Do Overseas Development Assistance and Foreign Direct Investment Impact The Carbon Dioxide Emissions Of Developing Countries?

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Abstract

This paper analyzes the effects of overseas development assistance (ODA) and foreign direct investment (FDI) on carbon dioxide (CO_2) emissions between 2007 and 2018 on 118 aid-receiving countries. It builds upon the work of Lim (2014), who analyzed the impact of ODA and FDI on sulfur dioxide (SO_2) between 1980 and 2005, instead running ordinary least squares (OLS) estimations focusing on CO_2 emissions' relationships with ODA and FDI. The models in this paper control for GDP, the presence of carbon taxes and emissions trading systems, and add country and time-fixed effects. The results of the equations find a small and statistically insignificant, but negative association between CO_2 emissions and ODA, which is similar to Lim's findings of a negative and statistically significant relationship between the variables for small-aid-recipient countries. Meanwhile, a statistically significant and positive association does exist between CO_2 emissions and FDI. JEL Codes: F20, F21, F30, F31, O10, O19, Q50, Q53, Q56

1 Introduction

The relationships that overseas development assistance (ODA) and foreign direct investment (FDI) have with carbon dioxide (CO_2) emissions is key for policymakers to understand. Since the late 20^{th} century, world leaders have expressed concern about the future of the earth's environment and climate. While many politicians recognize the environmental problem and the role of CO_2 in creating this problem, many are reluctant to act. At its core, clean environments are often viewed as a normal good (Mak Arvin, 2009), meaning that countries will only prioritize environmentally focused policies when they are financially secure.

With today's international dialogue on the causes and effects of climate change, countries with increased wealth will typically choose environmentally friendly policies. Because lower-income countries cannot yet afford environmentally focused policies, developed countries have an incentive to increase the wealth of lower-income countries for their own future well-being.

A common and direct way for wealthy countries and their institutions to assist developing countries is through overseas development assistance. ODA's ability to cause true economic growth has been disputed by some economists, though its effectiveness

depends on the climatic and governance situations within the recipient country (Dalgaard, 2004).

Developing countries similarly receive foreign direct investment (FDI), which differs from ODA in that it is typically given as a private investment. To receive FDI, countries usually have locational advantages and cheap labor for businesses to utilize (Wang, 2011). Because of questions regarding the overall effectiveness of ODA, Moyo (2010) argues that donor countries should reduce ODA while developing countries should work towards receiving more in FDI. Wang disputes this claim, instead arguing that the two should be paired and well-balanced. This paper utilizes updated data from 118 countries between 2007 and 2018 and an ordinary least squares (OLS) model based off Lim's 2014 study on sulfur dioxide (SO_2), ODA, and FDI to verify these relationships. Four main regressions analyze the relationships between CO_2 emissions, ODA, and FDI with combinations of GDP and the presence of carbon taxes and emissions trading systems as control variables in addition to country and time fixed effects. This paper's findings suggest that policymakers interested in promoting decarbonization in the Global South could use ODA as a tool to accomplish this goal but should focus more on cautiously utilizing FDI.

2 Literature Review

This paper analyzes the effects that ODA and FDI have on CO_2 emissions in ODA and FDI receiving countries. Both variables are necessary to include due to the different procedures countries go through to receive both.

As outlined by Wang, FDI requires recipient countries to be competitive. One way developing countries will attempt to compete for investment is through relaxed environmental regulations, commonly known as the "pollution haven" hypothesis. Levinson and Taylor (2008) find that American environmental regulations between 1977 and 1986 caused a 10% increase in net imports. The pollution haven hypothesis challenges the normal good assumption of a clean environment, as developing countries with booming export economies may not have the incentive to strip themselves of their comparative advantage. Previous analyses show a positive relationship between FDI and pollution (Yousef, 2016).

