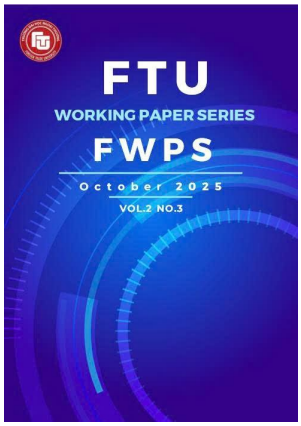

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TÁC ĐỘNG CỦA THUẾ THAN ĐẾN LƯỢNG PHÁT THẢI CO_2 BÌNH QUÂN ĐẦU NGƯỜI: BẰNG CHỨNG THỰC NGHIỆM TỪ MỘT SỐ QUỐC GIA CHÂU Á VÀ MỘT SỐ KHUYẾN NGHỊ CHO VIỆT NAM

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Tóm tắt

Nghiên cứu này đánh giá tác động của thuế than đối với lượng phát thải CO_2 bình quân đầu người tại bốn quốc gia đang phát triển ở châu Á gồm Trung Quốc, Việt Nam, Ấn Độ và Philippines, sử dụng dữ liệu bảng trong giai đoạn 2010–2024. Bằng cách kết hợp phương pháp Difference-in-Differences (DID) với System Generalized Method of Moments (System GMM), nghiên cứu chỉ ra rằng tác động của thuế than có sự khác biệt rõ rệt giữa các quốc gia. Trung Quốc và Ấn Độ đạt được hiệu quả cắt giảm phát thải tương đối rõ ràng nhờ mức thuế cao và hệ sinh thái chính sách hỗ trợ đồng bộ. Ngược lại, Việt Nam và Philippines cho thấy hiệu quả hạn

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chế hoặc tiêu cực do năng lực thể chế yếu, mức thuế thấp và thiếu cơ chế tái đầu tư nguồn thu cho mục tiêu môi trường. Kết quả nhấn mạnh rằng thuế than chỉ thực sự phát huy hiệu quả khi được triển khai trong một khuôn khổ chính sách – thể chế nhất quán. Đối với Việt Nam, nghiên cứu đề xuất cần nâng mức thuế, thiết lập cơ chế sử dụng nguồn thu minh bạch và tăng cường năng lực thể chế để chuẩn bị cho lộ trình triển khai cơ chế định giá carbon trong tương lai.

Từ khóa: các quốc gia châu Á, Difference-in-Differences, phát thải CO_2, system GMM, thuế than

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THE IMPACT OF COAL TAXATION ON PER CAPITA CO_2 EMISSIONS: EMPIRICAL EVIDENCE FROM SELECTED ASIAN COUNTRIES AND SOME RECOMMENDATIONS FOR VIETNAM

Abstract

This study examines the impact of coal taxation on per capita CO_2 emissions across four developing Asian economies—China, Vietnam, India, and the Philippines—using panel data from 2010 to 2024. While coal remains a dominant energy source in the region, its environmental consequences necessitate fiscal interventions to reduce emissions. Employing a Difference-in-Differences (DID) approach combined with System Generalized Method of Moments (System GMM), the research identifies heterogeneous effects of coal taxes across countries. China and India show relatively strong mitigation outcomes, supported by higher tax rates and integrated environmental policies. In contrast, Vietnam and the Philippines demonstrate limited or adverse impacts, reflecting weak institutional enforcement, low tax levels, and absence of targeted reinvestment. The findings suggest that coal taxation can be an effective emissions reduction tool only when embedded within a cohesive policy and governance framework. For Vietnam, the results underline the need to raise tax rates, earmark revenues for clean energy, and build institutional readiness for future carbon pricing initiatives.

Keywords: Asian countries, carbon pricing, coal taxation, CO_2 emissions, Difference-in-Differences, System GMM.

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1. Introduction

In the 21st century, global warming represents a critical challenge, with CO_2 emissions from the burning of fossil fuels, especially coal, being a key driver. In response, several Asian countries have implemented various laws and policies aimed at reducing emissions and advancing the energy transition. These include carbon taxes in Singapore, emissions trading in South Korea, and direct fossil fuel taxes in the Philippines. China has also advanced environmental taxation and clean energy promotion.

Among several policy tools, environmental taxes have been recognized for their dual function of generating revenue for investments in clean technology and influencing consumer behavior through price signals. In particular, coal taxes may lower CO_2 emissions and encourage cleaner production when aligned with regional economic conditions and emission intensity. (Tang et al., 2017; Xu et al., 2018; Qin et al., 2020).

