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Revisiting The Impact of Trade Openness and FDI on CO_2 Emissions: Evidence from ASEAN-China FTA Countries

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Abstrak

Pertumbuhan ekonomi yang didorong oleh perdagangan bebas dan investasi asing langsung (FDI) berimplikasi pada degradasi lingkungan, terutama karena emisi karbon dioksida (CO2) yang dapat menyebabkan efek rumah kaca dan kemudian berkontribusi pada perubahan iklim. Perubahan iklim yang diakibatkan oleh emisi CO2 saat ini menjadi masalah di seluruh dunia dan merupakan salah satu Tujuan Pembangunan Berkelanjutan (SDGs). Meskipun demikian, korelasi antara keterbukaan perdagangan dan arus masuk FDI terkait emisi CO2 masih belum dapat disimpulkan. Penelitian ini bertujuan untuk mengisi kesenjangan penelitian ini dengan meninjau kembali pengaruh keterbukaan perdagangan dan FDI terhadap emisi CO2 dengan menggunakan data panel dari negara-negara ASEAN dari tahun 1990 hingga 2023, dan menggunakan pendekatan regresi panel *fixed effect*. Temuan menunjukkan bahwa keterbukaan perdagangan dapat meningkatkan emisi CO2, dan dampaknya semakin meningkat sejak diberlakukannya Perjanjian Perdagangan Bebas ASEAN-China. Para pembuat kebijakan dapat mengurangi dampak negatif dari perdagangan terhadap emisi karbon dengan menerapkan mekanisme penetapan harga karbon yang komprehensif, mempromosikan perdagangan hijau, meningkatkan kerangka peraturan FDI, mendorong kerja sama regional, dan membangun sistem pemantauan yang kuat.

Kata kunci: keterbukaan perdagangan, FDI, emisi CO2, ACFTA

Abstract

The rise of the economy driven by free trade and foreign direct investment (FDI) has implications for environmental degradation, chiefly due to carbon dioxide (CO2) emissions that may induce the greenhouse effect and subsequently contribute to climate change. Climate change resulting from CO2 emissions is presently a worldwide problem and is one of the Sustainable Development Goals (SDGs). Nonetheless, the correlation between trade openness and FDI inflows regarding CO2 emissions remains inconclusive. This study aims to fill this research gap by revisiting the effect of trade openness and FDI on CO2 emissions using panel data from ASEAN countries from 1990 to 2023, using a fixed effects panel regression approach. The findings indicate that trade openness can raise CO2 emissions, and the impact has grown since the introduction of the ASEAN-China Free Trade Agreement. Policymakers can mitigate the negative effects of trade on carbon emissions by implementing comprehensive carbon pricing mechanisms, promoting green trade, improving FDI regulatory frameworks, fostering regional cooperation, and establishing robust monitoring systems.

Keywords: trade openness, foreign direct investment, CO2 emissions, ACFTA

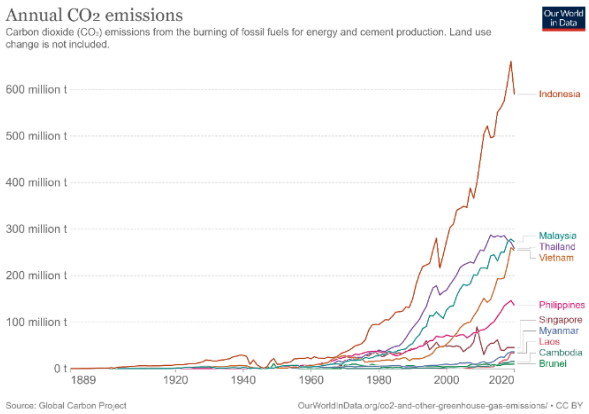
INTRODUCTION

Trade openness in the ASEAN region has markedly escalated annually. The growing number of bilateral regional agreements, including Free Trade Areas (FTAs), between ASEAN and other nations serves as proof of this trend. The ASEAN-China Free Trade Area (ACFTA) is the most utilized free trade agreement within ASEAN. Following its ratification in 2001 in Brunei, the implementation of ACFTA commenced in 2010 for six principal ASEAN nations: Indonesia, Malaysia, Thailand, Singapore, the Philippines, and Brunei. Additionally, in 2015, four new ASEAN member countries were admitted: Cambodia, Laos, Myanmar, and Vietnam.

