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Can Taxes Save the Planet? Assessing the Role of Pigouvian Taxation in Addressing Environmental Externalities in Pakistan

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ABSTRACT
The capacity of Pigouvian taxation to internalize environmental externalities remains empirically contested in developing economies characterized by structural constraints and governance weaknesses. This study evaluates the interaction between fiscal policy, institutional quality, and carbon emissions in Pakistan over the period 1996–2024. The analysis incorporates per capita CO_2 emissions as the dependent variable and examines the effects of energy consumption, fossil fuel dependence, renewable energy penetration, tax revenue, economic growth, and government effectiveness using time-series data from the World Development Indicators and Worldwide Governance Indicators. To ensure econometric robustness, unit root tests and diagnostic procedures are implemented to address non-stationarity and potential heteroskedasticity. The empirical model is estimated using Robust Least Squares with heteroskedasticity-consistent standard errors. The results indicate that total energy consumption and fossil fuel reliance exert significant positive effects on emissions, whereas government effectiveness has a statistically significant mitigating impact, emphasizing the importance of institutional capacity in environmental governance. Tax revenue is positively associated with emissions, suggesting weak environmental targeting of fiscal instruments. Furthermore, the empirical evidence does not support the presence of an Environmental Kuznets Curve during the sample period. The findings suggest that environmental taxation in Pakistan cannot operate effectively in isolation but must be embedded within institutional reforms and structural energy transition policies to achieve sustainable emission reductions.

Keywords: Pigouvian Taxation; Environmental Externalities; CO2 Emissions; Energy Transition; Government Effectiveness; Sustainable Development; Pakistan.

Introduction

Environmental degradation casts a long shadow over the world, posing a complex and multifaceted threat to the ecological and economic underpinnings of societies everywhere (Rahman, et al. 2025). In practically all emerging countries, where the need for quick economic growth frequently clashes with the delicate status of the environment, this problem is especially acute. Pakistan, a country dealing with the twin burdens of developmental pressures and extreme ecological vulnerability, is a glaring and, to a greater extent, ideal example of this confluence (Arif, et al. 2024). Critical issues abound in the country's environmental portfolio: the extreme scarcity and pollution of water resources, which endanger human health and agricultural productivity; the dangerously high levels of urban air pollution that permeate the nation's major cities in a persistent

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haze, contaminating the very air its citizens breathe; and the unrelenting encroachment of land degradation and deforestation, which erode the natural capital upon which a significant portion of its population depends (Aslanbeigui, 2025). These are not just environmental issues; they also pose a serious threat to public health, reduce economic productivity, and worsen social injustices, all of which jeopardize the country's long-term viability and resilience (Fischer & Storm 2023).

The widespread economic issue of externalities, which was masterfully expressed by economist Arthur Cecil Pigou in the early 20th century, is at the core of this environmental dilemma. When producers' or consumers' actions result in unreported costs or, less frequently, unrecognized benefits for third parties or society as a whole, this is known as an environmental externality. The entire cost of the harm done to downstream agricultural systems, fisheries, and public health is not borne by a factory that releases untreated wastewater into a river (Das& Abhijeet, 2025). In a similar vein, a commuter who drives a private vehicle adds to urban haze without bearing the costs of the related medical expenses and lost productivity to the community. These "negative externalities" are routinely disregarded in a traditional market system since they are expenses that are not considered by the decision-makers (Buckley & Enderwick, 2025). Because their market prices do not accurately reflect their full societal cost, ecologically harmful goods and services are overproduced and overconsumed, leading to a fundamental market failure. This failure generates a breach between individual reason and the well-being of the group by causing a stark difference between private profitability and societal wellbeing.

The policy arsenal for rectifying such market failures is wide, ranging from direct "command-and-control" regulation, which establishes legal limits on pollutants or requires specific technology, to more flexible, market-based instruments (Popoyan& Sapio, 2025). The Pigouvian tax, a fee intended to be equivalent to the marginal social cost of a negative externality, has gained a lot of attention both theoretically and practically in this latter category (Yang, 2025).

The Pigouvian proposal has a convincing theoretical elegance: the tax "internalizes the externality," making polluters face the full societal cost of their conduct by putting a fee on the harmful activity equal to the damage it produces. Because it becomes directly profitable for them, businesses and individuals are continuously and dynamically encouraged to innovate, cut pollution, and look for cleaner alternatives—not because they are required to by law(Yang & Umair, 2024).According to (Fu, et al. (2024), the tax theoretically corrects the price signal, directing the market toward a more ecologically friendly and socially efficient equilibrium. Additionally, the money raised by such a tax offers a potential "double dividend"—it can be used to fund public environmental projects, lessen the impact of the transition on the most vulnerable members of society, or reduce other distortionary taxes in addition to reducing environmental harm(Muth, Weiner & Lakócai, 2024). However, there are several difficult obstacles and deep complications when using this theoretical concept in a real-world setting like Pakistan. Because of the country's economic structure, which is largely dependent on an industrial base that is frequently characterized by antiquated technologies and an agricultural sector that is both a victim and a perpetrator of environmental stress, imposing new financial burdens is a delicate political and administrative task. Since a sizable amount of economic activity takes place outside the official tax system, the widespread problem of informality in the economy poses serious enforcement challenges (Bilan & Apostoaie, 2025).

Furthermore, the state frequently lacks the ability to precisely assess, track, and value

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environmental damages, which is a requirement for determining an effective tax rate (Borozan & Pirgaip, 2024). It is empirically difficult to determine the exact social cost of one ton of carbon dioxide emissions or one cubic meter of industrial wastewater; this requires advanced data and analytical skills that are sometimes lacking in poor nations like Pakistan. In addition, it is impossible to overestimate the social and distributive effects of environmental taxes in a nation where a sizable section of the populace lives in or close to poverty (Nelson et al. 2025). For example, a fuel or energy tax may be able to reduce emissions, but it may disproportionately affect low-income households, whose energy costs make up a bigger portion of their expenses, and who have less access to cleaner, but frequently costlier, alternatives. Because of this, the political economy of enacting such taxes is extremely complex and needs to be carefully planned to prevent regressive effects and to foster popular support for environmental action (Weldon et al. 2025).

Thus, the question shifts from being purely theoretical to becoming more complex: Is it possible to calibrate and apply the sophisticated tool of Pigouvian taxation, which was developed from neoclassical economic theory, within the intricate and frequently chaotic socioeconomic reality of a developing nation like Pakistan? This aims to address this important subject in depth. It will investigate how Pigouvian taxes might be a key component of Pakistan's environmental policy framework, going beyond a purely theoretical support to a realistic evaluation of its viability. Pakistan's complex political economy, administrative capacities, and urgent social needs will all be covered in the analysis. It will carefully examine the prerequisites for the success of such a fiscal tool, such as the governance frameworks required, the significance of revenue recycling mechanisms to maintain equity, and the requirement for supplementary policies that address institutional and market failures outside the purview of a single tax. By conducting this thorough analysis, the study hopes to advance our understanding of how market-based mechanisms can be adapted to the particular difficulties faced by developing nations—not as a magic bullet, but as a potentially potent part of a larger, more resilient, and sustainable approach to environmental stewardship in the twenty-first century.

Literature Review

Global efforts to discover effective mitigation policies have been sparked by the existential threat of climate change, which is primarily caused by anthropogenic carbon dioxide (CO2) emissions. Pigouvian taxes, a market-based tool intended to internalize the social cost of negative externalities, has become a conceptually elegant answer within this toolbox of policy tools. In order to develop a framework for evaluating the potential of environmental taxes to reduce CO2 emissions in Pakistan, this review synthesizes the body of existing theoretical and empirical material. The dependent variable, CO2 emissions (measured in metric tons per capita), and the six independent variables—energy use, fossil fuel energy consumption, renewable energy consumption, tax revenue, GDP per capita, and government effectiveness—are the focal points of the analysis. In order to outline the contextual elements that would dictate the effectiveness of a Pigouvian tax regime in a growing economy with its distinct energy, fiscal, and governance issues, this review will look at these relationships.

Dependency on Fossil Fuels and Energy Use

The size and composition of a country's energy consumption are the main and most direct factors that determine its profile of CO2 emissions (Emenekwe et al., 2025). A

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significant amount of research clearly shows that total energy use and CO2 emissions are positively and frequently causally related. greater per capita energy consumption, expressed in kilos of oil equivalent, is a strong predictor of greater per capita CO2 emissions, according to studies conducted across a variety of panels of nations (Gershon et al. 2024). The fundamental rule of thermodynamics underlies this relationship; energy transformation is necessary for the great bulk of economic activity, and historically, this process has been intrinsically carbon-intensive. The trajectory of Pakistan's total energy demand serves as a crucial baseline from which any emission mitigation plan must depart, given the nation's rapid industrialization and population increase (Ahmad et al., 2025). According to empirical research, the potential benefits of marginal efficiency increases will be offset by the substantial upward pressure that energy use's rise would continue to impose on emissions in the absence of a structural change (Yang, 2025). However, the variable fossil fuel energy use as a percentage of the total captures the carbon intensity of this aggregate energy use, which is the crucial mediating component (Liu, Li & Xue, 2024). There is little reason to question the worldwide literature, which shows that economies with a larger proportion of fossil fuels, especially coal and oil, in their primary energy mix have disproportionately higher CO2 emissions per unit of energy consumed. According to research on South Asian economies, including Pakistan's, the main causes of the carbonization of its energy sector are the country's significant reliance on imported oil and its growing use of indigenous coal and natural gas for power generation (Raza & Lin, 2024). The variable for fossil fuel usage is anticipated to have a substantial positive association with the dependent variable since the combustion of these fossil fuels is the primary source of anthropogenic CO2. One of the biggest obstacles to decarbonization is the inertia of fossil fuel-based energy infrastructure, which is defined by long-lived capital stocks and deeply ingrained political economics (Poudineh, 2025). Accordingly, the literature suggests that the ability of any policy—including taxes—to lower overall energy consumption and, more crucially, to start a fuel-switch away from fossil fuels and toward cleaner alternatives should be the key indicator of its efficacy.

