including support for the use of clean energy and energy efficiency to mitigate the effects of degradation of the natural environment. The results also show that the effect of regulatory quality is significant and negative for emissions, showing the importance of good governance for reducing emissions.

The results imply that countries with better-regulated systems of governance are more capable of controlling their influence on the environment, strengthening the assertion that good governance is an important factor in sustainable development. From a social perspective, the degree of ethnic power relations (EPR) shows that increased ethnic polarization or rivalry leads to a worsening of environmental conditions. This result suggests that social unrest and ethnic polarization have an influential and significant role to play in environmental quality. Such circumstances lead to a decrease in the effectiveness of enforcing policies that are supposed to decrease emissions and achieve environmental sustainability.

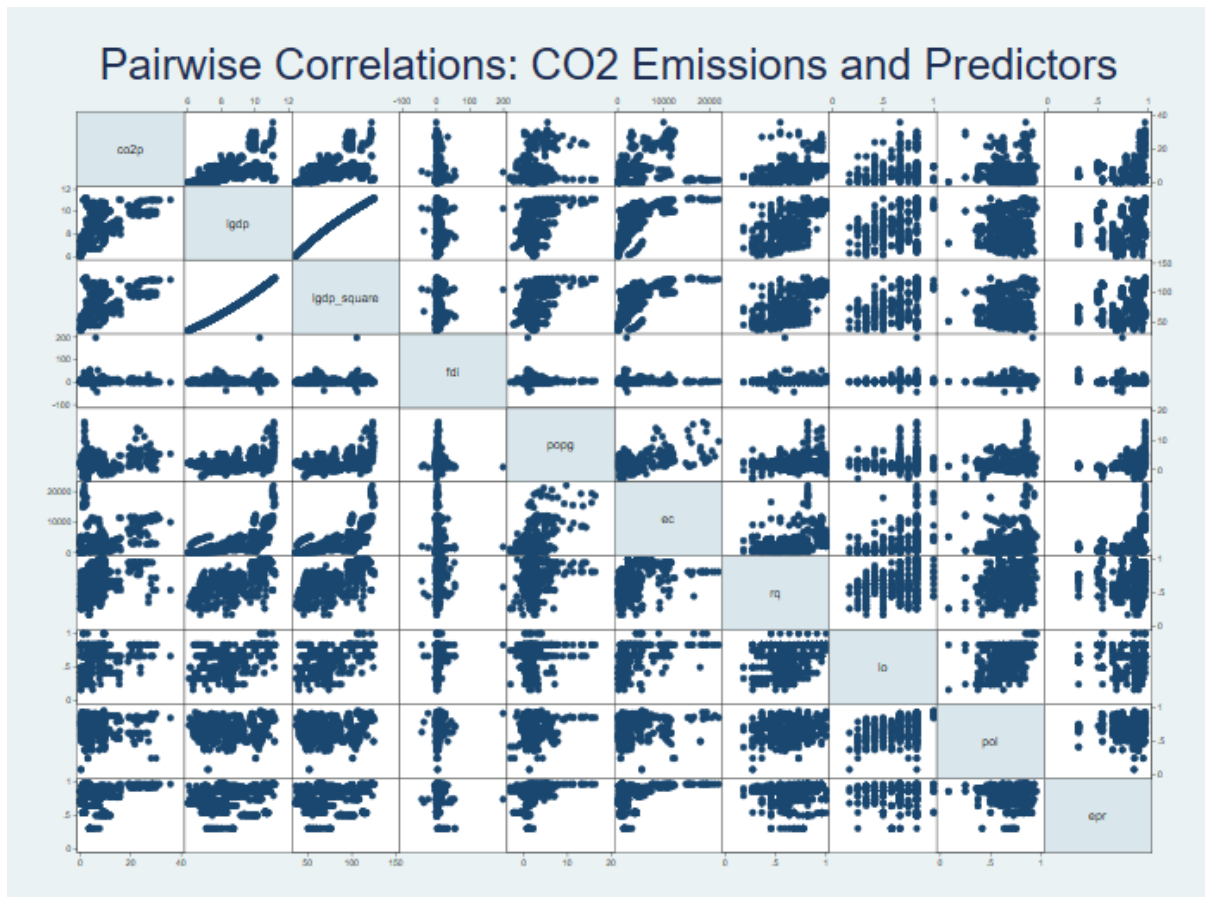


Fig. 1 - Correlation Graph. Source: own search

The coefficients of FDI and population growth are insignificant. FDI, for example, is only significant at a one percent level of significance in one model, which implies that its effect on emissions could depend on the kind of investment and the institutional framework of the host country. Population has a low and negative correlation with environmental pressure, with very small coefficient values. However, it assumes importance when compared to energy use and the impact of institutions on emission intensities.

