The Determinants of Carbon Emission in Asia and Europe: A Panel Data Analysis

Erika Hauser

Abstract:

This paper investigates the numerous variables that influence carbon emissions in selected Asian and European countries. The study examines the countries with the highest gross domestic product (GDP) in each region, considering the possible impact of economic growth on greenhouse gas emissions. The study also analyzes the role of other variables such as tourism, foreign direct investment (FDI), ecological footprint level (EFL), and agricultural output. The ecological footprint level is modeled by global hectare or the countries' gha, which is a measure of the impact of human activities on the environment. The study estimates tourism and FDI reduce emissions, while economic growth, agriculture, and ecologic footprint level increase carbon emissions.

JEL Classification: O13, Q53
Keywords: Natural Resources, Environmental Economics, Air Pollution

1.0 INTRODUCTION

The state of the planet has been in question for future years as greenhouse gases (GHG) are emitted into the atmosphere, the main contributor being carbon dioxide. This happens through the burning of fossil fuels, which occurs globally, as energy use for electricity, transportation, heating, and other purposes. These GHG emissions are causing the planet to warm, sea levels to rise, ice caps to melt, air pollution, and many other things. In some extreme cases, humans are being forced to migrate from their homes because they are no longer habitable.

Countries have set parameters and regulations to try and reverse or lessen the damage caused by reducing their carbon emissions; however, certain industries make it difficult to operate without the negative effects. China is a leading contributor to the release of carbon dioxide and has shown a dramatic increase throughout the decades because of its staggering economic growth. This study aims to enhance understanding of the leading economic and environmental contributors to higher emissions of carbon dioxide in Asia and Europe. The countries studied have the top ten GDP in Asia and the top nine in Europe while analyzing FDI, economic growth, ecological footprint level, agriculture, and tourism. From a policy perspective, this analysis is important because it will show whether there is a linkage between wealth and carbon emissions in a country. The relevance of this study is that it can provide insight into how the emission of greenhouse gases can be reduced based on what the leading factors are that cause it.

It is important to decrease carbon emissions because greenhouse gases (GHG) lead to global warming, which will have serious effects on the environment as it continues to worsen: some examples are the sea level will rise, polar ice will be lost, and the ocean will increase in temperature. These events will lead to the extinction of species, the displacement of people in areas that are no longer suitable for living, and a decrease in biodiversity, which means less food.

Short-term studies show that efforts to reduce carbon emissions will decrease economic growth, but as countries continue to create incentives to “go green”, new industries are blooming and thriving. One sector of economic growth is measured through transportation, which is one of the highest pollutants; the promotion of biofuels

and electric vehicles has been introduced to reduce the negative effects of GHG emissions through transport. (Rehermann and Pablo-Romero, 2018).

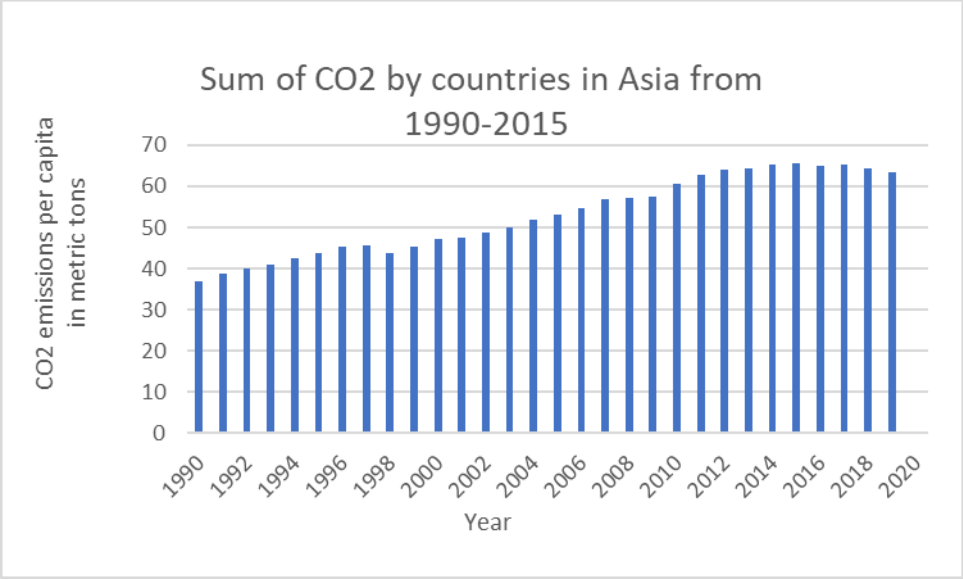
This paper was guided by three research objectives that differ from other studies: First, it investigates the ecological footprint level of each country in the study, which measures how fast humans utilize resources and generate waste compared to how fast nature can absorb the waste and generate resources. Second, it incorporates the tourism expenditures in each country which refers to the amount of money spent by tourists or visitors in a particular destination or country. Finally, this study will investigate the agricultural share of gross domestic product (GDP) as a proxy for economic growth; this will measure agriculture, fishing, and forestry.