If the pollution haven hypothesis holds true as the primary reason for a positive relationship between CO_2 emissions and FDI, then it is important to distinguish between the investment itself and the agency of the country's government to act, specifically on environmental matters. When countries with high levels of foreign direct investment additionally have strong governance metrics, CO_2 emissions continue to decrease (Farooq, 2021). Therefore, countries with both high amounts of CO_2 emissions and high amounts of FDI are likely to suffer from bad governance or a lack of environmental laws. One solution to this problem could be for developing countries to implement a market for pollution (Lim, 2014).

While countries must "compete" for FDI, they must fulfill other sets of objectives to receive and continue receiving ODA. Mak Arvin and Lew (2009) discuss the importance of donor countries' motives in giving aid. They find that donors between 1990 and 2002 rewarded recipient countries for certain environmental outcomes, such as forestation, while not emphasizing carbon dioxide emissions. Yet, their results show

that higher sums of bilateral aid decrease carbon emissions to a greater magnitude than deforestation.

3 Data Description

This paper uses publicly available data from the World Bank's World Development Indicators and Carbon Pricing Dashboard. CO_2 emissions (measured in kilotons), FDI (measured in net inflows, current U.S. dollars (USD)), and ODA (measured in current USD) are found in the DataBank World Development Indicators database. Data from the 118 countries that report yearly ODA and FDI numbers between 2006 and 2017 (timeframe explained below) is included as well as yearly CO_2 emissions data between 2007 and 2018. Data on carbon taxes came from the World Bank's Carbon Pricing Dashboard. Model 1 below is used by Lim (2014) and is the basis for this paper's model:

$$SO_2Intensity_{i,t} = \phi_1 SO_2Intensity_{i,t-1} + \gamma_1 Aid_{i,t-1} + \gamma_2 GlobalizationFlow_{i,t-1} + \gamma_3 Aid * GlobalizationFlow_{i,t-1} + X_{1,t}\beta_1 + \alpha_i + \tau_t + \epsilon_{it}.$$

Lim's model follows theories developed by economists that ODA tends to decrease a country's carbon emissions, while FDI causes an increase. ODA is often tied to environmental programs and conditions applied by the donor country, while FDI is invested by private companies looking to maximize profits and sometimes evade environmental regulations. Therefore, greater sums of ODA will tend to decrease emissions while greater FDI sums increase emissions.

This paper makes several changes to Lim's model. First, since Lim used data on independent variables between 1980 and 2005, this paper uses updated data on the independent variables from 2006 to 2017. Secondly, CO_2 emissions replaces SO_2 emissions because recent international climate agreements such as the Kyoto Protocol and the Paris Climate Accords focus on reducing CO_2 emissions.

Lim's discussion on the importance of environmental laws leads to the addition of binary variables for two popular environmental policies. Lim specifically suggests a cap-and-trade or emissions trading system (ETS). However, as only one country (Kazakhstan) in this paper's dataset employed an ETS during the timeframe analyzed, a variable for a carbon tax, a policy that is still rare but more prevalent among ODA-receiving countries, is also added. Data on environmental laws follows the 1-year lagged timeframe for CO_2 emissions (2007-2018). For example, Mexico first enacted its carbon tax legislation in 2014. In order to capture the full affects of the legislation on CO_2 emissions from the moment it was enacted, the dataset constructed for this paper records a "1" from the year 2014 onward for CO_2 emissions, which corresponds to ODA, FDI, and GDP data from 2013.

Finally, two equations divide CO_2 emissions, ODA, and FDI by GDP while removing GDP as a control variable. These equations allow for an analysis of a hypothetical relationship between ODA and FDI as a fraction of a country's GDP.

Table 1 below describes each variable, while Table 2 provides descriptive statistics. Figure 1 displays a scatterplot with CO_2 emissions on the vertical axis and ODA on the horizontal axis, while Figure 2 displays a scatterplot for the relationship between

CO_2 emissions and FDI. Figure 3 shows the relationship between CO_2 emissions per USD of GDP and ODA per USD or GDP, with Figure 4 providing a zoomed in scale of the x-axis. Figure 5 shows the relationship between CO_2 per USD of GDP and FDI per USD of GDP.

