THE IMPACT OF FISCAL POLICY ON CO_2 EMISSIONS: A MULTI-GROUP ANALYSIS BY NATIONAL INCOME USING THE GMM MODEL

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ABSTRACT

This paper investigates the differences in the impact of fiscal policy on CO_2 emissions reduction across countries with varying income levels during both the COVID-19 period and the preceding years. The authors employ the GMM method for analysis, using secondary data collected from the World Bank and the Sustainable Development Report 2024 by Sachs et al. (2024), covering 35 countries from 2015 to 2023. The findings reveal that the influence of fiscal policy on CO_2 emissions differs across country income groups. High-income countries tend to implement environmental investment policies early, while lower-middle-income countries, although they have integrated environmental considerations into their post-COVID-19 economic recovery packages, still need to enhance monitoring mechanisms and budget allocation for green development. As a lower-middle-income country, Vietnam should draw lessons from higher-income nations to improve its policy framework and accelerate progress toward achieving sustainable environmental goals.

TÁC ĐỘNG CỦA CHÍNH SÁCH TÀI KHÓA ĐẾN GIẢM PHÁT THẢI CO_2: PHÂN TÍCH ĐA NHÓM QUỐC GIA THEO THU NHẬP BẰNG MÔ HÌNH GMM

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TỪ KHÓA

Chính sách tài khóa
Môi trường bền vững
Phát thải khí CO_2
Covid – 19
Việt Nam

TÓM TẮT

Bài báo nghiên cứu sự khác biệt trong tác động chính sách tài khóa đến việc giảm phát thải CO_2 ở các quốc gia có mức thu nhập bình quân khác nhau trong cả giai đoạn Covid – 19 và giai đoạn trước đó. Các tác giả sử dụng phương pháp GMM để phân tích, dựa trên dữ liệu thứ cấp được thu thập từ nguồn của World Bank, và báo cáo phát triển bền vững năm 2024 của Sachs và cộng sự (2024) cho 35 quốc gia trong giai đoạn 2015–2023. Kết quả nghiên cứu cho thấy, ở các nhóm quốc gia khác nhau, tác động của chính sách tài khóa đến phát thải khí CO_2 là khác nhau. Các nước có thu nhập cao thường sớm ban hành chính sách đầu tư vào môi trường, trong khi các quốc gia thu nhập trung bình thấp, mặc dù đã có sự lồng ghép chính sách về môi trường trong các gói phục hồi kinh tế sau Đại dịch Covid – 19, song vẫn còn cần tiếp tục cải thiện các cơ chế giám sát và phân bổ ngân sách hướng vào môi trường xanh. Việt Nam là một nước thu nhập trung bình thấp, bởi vậy, cần học hỏi kinh nghiệm từ các quốc gia trong nhóm thu nhập cao hơn để hoàn thiện chính sách, đẩy nhanh tiến độ thực hiện các mục tiêu môi trường bền vững.