The paper is structured as follows: Section 2 provides a concise literature review. Section 3 outlines the empirical model, while Section 4 discusses the data and estimation methodology. In Section 5, the empirical results are presented and analyzed. The paper concludes the findings in Section 6.

2.0 TEND OF CO2 EMISSIONS

Figure 1 shows that carbon dioxide emissions in Asia, measured in metric tons per capita, have been on increasing for the past three decades. The diagram depicts a rise in CO2, which is most likely due to a spike in economic growth in the region. Saudi Arabia had the highest per capita CO2 emissions in 2020, but it has since decreased. Now, Qatar, which shares a land border with Saudi Arabia, is the top country in the world with the highest emissions per capita at 37.29 tons per capita.

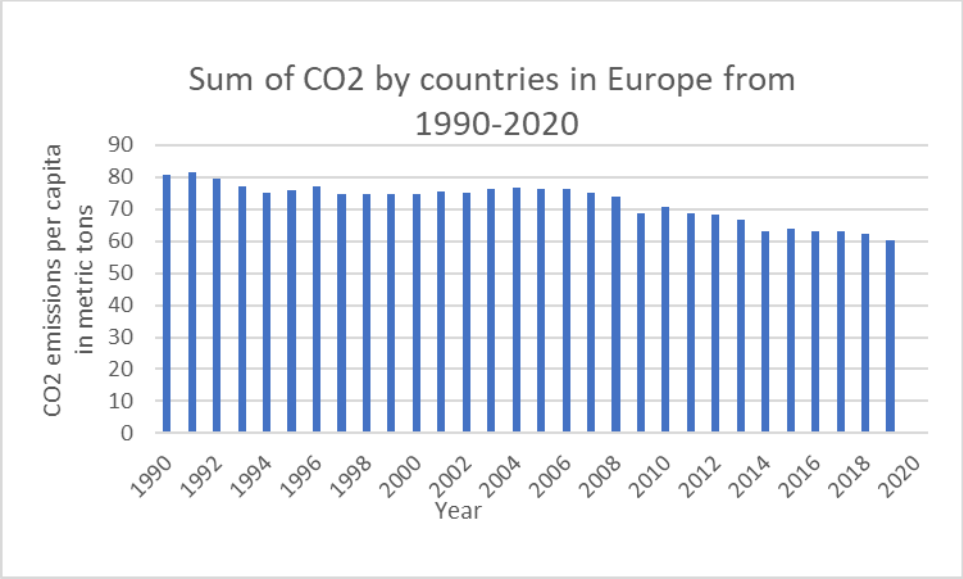
Figure 1: Carbon Emissions in Asia 1990-2020



Source: World Bank Indicators Database

Figure 2 shows the course of carbon dioxide emissions in Europe over the past thirty years, which differs from Figure 1. The graph displays there is a decrease in emissions, while in Asia it was mostly increasing. There is a much lower correlation between economic growth and CO2 emissions but showed a greater relationship between agriculture.

Figure 2: Carbon Emissions in Europe 1990-2020



Source: World Bank Indicators Database

Figure 3 shows the combined sum of CO2 emissions per capita in metric tons for Europe and Central Asia. In total, the overall production level decreases significantly for these regions; however, when looking at the wealthiest countries in Asia and some in Europe, the emissions increase throughout the years. This study asserts the reason for this is that the richer countries saw a spike in economic growth during this time, which led to higher emissions in those countries.