Although ASEAN and China operate under a unified trade framework established by ACFTA, their economic frameworks exhibit significant disparities. The economic accomplishments of the ASEAN countries markedly contrast with those achieved by China, primarily through disparities in foreign direct investment (FDI) inflows, trading patterns, and industrial emphasis. FDI has been a crucial driver of economic development in ASEAN countries, with significant efforts made to attract foreign investment as a method of accelerating growth (Prasetyo & Susandika, 2022). In contrast, China's economic model has exploited its huge manufacturing capabilities and wide industrial base, resulting to stronger advances in high-value industries compared to the modest sectoral improvements witnessed in several ASEAN nations (Shuquan, 2019).

ACFTA attempts to reduce trade barriers, encompassing both tariffs and non-tariff obstacles. Furthermore, the implementation of ACFTA is anticipated to enhance economic collaboration, fostering economic growth and community welfare in ASEAN nations and China. In 2021, the Ministry of Commerce of China (Mofcom) reported that the trade volume between China and ASEAN attained a record high of US$ 878.2 billion, constituting 14.5% of China's total foreign trade. Nevertheless, the environmental consequences of these accords, especially regarding greenhouse gas emissions, have attracted greater attention from both scholars and government officials. China's position as a principal source of foreign direct investment in ASEAN is crucial for comprehending the impact of trade and investment on CO_2 emissions in diverse economies.

Trade openness, marked by the diminishment of tariffs and non-tariff barriers, frequently results in augmented economic activity and, subsequently, elevated energy consumption and CO2 emissions. Zhao et al. (2021) emphasize that although trade liberalization might improve economic efficiency, it may also lead to heightened imports from nations with lax environmental restrictions, thereby worsening greenhouse gas emissions. This phenomenon is especially relevant within the framework of the ACFTA, where trade liberalization might result in an increase in imports from China, a nation recognized for its substantial carbon emissions stemming from industrial operations. Figure 1 shows the comparison of CO2 emissions among ASEAN countries.



source: *Global Carbon Project Oxford University*

Figure 1. CO2 Emissions Among ASEAN Countries

Furthermore, the empirical study conducted by Qiu et al. (2022) indicates that FTAs such as the ACFTA may provide sustainable trade impacts; however, these results depend on several aspects, including the economic structures of the participating countries and the existing environmental laws. The research suggests that although trade creation may happen, it does not necessarily lead to decreased emissions. The reorganization of industries to facilitate more commerce may result in elevated emissions if the new manufacturing methods are not ecologically sustainable.

The association of trade openness, foreign direct investment (FDI), and CO2 emissions within the framework of the ASEAN-China Free Trade Agreement (ACFTA) is complicated and diverse. The impact of international trade on the greenhouse effect may be articulated in two dimensions. Trade between countries or regions will speed up the movement of capital and goods, thus elevating CO2 emissions (Ahmed et al., 2017; Shahzad et al., 2017). Conversely, trade openness may facilitate technological spillover among nations, hence promoting carbon reduction (Gozgor, 2017; Lv and Xu, 2019).

Numerous studies have been undertaken on the correlation between trade openness and CO2 emissions. Nevertheless, the findings from prior research about the link between trade openness and CO2 emissions have not achieved consensus and remain contentious. Chebbi et al. (2011), Fang et al. (2019), Mahmod et al. (2019), and Shahzad et al. (2017) identified a positive correlation between trade openness and carbon emissions, indicating that trade openness leads to an increase in CO2 emissions. Conversely, Gozgor (2017) and Zhang et al. (2017) found negative correlations between trade openness and carbon emissions, indicating that trade openness leads to a reduction in CO2 emissions. The assessment of the trade openness variable in prior research predominantly use conventional methods, namely the ratio of the sum of exports and imports to GDP.