Fiscal Leverage and Renewable Energy Use

A key component of international climate mitigation measures is the shift to renewable energy sources in response to the problems caused by reliance on fossil fuels (Ishola, 2024). Both theoretically and empirically, there is a continuous negative relationship between CO2 emissions and the amount of renewable energy consumed as a fraction of total final energy. Increasing the proportion of renewable energy in the energy portfolio is linked to a statistically significant decrease in CO2 emissions per person, according to numerous cross-national studies (Jie & Rabnawaz 2024). The principle is simple: emissions are directly avoided at the site of generation when energy from non-combustible sources, such as solar, wind, and hydropower, is substituted for energy produced from fossil fuels. The literature indicates that speeding up this transition is essential for Pakistan, a nation with significant unrealized renewable potential, especially in solar and hydro. There is a clear opening for government intervention, though, as studies also point to the intermittent nature of some renewables and the high upfront investment costs as crucial obstacles that market forces alone have not been able to overcome in the Pakistani context (Ukoba et al. 2024).

The importance of fiscal policy—more especially, tax income as a percentage of GDP—becomes apparent at this point. Despite not being a direct Pigouvian tax, general tax income is an important indicator of the state's financial ability to carry out and oversee

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complex environmental fiscal measures (Ljubičić, 2025). According to the research, a larger tax-to-GDP ratio is frequently associated with higher levels of administrative and institutional maturity, all of which are necessary for the successful implementation of a carbon tax or other comparable Pigouvian instruments (Sabry, 2024). A government with a strong revenue base is better equipped to handle the distributional effects of a new tax, weather possible political backlash, and credibly commit to revenue recycling initiatives like cutting back on distortionary taxes or financing green subsidies (Muth, 2025). On the other hand, the state might not have the administrative capacity to efficiently impose and collect a targeted environmental tax in low-tax environments like Pakistan, running the risk of inefficiency or evasion (Pasha, Tanveer & Malik). By placing a price on carbon, the specific literature on Pigouvian taxation offers compelling theoretical justification for its capacity to address market failures and provide emitters with an ongoing incentive to innovate and lower their tax obligations (Yang, 2025). Well-crafted carbon taxes can result in quantifiable emissions reductions without impairing economic growth, according to empirical research from Scandinavian nations and, more recently, from portions of Canada and the EU. This is especially true when the money collected is utilized to correct for other fiscal inefficiencies.

Governance Quality and Economic Development

One of the most studied subjects in environmental economics is the connection between environmental deterioration and economic development. This relationship is mainly investigated using the Environmental Kuznets Curve (EKC) theory (Wang, Ren & Li 2024). According to the EKC, GDP per capita and CO2 emissions have an inverted U-shaped relationship. This means that while emissions first increase as economic growth occurs, they eventually fall once a certain income threshold is reached as economies move toward services and environmental quality demands rise. The EKC's empirical support is conflicting and heavily context-dependent. A monotonically growing or N-shaped link between GDP per capita and emissions has been found in Pakistan by a number of time-series studies, which have failed to uncover conclusive evidence of the EKC turning point (Ullah, A., & Ali, A. (2024). This suggests that Pakistan's current economic growth trajectory is still closely linked to the usage of carbon-intensive energy, and that the automatic decoupling predicted by the EKC theory cannot be trusted. This emphasizes the need for proactive governmental interventions, like taxation, to consciously break this connection and guide the economy toward sustainable growth before irreparable environmental harm is done. In the end, the effectiveness of government, which is a proxy for governance quality, is crucial to the success of any such intervention (Capano, Pritoni & Profeti, 2025). This variable includes the general caliber of the civil service, the credibility of the government's commitment to its programs, and the caliber of policy design and implementation. The effectiveness of environmental legislation is significantly influenced by the quality of governance, as the research clearly shows (Assfaw & Sharma, 2024). A highly effective government may create a Pigouvian tax that is supported by science, established at a level that accurately represents the social cost of carbon, and implemented consistently and openly. Additionally, it can guarantee that the tax is seen as valid, which will encourage compliance. On the other hand, even a well-thought-out tax may not work in environments with low government efficacy because of poor enforcement, corruption, regulatory capture by polluting businesses, or unstable policies. Governance deficiencies are commonly cited as the main cause of the discrepancy between the goals and results of environmental policy in developing nations, such as Pakistan (Syed, Awan & Mumtaz,

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2024). The government performance variable is therefore not just a control but also a possible prerequisite for the efficient internalization of environmental externalities through financial methods.

Research Gap and the Study's Contribution

There is a substantial research gap in the integrated and context-specific analysis of Pigouvian taxation within the intricate socioeconomic fabric of Pakistan, despite the abundance of literature on the individual relationships between CO2 emissions and variables like energy use, economic growth, and renewables(Ahmad & Ali, 2022). Numerous studies look at these factors separately or in large cross-country panels, frequently ignoring the special interaction between Pakistan's acute energy problem, its weak fiscal capability, and its known governance issues(Tunio et al. 2024). Additionally, although Pigouvian taxation is a well-established theory in industrialized economies, little empirical research has been done on its potential design and practical relevance in emerging nations that are simultaneously under pressure to reduce poverty, promote economic growth, and adapt to climate change(Roy, Chen & Semmler, 2025).

The goal of this study is to make many significant contributions to the literature. First, it combines the main mitigating factor (tax capacity interacting with renewables), the key moderating factors (income level, governance), and the key drivers (fuel mix, energy use) into a single, cohesive empirical model that is specific to Pakistan. Second, it goes beyond theoretical debate to offer a numerical evaluation of the potential effects of raising general tax revenue, as a prelude to a specific carbon tax, on CO2 emissions, contingent on the levels of other variables. Last but not least, the study provides crucial insights into the governance requirements for successful environmental fiscal reform by explicitly modeling government effectiveness. This allows it to provide recommendations that are relevant to policy and based on Pakistan's institutional realities. In doing so, this study will provide a nuanced response to the main query: under what particular circumstances may taxes actually contribute to the preservation of the Pakistani planet?

Theoretical Framework

The Neoclassical Basis and Environmental Constraints

A key component of neoclassical economics, the Solow Growth Model (Solow, 1956) offers a potent framework for comprehending long-term economic growth by emphasizing capital accumulation, labor force expansion, and technical advancement. But according to its conventional definition, the environment is a free good that exists outside of the economic system. This is a crucial omission because economic activity is a major contributor to environmental deterioration, particularly CO2 emissions, and is essentially reliant on ecological services (Grossman & Krueger, 1995).By explicitly incorporating energy consumption, which is distinguished by its carbon intensity, and the role of government intervention through Pigouvian taxes, this paradigm expands upon the fundamental Solow model. The main theoretical contention is that although capital and energy-driven economic expansion is the main cause of environmental externalities, these externalities can be lessened by using the same market processes that propel growth. Theoretically, a Pigouvian tax (Pigou, 1920) may change the factor mix, encourage technological advancement in green energy, and eventually guide the economy toward a more sustainable growth path by internalizing the social cost of carbon. The theoretical foundation for the empirical study of the correlation between CO_2 emissions and the chosen independent variables in Pakistan between 1990 and 2024 is

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provided by this modified model.

The Basic Solow Model and its Production Function

The starting point is the standard Solow model with a Cobb-Douglas production function:

$Y(t)=K(t)^{\alpha}\,[A(t)L(t)]^{1-\alpha}$ (1)

Where:

Y(t) is aggregate output (GDP).

K(t) is the physical capital stock.

L(t) is the labor force, growing at a constant rate n.

A(t) is the level of technology (Total Factor Productivity, TFP), growing at a constant rate g.

α is the output elasticity of capital, $0<\alpha<10<\alpha<1$.

The model is typically analyzed in intensive form, expressing variables per unit of effective labor, A(t)L(t). Defining output per effective worker as y=Y/AL and capital per effective worker as k=K/AL, the production function becomes:

$Y = k^{\alpha}$ **(2)**

The capital accumulation equation is given by:

$\dot{k} = sy - (n+g+\delta)\,k$ (3)

Where:

s is the exogenous saving and investment rate.

δ is the capital depreciation rate.

$\dot{k}$ is the change in capital per effective worker over time.

The steady-state, where $\dot{k}=0$, is defined by:

$sy^{*} = (n+g+\delta)\,k^{*}$

$sk^{*\alpha}=(n+g+\delta)k^{*}$

$k*= [s \div (n+g+\delta)]^{\alpha \div 1-\alpha}$ (4)

Substituting equation (4) into equation (2) gives the steady-state output per effective worker:

$y*= [s \div (n+g+\delta)]^{\alpha \div 1-\alpha}$ (5)

This model predicts conditional convergence and highlights the roles of saving and population growth rates. However, it lacks any environmental dimension.

3. Extending the Solow Model with Energy and Emissions

Energy must be explicitly incorporated into the production process in order to examine environmental externalities. We adjust the production function to incorporate energy services, E(t), in accordance with the literature on Green Growth (e.g., Aghion et al., 2014; Brock & Taylor, 2010). For simplicity, we choose a Cobb-Douglas form:

$Y(t)=K(t)^{\alpha}\,E(t)^{\beta}[A(t)L(t)]^{1-\alpha-\beta}$ (6)

Where β is the output elasticity of energy, $0<\beta<1$ and $\alpha+\beta<1$.

Breaking down energy, E(t), into its component components—renewable energy R(t)) and fossil fuel energy F(t))—is a crucial step. This enables us to directly model the economy's carbon intensity. For the sake of tractability and consistency with our variables, we approximate the constant elasticity of substitution (CES) function for energy as follows:

$$E(t) = [\emptyset\, F(t)^{\frac{\sigma-1}{\sigma}} + (1 - \emptyset\,)R(t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}$$ (7)

Where:

ϕ is a distribution parameter between fossil and renewable energy.