Figure 3:

Source: World Bank Indicators Database

3.0 LITERATURE REVIEW

The environmental Kuznets curve (EKC) hypothesis was introduced by Grossman and Krueger (1995), which denotes to an inverted U-shaped relationship concerning environmental degradation and per capita income. Essentially, the hypothesis states that environmental quality decreases initially to then increases as per capita income rises. The study done by Fang et al. (2018) examines the EKC using trade openness to determine at which point it changes in China. The paper focuses on trade and the environment and

measures the relationship between trade and its effect on pollution and economic growth. It has been concluded that developing countries are larger contributors to environmental pollution through economic growth, especially those that have seen rapid growth from 1990 and onwards, and the total figures of greenhouse gas emissions have more than doubled (Jahanger et al., 2022). The study conducted by Zhang and Zhang (2018) indicates that the EKC hypothesis holds true for China, and while both services trade and exchange rates had a negative effect on China's carbon emissions,

The tourism industry is a significant contributor to the global economy, accounting for a considerable portion of the world's gross domestic product (GDP) and employing a substantial percentage of the global workforce. Additionally, it plays a significant role in overall exports and foreign direct investment (FDI), making it a crucial aspect of the world's tourism investment. However, the expansion of this industry has led to a rise in fossil fuel consumption and significant greenhouse gas (GHG) emissions (Jebli et al., 2019). While Zhang and Zhang (2018) saw a negative effect on carbon emissions from services trade and exchange rates, FDI inflows had a positive impact.

The study by Dogan et al. (2022) confirms the Environmental Kuznets Curve Hypothesis for G7 countries and looks at the impact of environmental taxes on energy consumption and CO2 emissions. It's the first study to investigate the effect of an environmental tax on both renewable and non-renewable energy consumption, natural resource rent, and CO2 emissions. The results show that environmental taxes are effective in reducing emissions and that higher taxes lead to more significant effects on traditional energy consumption, natural resources rent, and renewable energy consumption.

The transportation industry uses a lot of fossil fuels and contributes significantly to greenhouse gas emissions. To reduce its impact on the environment and achieve carbon neutrality, developing smart transportation has become a popular solution. Zhao et al. (2021) uses spatial econometric models to investigate the impact of smart transportation on CO2 emissions in China. The study found that smart transportation is becoming more prevalent in China, but there are differences between regions. The study also found that

smart transportation can have an impact on CO2 emissions, not only in the transportation industry but also in other areas. There is a spillover effect, meaning that neighboring provinces' development of smart transportation can also affect carbon mitigation in a given province. Gillingham et al. (2021) look at the effects of carbon pricing and its impact on electric cars and concluded that if carbon prices remain moderate like they are now, electric cars will probably still be charged using coal-based electricity. This was confirmed using a detailed model that looks at both transportation and electricity. However, if carbon prices increase significantly, then the situation will change and electric cars will more likely be charged using cleaner energy sources.

4.0 DATA AND EMPIRICAL METHODOLOGY

4.1 Data

The study uses annual data **(panel data)** from 1990 to 2020. Data were obtained from the Bureau of Economic Analysis (BEA) website, World Development Indicators, and World Population Review. Summary statistics for the data are provided in Table 1. Originally, the variables from the papers were going to include transportation, renewable energy, and trade; however, after further review, the model was simplified to only five dependent variables.

Table 1 Summary Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
CO2	300	5.293967	4.228137	.51	17.3
FDI	310	1.96e+10	4.69e+10	-4.95e+09	2.91e+11
Growth	308	9327.516	11884.67	302	49145
EFL	290	2.770586	1.626906	.72	6.32
Agriculture	306	11.09006	7.347499	.9966057	27.66271
Tourism	240	2.05e+07	3.42e+07	369000	1.63e+08

4.2 Empirical Model

Following Jebli et al. (2019) and Jahanger et al. (2022) the study adapted and modified the relationship between carbon dioxide emissions, tourism, and economic growth:

$$y_{it} = a + bx_{it} + \mathcal{E}_{it}$$

I have added FDI, economic footprint level, and agriculture.

The model could be written as follow:

(1)

$$CO2_{it} = a + b(FDI)_{it} + c(Growth)_{it} + d(EFL)_{it} + e(Ag)_{it} + f(T)_{it} + \mathcal{E}_{it}$$

$CO2_{it}$ is the measure of carbon dioxide emissions per capita in country *i* at year *t*. Measured in metric tons, $CO2_{it}$ represents how much carbon is being emitted each year throughout the regions. Carbon dioxide is a greenhouse gas that comes from the removal of and burning of fossil fuels, and has been increasingly warming the atmosphere of the earth. The definition of CO2 in this paper is consistent with the definition used in various studies, (Dogan et al. 2022; Jahanger et al. 2022; Jebli et al. 2019).

There are five independent variables obtained from various sources. Appendices A and B provide data sources, acronyms, explanations, expected signs, and justification for using the variables. First, FDI_{it} (annual flow of FDI from the US to country i at year t) represents funds that US parent companies provide to their foreign affiliates. $Growth_{it}$ represents the per capita GDP of each country in USD which data is obtained from the WDI. $(Ag)_{it}$ is a proxy for economic growth, which measures a share of GDP per country. $(EFL)_{it}$ measures the economic footprint level of each country in global hectares, which is how fast we consume resources and generate waste compared to

how fast nature can absorb our waste and generate resources. Lastly, $(T)_{it}$ measures tourism arrivals and how many tourists visit the country each year.