Political risk (POL) has a modest level of significance in one model; thus, political stability can be a factor in reducing emissions, but the effect is less strong than other governance indicators, such as regulatory quality. Lastly, rule of law yields insignificant findings. Even though legal structures play an important role in governance and stability, there is a weak correlation between them and emissions in this case. These findings show that in order to decrease carbon emissions in Asia, it is important to focus on regulatory quality (RQ). In all the models, there is a persistent negative correlation between RQ and emissions, meaning that Asian countries with relatively strong quality regulations are likely to have lower emission levels. In the Asian context, improved regulatory quality is likely to mean stricter environmental requirements, and the capability to implement these requirements, thus lowering emissions, such as those from production processes. Therefore, this study suggests that

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pragmatic environmental legislation, together with compliance mechanisms, is fundamental in mitigating carbon emissions in Asia because it leads to improved efficiency, cleaner technology, and sustainable practice.

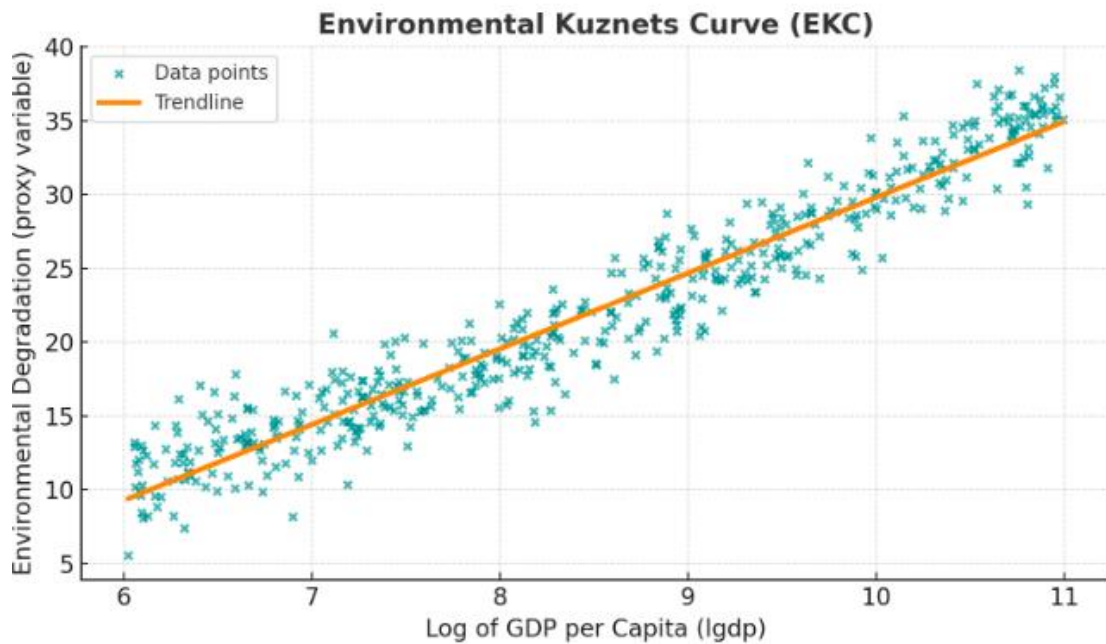


Fig. 2 - An illustration of the relationship between economic growth and environmental impact. Source: own search

On the other hand, law and order (LO), which measures the general stability of and conformity with laws, does not have a significant negative impact on emissions in these models. Therefore, even though legal systems are important for governance throughout the region, legal stability cannot, on its own, enhance the quality of the environment. It needs to be backed by strong environmental legislation as well as implementation measures. To engender major changes, general legislation with no specific laws directed at certain issues is not sufficient. While Asia is characterized by law and order for effective governance, the region lacks tailored environmental policies to discourage carbon emissions. These findings provide an understanding that, while governance quality may affect emissions across Asia, it is the environmental-specific regulatory frameworks that are most effective in influencing emissions, as only targeted regulation can bring about demonstrable positive change to the environment.