However, scientific research on the effectiveness of coal taxes in Asia remains limited, often constrained to single-country analyses. This study addresses that gap by employing a panel dataset (2010-2024) and a combined Difference-in-Differences and System GMM approach to examine the impact of coal taxation on per capita CO_2 emissions in four representative Asian countries being China, Vietnam, India, and the Philippines. The findings aim to inform tax policy design and provide actionable insights for Vietnam's ongoing energy transition.

2. Literature review

2.1. Theoretical framework

2.1.1. Definition & Concepts

Coal taxation

Coal taxation refers to the imposition of a direct tax on the extraction or consumption of coal, designed to account for and mitigate the environmental externalities associated with coal use (Tang et al., 2017; Xu et al., 2018). Coal taxes are widely acknowledged to yield both economic and environmental benefits (Qin et al., 2020) by altering consumer and producer behavior. Taxing coal is regarded as a necessary step to internalize the severe environmental

damages caused by this fossil fuel, especially in the context of countries pursuing greenhouse gas emission reduction commitments (Goulder & Schein, 2013).

Environmental protection tax

Environmental protection taxes are levied on energy products, electricity, and other inputs such as fuel oil, natural gas, coal, and heating electricity, and serve two main purposes: (1) to raise public revenue and (2) to influence consumption patterns toward more environmentally friendly alternatives. By taxing pollution-generating activities, environmental taxes create price signals that prompt both consumers and firms to adopt cleaner choices, while simultaneously generating fiscal resources to fund environmental protection initiatives and sustainable development (Xu et al., 2018). Coal is among the commodities subject to environmental taxation in many countries (Aldy, 2016), intending to reduce CO_2 emissions associated with different coal types and discourage overall coal consumption (Tang et al., 2017).

Excise taxation

Excise taxes are imposed on the production or sale of specific goods - both domestically produced and imported, and may take the form of either specific or ad valorem rates. They serve two key objectives: (1) revenue generation for the government and (2) behavioral modification to reduce the consumption of targeted products or services (Boesen, 2021). Coal is subject to excise taxation in several countries, including the United States and China, reflecting a global regulatory trend toward green growth. In this context, excise taxes on coal can serve a function similar to environmental taxes by exerting economic pressure that changes consumer behavior and encourages firms to invest in clean energy technologies (Aldy, 2016). Over the long term, as alternatives such as solar, wind, or natural gas become more cost-competitive, the environmental benefits of coal excise taxation are expected to become more pronounced.

2.1.2. Relevant theories

Pigouvian tax theory

The Pigouvian tax theory posits that economic activities generating negative externalities, such as environmental pollution, should be taxed to fully reflect their social cost. A Pigouvian tax seeks to internalize these externalities by imposing a levy equivalent to the marginal external

cost, thereby incentivizing both firms and consumers to minimize environmentally harmful behaviors (Aldy, 2016).

Typical examples of Pigouvian taxes include tobacco taxation, implemented in response to public health concerns, and carbon taxes, which are designed to curb greenhouse gas emissions by raising the cost of fossil fuel consumption. However, determining the optimal tax rate that accurately reflects the external cost remains a key challenge. Moreover, Pigouvian taxation may not be feasible without a higher-level authority capable of imposing the tax, particularly in cases of cross-border externalities, such as environmental spillovers between neighboring countries (Deryugina et al., 2021).

Two Instruments Theory

The Two Instruments Theory suggests that governments have two primary policy tools for pollution control: environmental taxation and emissions trading systems. A classic application of this theory includes the carbon tax - a form of environmental tax aimed at increasing the cost of emitting greenhouse gases and encouraging a shift toward clean energy, and the European Union Emissions Trading System (EU ETS), in which emission allowances are allocated and traded among firms in a regulated market, thereby achieving emission reduction targets at minimum cost (Goulder & Schein, 2013).

In the presence of negative externalities such as air pollution, the theory emphasizes that coal taxation is considered a specific application of environmental tax policy, offering advantages such as ease of implementation, simplicity in monitoring, and strong behavioral incentives to reduce emissions (Fullerton & Metcalf, 2001). Nevertheless, the appropriateness of each instrument depends on market characteristics, institutional capacity, and the government's ability to accurately assess and manage the social costs of pollution (Goulder & Schein, 2013).

2.2. Literature research

In the context of intensifying environmental challenges, researchers have increasingly identified CO_2 emissions from energy production and consumption as the primary driver of the greenhouse effect and global climate change. In addition to exploring the relationships between CO_2 emissions and variables such as GDP, urbanization, international trade, energy structure, and

technological innovation, scholars have also turned their attention to the role of legal and policy frameworks in shaping emission trajectories (McDonald, 2021).