Shahbaz et al. (2019) asserted that Foreign Direct Investment (FDI) and trade openness uniquely contribute to CO2 emissions. Following its accession to the World Trade Organization (WTO), China has emerged as a premier destination for foreign direct investment (FDI) globally. Empirical research undertaken thus far indicates that the interaction between FDI and the environment remains a subject for additional investigation (Xu et al., 2021). Consequently, this study will use FDI characteristics as additional interest variables, alongside trade openness, to assess their impact on CO2 emissions in ASEAN nations.

Recent economic and environmental research has focused heavily on the link between trade openness, foreign direct investment (FDI), and CO2 emissions. The literature provides a multifaceted understanding of the link between trade openness, FDI, and CO2 emissions. While greater trade and investment may raise emissions, they also have the ability to stimulate economic development and technological innovation, both of which can help to reduce environmental concerns. Therefore, recent research is urgently needed to revisit the inconclusive relationship between trade openness and FDI on CO2 emissions with empirical evidence from China and ASEAN countries that implemented ACFTA, particularly in light of global efforts to achieve sustainability and carbon neutrality.

This research contributes to the literature in two ways: first, the use of recent panel data that has a long time series (1990-2023) is able to describe the current conditions of each country. Second, the use of fixed effect panel regression method is able to eliminate bias from unobserved time-invariant heterogeneity so that the impact of trade openness and FDI on CO2 emissions can be calculated more clearly.

METHODOLOGY

Data

This study employs panel data comprising cross-sectional data from China and six ASEAN nations (Indonesia, Malaysia, Thailand, Singapore, the Philippines, and Brunei Darussalam) and time series data spanning the years 1995 to 2023. The reason why only 6 ASEAN principal countries are used is because these six countries implemented ACFTA first (2010). While the other four ASEAN countries only implemented ACFTA in 2015. The data source is derived from the World Development Indicators of the World Bank 2023. The variables used, operational definitions, and descriptive statistics in this study are shown in Table 1.

Table 1. Descriptive Statistics

Variable	*Operational Definition*	*Obs*	*Mean*	*Std. Dev.*
CO2	CO2 emissions per capita (t CO2e/capita)	238	6.782	6.092
TO	Trade Openness (% of GDP)	238	126.037	101.947
FDI	Foreign direct investment, net inflows (% of GDP)	238	106.471	67.350
GDP	GDP per capita, PPP (constant 2021 international $)	238	34536.610	37476.820

Urban	Urban population (% of total population)	238	59.587	21.438
Forest	Forest area (% of land area)	238	112.252	66.708
Energy	Energy use (kg of oil equivalent per capita)	238	65.706	58.292