Tab. 3 - Comparing Carbon Emission Models across Methods. Source: own search

	(Regression with Driscoll-Kraay standard errors)	(Cross-sectional time-series FGLS regression)	(HDFE linear regression)
VARIABLE	Model 1	Model 2	Model 4
GDP	-9.482** (3.577)	-9.482*** (2.357)	-8.594** (3.841)
GDP ²	0.691*** (0.231)	0.691*** (0.145)	0.664** (0.262)

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FDI	-0.0040 *	0.000424	0.00284
	(0.002)	(0.00579)	(0.00498)
POPG	0.0100 *	0.00795	0.00473
	(0.003)	(0.0436)	(0.0682)
EC	0.000315***	0.000315***	0.000300
	(9.78e-05)	(0.000104)	(0.000190)
RQ	-2.412***	-2.412***	-2.398**
	(0.498)	(0.518)	(0.992)
LO	0.185	0.185	-0.474
	(0.375)	(0.723)	(1.025)
POL	-1.148	-1.148	-1.573**
	(0.930)	(0.699)	(0.787)
EPR	-54.94***	-54.94***	-54.24***
	(11.10)	(10.13)	(9.767)
Constant	81.13***	81.13***	75.69***
	(13.12)	(12.17)	(14.17)
Observations	487	487	487
R-squared		0.281	0.967
Number of groups	32		
Number of countries		32	

Note: Per capita carbon emission (CO₂), per capita energy consumption (EC), ethnic powers relations (EPR), regulatory quality of institutions (RQ), law and order (LO), per capita gross domestic product (GDP), population growth (POPG), foreign direct investment net inflows (FDI), political risk index (POL). *p<0.1, **p<0.05, and ***p<0.01.

Table 4 includes the quantile regression results, which show the factors affecting CO₂ emissions across quantiles. The impact of the factors depends on levels of carbon emissions, providing additional information on the effects of these factors in various conditions. For both GDP and GDP², there exists a strong non-linear relationship. At lower levels of quantiles (Q1/25th percentile), GDP has a negative and significant influence on CO₂ emissions. During the early stages of economic development, Asian economies adopt cleaner production technologies to reduce emissions. However, at higher percentiles, say 75% and 90%, GDP emerges as a positive and significant variable, indicating that an upsurge in emissions in a highly emitting economy also raises emissions in association with economic growth. This feature holds across the percentiles and points to the existence of an EKC, where emissions are expected to decline with development and to improve with growth before rising again due to industrialization and higher energy use. However, the results indicate that energy consumption (EC) is a substantial determinant with a positive sign, especially in the 75th and 90th percentiles. Thus, in countries where emissions are high, higher energy utilization is positive for CO₂ emissions. Notably, the trend abruptly ends at the 25th percentile, and the corresponding point exhibits a negative and significant value. This implies that some countries with lower emissions may be utilizing more natural and renewable energy sources in their production processes or using energy in more effective ways.

The role of FDI could be clearer, as FDI produces no notable results across the quantiles. This implies that FDI does not have any direct effect on the various quantiles of CO₂ emissions in

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Asian economics. The impact of FDI on the environment is contingent on the nature of investment. At the 25th percentile, POPG has a negative, albeit marginal and statistically insignificant, relationship, implying that in less emission-intensive countries, population growth could have a bearing on lowering per capita emissions because of aggregation and better management. However, this effect ceases to have much consequence further up the quantiles, where other factors such as energy consumption and economic growth have greater impacts on emissions. For the institutional characteristics, regulation quality (RQ) does not influence any quantile of CO₂ emissions, whereas rule of law (LO) has ambiguous outcomes.

For the lower percentile regression results, the LO coefficient is positive and statistically significant, consistent with the hypothesis that higher legal structures are associated with lower emission levels in countries with comparatively low emissions. However, at the 90% level, LO has a highly significant negative coefficient, indicating that, while the strength of law as a constraint may be able to reduce emissions in high-emitting countries, it is not sufficient because of mature industries.