To curb CO_2 emissions, governments have adopted a variety of policy instruments, including emissions trading systems, emission standards, environmental protection taxes, and energy taxes (Dupont et al., 2024). Among these, carbon taxation stands out for its capacity to directly price CO_2 emissions, thereby creating clear incentives for both firms and consumers to shift toward cleaner energy sources. In addition, carbon tax revenues can be recycled to subsidize environmental protection projects and low-carbon technologies, thereby reinforcing the intended environmental impacts. However, in developing countries - particularly in Asia - carbon taxation remains at a pilot or proposal stage. A study in Indonesia by Siregar (2025) warns that carbon taxes may have regressive effects, placing a disproportionate financial burden on low-income households if not accompanied by compensatory policies. In Vietnam, carbon taxation is still under review as part of the national strategy to achieve net-zero emissions by 2050.

Within developing Asian economies, alternative fiscal tools - especially resource taxes - have emerged as important instruments for regulating fossil fuel extraction and consumption (Zhang et al., 2022). Given coal's continued dominance in many national energy mixes, coal tax reform is considered a direct and practical measure to reduce emissions and promote a cleaner energy structure (Tang et al., 2017). A prominent example is China, where resource tax reform on coal has been recognized as a central component in reducing CO_2 emissions and mitigating smog-related pollution, while also improving environmental welfare (Xu et al., 2018). In Vietnam, it has been proposed that the environmental protection tax on coal be structured according to the CO_2 emissions intensity of different coal types, to reduce overall emissions, encourage cleaner technologies, and promote more efficient and rational coal use.

Recent studies have further examined the distributive impacts of carbon-related taxes, especially in emerging economies. Qin et al (2020) analyzing China's coal tax reforms, found that both the former quantity-based and current ad valorem systems remained regressive, with Suits Index scores of -0.6796 and -0.6793, respectively. These taxes disproportionately affected nearly 30% of rural and 6% of urban households, particularly in lower-income provinces. Zhang (2022) also emphasize that rural households in China are particularly vulnerable to energy poverty under uniform pricing policies, given their dependence on inefficient heating systems

and raw coal for fuel. Similarly, Siregar (2025) used a Miyazawa input–output model to demonstrate that Indonesia's proposed carbon tax would significantly burden rural households unless accompanied by compensatory measures such as cash transfers or energy subsidies.

2.3. Research gap

Although carbon taxation has been widely recognized as an effective tool for pricing emissions and promoting energy transition, most Asian countries have yet to implement such policies in a comprehensive and consistent manner (Abbasi et al., 2022). In this context, evaluating the role of alternative fiscal instruments such as excise taxes or environmental taxes on coal has become particularly urgent (Liu et al., 2017).

Existing research on coal taxation has primarily focused on individual country case studies, such as India (Mukherjee, 2022), China (Qin et al., 2020), and Indonesia (Yusuf & Resosudarmo, 2007). However, given the substantial differences in institutional quality, energy structures, and tax rates across countries, the practical effectiveness of coal tax policies remains inconclusive due to the absence of systematic cross-country comparisons. In other words, there is a significant gap in the literature regarding national-level evaluations of coal tax instruments that explicitly account for such heterogeneity. Bridging this gap is crucial not only for understanding the current effectiveness of coal taxation but also for deriving practical lessons to inform the future design and implementation of carbon tax regimes, particularly in developing economies such as Vietnam.

This study aims to address that gap by conducting a counterfactual and quantitative assessment of the impact of coal taxation on per capita CO_2 emissions in developing Asian countries, where carbon taxation is still in its early stages or under consideration. Specifically, it applies a Difference-in-Differences (DID) approach combined with the System Generalized Method of Moments (System GMM) estimator to compare countries that have implemented coal taxation with those that have not. Through this approach, the study isolates the net effect of the policy on emissions. In doing so, it provides an in-depth analysis of four representative countries: China, Vietnam, India, and the Philippines using panel data from 2010 to 2024. These countries offer diverse institutional and energy structures, which allows for a nuanced evaluation of coal tax effectiveness under varying national contexts. Based on the empirical results, the study proposes actionable policy recommendations to improve Vietnam's current coal tax framework,

while also offering evidence-based insights to support the eventual implementation of a comprehensive carbon tax system.

3. Research methods and data

3.1. Research models

The research model developed in this study draws upon the Difference-in-Differences (DID) framework and incorporates the System Generalized Method of Moments (System GMM) approach, following and expanding on the methodology proposed by (Lin & Li, 2011).

$$\ln\left(\frac{E_t}{E_{t-1}}\right) = \alpha - blnE_{t-1} + \beta_0 X_t + \beta_1 . tax + \beta_2 . post + \delta_1 . tax_{post} + \varepsilon_t$$

where tax denotes the sectional dummy variable, zero and one represents the control group and treatment group, respectively. $post$ is the time dummy variable, zero and one represent the first time and the second time periods. tax_post, an interaction terms of time dummy and sectional dummy variables equals one, only when both the values of tax and post are one. The parameter β_1 captures possible differences between the treatment and control groups prior to the policy, and the parameter β_2 captures aggregate factors that would cause changes to Y even in the absence of a policy change. The parameter δ_1 measures the effects attributed to the policy, so it is the key estimated variable. The error ε_t represents unobserved individuality.