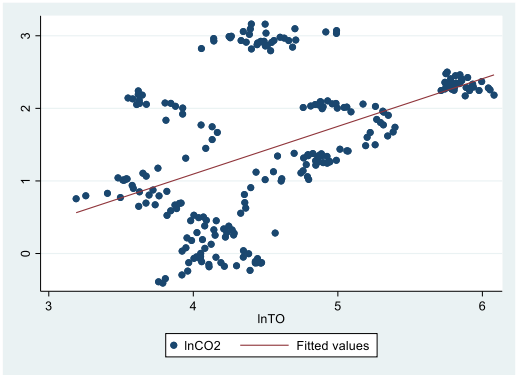


Figure 2. Trade Openness vs CO2 Emissions

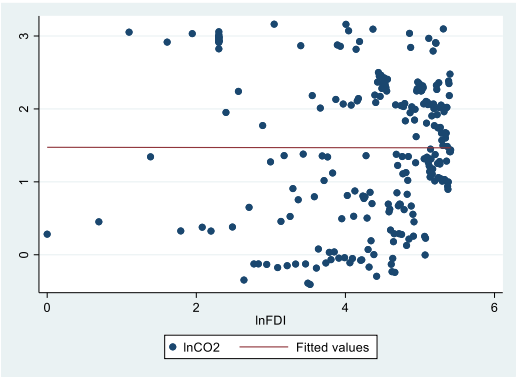


Figure 3. FDI vs CO2 Emissions

To illustrate the relationship between trade openness and FDI on CO2 emissions in China and 6 ASEAN countries, I have created scatter plots and fitted values using STATA 17 in Figures 2 and 3. To draw the line of fitted values, I used a linear regression approach (linear prediction) based on the OLS (Ordinary Least Squares) model. Figure 2 shows clearer fitted values than Figure 3. From this, it can be estimated that the effect of trade openness on CO2 emissions is more significant than that of foreign direct investment.

Empirical Strategy

This research examines the impact of trade openness and foreign direct investment on CO2 emissions in the context of the established free trade agreement between ASEAN and China. In this part, we intend to develop a CO2 function that encompasses the primary determinants of CO2 emissions. Researchers often employ the Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model, introduced by Dietz and Rosa (1997), in order to clarify the relationship between CO2 emissions and the factors behind them. The STIRPAT model posits that environmental degradation is influenced by three socioeconomic factors: population impact, affluence effect, and technology effect. Consequently, population size, economic expansion, and technological advancement are commonly seen as the primary factors of CO2 emissions (Shahbaz et al., 2015).

In this study, urbanization calculated by the ratio of urban population divided by total population is used as a proxy for the population effect (Dogan and Turkekul, 2016). Urbanization is viewed as a more accurate indicator of demographic pressures on a nation's economic activities and environment. Meanwhile, GDP variables using total GDP and energy intensity of each country are used as the affluence effect and technical effect on national CO2 emissions following Ali et al. (2021). This study also added a forest variable, which is the forest area divided by the land area in each country (%), which may affect CO2 emissions. Furthermore, to eliminate potential heteroscedasticity problems in the data series, all variables are expressed in logarithmic form.

To calculate the impact of trade openness and FDI on CO2 emissions, we used fixed effects panel regression. This method is widely employed in empirical research to estimate the effects of trade openness on CO2 emissions due to its ability to control for unobserved heterogeneity and endogeneity issues that may bias results. Fixed effects estimation effectively removes the unobserved endogeneity bias by focusing on within-entity variations over time. This is crucial in environmental studies, where factors such as technological advancements, regulatory changes, and economic conditions can influence both trade practices and emissions levels (Shakil, 2020). By controlling for these time-invariant characteristics, the fixed effects model provides a clearer picture of the causal relationship between trade openness

and CO2 emissions. The regression model used is shown in Equation 1.

$$Ln\ CO_{2_{it}} = \beta_0 + \beta_1 LnTO_{it} + \beta_2 LnFDI_{it} + \beta_3 LnGDP_{it} + \beta_4 LnUrb_{it} + \beta_5 LnEn_{it} + \alpha_i + \varepsilon_{it} \quad (1)$$

where *i* and *t* denote country and year cross sections, respectively; CO2 signifies national CO2 emissions; TO represents a country's trade openness; FDI is foreign direct investment net inflows; GDP stands for national economic output; *Urb* denotes the urbanization rate, which illustrates the population effect; *En* depicts a country's energy use level; α_i denotes the unobservable time-invariant characteristics; and ε_{it} denotes the error term.

RESULT AND DISCUSSION

Impact of Trade Openness and FDI on CO2 Emissions

The author first estimates the effect of trade openness and FDI on CO2 emissions in China and 6 ASEAN countries using the Ordinary Least Square (OLS) regression method and then uses fixed effect panel regression. This is done to show that the OLS method cannot overcome the bias caused by unobservable time-invariant country characteristics. The analysis was conducted using STATA 17.