Tab. 4 - Simultaneous Quantile Analyses. Source: own search

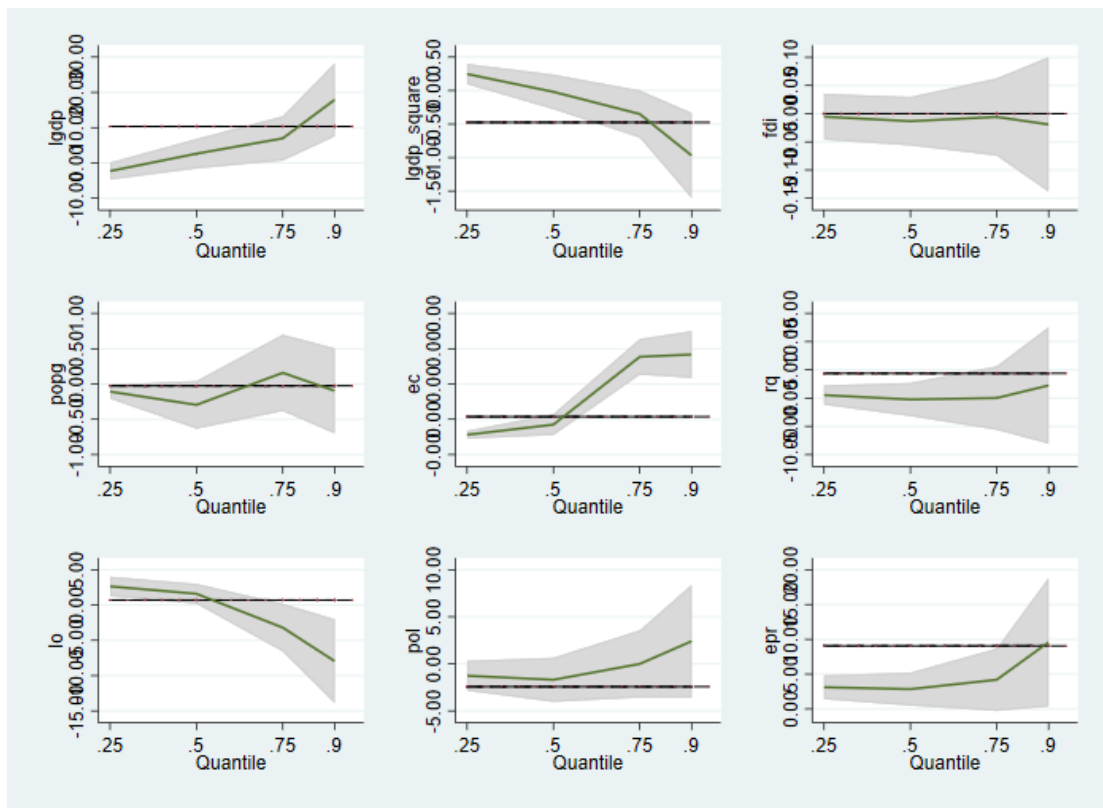
	(25Th)	(50Th)	(75Th)	(90Th)
VARIABLE	Model 1	Model 1	Model 1	Model 1
GDP	-2.297**	2.626	6.964***	17.90***
	(1.120)	(2.451)	(1.948)	(4.713)
GDP ²	0.247***	-0.0193	-0.350***	-0.970***
	(0.0677)	(0.144)	(0.106)	(0.294)
FDI	-0.00542	-0.0133	-0.00576	-0.0191
	(0.0194)	(0.0177)	(0.00920)	(0.0370)
POPG	-0.108*	-0.295	0.159	-0.0966
	(0.0643)	(0.216)	(0.279)	(0.354)
EC	-0.000438***	-0.000150	0.00177***	0.00184***
	(4.45e-05)	(0.000218)	(0.000187)	(0.000346)
RQ	0.539	-0.239	0.0226	2.253
	(0.943)	(0.953)	(1.234)	(3.712)
LO	2.645***	1.598**	-3.197	-7.949**
	(0.704)	(0.792)	(2.272)	(3.513)
POL	-1.264*	-1.687*	-0.00415	2.408
	(0.678)	(0.964)	(1.574)	(3.956)
EPR	3.119***	2.848*	4.201**	9.595*
	(0.894)	(1.500)	(1.662)	(5.104)
Constant	1.974	-17.39*	-31.45***	-79.23***
	(4.837)	(10.19)	(8.999)	(19.87)
Observations	487	487	487	487

Note: Per capita carbon emission (CO₂), per capita energy consumption (EC), ethnic powers relations (EPR), regulatory quality of institutions (RQ), law and order (LO), per capita gross domestic product (GDP), population growth (POPG), foreign direct investment net inflows (FDI), political risk index (POL). *p<0.1, **p<0.05, and ***p<0.01.