3.2. Data

3.2.1. Treatment group

In the scope of this study, the authors identify four Asian countries—China, Vietnam, India, and the Philippines—as the treatment group. These countries have yet to introduce formal carbon taxation schemes but have implemented coal taxation as a principal policy mechanism aimed at addressing environmental externalities.

China introduced a resource tax on coal in 2011, with ad valorem rates ranging from 2% to 10%, depending on the coal's type and quality. While initially designed to conserve natural resources, discourage overexploitation, and mitigate local air pollution, the coal tax has progressively evolved into a key policy tool to reduce greenhouse gas emissions. This evolution

aligns with China's national commitments to peak CO_2 emissions by 2030 and achieve carbon neutrality by 2060 (Li & Peng, 2020). The policy exerts its most significant impact on the coal mining and power generation sectors, which together contribute over 70% of the country's total CO_2 emissions. Vietnam has imposed a coal resource tax since 2010, with rates between 5% and 10% applicable to both domestically mined and imported coal. The tax is integrated into the National Green Growth Strategy and the National Climate Change Strategy, signifying an institutional effort to reduce carbon intensity per unit of GDP and to curtail reliance on fossil fuels. India stands out as one of the earliest emerging economies to introduce coal taxation in the form of a coal cess, implemented in 2010 at a rate of 50 rupees per ton and subsequently increased to 400 rupees per ton by 2016 (Government of India, 2016). As one of the first indirect carbon pricing instruments in a non-OECD context, the cess was intended to both curb emissions and mobilize financial resources for the National Clean Energy Fund. Philippines introduced an excise tax on coal through the Tax Reform for Acceleration and Inclusion (TRAIN) Law—Republic Act No. 10963—in 2018. The tax was set at 50 pesos per ton initially, rising to 100 pesos in 2019 and 150 pesos in 2020 (Department of Finance Philippines, 2018). The primary objective of this measure was to reduce the country's dependence on coal-fired electricity, which constitutes approximately 50% of its installed generation capacity.

3.2.2. Control group

The control group in this study comprises Asian countries that did not implement carbon taxation or coal taxation during the period under review, with the exception of countries with formal carbon tax policies such as Singapore, Japan, and South Korea. The remaining countries included in the control group are: Malaysia, Thailand, Myanmar, Laos, Cambodia, Indonesia, Brunei, Bangladesh, Saudi Arabia, the United Arab Emirates, Qatar, Turkey, Kazakhstan, and Uzbekistan. These countries were selected based on the following criteria: (i) the absence of any carbon pricing policy intervention throughout the study period; (ii) comparable economic, social, and energy structure characteristics with those of the treatment group; and (iii) the availability of consistent and complete data across all years observed.

Including these countries in the control group provides essential value to the Difference-in-Differences (DID) analysis by generating a baseline trend against which the policy effects on the treatment group can be evaluated. Furthermore, the diversity in levels of economic

development, population size, and energy profiles within the control group enhances the generalizability of the research findings and minimizes potential bias in the comparative assessment between policy-adopting and non-policy-adopting countries.

3.2.3. Selection of control variables

The inclusion of control variables in this study is theoretically informed and empirically grounded in a substantial body of literature that investigates the structural and economic determinants of carbon emissions. Previous empirical studies have consistently demonstrated that CO_2 emissions are shaped by a range of macro-level variables, including economic growth (Vogel & Hickel, 2023), demographic pressure (Wang & Li, 2021), the degree of industrialization (Sikder et al., 2022), the share of renewable energy in the total energy mix (Mirziyoyeva & Salahodjaev, 2023), and fossil fuel dependency (Abbasi et al., 2022).

Based on these theoretical insights, the following control variables are incorporated into the empirical model: GDP per capita (current US$), urban population (% of total population), industry value added (including construction, as a percentage of GDP), renewable energy consumption (% of total final energy consumption), and fossil fuel energy consumption (% of total energy use). The integration of these variables ensures that the model adequately captures the structural and policy-invariant determinants of CO_2 emissions. This approach enhances the model's capacity to isolate the marginal effect of energy-related tax interventions, thereby improving the internal validity of the estimated policy impact.