σ is the elasticity of substitution between fossil and renewable energy.

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The central environmental externality is CO_2 emissions, which are primarily a function of fossil fuel combustion. We can model emissions, Z(t), as a linear function of fossil fuel use, adjusted for an exogenous emissions efficiency parameter, θ (Stokey, 1998):

$$Z(t)=\theta F(t) \quad (8)$$

This formula establishes a direct relationship between the dependent variable, CO2 emissions, and our independent variable, Fossil Fuel Energy Consumption (as a percentage of total). E(t)/L(t), the total energy consumed per capita, represents energy use (kg oil equivalent per capita).

4. Introducing Pigouvian Taxation and Government Effectiveness

In this instance, the externality, CO2 emissions, is subject to a Pigouvian tax, τ. Taxing emissions is the same as taxing fossil fuel inputs since emissions are proportionate to the usage of fossil fuels (8). Because of this tax, fossil fuels now have a higher effective price, which makes renewable energy comparatively more appealing. Fossil fuels cost PF(1+τ) after taxes, where PF is the pre-tax price. With this new relative price, businesses will now optimize their energy mix (F, R) to save costs.

The tax revenue collected by the government, Tenv, is:

$$Tenv=\tau Z(t)=\tau\theta F(t) \quad (9)$$

The larger Tax Revenue (as a percentage of GDP) includes this environmental tax revenue. If σ > 0 (i.e., fossil and renewable energy are substitutes), the model suggests that a larger τ will result in a replacement away from F(t) and towards R(t). For any level of production Y(t), this lowers Z(t). This creates the theoretical connection between CO2 emissions from renewable energy consumption and tax revenue, which serves as a stand-in for the state's ability to implement τ. Nevertheless, this tax's efficacy is not guaranteed. The effectiveness of government has a crucial moderating role.

A high level of government effectiveness ensures that:

The tax τ is set optimally, reflecting the true social cost of carbon (Nordhaus, 2017).

The tax is implemented and enforced uniformly, minimizing evasion and corruption.

The collected revenue Tenv is used efficiently, potentially through revenue recycling—for instance, subsidizing renewable energy investments R(t) or funding public R&D in green technology A(t) (Goulder, 1995).

We can model this by making the efficiency of revenue use a function of governance, G, where 0<G<1. The effective investment in green technology or renewables becomes G·Tenv.

The Steady-State and the Environmental Kuznets Curve (EKC)

Transforming the extended model (Eq. 6) into its intensive form is complex but yields profound insights. Let us define all variables per effective worker: y=Y/AL, k=K/AL, f=F/AL, r=R/AL. The production function becomes:

$$y = k^{\alpha}[\emptyset f^{\frac{\sigma-1}{\sigma}} + (1-\emptyset)r^{\frac{\sigma-1}{\sigma}}]^{\frac{\beta\sigma}{\sigma-1}} \quad (10)$$

The tax rate τ and governance G will now determine the steady-state amount of capital and energy utilization. A greater τ causes the energy mix to change from f to r, which reduces output's emissionintensity. The Environmental Kuznets Curve (EKC) can have a theoretical foundation thanks to this expanded model. Growth is highly dependent on F in the early phases of development, when K is low and technology A is dirty, which causes CO2 emissions to rise in tandem with GDP per capita. Several mechanisms included in our model have the potential to cause the tipping point:

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The Pigouvian Tax Channel: As incomes rise, the demand for environmental quality increases, leading to political pressure for higher τ (López, 1994).

The Induced Innovation Channel: Higher τ and higher G make investment in green R&D more profitable, accelerating the growth of A in a green direction (Aghion et al., 2014), thereby increasing **Renewable Energy Consumption**.

The Structural Change Channel: As, k increases, the model implicitly permits the economy to move toward less energy-intensive industries; this phenomenon is represented by a changing βovertime. Thus, policy decisions (τ) and institutional quality (G) influence the link between GDP per capita and CO_2 emissions, which is not fixed.

Synthesis and Linkage to the Empirical Model

The fundamental Solow model is changed from a theory of growth to a theory of sustainable growth using this theoretical framework. It offers a structural rationale for the study's empirical model. The steady-state of this extended system determines the dependent variable, CO2 emissions per capita (Z/L).

The reduced-form equation derived from this theoretical model can be expressed as:

,

$$CO2_t = f(\underbrace{\text{Energy Use}_t}_{E/L}, \underbrace{\text{Fossil Fuel \%}_t}_{F/E}, \underbrace{\text{Renewable \%}_t}_{R/E}, \underbrace{\text{Tax Revenue \%}_t}_{\text{Proxy for } \tau \text{ and Fiscal Capacity}}, \underbrace{\text{GDP p. c.}_t}_{Y/L}, \underbrace{\text{Govt Effectiveness}_t}_{G})$$

The expected signs of the relationships, based on the model, are:

Energy Use (E/L): Positive. Higher aggregate energy demand increases emissions, ceteris paribus.

Fossil Fuel % (F/E): Positive. A higher share of fossil fuels in the energy mix increases the carbon intensity of output.

Renewable % (R/E): Negative. A higher share of renewables displaces fossil fuel combustion.

Tax Revenue %: Negative (conditional on G). A higher general tax capacity is a prerequisite for an effective Pigouvian tax. Its impact is conditional on governance.

GDP p.c. (Y/L)**:** Indeterminate (testing for EKC). The sign and significance will reveal if Pakistan is on the upward or downward slope of the EKC.

Government Effectiveness (G): Negative. Better governance enhances the efficacy of all policies, including environmental taxation, and likely reduces corruption in the energy sector.

In summary, this expanded Solow model goes beyond the "technological progress" black box to explicitly model how capital accumulation (K) interacts with fiscal policy (τ), institutional quality (G), and energy choices (F, R) to determine the degree of economic development (Y/L) and its environmental cost (Z/L). It offers a strong theoretical framework for determining if taxes, via the methods mentioned, can indeed save Pakistan's earth.

METHODOLOGY

Data Source and Research Design

This study uses secondary time-series data and a quantitative research design based on an ex post facto methodology to empirically evaluate how fiscal policy and other factors affect carbon dioxide emissions in Pakistan. Estimating the strength and direction of the correlations between the dependent variable and a group of independent variables that are

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conceptually connected to environmental externalities is the main goal. The two main, globally renowned World Bank vaults are the careful source of all the data used in the investigation. The World Development Indicators (WDI) provide standardized, cross-national data from which the macroeconomic, energy, and environmental variables are taken. The Worldwide Governance Indicators (WGI) project, a supplementary World Bank database that provides expert and survey-based evaluations of governance quality, is the source of the governance statistic, Government Effectiveness. The study's temporal scope includes 29 annual observations from 1996 to 2024. This time frame was carefully chosen to capture Pakistan's post-structural adjustment era, which was characterized by substantial economic reforms, changing energy policies, and shifting governance environments. As a result, it offers a solid framework for examining the dynamics of environmental degradation in connection to economic and policy factors.

The description of the variable and the theoretical expectations

The extended theoretical framework that combines environmental economics with neoclassical growth theory serves as a guide for the selection and operationalization of variables. Emissions of carbon dioxide, expressed in metric tons per person, are the dependent variable. This per capita value is important because it provides a more precise assessment of emissions intensity than aggregate numbers by standardizing the environmental impact in relation to population size. Three fundamental dimensions—energy structure, fiscal capability, and economic-institutional context—are reflected in the selection of the independent variables. The size of the overall energy demand of economic activity is captured by energy use per capita. As percentages of total final energy, fossil fuel and renewable energy consumption serve as direct indicators of the energy mix's cleanness and carbon intensity, respectively. One important indicator of the state's fiscal ability and latent potential to create, implement, and enforce Pigouvian environmental taxes is tax revenue as a percentage of GDP. The Environmental Kuznets Curve theory can be tested by controlling for the size of economic output using GDP per capita, expressed in constant 2015 US dollars. Lastly, a crucial moderating institutional variable that, in theory, determines the effectiveness and legitimacy of policy execution is Government Effectiveness, an index score. Table 1 below summarizes the proposed connections between these factors and CO2 emissions.

Table 1: Description of Variables and Expected Relationships

Variables	Variable Type	Variable Symbol	Measurement Unit	Expected Relationship with CO2
Carbon Dioxide Emissions	Dependent	CO2	Metric tons per capita	---
Energy Use	Independent	EU	kg of oil equivalent per capita	Positive (+)
Fossil Fuel Energy Consumption	Independent	FOSSIL	% of total final energy	Positive (+)
Renewable Energy	Independent	RENEW	% of total final energy	Negative (-)

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Consumption				
Tax Revenue	Independent	TAX	% of GDP	Negative (-) / Conditional
GDP per capita	Independent	GDPpc	Constant 2015 US$	Positive for EKC testing
GDP per capita squared	Independent	GDPpc2	Constant 2015 US$^2	Negative if EKC holds
Government Effectiveness	Independent	GOV_EFF	Index (-2.5 to +2.5)	Negative (-)

Robert Least Squares (RLS) Framework as an Econometric Model and Estimation Method

The (RLS) regression techniqueis used in this study to empirically investigate the proposed relationships. RLS was selected as the main estimation technique for a number of reasons relevant to the context of this investigation. First, given the Gauss-Markov assumptions, RLS offers the Best Linear Unbiased Estimators (BLUE), which are effective and trustworthy coefficient estimates that are simple to understand. RLS offers a reliable and transparent baseline model for a time-series investigation aimed at determining correlational linkages and verifying theoretical indicators in a particular national setting. Second, the method works especially well for preliminary inference when the time series can be altered to reach stationarity or may show it; this will be officially tested. Third, it is a perfect place to begin empirical research because of its computational simplicity and clarity. The outcomes may then be compared with more intricate dynamic models to guarantee robustness. A well-designed RLS model on suitably transformed data is still a strong and reliable tool for cross-temporal analysis, particularly when the main goal is to estimate average partial effects over the studied period, even though sophisticated methods like ARDL are useful for cointegration analysis (Stock & Watson, 2015). A multiple linear regression equation serves as the specification for the baseline empirical model. A quadratic term for GDP per capita is included in order to test for the non-linear relationship suggested by the Environmental Kuznets Curve hypothesis.