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The coefficient of political risk (POL) at lower quantiles of CO2 emissions is insignificant and negative, suggesting that political stability assists in emission reduction in lower CO2 countries. However, this impact is lower at the higher quantile, where we hypothesize that political factors are less relevant than economic growth or energy use. Lastly, EPR demonstrates a strong positive influence on emissions in nearly every quantile; thus, ethnic tensions or competition increase CO2 emissions, notably in countries with higher emission tendencies. This leads to an increase in emissions, which is a clear indication that social instability deters the effectiveness of governance and impairs the implementation of environmental policies.

Figure 3 gives the quantile regression results, showing how variables such as GDP per capita, energy consumption per capita, and ethnic power relations affect CO2 emissions at the 25th, 50th, 75th, and 90th percentiles. In the case of GDP, the graph is in the form of an inverted U, with a decrease in emissions at lower quantiles and an increase in emissions at higher quantiles, reflecting the EKC. This is proven at the higher quantiles, where the coefficients are positive, suggesting that energy use in high-emission nations contributes significantly to environmental degradation. Alternatively, ERP has a positive influence in every quantile, stressing social instability as the main driver of emissions. The graph adds credence to the previous findings by illustrating how the influence of the variables escalates in countries with higher emissions compared to the governance factors, such as rule of law and political stability, that have a larger effect in low-emitting countries.



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Fig. 3 - Quantiles Graph

Figure 4 shows the plot of the elastic net regression, showing how many of the predictors contribute significantly to the model as the regularization parameter (lambda) increases. When the value of lambda is low, a large number of variables are nonzero, which characterizes their significance in the model. However, as lambda increases, the size of some of the coefficients diminishes to near zero, implying that some of the variables are either unimportant or omitted from the model. Several variables, the coefficients of which in relation to lambda are far from zero, including GDP, energy consumption (EC), and ethnic power relations (EPR), are significant predictors of CO2 emissions. Such variables remain invariant across various degrees of penalization, demonstrating a robust relationship between these vectors and environmental quality. In contrast, variables such as FDI and population growth (POPG) have coefficients that decays to zero faster than those of CO2 emission. Hence, they have a weak or inconsistent impact on CO2 emissions. Altogether, the plot reveals which variables remain significant with increasing lambda, the principal economic and social causes of environmental degradation, and the less relevant variables which are eliminated from the model to account for added model complexity. This is very useful for deducing which factors assume the most importance as far as CO2 emissions are concerned, given the economic perspective of the analysis.