4. Proposed research model

Research model is proposed as follow:

$$lnCO_{2it} = \beta_0 + \beta_1 lnCO_{2i(t-1)} + \beta_2 lnGDP_{it} + \beta_3 lnIn\_value_{it} + \beta_4 Re_{it} + \beta_5 Ff_{it} + \beta_6 lnUr_{it} + \beta_7 tax_{it} + \beta_8 post_{it} + \beta_9 lntax\_post_{it} + u_{it}$$

where:

- β_0: Intercept term
- β_j: Coefficients to be estimated (j = 1, ..., 9)
- u_{it}: Error term for country i at time t

- $lnCO_{2it}$: Log of per capita CO_2 emissions in country i at time t (metric tons/person)
- $lnCO_{2i(t-1)}$: One-period lag of the log of per capita CO_2 emissions (to control for emission inertia)
- $lnGDP_{it}$: Log of GDP per capita (PPP, USD)
- $lnIn\_value_{it}$: Log of industrial value added (% of GDP)
- Re_{it}: Renewable energy consumption (% of total final energy consumption)
- Ff_{it}: Fossil fuel consumption (% of total fossil fuel consumption)
- Ur_{it}: Urban population (% of total population)
- tax_{it}: Dummy variable indicating whether coal taxation is in effect (1 = yes; 0 = no)
- $post_{it}$: Dummy variable indicating the post-treatment period (1 = after policy implementation; 0 = before)
- tax_post_{it}: Interaction term between tax and post, capturing the net treatment effect under the Difference-in-Differences (DID) framework

5. Results

5.1. Data description

This study utilizes an unbalanced panel dataset comprising 21 Asian countries over the period 2010–2024 to empirically examine the effect of coal taxation on per capita CO_2 emissions. The sample is stratified into treatment group and control group. The dataset yields approximately 194 country-year observations, with an average of 15 years of data per country, capturing sufficient temporal variation and regional heterogeneity. Missing values are addressed through linear interpolation, and robustness checks are conducted using a balanced subsample to ensure the validity of estimates.

Table 1: Data description

Variable	Obs	Mean	Std. Dev.	Min	Max

lnCO2	313	14.52457	1.179926	9.069122	16.80321
lnGDP	315	21.52081	1.084529	16.20444	23.02421
lnIn_value	315	21.72347	.8283741	17.47783	22.72031
Re	315	18.87778	20.87704	0	84.6
Ff	315	82.48213	18.52263	21.62	100
Ur	315	6084315	23.79918	20.294	100
tax	315	.3333333	.4721546	0	1
post	315	.215873	.4120812	0	1
tax_post	315	.215873	.4120812	0	1

Source: Author's estimation

Descriptive statistics reveal substantial cross-country variation: GDP per capita ranges from roughly US$1,000 (e.g., Bangladesh, Myanmar) to over US$60,000 (e.g., Qatar, UAE); per capita CO_2 emissions span from approximately 0.3 metric tons (e.g., Laos, Cambodia) to over 40 metric tons (e.g., Qatar). Urbanization rates vary between 20% and nearly 100%, while the share of services in GDP ranges from 30% to 70%. This diversity provides a rich empirical context for identifying the causal impact of coal taxation on carbon emissions while accounting for underlying socio-economic and energy-structural heterogeneity across countries.

5.2. Model diagnostic tests

To ensure the reliability and validity of the estimations obtained through the System Generalized Method of Moments (System GMM) approach, the authors conducted a series of standard diagnostic tests.

Table 2: Diagnostic test results

Country	AR(1) p-value	AR(2) p-value	Sargan p-value	Hansen p-value	Diff-in-Hansen p-value	Wald chi² (p-value)
China	0.79	0.524	0.971	1.0	1.0	18,72; p = 0,042
Vietnam	0.894	0.559	0.994	1.0	1.0	21,36; p = 0,031
India	0.953	0.165	0.945	1.0	1.0	16,95; p = 0,048

Philippines	0.686	0.918	0.966	1.0	1.0	133.29; p= 0.00

Source: Author's estimation

Arellano–Bond Autocorrelation Tests (AR(1), AR(2)): Test results for China (AR(1): p = 0.790; AR(2): p = 0.524), Vietnam (AR(1): p = 0.894; AR(2): p = 0.559), India (AR(1): p = 0.953; AR(2): p = 0.165), and the Philippines (AR(1): p = 0.686; AR(2): p = 0.918) provide no evidence of second-order autocorrelation. This confirms that the model is correctly specified and satisfies the fundamental assumption of error independence in System GMM estimation (Arellano & Bond, 1991)

Sargan and Hansen Tests of Overidentifying Restrictions: For all four countries, the results indicate high p-values (Sargan: 0.971–0.994; Hansen: 1.000), suggesting that the null hypothesis of instrument validity cannot be rejected. These findings support the appropriateness of the chosen instruments, including lagged endogenous variables, and confirm the absence of overidentification bias (Hansen, 1982; Sargan, 1958).