Table 1: Variable Descriptions

Variable	Description	Source
Carbon dioxide Emissions	Kilotons emitted per year	World Bank: World Development Indicators
Overseas Development Assistance (ODA)	Net amount of aid received per year. Measured in current US dollars.	World Bank: World Development Indicators
Foreign Direct Investment (FDI)	Net inflows per year. Measured in current US dollars.	World Bank: World Development Indicators
Carbon Tax	Indicates whether or not country had a carbon tax law in a given year.	World Bank Carbon Pricing Dashboard
Emissions Trading System	Indicates whether or not country had an emissions trading system implemented in a given year.	World Bank Carbon Pricing Dashboard

Table 2: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Emissions (kt)	1,416	142741.2	858026	10	1.03e+07
Emissions per capita (kt)	1,416	.0021793	.0026445	.0000246	.0162839
ODA (current USD)	1,416	6.59e+08	9.58e+08	-9.90e+08	1.14e+10
FDI (current USD)	1,416	4.55e+09	2.11e+10	-1.02e+10	2.91e+11
GDP (current USD)	1,416	1.70e+11	8.11e+11	2.29e+07	1.23e+13

Figure 1

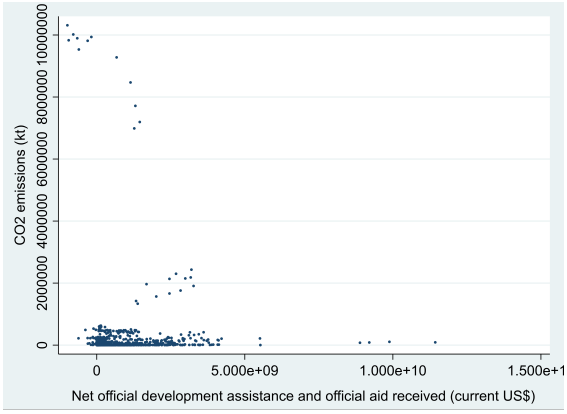


Figure 2

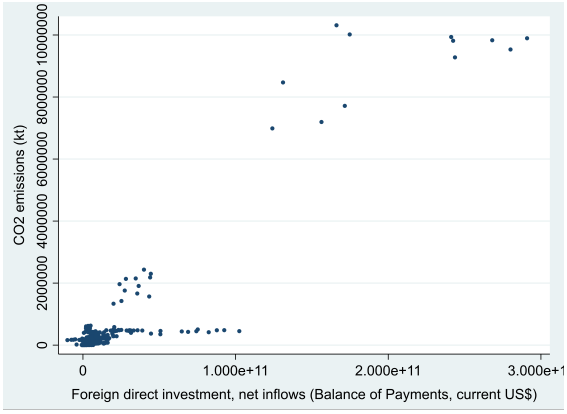


Figure 3

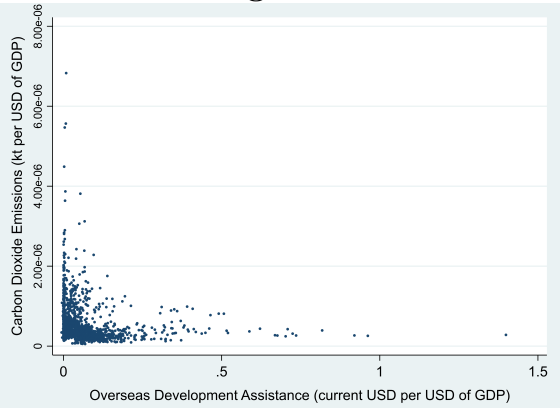


Figure 4

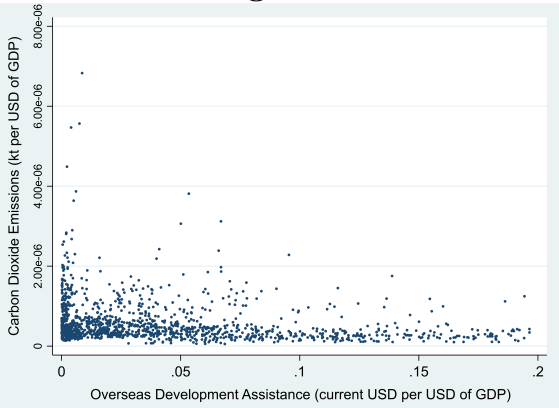
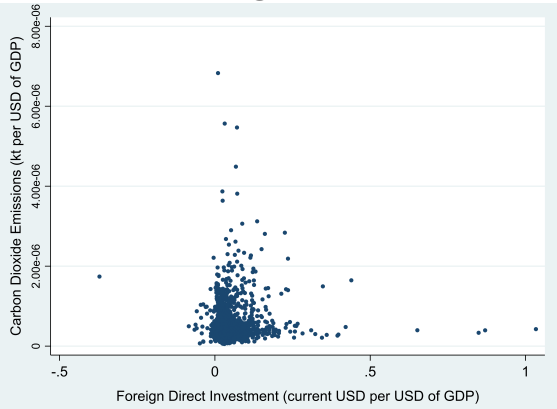


Figure 5



In order to test the theory that ODA causes CO_2 emissions to decrease while FDI causes CO_2 emissions to increase, 4 ordinary least squares (OLS) regressions are run with slight variations. Lim's 1-year lag on CO_2 emissions data is maintained, meaning the CO_2 data was collected between 2007 and 2018. This lag allows the model to better estimate the true effects of ODA and FDI since their potential effects on CO_2 emissions do not happen overnight. Equations (2) and (4) contain country and year fixed effects in order to control for potential country and year-specific qualities that could change the relationship between ODA, FDI, and CO_2. In (1) and (2), GDP is added as a control variable to prevent differing results between small and large countries. Meanwhile,