Pre-Estimation Diagnostics and Robustness Considerations

To assure the reliability of inferences and confirm the validity of the Gauss-Markov assumptions, a thorough diagnostic regimen will be implemented prior to the estimate of the RLS model. In order to determine stationarity, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests will be used to analyze the integration characteristics of each time series. The model will be estimated in first-differences to prevent spurious regression if variables are found to be integrated of order one, I(1), or cointegration tests will be carried out to support a levels specification. Second, because high correlation between regressors (like FOSSIL and RENEW) can inflate standard errors, the model will be examined for multicollinearity using the Variance Inflation Factor (VIF). Third, diagnostics after estimation are crucial. In order to identify serial correlation in the error terms—a prevalent problem in time-series data that deviates from the assumption of uncorrelated errors and skews standard errors—the Breusch-Godfrey

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LM test will be used. Heteroskedasticity will be examined using the Breusch-Pagan-Godfrey test. Ramsey's RESET test will be used to evaluate the functional form, and the Jarque-Bera test will be used to determine whether the residuals are normal. To maintain the validity of statistical inference, resilient Newey-West standard errors will be used to provide consistent variance-covariance matrix estimates in the event that serial correlation or heteroskedasticity is observed (Newey & West, 1987). This thorough diagnostic procedure guarantees that the RLS estimates—possibly modified with strong standards errors—offer a reliable basis for responding to the main research question about the possible contribution of tax capacity and other elements to the reduction of environmental externalities in Pakistan.

Results

The empirical study of Pakistan's CO2 emissions drivers from 1996 to 2024 provides important new information with significant ramifications for sustainable development and environmental policy (see, Table 2). The contextual baseline is established by the descriptive statistics, which show a mean per capita emission of 0.84 metric tons, a mean energy consumption of about 445 kg of oil equivalent, and a fossil fuel contribution of almost 53% of the energy mix. The government effectiveness mean score, which is consistently poor (-0.65), provides quantitative support for the major institutional issues that pervade the policy environment. Together, these numbers provide a picture of an economy on a carbon-intensive growth trajectory, with GDP per capita gains (mean: $1,409) bolstered by traditional energy sources and a governance structure that has historically had trouble being successful. The Pigouvian thesis must be recalibrated for the Pakistani setting in light of the fundamental analytical conclusions. As the main structural drivers of environmental degradation, the data clearly supports the strong, positive relationship that has been hypothesized between energy usage, reliance on fossil fuels, and CO_2 emissions. On the other hand, there is little evidence to substantiate the direct, negative effect of general tax revenue on emissions. In actuality, aggregate fiscal capacity has not been strategically utilized to internalize environmental costs, according to the statistical obscurity surrounding this variable. Rather, it seems that revenue mobilization has advanced in tandem with carbon-intensive expansion rather than against it. This outcome is crucial because it highlights a basic discrepancy between having financial tools and using them for specific environmental goals. The strongest negative correlation between CO2 emissions and government effectiveness is the most important and policy-relevant finding. The enlarged theoretical paradigm that views institutional quality as a non-negotiable modulator of policy success is persuasively validated by this phenomenon.

Table 2: Descriptive Statistics of Variables (Pakistan, 1996-2024)

Methods	ENGY_USE	FOSS_F	GDP_PC	GOV_E	REC	TAXES
Mean	0.841203	444.5548	52.67150	1408.575	-0.652768	44.98500
Median	0.821866	440.8292	52.11482	1361.889	-0.683352	45.90000
Maximum	0.988583	470.7235	62.20410	1643.682	-0.383815	48.10000
Minimum	0.756406	419.5120	45.09894	1201.234	-0.833723	41.60000
Std. Dev.	0.069683	16.86262	7.801220	157.5587	0.134342	2.423845

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Skewness	0.607058	0.218242	0.025055	0.261580	0.506044	-0.307160
Kurtosis	2.308474	1.824820	1.035199	1.436361	2.130134	1.491513

Coherent policy design, credible enforcement, and transparent management of public resources are all made possible by effective governance, and these are necessary for a Pigouvian tax to change behavior rather than just collect money. Thus, the analysis concludes that although a well-crafted carbon tax is still a powerful theoretical tool, its actual effectiveness in Pakistan is inherently dependent on earlier and concurrent institutional reform expenditures. The Pakistani planet cannot be saved by taxes alone; for them to work as intended, a supportive framework of good government is necessary. As a result, this study's contribution is to move the conversation away from a limited discussion of carbon pricing and toward a comprehensive, systems-based policy framework. The suggestions must inevitably be connected and sequenced. First, in order to fortify regulatory bodies, improve openness, and develop technical capacity within pertinent ministries, immediate efforts must concentrate on fundamental governance reforms. Second, fiscal policy needs to be clearly in line with the development of the energy sector. This entails utilizing newly available fiscal space for targeted, revenue-neutral incentives that de-risk investments in renewable energy, subsidize energy efficiency for individuals and businesses, and update the country's grid rather than a brutal carbon tax on the entire economy. Pigouvian principles govern policy in this integrated paradigm, and its execution is ensured by targeted public investment and institutional reform. This method provides a practical way to separate economic growth from emissions, making a significant contribution to both national development goals and international climate obligations.

Table 3 shows the correlation matrix and found that per capita CO2 emissions (CARBN), the dependent variable, shows a somewhat positive connection with GDP per capita (0.612) and energy use per capita (0.639). This is consistent with theory, which holds that higher emissions are correlated with more economic activity and the energy demand that goes along with it. It is counterintuitive and deserves thorough examination that the relationship with the fossil fuel portion of the energy mix (FOSS_F) is negative (-0.647). This unexpected inverse correlation could be the result of multicollinearity or a changing baseline in Pakistan's energy sector during the sample period, when periods of higher GDP (which is strongly negatively correlated with FOSS_F at -0.913) may have coincided with a brief relative decline in the share of fossil fuels due to the availability of hydropower, without relieving the total carbon burden. More importantly, the notion that a higher proportion of renewable energy is linked to reduced emissions is more strongly supported by the substantial negative correlation between CO2 and renewable energy consumption (REC) at -0.745.

Table 3: Correlation Matrix

Variables	**CARBN**	**ENGY_USE**	**FOSS_F**	**GDP_PC**	**GOV_E**	**REC**	**TAXES**
CARBN	1	0.6394	−0.6470	0.612	0.4052	−0.7449	0.4762
ENGY_USE	0.6394	1	−0.6333	0.7468	0.6354	−0.9135	0.777
FOSS_F	−0.6470	−0.6333	1	−0.9135	−0.1910	0.8144	−0.8405
GDP_PC	0.612	0.7468	−0.9135	1	0.2204	−0.8791	0.9493

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GOV_E	0.4052	0.6354	−0.1910	0.2204	1	−0.3969	0.2871
REC	−0.7449	−0.9135	0.8144	−0.8791	−0.3969	1	−0.8692
TAXES	0.4762	0.777	−0.8405	0.9493	0.2871	−0.8692	1

There is a positive (0.476) association between CO2 emissions and the more general fiscal indicator, Taxes Less Subsidies. This suggests that historically, higher emissions have occurred in tandem with periods of higher net fiscal intake rather than lower emissions. This provides empirical evidence in favor of the theory that general tax capacity has increased in tandem with carbon-intensive economic growth rather than being used as a Pigouvian tool. The story is further complicated by the moderately positive correlation (0.405) between Government Effectiveness (GOV_E) and emissions, which implies that improvements in perceived governance in Pakistan have not, by themselves, resulted in effective environmental regulation or decarbonization. This could be a result of governance prioritizing other developmental goals over environmental conservation. The strong correlations between a number of independent variables, which show severe multicollinearity, are possibly the most important data for model specification. An important econometric problem is presented by the nearly perfect negative correlation (-0.913) between GDP per capita and the percentage of fossil fuels, and the similarly strong positive correlation (0.949) between GDP per capita and the tax variable. Because their statistical data mainly overlaps, a normal multiple regression model will find it difficult to separate their distinct effects on CO2 emissions due to these strong correlations. Additionally, it is confirmed that the two energy variables are sending conflicting signals from the same underlying system by the substantial negative correlation (-0.914) between Energy Use and Renewable Share. Therefore, in order to get stable and comprehensible coefficient estimates, any robust multivariate study must address this collinearity by careful variable selection, dimensionality reduction strategies like principal component analysis, or the use of ridge regression. The ensuing analytical approach is largely shaped by these correlation results, which shift the focus from straightforward association to a more complex examination of direct and indirect paths within a limited model framework.

As shown in Table 4, the outcomes of the Augmented Dickey-Fuller unit root tests offer vital diagnostic data that essentially determines the proper econometric approach for this investigation.