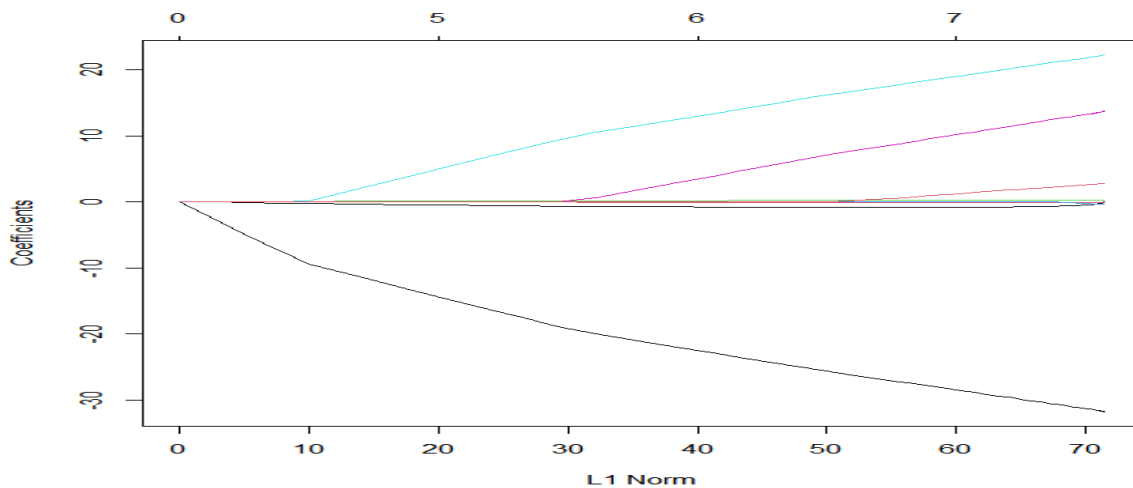


Fig. 4 - Elastic Net Regression Plot. Source: own search

4.2 Discussion

The examination of carbon dioxide emissions in Asian economies proves very insightful, having essential policy implications. It brings out important patterns of growth, energy, and governance in relation to the environment, which is vital for policymakers and researchers. One of the most significant observations made is the identification of the EKC hypothesis supporting H1, which implies that although emissions rise in the early stages of economic development, they begin to fall as countries attain higher levels of income and transition to

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better technologies. However, the pattern is not fully applicable to all Asian countries. Some countries which have low standards of governance or limited capacity to access efficient technologies lie below the curve, suggesting that growth is not a comprehensive solution to environmental challenges. Such variation points to the need for ongoing measures to disconnect economic development from environmental pollution and degradation in countries where industrialization fuels emissions. Energy consumption also plays a significant role, thus supporting H4. As the economies of India, China, and other Asian countries progress with industrialization, the emissions coming from fossil fuels remain enormously high. This evidence heightens the need for energy policy change—increasing renewable energy and implementing energy efficiency standards could be a favourable shift. These efforts are not only required to address increasing energy requirements but are also imperative to avoid the environmental degradation associated with unbridled consumption of fossil fuels. Good governance, which contributes to the validity of H5, is another factor that plays a role in containing emissions.

The level of emissions is lower in those countries possessing robust regulation and institutional structures, while countries with weak governance are unable to enforce environmental legislation. This suggests a need to enhance regulatory clarity and anti-corruption measures as well as embrace the use of market instruments such as carbon taxes, charges, or emissions trading. By applying sound governance, countries can build a solid platform for sustainable development and help industries overcome barriers to green transformation. The role of FDI, as it relates to H2, is multi-faceted. Though FDI might pose pollution risks, as indicated by the pollution haven hypothesis, it can also help foster sustainability through technical know-how and environmentally friendly technology. This suggests a balanced approach, in which developing countries should encourage ecological FDI that supports technologically sustainable sectors such as renewable energy while ensuring investors are environmentally sensitive. Thus, FDI could be a positive force that contributes to sustainable development instead of a factor with environmental impact.

The findings relating to H3, in terms of the effects of population growth on emissions, show another noteworthy relationship. High demographic density and population growth, especially in Asia, may exert pressure on the environment. While it is true that growth impacts the environment negatively, with efficient urban planning and management of resources, governments can decrease this effect. Subsidized buses and trains, garbage collection, and sustainable urban structures allow cities to expand without harming the environment. Hence, H3 highlights how population growth can be a factor in emissions, but, when planned for, becomes a strength for sustainability.

The result concerning ethnic polarization, supporting H6, highlight how social issues can impact the environment. For policy implications related to Asia, there is a need to enhance the quality of the regulations implemented, emphasizing the intensity of environmental standards and the enforcement necessary to curb carbon emissions. Targeted regulation that boosts the adoption of clean technologies can, therefore, be further enhanced, especially for sectors that emit high levels of pollutants. Furthermore, promoting responsible governance that incorporates environmental concerns into other policies can go a long way to enhance

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sustainable development in the region. Ethnic polarization implies that governance is weak in the affected nations, which hinders the implementation of environmental regulation and results in increased emissions. To counter this, Asian countries have to pay adequate attention to inclusive governance and social inclusion so everyone can access resources and participate in decision-making processes. Such an approach would not only enhance governance but also ensure better environmental quality due to enhanced social stability and cooperation. Due to this, the policy recommendations made should be specific in addressing the features of Asian countries which have direct influence on carbon dioxide emissions and the achievement of sustainable development. The EKC hypothesis captures the idea that emissions increase alongside initial development but decrease with enhanced technology. Policies should encourage the use of cleaner technologies through subsidies, tax credits, and technology promotion so that nations can develop their economic bases and, at the same time, have smaller ecological footprints. Industrializing economies' energy appetites remains high, as seen in India and China, and rely overwhelmingly on fossil fuels. A clear and strict shift to renewable sources of energy and efficient policy is required. Government policies that support the development of renewable energy sources and consumption reduction would help meet industrial energy requirements while reducing environmental impact.