in (3) and (4) GDP is removed as a control variable, and the rest of the equations' numerical variables are divided by GDP in order to measure intensity, or units per dollar of GDP. In (3) and (4), an interaction term for ODA/GDP and FDI/GDP is added in order to avoid the potential collinearity caused by a statistically significant relationship between the two variables (Table 3).

Table 3: Interaction Term

FDI/GDP	Coefficient	Robust SE	t	p > |t|	[95% Conf.	Interval]
ODA/GDP	.0805633	.0471554	1.71	0.088	-.0119387	.1730653
_cons	.0443104	.0025178	17.60	0.000	.0393714	.0492493

Below are the regression equations used in this paper:

$$(CO_2)_{i,t} = \beta_1 ODA_{i,t-1} + \beta_2 FDI_{i,t-1} + \beta_3 GDP_{i,t-1} + \beta_4 Tax_{i,t} + \beta_5 ETS_{i,t} + \alpha_{i,t} \quad (1)$$

$$(CO_2)_{i,t} = \beta_1 ODA_{i,t-1} + \beta_2 FDI_{i,t-1} + \beta_3 GDP_{i,t-1} + \beta_4 Tax_{i,t} + \beta_5 ETS_{i,t} + \alpha_{i,t} + \epsilon_i + \tau_t \quad (2)$$

$$\begin{aligned}(CO_2)_{i,t}/GDP_{i,t-1} = (\beta_1 ODA_{i,t-1})/GDP_{i,t-1} + (\beta_2 FDI_{i,t-1})/GDP_{i,t-1} \\ + \beta_4 Tax_{i,t} + \beta_5 ETS_{i,t} + \beta_6 (ODA/GDP) * (FDI/GDP) + \alpha_{i,t}\end{aligned} \quad (3)$$

$$\begin{aligned}(CO_2)_{i,t}/GDP_{i,t-1} = (\beta_1 ODA_{i,t-1})/GDP_{i,t-1} + (\beta_2 FDI_{i,t-1})/GDP_{i,t-1} \\ + \beta_4 Tax_{i,t} + \beta_5 ETS_{i,t} + \alpha_{i,t} + \epsilon_i + \tau_t\end{aligned} \quad (4)$$

Where α represents the error term, ϵ represents country fixed effects, and τ represents time fixed effects. Table 4 below displays the results of these regressions. The coefficients reported here are standardized, meaning a one-unit change in standard deviation of the independent or control variable causes a change in standard deviation equal to the coefficient's magnitude for CO_2 emissions. Numbers in parentheses below each coefficient represents that coefficient's robust standard error.