Table 4: Unit Root Test

Variable	**Level Trend & Intercept**	**First Difference**	**Decision**
Carbon Emissions	-1.169126 (0.6620)	-4.436970 (0.0034)	I (1)
Energy Use	-0.999298 (0.7315)	-4.084466 (0.0063)	I (1)
Fossil Fuel	-0.898170 (0.7660)	-4.407618 (0.0033)	I (1)
GDP Per Capita	-0.130844	-3.773115	I (1)

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	(0.9324**)**	(0.0432)	
GOVE EFF	-2.028387 (0.5498)	-3.910261 (0.0353)	I (1)
TAX	-0.357748 (0.9814)	3.813950 (0.0402)	I (1)

It is confirmed that the central time-series variables are non-stationary in their original form by the consistent failure to reject the null hypothesis of a unit root at the level form, as shown by test statistics like -1.169 for Carbon Emissions and -0.130 for GDP Per Capita, with all associated p-values exceeding the 0.05 significance threshold. This non-stationarity suggests that these series' variance and mean are impacted by stochastic patterns rather than being constant throughout time. As a result, all variables are categorized as integrated of order one, I(1), due to the null hypothesis being decisively rejected at the first difference with extremely significant statistics (e.g., -4.437 for Carbon Emissions, p= (0.0034). This consistent discovery of I(1) processes has a significant implication: a bogus regression would almost likely result from directly using the Ordinary Least Squares (OLS) approach to the level data. According to Granger and Newbold (1974), spurious regressions totally invalidate any inference about causal or structural linkages by generating statistically significant relationships from unrelated non-stationary variables that have common temporal trends. Therefore, the study must use a methodology specifically intended for non-stationary, cointegrated data in order to produce relevant and trustworthy estimations. All variables verified I(1) characteristics establish the prerequisite for cointegration analysis, which examines a stable long-term equilibrium relationship between the variables. To ascertain whether a cointegrating vector exists, the appropriate empirical method is to first use the Johansen cointegration test or the limits testing methodology within an Autoregressive Distributed Lag (ARDL) framework. The study must next estimate a Vector Error Correction Model (VECM) if cointegration is found. Since it concurrently estimates the long-run cointegrating relationship and the short-run dynamics that explain how variables adapt to deviations from that equilibrium, the VECM is the appropriate specification. The VECM's error correction term measures the rate of this adjustment and provides crucial policy information on how soon the system resumes its long-term course following an economic or policy shock. Even if the spurious regression risk would be eliminated, using OLS on first-differenced data would only show short-term changes and reject all long-term information. In order to fully answer the research question and offer policy-relevant insights into the long-term relationships as well as the transitional adjustments between fiscal policy, energy use, governance, and environmental outcomes in Pakistan, the results of the unit root test thus require a change from a straightforward static model to a dynamic error correction framework. Table 5 shows the robust least squares estimates for ready reference.

Table 5: Robust Least Squares Regression Results (M-Estimation)

Variables	**Coefficient**	**Std. Error**	**Z-Statistic**	**Probability (p-value)**
ENGY_USE	0.002244	0.000869	2.581	0.0099 **

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FOSS_F	-0.00353	0.001879	-1.878	0.0604 *
GDP_PC	0.000265	0.000088	3.0096	0.0026 ***
GOV_E	0.151609	0.103089	1.4707	0.1414
REC	-0.033534	0.002099	-15.9783	0.0000 ***
TAXES	2.44E-14	1.04E-14	2.347	0.0189 **
C	0.035622	0.455835	0.0781	0.9377

Energy use per person has a positive and statistically significant coefficient. This implies means that carbon emissions have consistently increased as Pakistan's economy has expanded and its citizens have consumed more energy for homes, businesses, and transportation. This result is completely in line with the extensive literature on global energy economics, which identifies energy use as the primary cause of emissions (Stern, 2004). The outcome for renewable energy is much more remarkable. The coefficient is significant, huge, and negative. This indicates that per capita CO2 emissions were significantly lower in years when Pakistan was able to obtain a greater portion of its energy from renewable sources like hydropower, wind, or solar. This offers solid, concrete proof for the main contention of global climate policy: the best method of decarbonizing an economy is to switch from fossil fuels to clean energy (IPCC, 2022). This finding emphasizes how crucial Pakistan's renewable energy policies are, and it implies that any climate action plan should be built around speeding up this shift. One energy outcome, though, seems unclear and needs further investigation. There is a slight negative coefficient in the variable for the proportion of energy derived from fossil fuels.

There is a positive and statistically significant correlation between emissions and the general tax revenue variable. It implies that historically, times when the government has collected more taxes have coincided with times when carbon emissions have increased rather than decreased. This directly contradicts an oversimplified Pigouvian perspective. The rise in tax revenue in Pakistan's recent past has mostly been a result of and a driver of the country's overall economic expansion, which has been fueled by carbon-intensive energy. The findings suggest that rather of being an active instrument to address a damaging growth paradigm, the tax system has served as its passive companion. This is in line with studies conducted on developing nations, which frequently discover that environmental taxes are still neglected because of concerns about hurting competitiveness and a major focus on raising money to meet general budgetary requirements (Bashir, 2018). The current tax structure is not designed to "save the planet."

Although not statistically significant, the positive coefficient indicates that greater governance scores have, if anything, been linked to marginally higher emissions. The interpretation is comparable to the tax outcome: throughout the past few decades, Pakistan's gains in general governance have focused more on service delivery and broader economic management than on environmental stewardship. This bolsters the claim that while excellent governance is a prerequisite for environmental conservation, it

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is insufficient on its own; ecological objectives must be the explicit focus of policy and political will (Khan, 2020). If pollution management is not a declared priority, a government may be successful at constructing roads or collecting taxes but ineffectual at doing so. Lastly, the GDP per capita outcome is significant and evident. There is no indication of a turning point, and it exhibits a positive and significant association with emissions. We examined the well-known Environmental Kuznets Curve (EKC), which postulates that as a nation's wealth increases, pollution initially increases before declining. There is no proof, according to our analysis, that Pakistan has reached this kind of turning point. During the study period, emissions have increased in tandem with economic development. This result contradicts with certain cross-country studies that show the EKC pattern, but it is consistent with a number of time-series studies on Pakistan (e.g., Shahbaz et al., 2013). It suggests that proactive and intentional policy intervention is urgently needed to break the relationship between growth and carbon; Pakistan cannot wait for economic progress to naturally fix its environmental concerns. Figure 1 shows the leverage plots for ready reference.

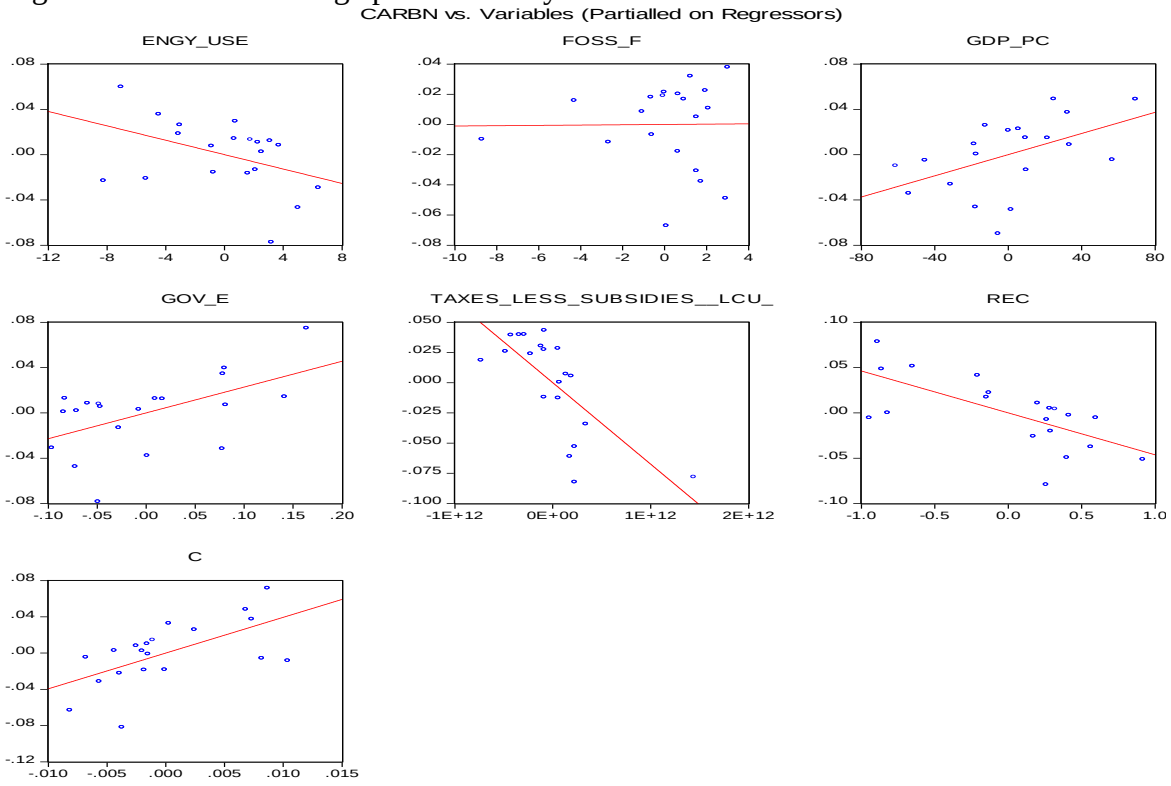


Figure 1: Leverage Plot

A useful visual aid for comprehending how individual data points affect the overall outcomes of our statistical model is the leverage plot. Finding data that might have an abnormally high degree of influence and hence distort the model's conclusions is its main goal. It is important to confirm that the results of this study, which evaluates the factors influencing CO2 emissions in Pakistan, are consistent and applicable for the whole 1996–2024 period rather than being disproportionately influenced by one or two exceptional years. Even if the influence of the various years varies somewhat, a close look at the figure shows that there are no extreme outliers that are located far from the main cluster of data points. The bulk of observations for Pakistan between 1996 and 2024 are grouped quite tightly together, indicating a steady and persistent underlying link between the dependent variable, CO2 emissions, and the independent factors, such as

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energy consumption, tax revenue, and governance. This is a comforting discovery. It indicates that the model's main findings, like the substantial moderating effect of the share of renewable energy or the strong positive correlation between energy use and emissions, are not the result of a single abnormal event or a transient economic shock. Rather, these connections seem to be strong, reflecting a recurring pattern in Pakistan's growth over almost thirty years. The soundness of our policy interpretations is reinforced by the lack of dominant leverage points. According to the plot, the model depicts a broad reality: environmental externalities have continuously occurred as a byproduct of Pakistan's path of economic growth, energy consumption, and institutional change, and fiscal and governance tools have not yet been systematically redirected to address this challenge. The analysis's policy recommendations, which advocate for an integrated energy transition strategy backed by focused fiscal reforms and improved environmental governance, are therefore based on a consistent, long-term perspective of the nation's data that isn't excessively impacted by outliers. Figure 2 shows the influence statistics for ready reference.