5.0 EMPIRICAL RESULTS

The study's empirical findings are presented in Tables 2 and 3, demonstrating a statistically significant positive correlation between ecological footprint level and economic growth in regard to carbon dioxide emissions. Both a fixed-effect and random-effect regression are run. Table 2 displays regression results for the Asian countries, while Table 3 showcases the results for the European countries.

Table 2: Regression results for the 10 Asian countries

	CO2		
	OLS	FE	RE
Constant	-3.300546 (.7721003)	.4732555 (1.050576)	.54363 (.8873555)
FDI	-2.20e-12 (9.21e-12)	1.83e-12 (7.69e-12)	1.89e-12 (7.77e-12)
Growth	-.0000575** (.0000239)	.0000803*** (.0000109)	.0000793*** (.0000111)
EFL	2.942868*** (.1630489)	1.73921*** (.2496486)	1.762006*** (.2615809)
Ag	.0691275* (.0343078)	-.0611998* (.0427496)	-.061319* (.0419836)
T	8.67e-12 (2.18e-11)	-2.75e-11 (1.38e-11)	-2.83e-11 (1.38e-11)
R^2	0.9038	0.8617	0.8629
Number of obs.	189	189	189

Note: *** , **, and * denotes significance at the 1%, 5%, and 10% respectively. Standard errors in parentheses

Table 3: Regression results for the 9 European countries

	CO2

	OLS	FE	RE
Constant	-1.312503 (1.774682)	5.282834 (1.942821)	5.219532 (2.027002)
FDI	4.57e-12** (1.93e-12)	-1.33e-13 (3.54e-13)	-1.05e-13 (3.53e-13)
Growth	-.0000214** (.0000108)	-.0000187** (8.62e-06)	-.0000196** (8.45e-06)
EFL	1.28308*** (.2366782)	.6296567 (.3667816)	.6326294* (.3677761)
Ag	.7435829 (.1947978)	.1025887 (.175187)	.104029 (.1641628)
T	4.11e-11 (6.01e-12)	-9.22e-12 (7.12e-12)	-8.10e-12 (6.86e-12)
R^2	0.4936	0.1458	0.1623
Number of obs.	154	154	154

In Table 2, the *Growth* and *EFL* variables are significant at the 1% level. The parameter estimate of Growth is consistent with the results of Jahanger et al. (2022) and Jebli et al. (2019), which implied that economic growth was positively associated with CO2 emissions in the Asian region, more specifically China. *EFL* is significant because it represents the use of natural resources, such as the burning of fossil fuels which emits carbon dioxide. The results conclude that the correlation is more statistically significant over the years which is shown within the random-effects regression. The effect of *T* is also significant at the 5% level; however, the analysis reveals that *FDI* and *Ag* on carbon emissions proved to be statistically insignificant. Overall, the regression suggests that economic growth and ecological footprint levels have a positive and significant relationship with CO2 emissions. However, the relationship between CO2 emissions and agriculture and tourism is not statistically significant. The R-squared values indicate that there may be substantial differences in CO2 emissions between countries that are not accounted for in this model.

Table 3 similarly shows more statistical significance through the years within the random-effects regression; however, it is substantially less correlated than Table 2. With R-squared values of only 0.1458 and 0.1623, the overall results are insignificant. Only the variables of *Growth* and CO2 are statistically significant at the 10% and 5% levels. The coefficients *FDI, Ag,* and *T* are not statistically significant, and *EFL* is significant at the 10% level when looking through the time period of 1990-2020. The overall R-squared value is low, indicating that the independent variables in the model explain only a small portion of the variance in CO2 emissions, or that there is a lack of evidence to prove they have a greater effect.

6.0 CONCLUSION

In summary, both regions show a statistical significance of economic growth and EFL on carbon dioxide emissions. The study estimated a negative effect on emissions from tourism and FDI, but both variables proved to be mostly insignificant. Although the Asian countries displayed tourism as 10% significant with a negative effect, the European countries showed no correlation and neither showed relevance for FDI.

For the 10 Asian countries, the regression results indicate that *FDI, Growth*, and *EFL* have positive and significant impacts on CO2 emissions, while *Ag* has a negative but insignificant effect. The coefficient of *T* is negative and significant at the 10% level, implying that trade openness leads to lower CO2 emissions. The R-squared value of the regression is 0.8629, indicating that the independent variables explain 86.29% of the variance in CO2 emissions.