In each equation, the coefficient for ODA is negative, while the coefficient for FDI is positive, in accordance with previous literature and theory. While FDI's positive coefficient maintains at least some level of statistical significance in each equation, ODA's coefficient only has statistical significance in Equation (3). Moreover, the size of ODA's coefficients are minuscule, with a one-unit change in ODA only changing the standard deviation of CO_2 emissions in the thousandths. In Equations (1), (2), and (3), the standard error is greater than the coefficient, suggesting the unreliability of a consistently negative coefficient.

Table 4: Regression Results

Variable	(1) CO^2 Emissions (kt)	(2) CO^2 Emissions (kt)	Variable	(3) CO^2 Emissions (kt/GDP)	(4) CO^2 Emissions (kt/GDP)
ODA (USD)	-0.00081138 (0.00586373)	-0.00078225 (0.00299160)	ODA/GDP (USD)	-0.15372242*** (0.02256842)	-0.00293739 (0.01188576)
FDI (USD)	0.41700090*** (0.12076048)	0.07985355** (0.03355167)	FDI/GDP (USD)	0.07462314** (0.03724286)	0.03729267* (0.02062566)
GDP (USD)	0.55198446*** (0.09369789)	0.28800860*** (0.02699875)			
Carbon Tax	-0.31215015** (0.12837643)	-0.06242748*** (0.01591567)	Carbon Tax	0.82350164** (0.34348577)	-0.15052729 (0.17847225)
ETS	-0.03182098 (0.04543385)	-0.01415637 (0.01359590)	ETS	1.10428532*** (0.18890021)	-0.89996742*** (0.29678803)
			ODA/GDPx FDI/GDP	-0.00978873 (0.00994719)	-0.00507825 (0.00430003)
Fixed Effects	No	Yes	Fixed Effects	No	Yes
Adj. R-sq	.90641936	.99745188	Adj. R-sq	.03732852	.79391393

Note: Robust standard errors in parentheses: ***p<0.001, **p<0.05, *p<0.1

Among the control variables, the coefficient for a carbon tax is statistically significant in (1), (2), and (3). However, (3) is also the only equation where the carbon tax has a positive coefficient, suggesting that the presence of a carbon tax increases the carbon intensity of a country by more than one standard deviation. Emissions trading systems gain statistical significance in (3) and (4) and experience the same phenomenon as carbon taxes with a positive coefficient in (3).

3.1 Robustness Checks

The adjusted R-squared statistic remains high for (1), (2), and (4); however, its value in (3) is 0.03732852, showing that the model explains very little of the variance in emissions. The positive coefficients given to both carbon taxes and ETS are therefore less verifiable, especially considering that their coefficients are negative in the three other equations with higher adjusted R-squared values.

Equations (2) and (4) have higher adjusted R-squared values than (1) and (3), respectively, suggesting the value of adding fixed effects to the equation. Therefore, I run additional regressions with only country and year fixed effects as independent variables. When emissions are measured in kilotons, the adjusted R-squared value is .98254381. When emissions are measured in kilotons per dollar of GDP, the adjusted R-squared value is .79204029. The massive jump in adjusted R-squared value between (3) and (4) show how the tremendous effect the fixed effects have in explaining the variance of (4).

An alternative control to fixed effects is population. To measure whether the fixed effects or population fit the model better, population replaces fixed effects in equations (2) and (3). Population additionally has a bivariate relationship with ODA, FDI, and

GDP, leading to the inclusion of interaction terms in both equations. Table 5 below shows the results. All numeric variables have standardized coefficients.

Notably, the adjusted R-squared in (6) remains low as with (3), suggesting that the fixed effects are unique in explaining the large variance in (4).