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1. Introduction

Although the COVID-19 pandemic has passed its peak, its lingering impacts, together with geopolitical tensions, ongoing conflicts, erratic climate events, and economic instability, continue to hinder global progress toward achieving the Sustainable Development Goals (SDGs), including in Vietnam [1]. Environmental targets such as SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land) require countries to reduce CO_2 emissions through sustainable fiscal policies and strategic investments. Public spending, long regarded as a key driver of sustainable development, also plays a vital role in post-pandemic economic recovery [2], [3]. Many governments adopted expansionary fiscal policies with large support packages to stabilize the economy and strengthen public health systems [4], [5], but their effectiveness varied depending on income levels and institutional capacity [6]. Keynesian theory emphasizes the role of public spending in driving economic recovery. In response to COVID-19, many governments have implemented fiscal measures to mitigate the economic consequences, promote recovery and maintain social welfare [7]. When properly designed, fiscal policies can help reduce CO_2 emissions through targeted investments in renewable energy, public transportation, and green infrastructure [8, p.6]. Additionally, the development of information and communication technology (ICT) serves as both a driver of improved energy efficiency and a potential contributor to emissions if not properly managed [9]. The environmental Kuznets curve hypothesis suggests that CO_2 emissions tend to rise in the early stages of economic growth and decline as per capita income increases and cleaner technologies are adopted [10, p.1235]. However, the relationship between public health spending and CO_2 emissions remains debated. Some studies indicate that higher spending may lead to increased emissions [11, p. 44954] while others suggest the opposite, although the direction of causality is unclear [12]. Furthermore, urbanization and investment in clean energy also contribute to emission reductions, as illustrated by the case of South Africa [13]. Differences in economic size and fiscal capacity shape how countries influence the SDGs. While wealthier nations can invest more in sustainability, developing countries can still make significant progress through well-targeted and efficient spending [14]. This study thus poses two critical questions: In the context of the COVID-19 pandemic, did fiscal policies have a greater impact on promoting environmental sustainability than in the pre-pandemic period? And which income group of countries saw the most positive effects of fiscal policy on sustainability outcomes? Answering these questions will inform policy recommendations, especially for low-income countries like Vietnam, as they work toward long-term environmental goals.

2. Research Model and Methodology

Based on theoretical foundations and previous empirical studies, this paper proposes a research model to examine the relationship between fiscal policy and CO_2 emissions as follows:

$$CO_2\_emissions_{it}=f(FiscalSupport\_GDP_{it},PostCOVID_t,FiscalSupport\_GDP_{it}\times PostCOVIDt, UrbanPop_{it}, internet_{it,} GDP\_per\_Capita_{it}, PublicHealthExp\_GDP_{it}, SDG_{it,} CO2\_emissions_{it-1})$$

Where:

- **Dependent variable**: $\mathbf{CO_2\_emissions_{it}}$: Represents per capita CO_2 emissions of country i in year *t*, used as the dependent variable representing environmental degradation.
- **Independent variables**: (i) $\mathbf{FiscalSupport\_GDP_{it}}$: The share of government fiscal support in GDP (%); this variable is expected to have a negative impact on CO_2 emissions due to increased green spending, assuming fiscal spending is oriented toward green investments and recovery. (ii) $\mathbf{PostCOVID_t}$: A dummy variable equal to 1 for the years from 2020 onward (post-pandemic period) and 0 otherwise. (iii) $\mathbf{FiscalSupport\_GDP_{it}\times PostCOVIDt}$: Interaction term used to assess whether the impact of fiscal spending on CO_2 emissions changes after the COVID-19 outbreak; it is expected to be negative, reflecting the shift toward green recovery.
- **Control variables**: (i) $\mathbf{UrbanPop_{it}}$: the urban population as a percentage of total population; this variable is expected to have a negative impact on CO_2 emissions due to improved access to

cleaner technologies and higher environmental awareness in urban areas. (ii) **$internet_{it}$**: The percentage of internet users in the population; this variable is expected to reduce emissions, as greater digital connectivity help optimize logistics, enable smart services, and support dematerialization. (iii) **$PublicHealthExp\_GDP_{it}$**: Public health expenditure as a share of GDP; it is expected to be negative effect, assuming that improved public health systems are typically accompanied by investments in clean and healthy environments. (iv) **SDG_{it}**: The country's Sustainable Development Goals (SDG) index score for each year; it is expected to be negatively correlated with CO_2 emissions, as better SDG performance reflects stronger climate and environmental policies. (v) **$GDP\_per\_Capita_{it}$**: GDP per capita (USD) by year; this variable is expected to show a negative association with emissions at higher-income levels, consistent with the Environmental Kuznets Curve theory. (vi) **$CO_2\_emissions_{it-1}$**: The lagged dependent variable; this variable is included to capure the inertia or persistence in emission levels over time.