Table 2. Estimation results of the effect of TO and FDI on CO2 emissions

	(1) **OLS**	(2) **FE**
lnTO	-0.345***	**0.084****
	(0.062)	(0.038)
lnFDI	0.134***	**0.008**
	(0.030)	(0.008)
lnGDP	0.999***	0.282***
	(0.053)	(0.035)
lnUrb	-0.132	0.924***
	(0.166)	(0.082)
lnFOR	-0.109***	0.002
	(0.026)	(0.009)
lnEN	0.045***	0.003
	(0.015)	(0.005)
_cons	-6.497***	-5.457***
	(0.383)	(0.283)
N	238	238
R^2		0.840

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

The estimation results using OLS show that a 1% increase in Trade Openness has a significant effect on a 34.5% decrease in CO2 emissions. Meanwhile, a 1% increase in FDI has a significant effect on a 13.4% increase in CO2 emissions. On the other hand, the estimation results using fixed effect panel regression show the opposite result, namely that a 1% increase in trade openness effect on an 8.4% increase in CO2 emissions. Meanwhile, a 1% increase in FDI has no effect on CO2 emissions.

This difference occurs because the use of the fixed effect method has eliminated the bias caused by unobservable time-invariant heterogeneity while the OLS method is not able to. The fixed effect method accounts for each entity's unique characteristics, which would otherwise confound the results. Countries may have different baseline levels of emissions due to differences in industrial structures, energy sources, and regulatory environments. By using fixed effects, we can focus on how changes in trade openness within each country correlate with changes in emissions, thereby enhancing the robustness of the findings. Therefore, this study refers to the results shown by the fixed effect model.

Furthermore, the coefficient on the control variable shows that an increase in GDP and urbanization affects the increase in CO2 emissions. Meanwhile, forest area and energy use have no effect on CO2 emissions.

Table 3. Heterogeneity Analysis

	(1) **Before ACFTA**	(2) **After ACFTA**
lnTO	**0.109****	**0.377*****
	(0.055)	(0.054)
lnFDI	-0.011	0.008
	(0.010)	(0.007)
lnGDP	0.187**	0.558***
	(0.073)	(0.072)
lnUrb	1.285***	-0.096
	(0.129)	(0.212)
lnFOR	-0.119***	0.002
	(0.037)	(0.005)
lnEN	-0.035***	-0.006*
	(0.012)	(0.003)

_cons	-5.297***	-5.362***
	(0.379)	(0.778)
N	140	98
R^2	0.806	0.689

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

The author conducted a heterogeneity analysis by dividing the observations into two periods, namely before the implementation of ACFTA (1990 - 2009) and after the implementation of ACFTA (2010 - 2023). Table 3 shows that the impact of trade openness and FDI on CO2 emissions in the period after ACFTA implementation is greater (37.7%) than before ACFTA implementation (10.7%). This shows that the FTA has an effect on increasing CO2 emissions due to increased trade intensity between countries.

Discussion

Trade openness is frequently connected with increased economic activity, which can result in higher CO2 emissions. Bayar and Dabakoğlu (2024) discovered that trade openness, together with economic growth and urbanization, leads to higher CO2 emissions in VISTA nations. Similarly, Widyawati et al. (2021) found a unidirectional correlation between trade openness and CO2 emissions, implying that as countries participate more in international trade, their emissions tend to rise. This association is reinforced further by Mahmood et al. (2019), who found that free trade in Tunisia has a negative environmental impact, consistent with the pollution haven hypothesis, which holds that countries with weak environmental rules attract more polluting firms.

Some research, however, imply that trade openness can help to accelerate the shift to reduced emissions. Wang et al. (2023) proved that trade openness may contribute to carbon neutrality by decoupling economic development from carbon emissions, especially after 2015. This decoupling implies that, while trade may initially raise emissions, it may also lead to technical improvements and cleaner manufacturing practices, reducing environmental consequences. Furthermore, Gözgör (2017) argued that trade openness, when combined with efficient environmental measures, might result in reduced per capita emissions in countries in the OECD.