Difference-in-Hansen Test: Across all four countries, the test yields p-values of 1.000, indicating no violation of the exogeneity assumption. This result reinforces the internal validity of the instrument matrix and the robustness of the model specification (Roodman, 2009).

Wald Chi-Square Test of Joint Significance: Results for China (χ^2 = 18.72, p = 0.042), Vietnam (χ^2 = 21.36, p = 0.031), and India (χ^2 = 16.95, p = 0.048) confirm that the explanatory variables collectively exert a statistically significant effect on per capita CO_2 emissions at the 5% significance level. Notably, the Philippines reported a Wald chi² of 133.29 (p = 0.000), indicating a highly significant model and strong overall explanatory power.

5.3. Empirical results

The estimation results presented in Table 3 summarize the estimated coefficients of the control variables across the four countries in the treatment group.

Table 3: Estimated result of the model

	China	Vietnam	India	Philippines
ln CO2	-0,2348	-0,5022	-0,6803	-0,0257
ln GDP	-0,1725	0,0366	0,2259	-0,0103

ln In_value	0,0890	0,0942	0,1518	0,0371
Ur_po	0,2563	0,0072	0,1180	0,0073
Re_con	-0,0076	-0,1795	-0,4472	-0,2602
Ff_con	0,2662	0,1560	0,0898	0,2565
tax	103,5200	2,5189	11,1096	-5,9740
tax_post	-2,3168	-1,2111*	-2,6165*	1,5878*

** Denoted that the value is insignificant*

Source: Author's estimation

First, a positive association between GDP per capita and per capita CO_2 emissions is observed in China and India, indicating that rapid economic growth in these countries tends to drive up carbon emissions. In contrast, the coefficients for Vietnam and the Philippines suggest an inverse relationship, although the magnitude of this effect is relatively weak. This divergence may be explained by differences in economic scale and urbanization trajectories. China and India, with their large economies and rapid urbanization, have experienced strong increases in energy demand, particularly in energy-intensive sectors such as heavy industry, transportation, and construction. As such, GDP growth in these contexts is typically accompanied by rising CO_2 emissions, reflecting their reliance on high-carbon development pathways. Additionally, the use of per capita data may accentuate emission-reduction trends in smaller economies like Vietnam and the Philippines, where the service sector comprises a larger share of GDP. In contrast, improvements in emission efficiency in larger economies may be insufficient to offset surging energy demand.

Second, industrial value added, urbanization, and fossil fuel consumption are all found to be positively associated with per capita CO_2 emissions. This finding supports the notion that industrialization and urban growth, when not accompanied by technological upgrades and robust environmental governance, contribute significantly to emissions growth (Xu et al., 2022). Conversely, renewable energy consumption exhibits a consistently negative effect on emissions across all countries, aligning with empirical expectations and prior evidence (Nguyen, 2023).

Third, the estimated effect of coal taxation on per capita CO_2 emissions varies considerably across countries. In China, a large negative coefficient suggests that coal taxation is

strongly associated with emission reductions. In Vietnam and India, smaller negative coefficients indicate a modest mitigating effect, implying that current tax levels may be insufficient to generate meaningful impact without complementary policies. Notably, in the Philippines, the estimated coefficient is positive, suggesting that the coal tax is not achieving its intended environmental objectives. This may be attributable to tax exemptions, enforcement gaps, or weak regulatory design.

Fourth, the interaction term (tax × post), representing the policy effect of coal taxation under the DID framework, yields a negative coefficient in most cases. This implies that, relative to countries without such policy intervention, those adopting coal taxation have experienced a relative slowdown in CO_2 emission growth. As shown in Table 3 this coefficient is negative for all countries except China. In other words, coal taxation in China, Vietnam, and India has been associated with emission reduction, whereas in the Philippines, emissions have continued to rise. Importantly, among the three negative coefficients, only China's result is statistically significant. This suggests that the emission-reducing effect of coal taxation in the other countries is limited—an outcome consistent with much of the existing literature (Sikder et al., 2022).

5.4. Discussion

This study finds that the effectiveness of coal taxation in reducing per capita CO_2 emissions varies substantially across countries, with China and India showing more favorable outcomes compared to Vietnam and the Philippines. These differences can be largely attributed to variations in governance quality, tax design, enforcement capacity, and the presence (or absence) of complementary environmental policies.