Data and Methodology: The study utilizes a panel dataset of 35 countries from different continents, categorized into three income groups: lower-middle income, upper-middle income, and high income, covering the period from 2015 to 2023. The SDG index is sourced from The SDGs and the UN Summit of the Future – Sustainable Development Report 2024, a report compiled by Sachs et al. [15], and supported by the Sustainable Development Solutions Network and the German Federal Ministry for Economic Cooperation and Development (BMZ). The remaining variables are obtained from the World Bank database [16]. To address the issue of endogeneity, particularly the reciprocal relationship between fiscal policy and CO_2 emissions, as well as the inclusion of lagged dependent variables, this study employs the Generalized Method of Moments (GMM) estimator using R version 4.3.3. While Ordinary Least Squares (OLS) assumes strict exogeneity, which is unlikely here, Fixed Effects (FE) suffers from Nickell bias in short panels, and Random Effects's (RE) assumptions about uncorrelated effects may not hold in cross-country data. GMM provides a practical solution by using lagged variables as instruments, helping to reduce both endogeneity and autocorrelation. This makes it a reliable tool for assessing the fiscal–emissions relationship in a panel of 35 countries over 9 years.

3. Results and discussion

Descriptive statistics reveal significant variations among countries in indicators such as CO_2 emissions, per capita income, and internet usage. These differences suggest that the impact of fiscal policy on CO_2 emissions may vary across country groups. Control variables, including the SDG index and urban population share (UrbanPop), assist in capturing countries' efforts toward sustainable development and urbanization processes when assessing the effect of fiscal spending on the environment. Table 1 shows this difference.

Table 1. *Statistical description of variables used in the model*

Variable	Mean	Standard deviation	Min	Max
CO_2_emissions	6.33	4.91	0.13	20.51
FiscalSupport_GDP	33.03	12.67	10.82	97.61
GDP_per_Capita	22600.87	23165.79	621.85	108798.45
UrbanPop	69.42	19.97	19.43	100.00
Internet	71.35	23.72	12.90	100.00
PublicHealthExp_GDP	7.28	3.35	2.26	18.81
SDG	71.30	7.95	50.23	85.86

(Source: Author's calculations from data from Sachs et al. [15] and World Bank [16])

Before estimating the GMM model, a multicollinearity test was performed. The Variance Inflation Factor (VIF) values for all variables were below 3, with the exception of the internet variable, which remained under 5. These results suggest no serious multicollinearity, and therefore, all variables were included in the analysis.

The authors estimated the relationship between fiscal policy and CO_2 emissions before and during the Covid-19 pandemic. The estimation results in Table 2 showed that the relationship between fiscal policy and the implementation of CO_2 emission reduction targets was unclear before the Covid-19 pandemic.

Table 2. *Estimation results in the case of no impact from Covid-19 and taking into account the impact of Covid-19*

Explanatory variables	No impact from Covid	Taking into account the impact of Covid
CO_2_emissions$_{i-1}$	0.0928 (0.603)	-0.1296 (0.3695)
FiscalSupport_GDP	-0.0064 (0.734)	0.00175 (0.7033)
PostCOVID		0.1157 (0.6016)
FiscalSupport_GDP * PostCOVID		-0.0127 (0.0819*)
UrbanPop	0.1481 (0.043**)	0.1722 (0.011**)
Internet	0.0118 (0.027**)	0.0130 (0.0077***)
PublicHealthExp_GDP	-0.3215 (0.001*)	-0.2046 (0.0131**)
SDG	-0.2448 (0.0096***)	-0.1919 (0.0245**)
GDP_per_Capita	-0.0000212 (0.114)	-0.000018 (0.097*)
Sargan test	P = 0.0543	P = 0.15449
Autocorrelation test – Arellano-Bond	AR(1): p = 0.1691 AR (2): p = 0.3783	AR(1): p = 0.49205 AR (2): p = 0.69356
Wald test	P = 0.00013	P = 0.000039

(Source: Author's calculations using R 4.3.3 software)