Foreign direct investment (FDI) also plays an important part in this approach. Research suggests that FDI can have both beneficial and negative effects on CO2 emissions. For example, Alvi et al. (2019) discovered that, while FDI helps economic growth, it may also worsen environmental deterioration if not handled appropriately. In contrast, research such as those by Safdar et al. (2020) demonstrate that FDI can help to develop cleaner technology and practices, lowering emissions over time. This dichotomy highlights the necessity of regulatory systems that can maximize the advantages of FDI while minimizing its environmental costs.

The relationship between trade openness, FDI, and CO2 emissions is complicated by the countries economic contexts. According to Nurgazina et al. (2021), trade openness in emerging nations may result in increasing emissions caused by industrialization and energy use. However, in more developed environments, the connection may move toward decoupling emissions from economic development, as evidenced by research on BRICS countries (Xiang et al., 2021). This implies that the impact of trade and FDI on emissions is not consistent and varies greatly depending on a country's degree of development and regulatory environment.

CONCLUSION AND POLICY IMPLICATIONS

The implementation of trade agreements such as the ASEAN-China Free Trade Agreement (FTA) has substantial consequences for carbon emissions, especially given evidence showing trade openness is associated with higher CO2 emissions.

First, it is critical to note that trade openness might result in higher carbon emissions because of to increased industrial activity and transportation linked with increasing trade. Wang (2023) points out that the development of the China-ASEAN Free Trade Area has been connected to rising greenhouse gas emissions, particularly in poorer nations with lax environmental standards. This discovery needs the development of strong environmental measures to offset the emissions associated with

rising trade. For example, including carbon pricing mechanisms such as carbon taxes or cap-and-trade systems might help to internalize trade's environmental costs and push sectors to adopt cleaner technology (Hu et al., 2020). Such regulations would encourage businesses to minimize their carbon footprints while still promoting economic growth.

Moreover, promoting green trade practices is crucial. Meng et al. (2023) advocate for the development of policies that encourage green trade, which includes prioritizing products with lower carbon footprints and implementing stricter environmental standards for imported goods. This approach not only helps in reducing emissions but also fosters a competitive market for sustainable products. Additionally, the establishment of a blue carbon trading market, as discussed by Zhao et al. (2022), could provide a platform for countries to trade carbon credits, thereby incentivizing emission reductions while promoting economic activities.

Furthermore, enhancing the regulatory framework surrounding foreign direct investment (FDI) is vital. As noted by Alvi et al. (2019), while FDI can drive economic growth, it can also lead to increased environmental degradation if not properly managed. Policymakers should ensure that FDI is directed towards sustainable projects that incorporate environmental considerations. This can be achieved through the establishment of environmental impact assessments (EIAs) as a prerequisite for foreign investments, ensuring that projects align with national sustainability goals.

In addition, fostering collaboration among ASEAN member states to share best practices and technologies for reducing emissions is essential. Wang (2023) emphasize the importance of regional cooperation in addressing the environmental impacts of trade liberalization. Joint initiatives could include technology transfer programs that enable less developed countries to adopt cleaner production techniques and renewable energy sources, thereby reducing their carbon emissions while benefiting from trade.

Lastly, continuous monitoring and evaluation of the environmental impacts of trade policies are necessary. As highlighted by Shahbaz et al. (2017), understanding the feedback loops between trade openness and carbon emissions can help in refining policies to achieve better environmental outcomes. Policymakers should establish metrics to assess the effectiveness of implemented measures and adjust strategies accordingly to ensure that trade liberalization does not compromise environmental integrity.

In brief, while trade openness and agreements like the ASEAN-China FTA might boost economic growth, they also pose considerable difficulties to environmental sustainability. Policymakers can mitigate the negative effects of trade on carbon emissions by implementing comprehensive carbon pricing mechanisms, promoting green trade, improving FDI regulatory frameworks, fostering regional cooperation, and establishing robust monitoring systems.