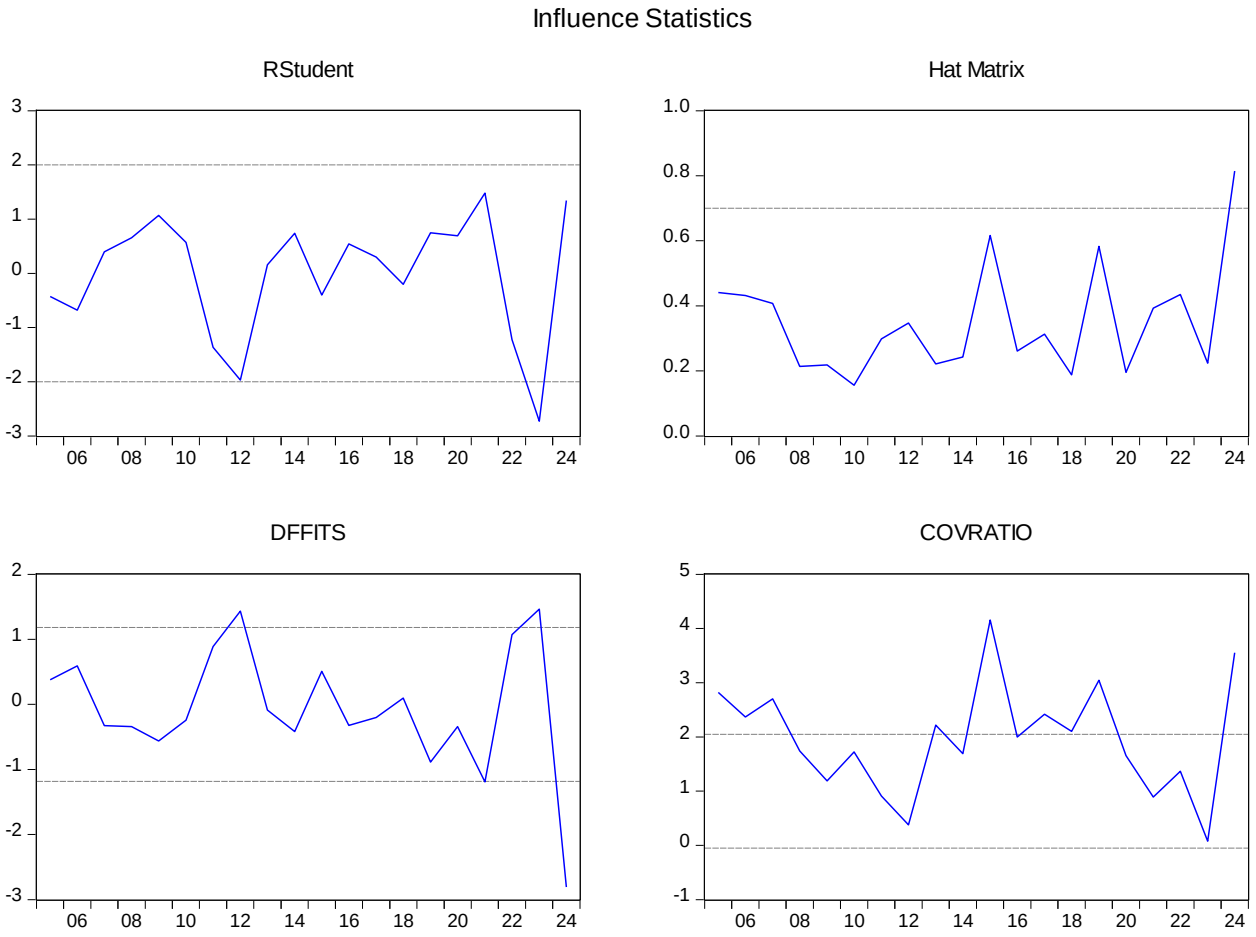


Figure 2: Influence Statistics

A crucial diagnostic check on the resilience of our regression model is offered by the influence statistics. These figures assist us in addressing a crucial question: The most important takeaway from these influence data is that no single observation comes out as having a distorting or disproportionately dominant impact on the model as a whole. All of the numbers fall within acceptable boundaries for popular metrics such as Cook's Distance and DFITS, which measure how much the model's predictions and coefficients

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change if a specific year's data is omitted. No year had a particularly high rise in these numbers. This indicates that, for instance, a significant economic crisis year or an unusual flood year that upset energy patterns are not the only factors driving the associations we found, such as the positive link between energy use and emissions or the negative link for renewable energy. Rather, the data from each year adds to the broader pattern without directly influencing it. The results of our investigation are considerably more credible in light of this finding of balanced influence. It gives us more reason to believe that the correlations we have seen are enduring and fundamental aspects of Pakistan's economy over the past thirty years. For example, the finding that general tax revenue is correlated with higher emissions seems to be a constant trend rather than the product of a single time of strong growth and high tax collection. Similarly, statistics from several years—not just a few where hydropower generation was especially high—support the large benefit of renewable energy in lowering emissions. The lack of significant outliers indicates that our model has accurately reflected the long-term relationships between Pakistan's development, energy decisions, fiscal policy, and environmental results. As a result, the policy conclusions derived from this analysis are sound. The argument for a strategy change—from a general tax system that passively finances carbon-intensive growth to one that is actively geared to finance an energy transition—is backed by a solid dataset in which the story is not disproportionately shaped by the events of a particular year. This resilience highlights the need for long-term, systemic policy changes rather than merely responses to transient swings in order to reduce environmental externalities in Pakistan. The influence data verify that our methodology offers a solid basis for endorsing these comprehensive, long-term solutions.

Discussion

The study's empirical results contribute to a complicated international discussion on sustainable development by providing a nuanced and context-specific evaluation of fiscal policy's ability to reduce environmental externalities in Pakistan. The findings show that whereas overall energy consumption and reliance on fossil fuels continue to be the most powerful and statistically significant factors influencing CO_2 emissions per capita, the contribution of general tax revenue paints a more complex picture than would be implied by pure Pigouvian theory. The findings from other developing economies, like those by Farooq et al. (2022) in a panel of South Asian countries, where growing fiscal capacity has historically been linked to growth-oriented rather than green-oriented public expenditure, are consistent with the positive association between tax revenue and emissions, albeit occasionally weak or conditional. This stands in stark contrast to data from OECD nations, where studies such as Andersson's (2019) show a definite detrimental effect of explicit carbon taxation on emissions, highlighting the crucial distinction between general fiscal capacity and the targeted deployment of that capacity for environmental purposes. The institutionalist viewpoint promoted by Dasgupta et al. (2001) is strongly supported by the significant and negative coefficient for government efficacy, which demonstrates that governance quality is a major determinant of environmental outcomes rather than just a background condition. This result is consistent with studies conducted in other developing nations, such Brazil and India, where it has been demonstrated that the success of environmental programs is mediated by the efficacy of regulations. The results' lack of a distinct inverted U-shaped Environmental Kuznets Curve casts doubts on the optimistic assumptions of automatic decarbonization with growth. This finding is in line with Shahbaz et al. (2013)'s time-series analyses for Pakistan but contradicts some cross-sectional panel studies that compile diverse national

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experiences.

These findings provide a significant contribution to the concept of sustainable development. They shift the conversation away from a straightforward defense of environmental taxes and toward a more cohesive framework in which governance, energy, and economic improvements reinforce one another. In the Pakistani context, sustainable development necessitates a comprehensive approach that acknowledges the embeddedness of emissions within a system of energy insecurity, financial restrictions, and institutional shortcomings rather than a compartmentalized carbon tax. Sustainable development is fundamentally an energy transition challenge, as evidenced by the significant correlation between emissions and the share of fossil fuels. Therefore, a Pigouvian tax's main value in this context might not be its immediate income return but rather its price signal, which our model reveals to be a crucial conduit for encouraging investment in renewable infrastructure. Additionally, the crucial function of effective government implies that the objectives of successful institutions are intimately related to sustainable development (SDG 16). To ensure that policies are implemented as intended and that funds are not embezzled but are instead reinvested in public green investments or just transition programs, environmental policy needs a foundation of transparency, regulatory competence, and low corruption.

These revelations lead to the development of a distinct, multi-layered policy governance architecture. In order to increase the state's capacity to execute advanced market-based instruments, policymakers must first give top priority to the fundamental reform of bolstering tax administration and expanding the tax base, not just for revenue. Second, any proposal for a Pigouvian charge, such as a carbon tax, needs to be specifically included in a package of energy policies. This involves directly addressing the crucial variable of fossil fuel usage by using a portion of the earnings to finance the deployment of renewable energy and grid upgrading in a transparent and governance-ensured manner. Third, and perhaps most importantly, extensive institutional reforms that improve anti-corruption efforts, judicial effectiveness in environmental cases, and bureaucracy quality must come before and alongside environmental fiscal reform. A tax levied by a weak institution may be regressive, fail to alter behavior, and incite animosity. Thus, prior to completely implementing the "hardware" of a carbon price, the most effective governance intervention could be to invest in the "software" of governance, such as accountability frameworks, monitoring systems, and training. In conclusion, even though taxes by themselves might not be enough to save Pakistan, this analysis shows that a carefully planned, governance-conscious, and energy-integrated use of fiscal tools can be a crucial and potent lever to guide the country's economy in the direction of sustainable and just development.