In (5), FDI notably has a statistically significant and negative coefficient with emissions, challenging previous literature and this paper's own results. It is possible that adding population creates extra noise in the model not present when fixed effects are added.

Residual plots for the primary 4 equations are displayed below. Figure 6 represents the residuals for emissions in (1), Figure 7 for emissions in (2), Figure 8 for emissions/GDP in (3), and Figure 9 for emissions/GDP in (4).

Table 5: Adjusted Regression Results

	(5)		(6)
Variable	Emissions (kt)	Variable	Emissions (kt/GDP)
ODA (in USD)	-.0064367	ODA/GDP	-.0915495***
	(.0053012)		(.0200637)
FDI (in USD)	-.2412494***	FDI/GDP	.1176027*
	(.0512808)		(.0586979)
GDP (in USD)	.3614664***		
	(.0827087)		
Population (total)	.2424995**	Population/GDP	-.0865683*
	(.0875618)		(.0464095)
ODAxPopulation	-.0561615	(ODA/GDP)x	-.0301333
	(.0454101)	(Population/GDP)	(.0420544)
FDIxPopulation	.7657716***	(FDI/GDP)x	-.0776304
	(.1054359)	(Population/GDP)	(.0491268)
GDPxPopulation	-.0838641		
	(.0966372)		
Tax	.1435399***	Tax	.7811195*
	(.0253904)		(.3478016)
ETS	.2457018***	ETS	1.034436***
	(.0285018)		(.1863496)
Adjusted R-squared	.97172433	Adjusted R-squared	.05180238

Note: Robust standard errors in parentheses: ***p<0.001, **p<0.05, *p<0.1

Figure 6: Emissions Residuals (1)

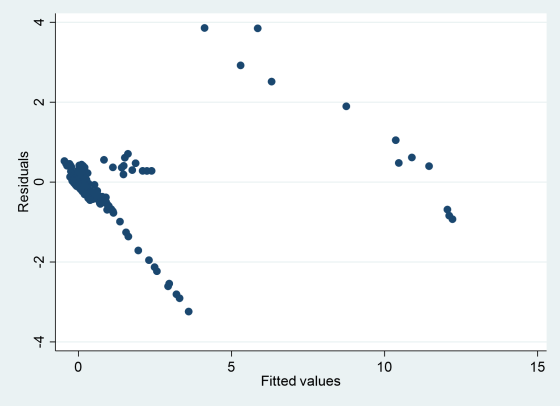


Figure 7: Emissions Residuals (2)

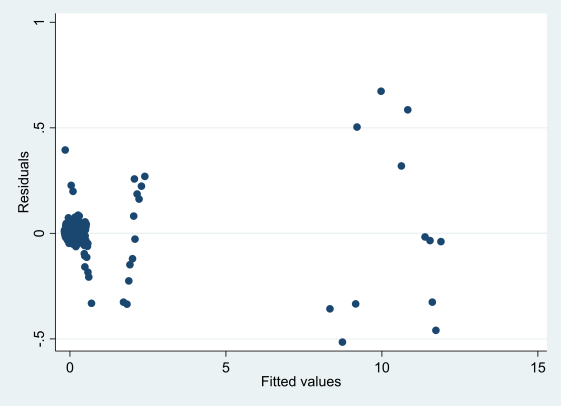


Figure 8: Emissions/GDP Residuals (3)