During the Covid-19 period, many countries increased fiscal spending to support economic recovery, while focusing more on environmental goals, contributing to reducing CO_2 emissions. However, urbanization and digital transformation were associated with increased emissions both before and after the pandemic, with the impact being stronger after the pandemic. In contrast, the implementation of the Sustainable Development Goals (SDGs) and increased public health investment contributed to emissions reduction, although the effect tended to decline after the pandemic. Per capita income was only statistically significant in the post-Covid-19 period, with a positive impact on emissions reduction. These differences suggest that more appropriate policies are needed, especially for middle-income countries, to balance industrialization, digital transformation and sustainable development. To ensure instrument validity, the Sargan test was applied. As the p-value was greater than 0.05, the null hypothesis could not be rejected. Similar results were obtained from the Arellano-Bond test for second-order autocorrelation. The Wald test, with $p < 0.0001$, indicates that the overall model is statistically sound. This result shows that the model is suitable for assessing the impact of fiscal policy on environmental outcomes in the post-Covid-19 contextas shown in Table 3.

Table 3. *Estimated results for groups of countries classified by income*

Explanatory variables	Low-middle income	Upper-middle income	High income
FiscalSupport_GDP	0.00022 (0.8631)	-0.0046 (0.0020***)	-0.0363 (0.2844)
PostCOVID	0.1098 (0.2924)	-0.3003 (0.2571)	-0.9227 (0.1268)
FiscalSupport_GDP * PostCOVID	-0.01003 (0.0194)*	0.00537 (0.4236)	0.0145 (0.2882)
UrbanPop	0.03304 (0.6930)	0.0705 (0.4704)	-0.3315 (0.0014***)
Internet	0.00489 (0.1853)	0.01255 (0.0621*)	0.0020 (0.8300)
PublicHealthExp_GDP	-0.00514 (0.9111)	-0.1166 (0.1888)	-0.1996 (0.1945)
SDG	-0.00518 (0.9436)	-0.1256 (0.089*)	-0.1036 (0.5743)
GDP_per_Capita	0.000087 (0.3516)	-0.000048 (0.0020***)	-0.000009 (0.2920)
Sargan test	P = 0.2732	P = 0.8810	P = 0.17798
Autocorrelation test – Arellano-Bond	AR(1): p=0.8636 AR (2): p = 0.5684	AR(1): p=0.3156 AR (2): p = 0.7439	AR(1): p = 0.9004 AR (2): p = 0.1565
Wald test	P < 0.0001	P < 0.0001	P < 0.0001

(Source: Author's calculations using R 4.3.3 software)

The results indicate that:

For lower-middle-income: Fiscal policy becomes effective only after COVID-19, which aligns with the fact that these countries have only recently begun integrating environmental considerations into public spending. This finding is also supported by studies on countries such as Vietnam, Bangladesh, Indonesia, and Kenya, which have incorporated environmental components into recovery packages through investments in renewable energy, green infrastructure, and public services. However, the effectiveness of implementation remains limited due to the absence of clear budget planning, weak monitoring mechanisms, and continued reliance on international funding. Studies in Bangladesh, Indonesia, and Kenya echo this situation, emphasizing that green recovery policies are unlikely to succeed without a strong institutional framework [17]- [23]. Furthermore, broader studies such as those by UNDP Vietnam [24] indicate that green fiscal policies in low-income countries became effective only after the pandemic and continue to face constraints related to governance capacity and resource allocation mechanisms.

In upper-middle-income countries: Fiscal policies in these countries have been consistently effective both before and after the COVID-19 pandemic. In addition, variables such as Internet access, SDG performance, and per capita income are statistically significant, highlighting their supporting roles in achieving environmental goals. These results suggest that economic modernization and technological development play important roles in environmental improvement. These findings are consistent with previous studies on Turkey [25, p.310], China [26], and Malaysia [27], where policies such as carbon taxes, emissions trading systems, and clean energy investments have been actively implemented. In a broader context, Li et al. [28] also emphasize the importance of institutional quality, fiscal capacity, and targeted green investments in enhancing the effectiveness of environmental fiscal policies in emerging economies. However, other studies, such as that by Timilsina et al. [29], indicate that without income protection and support mechanisms for low-income groups, carbon tax policies may have adverse effects in countries with large informal sectors.