Among the four countries examined, China and India exhibit relatively stronger mitigation effects, while Vietnam and the Philippines reflect notable limitations in both policy structure and execution. China, in particular, achieved the highest Government Effectiveness Index score in 2022 (0.49), substantially higher than Vietnam (0.17) and the Philippines (0.06), and above the global average of –0.04. This reflects the country's robust institutional framework, which combines a high coal resource tax (2–10% ad valorem) with stringent environmental mandates and centralized enforcement. In parallel, China has implemented a broad portfolio of complementary policies—ranging from ultra-low emissions standards for coal-fired power plants to nationwide feed-in tariffs for renewables and targeted green development funds. These

coherent and integrated measures likely explain why China's coal tax coefficient is the only one that achieved statistical significance in the model. It provides clear evidence that fiscal policy, when embedded in a supportive institutional and regulatory environment, can exert meaningful environmental effects.

Table 4: Tax rate and implementation time of four countries

Country	Tax rate (per tonne)	Implementation
China	2 - 10% of coal sales	Nationwide since 2016
India	₹50 → 100 → 300 → 400/t (2010 → 2016)	Began 2010 (Clean Energy Cess)
Vietnam	15,000 – 30,000 VND/t	EPT law 2010
Philippines	₱50 → 100 → 150/t (2018 → 2020)	TRAIN Act 2018

Source: KPMG International, Clean Environment (Energy) Cess, Vietnam Briefing, Philippine Institute for Development Studies

India presents a transitional case. Its Clean Energy Cess, peaking at ₹400 per tonne of coal (approximately US$5/t coal or ~US$2/tCO_2), was legally earmarked for the National Clean Energy Fund (NCEF) – intended to finance clean technology and renewable energy development. Despite the dissolution of the NCEF in 2017, India's broader ecosystem of energy and climate policies – such as Renewable Purchase Obligations (RPOs), the Perform-Achieve-Trade (PAT) scheme, and investment subsidies for renewables—has contributed to observable emissions reductions. These institutional supports appear to have compensated for the absence of a high tax rate or ring-fenced revenue in later years.

In contrast, Vietnam and the Philippines exemplify the challenges of implementing coal taxation in low-capacity settings. Vietnam, although more institutionally stable, imposes one of the lowest regional coal taxes (VND 15,000−30,000/t ≈ US$0.6−1.2/t coal, or ~US$0.1/tCO_2), offering virtually no incentive for firms to invest in cleaner technologies. In comparison, Marginal Abatement Costs (MACs) in coal-intensive sectors across Asia are estimated to range from US$50 to over US$100 per tonne of CO_2, and even exceed US$1,400/t$CO_2$ for structural

transitions like carbon capture in China. This vast gap highlights why current taxes in Vietnam (and elsewhere) remain far below the threshold needed to shift business behavior.

The Philippines with the lowest governance score, exemplifies poor policy effectiveness. Despite increasing its coal excise tax from ₱10 to ₱150 per ton between 2018 and 2020, the absence of earmarked environmental spending or robust enforcement mechanisms rendered the policy ineffective. Unsurprisingly, the Environmental Performance Index (EPI) of both countries declined sharply between 2010 and 2022—from 59.0 to 20.1 in Vietnam, and 65.7 to 28.9 in the Philippines—indicating persistent regulatory failures and limited institutional accountability. Notably, the Philippines even recorded an increase in CO_2 emissions after the tax was implemented, suggesting that, in weak institutional contexts, taxation alone may have perverse or negligible environmental effects.

Table 5: Environmental Performance Index (EPI) scores and country ranks (higher is better) for selected years

Country	EPI 2010 (Rank)	EPI 2020 (Rank)	EPI 2030 (Rank)
China	49.0 (19)	37.3 (120)	26.3 (172)
India	48.3 (20)	27.6 (168)	18.9 (191)
Vietnam	59.0 (15)	33.4 (141)	20.1 (189)
Philippines	65.7 (8)	38.4 (111)	28.9 (169)

Source: Yale Center for Environmental Law & Policy

Furthermore, the interaction term between treatment and post-treatment groups confirms that countries adopting coal-related taxes tend to exhibit slower CO_2 emission growth than non-adopters, aligning with Pigouvian tax theory. However, the fact that only China's coefficient is statistically significant highlights that policy efficacy is conditional—not solely on the presence of a tax, but on its rate, enforcement, governance context, and policy integration. In Vietnam and the Philippines, weak oversight, low tax levels, and the absence of earmarking or reinvestment mechanisms collectively dilute the potential impact of coal taxation.

These findings suggest that coal taxation can be an effective climate policy instrument, but only when implemented within a cohesive institutional ecosystem. For Vietnam specifically, strengthening the coal tax policy must go beyond adjusting nominal rates. It requires comprehensive institutional reform: stricter enforcement, revenue earmarking for clean energy,

and integration with national decarbonization strategies, particularly as the country explores the future implementation of a carbon pricing mechanism.