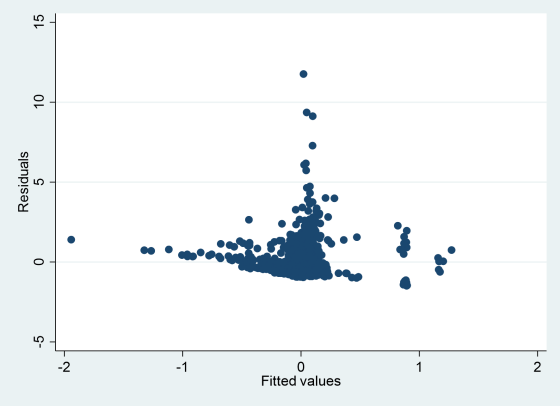
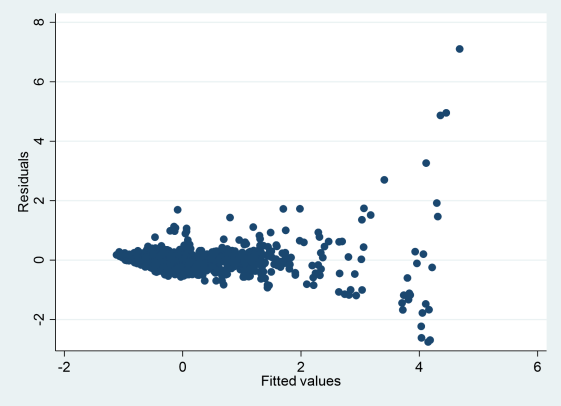


Figure 9: Emissions/GDP Residuals (4)



The absence of a polynomial form in each plot confirms that no logged terms are necessary in equations (1) through (4).

One major limitation of this study is that the data on ODA is the total value of bilateral and multilateral assistance received by the country in the given year. Development assistance often has conditions placed upon it by the donor country or agency. It is plausible that development assistance specifically earmarked for carbon mitigation projects or at least containing incentives for mitigation more strongly associates with reduced emissions.

While carbon taxes and emissions trading systems are innovative, market-based solutions touted by many economists as the most effective carbon mitigation policies, they are not the full breadth of environmental laws. It is possible that the countries denoted as implementors of carbon taxes or emissions trading systems are already more environmentally conscious than their contemporaries in this study. Thus, the true relationship between environmental laws and carbon mitigation could lie with other, unincluded laws and policies.

Inaccuracies within the data itself are likely considering the existence of rounded numbers within the dataset. Additionally, self-reporting countries and the World Bank have vested interests in ensuring future financial support, which could lead to higher tolerance of slightly inaccurate but believable data. However, due to the likely small nature of any inaccuracies, the relatively small change in magnitude by rounding, and the large number of countries included in the study, more accurate data likely does not

change the overall conclusions of this paper.

The data could have reached a different conclusion with a longer lagging period. This paper's model lagged CO_2, carbon tax, and ETS data by one year in accordance with Lim's lagging of the dependent variable. It is possible that development assistance, investment, and wealth from two or more years prior has a greater influence over emissions than the same data from only one year prior.

Countries included in this study are those that had data on each variable for each relevant year. Likewise, many countries, especially smaller island countries which typically receive ODA, are not included. This exclusion could lead to an exclusion bias, though arguably the minimal impact these countries have on world net CO_2 emissions prevents their exclusion from tampering with any important policy conclusions derived from these results. Had smaller island countries been the difference maker causing an association between ODA and CO_2 emissions to occur, the statistically insignificant association in the larger countries included in the regression means this study could have overestimated the total impact of ODA on net CO_2 emissions.

4 Conclusion

This paper estimates the relationship between CO_2 emissions per capita and ODA, FDI, and carbon taxes and emissions trading systems in an OLS regression. The model is unable to confirm a statistically significant negative relationship between carbon emissions and ODA but can confirm a statistically significant and positive relationship between emissions and FDI. Meanwhile, the presence of carbon taxes and emissions trading systems negatively relates to emissions. Because of this relationship between the presence of environmental laws and emissions, the model's results echo claims of previous papers on the importance of strong governance and environmental enforcement to mitigate CO_2 emissions, regardless of FDI's true effect.

Future research should analyze the limitations outlined in the robustness checks section. Utilizing nonlinear regressions and increasing lag time could lead to more significant results, as would utilizing conditional ODA data, dividing the variable between environmentally-focused assistance and non-environmentally-focused assistance. Studies several years from now will likely see clearer results on environmental laws as well, as the relatively small selection of aid-recipient countries with carbon taxes and emissions trading systems inevitably grows.

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