Another key factor is governance quality, which defines how effectively emission issues are managed. Nations with sound rules and strong institutions have a lower levels of emissions. Addressing regulatory uncertainty and compliance is complicated, and embracing market-driven measures, including carbon taxes and emissions trading, makes it easier to improve compliance, fostering cleaner industries. Thus, FDI can either exacerbate pollution or promote environmentally friendly technology through technology transfer. To optimize the environmental outcomes of FDI, policies should direct green investment and apply pressure through environmentally friendly standards, mainly in leading sectors such as renewable energy, transforming FDI into a catalyst for environmental sustainability. It is risky to allow population growth and the expansion of human settlement to continue without consideration, as it increases the pressure on resources and emissions. These effects can be offset by sustainable urban infrastructure policies such as affordable public transport, green building standards, and environmentally friendly waste management policies, making demographic growth a positive development. Finally, combating ethnic polarization in government operations is essential. Increased participation of all social categories in structures for developing, implementing, and overseeing legal measures could strengthen environmental protection against pollution. These specific measures would allow Asian economies to open up for development and growth while keeping sustainability and environmental costs under control.

5. CONCLUSIONS

This study tackles two pressing issues in Asian economies: (1) economic growth without compromising environmental conservation; and (2) energy utilization without an increase in CO₂ emissions. It emphasizes another, less visible but significant, problem, ethnic division, which diminishes the efficiency of governance and makes it difficult to implement proper environmental policies. Established ethnic conflicts and social tensions in many Asian

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countries make it difficult to implement coordinated policies, resulting in environmental degradation. This study offers instructive solutions, showing how governance and social connectedness can enhance the environment. Notably, the EKC hypothesis receives support from some of the contextual variables. However, the study indicates that it is hard for nations, particularly those with poor governance or high ethnic polarization, to make the transition to sustainable economic growth without worsening the environment. Energy demand is revealed as the main factor in the generation of emissions, especially in the rapidly industrializing nations of the developing world, including many Asian economies, which underlines the need to transition to renewable energy sources and increase energy efficiency in the near future. The lack of this transition puts these economies in a precarious situation, in which the demand for energy is rising while the environment feels the pinch. The solution lies in green growth strategies. Governments should promote investment in renewable energy assets, implement higher energy conservation policies, and decrease the dependence on petroleum products.

Enhancing governance is more important where there are profound ethnic divisions. More inclusive governance architectures that promote fairness of resources, lessening social conflict, can improve environmental stewardship. Ethnic polarization poses a primary challenge for governments and has to be tackled directly. The ability to promote social cohesion represents a direct solution to this problem, because it enhances the efficient implementation and enforcement of environmental policies. Where ethnicity tends to generate fragmentation in governance, integrated strategies can turn division into strength, in the sense that there can be unity in the drive towards sustainability.

The impact of FDI is multifaceted. Despite having a negative impact on the environment, it can promote the concept of sustainability through green technology transfer. The challenge for governments, therefore, lies in attracting green FDI, especially targeted towards renewable energy and sustainable industries. Environmental controls are required to minimize the ability of corporations to exploit deficits, specifically in ethnically fragmented areas where governance is generally poor. Environmental impact is an important factor in urban development, considering the rate at which the global population is growing, hence the expansion of urban centres coupled with the sustainable planning of available resources. Governments and municipal authorities must encourage the provision of reliable and efficient structures dealing with the effects of urban sprawl, such as public transport, waste management, and energy-efficient structures. What sets this research apart from others is its consideration of ethnic polarization as a factor contributing to the increase in emissions. Weakened governance, especially in countries with deep ethnic divides, leads to environmental degradation. Where governments continue to exclude a particular social group from governing in their country, they continue to weaken their ability to enforce environmental laws and mitigate the impacts of environmental degradation on the people and the environment.

Though this study is effective in suggesting sound policies for the future course of development, it recognizes its potential drawbacks, with panel data likely being more suitable for simultaneously capturing the dynamic nature of environmental policies and technologies. Further research into FDI and its environmental impacts should be carried out, with an emphasis on the impact of green technologies on emissions. For example, extending the study

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to other geographical areas or including more socio-political factors, such as ethnic tensions, could enhance the understanding of emission trends. Such country-specific or sector-based studies could further enhance the policy prescriptions for sustainable development appropriate to the conditions of various economies.

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