In the framework of ASEAN and China, each nation has taken some specific initiatives to promote environmentally friendly trade and investment policies. China, for example, has created the world's largest Emissions Trading Scheme (ETS), implemented green trade norms, and banned foreign direct investment in high-emission industries. Indonesia has enacted a carbon pricing system (Presidential Regulation No. 98/2021), offers fiscal incentives to green-certified industries, and formerly maintained a negative investment list to discourage ecologically destructive FDI. Singapore's environmental governance is much progressed. In 2019, the government adopted Southeast Asia's first nationwide carbon tax, with costs expected to rise gradually until 2030. Singapore also promotes green FDI through its Green Investment Program, enforces sustainability reporting for large firms, and requires Green Mark certification for buildings as part of its Green Plan 2030.

Unfortunately, this study was unable to incorporate government policy-related variables due to the restricted availability of consistent panel data across nations and throughout time. Future research should integrate government environmental policy variables, such as carbon taxation or emission regulations. Including these variables can provide a better understanding of the correlation between economic activity and CO_2 emissions in ACFTA countries.

REFERENCES

Ahmed, K., Rehman, M. U., & Ozturk, I. (2017). What drives carbon dioxide emissions in the long-run? Evidence from selected South Asian Countries. Renewable and Sustainable Energy Reviews. Elsevier Ltd. https://doi.org/10.1016/j.rser.2016.12.018

Alvi, S., Chaudhry, I., Farooq, F., & Safdar, N. (2019). Trade liberalization, foreign direct investment inflows, environmental quality and economic growth nexus: a comparative analysis of pakistan and china. Review of Applied Management and Social Sciences, 2(1), 17-26. https://doi.org/10.47067/ramss.v2i1.11

Bayar, İ. and Dabakoğlu, M. (2024). How do economic growth, trade openness, and non-renewable and renewable energy affect environmental quality in vista countries?. Economic Journal of Emerging Markets, 63-76. https://doi.org/10.20885/ejem.vol16.iss1.art6

Dietz, T., Rosa, E.A., 1997. Effects of population and affluence on CO2 emissions. P. Natl. Acad. Sci. 94, 175–179. https://doi.org/10.1073/pnas.94.1.175.

Dogan, E., & Turkekul, B. (2016). CO2 emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. Environmental Science and Pollution Research, 23(2), 1203–1213. https://doi.org/10.1007/s11356-015-5323-8

Dou, Y., Zhao, J., Malik, M. N., & Dong, K. (2021). Assessing the impact of trade openness on CO2 emissions: Evidence from China-Japan-ROK FTA countries. Journal of Environmental Management, 296. https://doi.org/10.1016/j.jenvman.2021.113241

Eddine Chebbi, H., Olarreaga, M., & Zitouna, H. (2011). Trade Openness and Co 2 Emissions in Tunisia. Middle East Development Journal, 3(1), 29–53. https://doi.org/10.1142/s1793812011000314

Fang, J., Gozgor, G., Lu, Z., & Wu, W. (2019). Effects of the export product quality on carbon dioxide emissions: evidence from developing economies. Environmental Science and Pollution Research, 26(12), 12181–12193. https://doi.org/10.1007/s11356-019-04513-7

Gözgör, G. (2017). Does trade matter for carbon emissions in oecd countries? evidence from a new trade openness measure. Environmental Science and Pollution Research, 24(36), 27813-27821. https://doi.org/10.1007/s11356-017-0361-z

Hu, X., Pollitt, H., Pirie, J., Mercure, J., Liu, J., Meng, J., … & Tao, S. (2020). The impacts of the trade liberalization of environmental goods on power system and co2 emissions. Energy Policy, 140, 111173. https://doi.org/10.1016/j.enpol.2019.111173

Lv, Z., & Xu, T. (2019). Trade openness, urbanization and CO 2 emissions: Dynamic panel data analysis of middle-income countries. Journal of International Trade and Economic Development, 28(3), 317–330. https://doi.org/10.1080/09638199.2018.1534878

Mahmood, H., Maalel, N., & Zarrad, O. (2019). Trade openness and co2 emissions: evidence from tunisia. Sustainability, 11(12), 3295. https://doi.org/10.3390/su11123295