For the high-income countries: We finds no substantial difference in the impact of fiscal policy on CO_2 emissions between the pre-pandemic and post-pandemic periods. The primary drivers of emission reductions in these countries tend to be non-fiscal factors, such as smart urbanization. These findings align with previous studies, which show that countries such as Sweden [30] and Germany [31], [32] implemented carbon and eco-tax policies years ago to establish stable and mature systems of environmental governance. Recent studies by Black et al. [33] in an IMF working paper, and by the OECD [34] further support the view that in high-income countries, environmental efficiency is driven not only by public spending but also by institutional capacity and broad societal consensus on sustainable development. Environmental education and fostering a sense of environmental responsibility among citizens play a crucial role in maintaining a clean and sustainable environment. This serves as an important lesson for developing and least-developed countries in designing effective environmental strategies.

*** Implications for Vietnam:**

The research findings highlight the urgent need for breakthrough solutions to accelerate the achievement of environmental goals, particularly in lower-middle-income countries such as Vietnam. To ensure that fiscal policies effectively support emission reduction and the fulfillment of sustainable environmental targets, the Vietnamese government should focus on the following priorities: (i) The government should prioritize the enactment of key policies on climate change. It should also promote the development of renewable energy. In addition, the government should support the construction of smart cities through the application of advanced digital technologies. Environmental objectives should also be integrated into medium- and long-term fiscal planning. (ii) Relevant ministries and agencies should conduct research on carbon tax policies. They should also develop and pilot these policies with a clear and feasible implementation roadmap, based on comprehensive assessments of socio-economic impacts across different population groups. These efforts must align with the Law on Environmental Protection 2020 and Decision 01/QD-TTg in

2022, which approved the project on developing the carbon market in Vietnam. The goal is to pilot the domestic carbon market from 2025. These policies must ensure minimal adverse effects on vulnerable communities and sensitive sectors, thereby contributing to the fulfillment of Vietnam's environmental SDG commitments. (iii) The government and relevant stakeholders should increase investment in environmental education and promote public awareness campaigns to enhance understanding among communities and businesses, particularly in urban areas, regarding environmental responsibility and regulatory compliance. This should include encouraging sustainable behaviors, thereby accelerating progress toward Vietnam's environmental sustainability goals.

4. Conclusion

The ecological environment is a critical concern not only for individual countries but also for the global community as a whole. At present, most countries have shown increased attention to protecting the ecological environment. However, as climate change and global environmental pollution intensify, there is an increasing need for countries to implement environmentally focused fiscal policies. The research findings indicate clear disparities among country groups based on income levels. In lower-middle-income countries, the Covid-19 pandemic appears to have heightened government awareness, as many of these nations have begun integrating environmental considerations into their economic stimulus packages. However, the effectiveness of these efforts remains limited due to the absence of clear mechanisms for monitoring, evaluation, and budget allocation. Meanwhile, upper-middle-income countries tend to adopt environmental goals at an earlier stage. Notably, high-income countries have prioritized emission reduction through stringent environmental policies and adaptive fiscal mechanisms supported by strong societal consensus. Vietnam, as a lower-middle-income country, can draw important lessons from more developed nations: achieving sustainable environmental goals not only requires appropriately directed fiscal policies but also demands coordinated efforts among the government, the private sector, and the public. For Vietnam, it is urgent to complete the green fiscal institutions, integrate medium- and long-term environmental goals into fiscal strategies, such as the National Green Growth Strategy and the Plan for the Implementation of the Sustainable Development Goals (SDGs). In addition, the government needs to promote the issuance of tools such as carbon taxes, develop the domestic carbon market according to the set roadmap, and increase public investment in green infrastructure and environmental education. Close coordination between the State, the private sector and the community will be a key factor in achieving long-term sustainable environmental goals.

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