For the 9 European countries, the regression results show that only *EFL* and *Ag* have significant impacts on CO2 emissions. *EFL* has a positive and significant effect, whereas *Ag* has a positive but insignificant impact. Both *FDI* and *T* are found to have negative but insignificant relationships with CO2 emissions. The R-squared value of the regression is 0.1623, indicating that the independent variables explain only 16.23% of the variance in CO2 emissions. This paper suggests that rapid economic growth is the leading factor to higher carbon emissions. To create a healthier environment and planet, governments should implement incentives, policies, and regulations for greener work.

This could include a permit to produce a certain amount of GHG, which would reduce the burning of fossil fuels and lead to a decrease in global warming.

Appendix A: Variable Description and Data Source

Acronym	Description	Data source
CO2	Carbon Dioxide emissions per capita in metric tons	World Bank
FDI	Foreign Direct Investment flows by country in millions of dollars	World Bank
Growth	Gross domestic product per capita in USD	US Bureau of Economic Analysis
EFL	Economic Footprint Level	World Population Review
AG	Agriculture's share of GDP	World Bank
T	Tourism expenditures in USD	World Bank

Appendix B- Variables and Expected Signs

Acronym	**Variable Description**	**What it captures**	**Expected sign**
FDI	Foreign direct investment current USD	Inflows of each country	-
Growth	How much the average person makes yearly in each country measured in USD	Measures economic growth	+
EFL	Ecological footprint level of each country in gha	How quickly humans use natural resources and generate waste versus how quickly	+

		the planet can consume our waste and create new resources	
Ag	Agriculture as an economic growth proxy as % of GDP	Agriculture, forestry, and fishing, value added	+
T	% of tourism expenditures in USD	Spending of outbound visitors in each country	-

BIBLIOGRAPHY

Doğan , B., Chu, L.K., Ghosh, S., Diep Truong, H.H., & Balsalobre-Lorente, D. (2022). "How Environmental Taxes and Carbon Emissions Are Related in the G7 Economies?" *Renewable Energy*, Pergamon, https://www.sciencedirect.com/science/article/pii/S0960148122000878.

Fang , Z., Huang, B., & Yang , Z. (2018). *Trade openness and the environmental kuznets curve: Evidence from cities in the People's Republic of China*. Asian Development Bank. Retrieved April 10, 2023, from https://www.adb.org/publications/trade-openness-environmental-kuznets-curve-evidence-cities-prc

Gillingham, K., Ovaere , M., & Weber , S. M. (n.d.). *National Bureau of Economic Research | NBER*. CARBON POLICY AND THE EMISSIONS IMPLICATIONS OF ELECTRIC VEHICLES. Retrieved April 10, 2023, from https://www.nber.org/system/files/working_papers/w28620/w28620.pdf

Grossman, G. M., & Krueger, A. 1991. Environmental Impacts of a North American Free Trade Agreement (NBER Working Papers No. w3914). National Bureau of Economic Research, Inc.

Jahanger, A., Usman, M., Murshed, M., Mahmood, H., & Balsalobre-Lorente, D. (2022). "The Linkages between Natural Resources, Human Capital, Globalization, Economic Growth, Financial Development, and Ecological Footprint: The Moderating Role of Technological Innovations." *Resources Policy*, Pergamon, https://www.sciencedirect.com/science/article/pii/S0301420722000204.

Mehdi, B. J., Slim, B. Y., & Apergis, N. (2019). The dynamic linkage between renewable energy, tourism, CO0RW1S34RfeSDcfkexd09rT421RW1S34RfeSDcfkexd09rT4 emissions, economic growth, foreign direct investment, and trade. Latin American Economic Review, 28(1), 1-19. doi:https://doi.org/10.1186/s40503-019-0063-7

Rehermann, F.,& Pablo-Romero, M. (2018) "Economic growth and transport energy consumption in the Latin American and Caribbean countries," Energy Policy, vol. 122. https://www.sciencedirect.com/science/article/pii/S0301421518305123.

Zhang, Y., & Zhang, S. (2018). "The Impacts of GDP, Trade Structure, Exchange Rate and FDI Inflows on China's Carbon Emissions." *Energy Policy*, Elsevier, https://www.sciencedirect.com/science/article/pii/S0301421518303598.

Zhao, C., Wang, K., Dong, X., & Dong, K. (2022) "Is smart transportation associated with reduced carbon emissions? The case of China," Energy Economics, Elsevier, vol. 105(C).