Meng, C., Li, D., Jin, J., & Cui, L. (2023). The carbon footprint of global trade: assessing the impact of trade liberalization on the carbon emissions of chinese listed companies. Natural Resources Forum, 48(4), 1371-1391. https://doi.org/10.1111/1477-8947.12371

Nurgazina, Z., Ullah, A., Ali, U., Koondhar, M., & Lu, Q. (2021). The impact of economic growth, energy consumption, trade openness, and financial development on carbon emissions: empirical evidence from malaysia. Environmental Science and Pollution Research, 28(42), 60195-60208. https://doi.org/10.1007/s11356-021-14930-2

Prasetyo, A. and Susandika, M. (2022). FDI led growth hypothesis and export led growth hypothesis in ASEAN. E-Journal Ekonomi Bisnis Dan Akuntansi, 9(2), 88. https://doi.org/10.19184/ejeba.v9i2.31602

Safdar, N., Ghaffar, H., Farooq, F., & Liaquat, M. (2020). Trade liberalization, economic growth and environmental quality nexus: an empirical evidence from pakistan. Review of Education Administration and Law, 3(3). https://doi.org/10.47067/real.v3i3.92

Shahbaz, M., Gozgor, G., Adom, P. K., & Hammoudeh, S. (2019). The technical decomposition of carbon emissions and the concerns about FDI and trade openness effects in the United States. International Economics, 159, 56–73. https://doi.org/10.1016/j.inteco.2019.05.001

Shahbaz, M., Solarin, S. A., & Ozturk, I. (2016). Environmental Kuznets Curve hypothesis and the role of globalization in selected African countries. Ecological Indicators, 67, 623–636. https://doi.org/10.1016/j.ecolind.2016.03.024

Shahbaz, M., Nasreen, S., Ahmed, K., & Hammoudeh, S. (2017). Trade openness–carbon emissions nexus: the importance of turning points of trade openness for country panels. Energy Economics, 61, 221-232. https://doi.org/10.1016/j.eneco.2016.11.008

Shahzad, S. J. H., Kumar, R. R., Zakaria, M., & Hurr, M. (2017, April 1). Carbon emission, energy consumption, trade openness and financial development in Pakistan: A revisit. Renewable and Sustainable Energy Reviews. Elsevier Ltd. https://doi.org/10.1016/j.rser.2016.11.042

Shakil, M. (2020). Environmental, social and governance performance and stock price volatility: a moderating role of firm size. Journal of Public Affairs, 22(3). https://doi.org/10.1002/pa.2574

Shuquan, H. (2019). Competition among china and asean-5 in the us market: a new extension to shift-share analysis. Socioeconomic Challenges, 3(4), 129-137. https://doi.org/10.21272/sec.3(4).129-137.2019

Wang, Q., Wang, L., & Li, R. (2023). Trade openness helps move towards carbon neutrality—insight from 114 countries. Sustainable Development. https://doi.org/10.1002/sd.2720

Wang, R. (2023). Trade liberalization and carbon neutralization: a quasi-natural experiment based on china-asean free trade area. Journal of World Economy, 2(2), 33-41. https://doi.org/10.56397/jwe.2023.06.03

Widyawati, R., Hariani, E., Ginting, A., & Mufida, Z. (2021). Effect of economic growth, urban population, trade openness on carbon dioxide emissions in asean-5. Proceeding of the International Seminar on Business Economics Social Science and Technology (Isbest), 1. https://doi.org/10.33830/isbest.v1i.612

Xiang, L., Chen, X., Shu-ling, S., & Yin, Z. (2021). Time-varying impact of economic growth on carbon emission in brics countries: new evidence from wavelet analysis. Frontiers in Environmental Science, 9. https://doi.org/10.3389/fenvs.2021.715149

Zhao, C., Sun, J., Gong, Y., Li, Z., & Zhou, P. (2022). Research on the blue carbon trading market system under blockchain technology. Energies, 15(9), 3134. https://doi.org/10.3390/en15093134