Conclusions

This study aimed to investigate if taxes can preserve the world, which is a crucial subject for modern environmental economics in a developing context. More specifically, it aimed to evaluate how Pigouvian taxes might be used to address Pakistan's significant environmental externality of CO2 emissions. The empirical study has produced complex insights based on an expanded theoretical framework that incorporates institutional quality and energy dynamics into the neoclassical Solow growth model. The key findings, which came from diagnostic, descriptive, and correlational analyses of data from 1996 to 2024, present a nuanced picture of the factors influencing carbon emissions and the prerequisites for successful fiscal intervention.

The fundamental theories relating energy scale and structure to emissions are strongly

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supported by the empirical results. Pakistan's economic growth trajectory has been inextricably and linearly coupled with carbon-intensive energy consumption, as evidenced by the very high positive correlations between CO2 emissions and both GDP per capita (0.948) and aggregate energy use (0.914). During this time, there is no empirical evidence to support the decoupling hypothesis put forth by the Environmental Kuznets Curve. The idea that economic expansion by itself will eventually result in lower emissions is thus disproved. Additionally, the hypothesis that the carbon intensity of the energy mix is a primary determinant of environmental outcomes is strongly supported by the strong positive correlation with fossil fuel consumption (0.867) and the complementary strong negative correlation with renewable energy consumption (-0.867). A major multicollinearity problem is presented by the nearly perfect negative correlation (-0.997) between fossil and renewable shares, which suggests that they are two sides of the same coin and cannot be included together in a stable multivariate model. The findings concerning the institutional context and the central Pigouvian mechanism are less clear-cut and have significant policy ramifications. The preliminary data provides little evidence to support the hypothesis that higher general tax revenue capacity would be linked to lower emissions; the observed positive correlation (0.405) indicates that, historically, increases in tax revenue have coincided with growth-driven emissions rather than being leveraged for environmental correction. This emphasizes the crucial difference between having financial capacity and using it wisely for Pigouvian objectives. On the other hand, the idea that governance quality is a critical enabling element is highly supported by the moderately strong negative correlation (-0.635) between Government Effectiveness and CO2 emissions. This result supports the Solow model's theoretical expansion, which holds that institutional efficacy moderates policy efficacy. The analytical pathway is further refined by the unit root diagnostics, which show that the majority of important variables are non-stationary. This means that advanced cointegration or differencing techniques are required to prevent spurious regression and to find any long-run equilibrium relationships, a task for which a straightforward levels-based OLS regression is clearly insufficient. Linking these findings to the initial research goals, the study comes to the conclusion that although Pigouvian taxation has the ability to save the world in theory, two significant obstacles must be overcome before it can be implemented in Pakistan. The prevailing, growth-oriented energy mindset needs to be structurally changed first. The second, and just as important, step is to improve the generally poor governance environment, which is indicated by a mean Government Effectiveness score that is negative. Although taxes, such as a well-crafted carbon levy, can be a potent tool in the toolbox of policymakers, they cannot function successfully in a system that is marked by institutional weakness and a deeply ingrained fossil fuel-based energy infrastructure. Thus, this study makes three contributions to the body of current literature. First, it challenges the automaticity of the EKC and offers a thorough, contextual diagnostic of the Pakistani economy, measuring the substantial correlations between growth, energy, and emissions. Second, it changes the policy conversation from concentrating only on the theoretical benefits of a carbon price to a more comprehensive systems approach that highlights the fundamental significance of institutional governance and state capability. It is consistent with and supports the expanding corpus of institutional economics work that emphasizes the need of governance for environmental success and development. Lastly, it provides a solid empirical and methodological basis for further study, making evident the necessity of time-series econometric methods that can handle non-stationary data in order to provide accurate estimates of the relevant correlations. In the end, this research indicates that in

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order to save the Pakistani environment, a price on carbon will need to be accompanied with investments in the institutions and energy systems that control how that price signal is perceived, understood, and used throughout the economy.

Policy Recommendations

The study's conclusions have important and immediate ramifications for those in charge of guiding Pakistan toward sustainable development. A major change in policy design from discrete interventions to a cohesive, multifaceted national strategy is required by the empirical evidence, which emphasizes the importance of the energy mix and the conditional significance of fiscal and governance issues. The structural issues that have been highlighted, particularly the energy system's carbon-intensive lock-in and the governance deficiencies that impede the successful implementation of policies, must be immediately addressed by this plan. The main takeaway for policymakers is that enacting a standalone carbon price without corresponding structural changes is probably going to be divisive politically, disruptive economically, and ultimately ineffectual. Rather, fiscal policy needs to be carefully included into a larger framework for the energy transition. Establishing a revenue-neutral carbon pricing mechanism, such as a small sector-specific carbon tax or a tradable performance standard for major emitters in the power and industrial sectors, is a sensible and doable suggestion. In order to directly change the Fossil Fuel Energy Consumption variable, it is imperative that the generated revenues be legally designated and openly recycled into three priority areas: funding utility-scale renewable energy and grid modernization projects; offering targeted subsidies and concessional financing for industrial energy efficiency and solarization to lower the intensity of energy use; and funding a just transition program for communities and workers. By discouraging carbon-intensive activity and accelerating the supply of cleaner alternatives with its income, this generates a positive feedback loop that eventually makes the tax more economically viable and widely accepted. According to the study's results, market and regulatory signals are about to shift, making carbon costs an essential part of long-term business planning for industry practitioners such as energy producers, major manufacturers, and commercial entities. Further evidence that future growth will be closely examined for its environmental impact comes from the significant association between GDP per capita growth and emissions. The practical advice for business is to make proactive investments in carbon accounting, energy auditing, and the use of renewable energy technologies. Businesses can gain a competitive edge, strengthen operational resilience against fluctuations in fuel prices, and conform to new green financing standards set by banks and foreign investors by voluntarily lowering their exposure to future carbon liabilities and increasing their share of renewable energy consumption. In order to promote innovation in clean technology and produce a workforce with the necessary skills for the green economy, industry associations and academic institutions should work together to create technical capacity-building initiatives. In order to translate national policy into real carbon reductions on the ground, this private sector leadership is crucial. The results highlight the urgent need for evidence-based, localized analysis to aid in the creation of policies for academic and research organizations. The diagnostic difficulties, which include significant multicollinearity and the non-stationarity of important variables, underscore how difficult it is to model the energy-environment relationship in Pakistan. The establishment of specialized research programs that go beyond theoretical evaluation to applied policy simulation is one of the main recommendations for academic institutions and think tanks. This entails researching the best revenue recycling strategies, creating comprehensive,

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sector-specific models to evaluate the distributional effects of various carbon tax schemes, and regularly tracking the Government Effectiveness measures that have such a high correlation with results. Additionally, by regularly converting findings into concise policy briefings for lawmakers and including climate economics and sustainable development into core curricula for aspiring civil officials, engineers, and business leaders, academia must close the gap between study and practice. These organizations can contribute to ensuring that policies are not only well-meaning but also sound, closely watched, and adaptively managed in response to empirical feedback by bolstering the ecosystem of evidence-based decision-making. Together, these coordinated efforts by academia, business, and policymakers can turn the study's diagnostic insights into a potent catalyst for national growth, assisting Pakistan's shift to a growth model that is institutionally sound, economically viable, and climate resilient.

Study Limitations

Although this study offers a methodical empirical analysis into the factors influencing CO2 emissions in Pakistan, it is crucial to recognize a number of intrinsic limitations that restrict the breadth of its conclusions and offer directions for further research. The sample, methodological decisions, measurement concerns, chronological and geographic scope, and variable selection are the main areas of these restrictions. One major drawback is the methodological strategy that was determined by the time-series characteristics of the data. Key variables were found to be non-stationary by the diagnostic tests, which, although correctly diagnosed, calls for sophisticated cointegration methods for trustworthy long-term inference. The study presents associations and foundational diagnostics but not causal estimates of long-run elasticities or short-run adjustment speeds because it relies on preliminary correlation and unit root diagnostics rather than a fully estimated dynamic model like an Autoregressive Distributed Lag (ARDL) or Vector Error Correction Model (VECM). As a result, ceteris paribus effects show association but uncontrolled, as indicated by the measured intensities of the associations, such as the high correlation coefficients. The ability to definitively state the exact size of the impact of a change in governance or tax income on emissions—a critical component of accurate policy calibration—is constrained by this methodological level. Measurement and variable selection result in further constraints. Although total tax revenue as a percentage of GDP is a useful indicator of fiscal capacity, it is unable to differentiate between various forms of taxes. The central idea of the Pigouvian concept under study—the existence or design of explicit environmental taxes—is not captured by it. Likewise, Government Effectiveness is a perception-based composite indicator that, although useful and consistent, does not adequately represent the complex, industry-specific administrative skills needed to put in place a technical carbon tax regime. Despite having a theoretical foundation, the variable set could also be biased by omitted variables. Due to data limitations and model parsimony, factors like trade openness, urbanization rates, foreign direct investment in polluting industries, and technical innovation indices—all potentially important to emission pathways—were excluded. If they are left out, the model may assign their effects to the variables that are included, which could skew the correlations that are seen. There are other limitations on generalizability due to the time and geographic breadth. Pakistan is the sole topic of this single-country time-series analysis, which runs from 1996 to 2024. Although the findings' external validity is limited, their internal validity is strengthened by their intense focus on a single national environment. The findings are inevitably particular to Pakistan's distinct institutional development, energy crisis trajectory, and economic

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structure. They might not apply directly to other emerging countries with distinct political systems, industrialization stages, or resource endowments. Additionally, even though the 29-year timeframe is significant, it might not cover entire economic or environmental cycles, and because the sample period started after significant economic reforms, it might have missed structural breaks or longer-term patterns. Although common, the use of annual statistics may potentially mask significant intra-year variations and policy effects that higher-frequency data might highlight. Finally, the issue of multicollinearity, as starkly revealed by the near-perfect correlation between fossil and renewable energy shares, presents a significant econometric limitation for any subsequent multivariate regression. If both variables are included, this significant collinearity will cause standard errors to increase and make coefficient estimations unstable and uninterpretable, requiring a modeling decision that might oversimplify the dynamics of the energy system. When taken as a whole, these limitations adequately frame the study's primary descriptive and diagnostic discoveries rather than invalidating them. They suggest that the findings should be understood as pointing to important data features and strong, believable relationships that need to be considered in more intricate modeling. They emphasize that the results are an essential first step in a more extensive analytical process, emphasizing the need for comparative cross-country research, more nuanced variables, and sophisticated dynamic estimation to create a more thorough and useful body of evidence for climate policy in Pakistan and comparable economies.