6. Implications, Limitations & Conclusion

6.1. Implications

The findings of this study indicate that Vietnam currently maintains a relatively low coal tax rate, while revenues generated from this tax are not yet strategically aligned with clearly defined environmental objectives. To enhance the environmental effectiveness of coal taxation, the study proposes a three-pronged policy approach.

First, the government should raise the minimum coal tax rate to better reflect the true social cost of CO_2 emissions. In parallel, there is a pressing need to establish explicit, time-bound criteria for tax exemptions, particularly for high-emission sectors such as coal-fired power, cement, and steel. Lessons from China and India demonstrate that taxation becomes effective only when implemented at sufficiently high levels and is not diluted by excessive exemptions. By contrast, the case of the Philippines illustrates how symbolic or poorly enforced taxation can fail to reduce emissions—and may even lead to unintended increases.

Second, Vietnam should develop a transparent and goal-oriented framework for the allocation and oversight of coal tax revenues. Specifically:

(i) Revenues should be reinvested in renewable energy infrastructure, emission-reduction technologies, and grid modernization to support the integration of clean energy sources;

(ii) Fiscal resources should also be directed toward reskilling programs and economic diversification efforts in regions dependent on coal mining, production, or consumption.

Notable institutional models—such as China's Green Development Fund and India's National Clean Energy Fund—offer practical lessons for designing dedicated climate finance mechanisms. Increasing the transparency and accountability of public expenditure not only enhances the perceived legitimacy of the policy but also builds public trust and attracts international climate finance.

Third, over the long term, coal taxation should be treated as a transitional policy instrument toward the establishment of a comprehensive carbon pricing framework. To that end, Vietnam must begin developing:

(i) A dedicated legal framework for carbon pricing aligned with its 2050 net-zero emissions pathway;

(ii) A sectoral pilot for an emissions trading system (ETS);

(iii) A standardized emissions database and sectoral/regional greenhouse gas inventory system;

(iv) Legal and technical infrastructure to support measurement, reporting, and verification (MRV) protocols.

International experience underscores the importance of institutional preparedness: without robust legal, administrative, and technical foundations, carbon taxation schemes are unlikely to produce meaningful environmental outcomes.

6.2. Limitations

While this study contributes to the empirical literature on coal taxation and its environmental effectiveness in developing Asian economies, this study faces several limitations that warrant cautious interpretation of the findings.

First, while the Difference-in-Differences (DID) and System GMM approaches are robust against certain forms of endogeneity, they still rely heavily on the assumption that unobserved heterogeneity is adequately captured by the model's structure. In practice, unobservable institutional shocks or policy spillovers may still confound the results, especially in countries with volatile governance or policy transitions. Second, the study covers a period (2010–2024) marked by significant exogenous shocks—including global energy market fluctuations, the COVID-19 pandemic, and geopolitical conflicts—that may independently influence emissions and confound causal inference. Incorporating structural break tests or employing event-study frameworks could enhance the precision of future estimations. Third, the study is limited by data availability and consistency across countries. Certain potentially important variables—such as enforcement strength, public perception of taxation, or actual revenue allocation—are not

observed or are difficult to quantify in a comparable way, which may restrict the comprehensiveness of the policy evaluation.

Future research should seek to refine causal identification by employing hierarchical models or instrumental variable techniques to better address unobserved institutional factors. It should also account for exogenous shocks—such as COVID-19 or energy price volatility—through structural break tests or event-study frameworks. Finally, integrating qualitative methods, such as stakeholder interviews or policy case studies, could offer valuable insights into enforcement, revenue allocation, and societal acceptance often absent from quantitative data.

6.3. Conclusion

This study employs a panel dataset of 21 Asian countries over the period 2010–2024, combining the Difference-in-Differences (DID) approach with the System Generalized Method of Moments (System GMM) to evaluate the impact of coal taxation on per capita CO_2 emissions. Four countries—China, Vietnam, India, and the Philippines—are selected as the treatment group, representing economies that have yet to implement comprehensive carbon taxation but have adopted indirect forms of energy taxation. Regression results indicate that coal taxation has contributed to emission reductions in three of the four countries. India and China exhibit notable mitigation effects, whereas Vietnam shows limited effectiveness, largely due to low tax rates and broad exemptions. The Philippines emerges as an outlier, with CO_2 emissions increasing following tax implementation—an outcome that reflects policy failure in the absence of coherent enforcement mechanisms.

These findings reinforce the notion that coal taxation can only be effective when supported by sufficiently high tax rates, robust institutional enforcement, and complementary policy instruments such as renewable energy investment and energy efficiency standards. The study not only addresses an important empirical gap in the literature on environmental taxation in developing countries but also offers actionable policy recommendations for improving Vietnam's current coal tax framework. More broadly, it lays an empirical foundation for the design of a future carbon tax regime in Vietnam, grounded in evidence and aligned with global climate commitments.

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