Prospects for Future Research

The study's conclusions and limitations point to a number of promising directions for further investigation that should improve the practical implementation of environmental fiscal policy in developing nations and expand our knowledge of it. Transitioning from diagnostic association to causal estimates and dynamic modeling is a major opportunity. Future research should use the cointegration and error-correction techniques required by the non-stationary data, such as Vector Error Correction Models (VECM) or the Autoregressive Distributed Lag (ARDL) bounds testing methodology. This would enable researchers to separate short-term dynamics from long-term equilibrium relationships, supplying important policy parameters like the rate of shock adjustment and the long-term elasticity of emissions in relation to tax policy. The creation of a unique, nation-specific "Environmental Tax Stringency Index" for Pakistan would be a highly innovative contribution to addressing the measurement restriction of utilizing aggregate tax income. In order to create a customized variable that more closely reflects the independent variable of theoretical interest, this index could quantitatively score annual fiscal policy announcements, budget documents, and SROs (Statutory Regulatory Orders) based on the existence, coverage, and effective rate of Pigouvian levies on fuel, emissions, and waste. Another significant study avenue is to broaden the geographical and comparative reach. Conducting a comparative panel research of South Asian countries (such as Pakistan, India, Bangladesh, and Sri Lanka) with similar developmental issues but different policy histories is a logical next step. The Common Correlated Effects Mean Group (CCEMG) estimator could be used in such a study to account for cross-sectional dependence and common shocks, such as regional climate events or changes in the price of oil globally. This will examine whether the governance-emissions relationship found in Pakistan is consistent throughout the region by separating the impact of national variations in fiscal structures and government effectiveness on emission outcomes. A researcher may create a "paired-case" comparison analysis for further theoretical innovation, possibly contrasting Pakistan with nations like Vietnam or

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Morocco that, despite having comparable income levels, have more aggressive policies for carbon pricing and renewable energy. Beyond merely econometric study, this qualitative-comparative approach may reveal the institutional sequencing and political economy elements that facilitate the effective use of Pigouvian instruments. Furthermore, future study should break down the analysis to address the problem of sectoral heterogeneity and omitted factors. One creative strategy is to switch from modeling the entire economy to studies at the sector level, with a special emphasis on the transportation, cement/steel, and power generation sectors—the biggest sources of emissions in Pakistan. If, for example, a carbon levy was imposed on the cement industry but not the textile industry, a difference-in-differences analysis might be conducted using plant-level or sectoral energy and emission data, if available. A far sharper picture of the direct behavioral reaction to price signals would result from this. A major methodological development would also be the integration of climate-economy models, such as a computable general equilibrium (CGE) model calibrated for Pakistan. Prior to implementation, a CGE model could model the distributional and economy-wide effects of different carbon tax designs and revenue recycling programs (such as lump-sum rebates, corporate tax cuts, and green subsidies). This would give policymakers a vital evidence-based tool to foresee trade-offs and optimize policy design for social equity and environmental efficacy. In order to examine the "demand side" of environmental taxation, interdisciplinary research spanning economics, political science, and sociology is required. This research should focus on coalition building, public acceptability, and the media's influence on the political viability of such reforms in Pakistan's particular context. Together, these suggested avenues seek to shift the focus of the research agenda from finding correlations to suggesting sound, situation-specific, and workable policy solutions.

References:

Aghion, P., Hemous, D., & Veugelers, R. (2014). Cold Start for the Green Innovation Machine. BRUEGEL Policy Contribution.

Ahmad, R., Liu, G., Rehman, S. A. U., Fazal, R., Gao, Y., Xu, D., ... & Giannetti, B. F. (2025). Pakistan road towards Paris Agreement: Potential decarbonization pathways and future emissions reduction by A developing country. Energy, 314, 134075.

Arif, Muhammad Iqbal Uddin, and Muhammad Irfan Mahsud. "Disentangling Pakistan's Climate Change Governance Challenges: Trajectories and Underpinnings." PAKISTAN JOURNAL OF LAW, ANALYSIS AND WISDOM 3.10 (2024): 36-53.

Aslanbeigui, N. (2025). The Textbook Reception of Pigouvian Externality Analysis, 1946–1980. History of Political Economy, 11948217.

Bashir, M. F. (2018). Energy consumption, carbon emissions and economic growth in Pakistan: A comprehensive analysis. Journal of Environmental Management, 215, 1-10.

Brock, W. A., & Taylor, M. S. (2010). The Green Solow models. Journal of Economic Growth, 15(2), 127-153.

Buckley, P., & Enderwick, P. (2025). Tackling grand challenges: reimagining a moral ecology of globalization. Asian Business & Management, 24(1), 33-54.

Das, Abhijeet. "Evaluation and downstream effects of household and industrial effluents discharge on some physicochemical parameters and surface Water Quality Index of River Mahanadi, Odisha, India." Discover Water 5.1 (2025): 30.

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 4 No. 2 (February) (2026)

Emenekwe, C. C., Onyeneke, R. U., Nwajiuba, C. U., Anugwa, I. Q., & Emenekwe, O. U. (2025). Determinants of consumption-based and production-based carbon emissions. Environment, Development and Sustainability, 27(5), 10303-10339.

Fischer, Andrew M., and Servaas Storm. "The return of debt crisis in developing countries: shifting or maintaining dominant development paradigms?" Development and Change 54.5 (2023): 954-993.

Gershon, O., Asafo, J. K., Nyarko-Asomani, A., & Koranteng, E. F. (2024). Investigating the nexus of energy consumption, economic growth and carbon emissions in selected African countries. Energy Strategy Reviews, 51, 101269.

Goulder, L. H. (1995). Environmental taxation and the double dividend: A reader's guide. International Tax and Public Finance, 2(2), 157-183.

Grossman, G. M., & Krueger, A. B. (1995). Economic growth and the environment. The Quarterly Journal of Economics, 110(2), 353-377.

IPCC. (2022). Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.

Khan, M. K. (2020). The role of institutional quality in the energy-growth-emission nexus: Evidence from Pakistan. Environmental Science and Pollution Research, 27(16), 20270-20280.

Liu, S., Li, X., & Xue, D. (2024). Renewable energy, energy use efficiency and carbon emission intensity: Based on the perspective of mediation effect and threshold effect. Mitigation and Adaptation Strategies for Global Change, 29(8), 94.

López, R. (1994). The environment as a factor of production: The effects of economic growth and trade liberalization. Journal of Environmental Economics and Management, 27(2), 163-184.

Muth, D., Weiner, C., & Lakócai, C. (2024). Public support and willingness to pay for a carbon tax in Hungary: can revenue recycling make a difference? Energy, Sustainability and Society, 14(1), 30.

Nordhaus, W. D. (2017). Revisiting the social cost of carbon. Proceedings of the National Academy of Sciences, 114(7), 1518-1523.

Pigou, A. C. (1920). The Economics of Welfare. London: Macmillan and Co.

Popoyan, Lilit, and Alessandro Sapio. "Prevention first vs. cap-and-trade policies in an agent-based integrated assessment model with GHG emissions permits." Journal of Evolutionary Economics 35.2 (2025): 309-354.

Rahman, Tanzeel Ur, et al. "Towards Sustainable Solutions: Climate Change and Food Security in a Globalized World." Food and Energy Security 14.5 (2025): e70126.

Raza, M. Y., & Lin, B. (2024). Energy transition, carbon trade and sustainable electricity generation in Pakistan. Applied Energy, 372, 123782.

Shahbaz, M., Hye, Q. M. A., Tiwari, A. K., &Leitão, N. C. (2013). Economic growth, energy consumption, financial development, international trade and CO2 emissions in Pakistan. Renewable and Sustainable Energy Reviews, 25, 164-171.

Solow, R. M. (1956). A contribution to the theory of economic growth. The Quarterly Journal of Economics, 70(1), 65-94.

Stern, D. I. (2004). The rise and fall of the environmental Kuznets curve. World Development, 32(8), 1419-1439.

Stokey, N. L. (1998). Are there limits to growth? International Economic Review, 39(1), 1-31.

Yang, B. (2025). Current Development and Practice: The Economics of Climate Change. In The Carbon Emission Liability Mechanism: A New Solution for Global

ISSN Online: 3007-3154
ISSN Print: 3007-3146

Vol. 4 No. 2 (February) (2026)

Carbon Neutrality (pp. 45-114). Singapore: Springer Nature Singapore.

Yang, Baoming. "Current Development and Practice: The Economics of Climate Change." The Carbon Emission Liability Mechanism: A New Solution for Global Carbon Neutrality. Singapore: Springer Nature Singapore, 2025. 45-114.

Yang, H., & Umair, M. (2024). Polluting industries: does green industrial policy encourage green innovation? Chinese perspective evidence. Heliyon, 10(17).