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RESEARCH ARTICLE

Green official development Aid and carbon emissions: do institutions matter?

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Abstract

This paper examines whether green Official Development Aid (ODA) has a significant role in mitigating carbon emissions in recipient countries, and if institutional quality matters for the effectiveness of green ODA. For 86 green ODA recipient countries over the period 2003–2014, we explore the nexus between green ODA, institutions and carbon emissions. By using a two-step system generalized method of moment (GMM), we find that green ODA overall has no direct association with the mitigation of carbon emissions. However, when institutional quality indices are included, we found a significant effect of institutional quality on the effectiveness of green ODA. In general, green ODA is associated with higher carbon emissions in countries with poor institutions. In particular, green ODA is effective in mitigating carbon emissions when channeled to countries that enjoy higher economic freedom as well as more freedom from corruption. Results are mixed for the rule of law.

Keywords: carbon emissions; corruption; economic freedom; green ODA; rule of law

JEL Code: Q54

1. Introduction

Climate change is fast becoming unmanageable. Carbon emissions have been rising even as the world economy recovers from the financial crisis and the great recession. Numbers presented by the International Energy Agency (IEA, 2017) indicate that global carbon emissions rose by 1.4 per cent in 2017, representing a historic high of 460 million tons (Mt). A recent Intergovernmental Panel on Climate Change report (IPCC, 2018) identifies the need to reach zero emissions by 2050 if global temperature rise is to be kept below 1.5°C, and notes that limiting temperature increase to 1.5°C will require a combination of measures such as reducing carbon emissions and energy intensities.

Historically, developing countries have not contributed much to greenhouse gas (GHG) emissions, but these countries require carbon-intensive investments to reduce poverty. Developing countries in East and South Asia and the Pacific that have dramatically reduced poverty have in turn increased carbon emissions dramatically, while regions like Sub-Saharan Africa that have faced a rise in poverty have also experienced decreases in carbon emissions (Goldstein, 2015). Developing economies also have the highest rate of increase in demand for energy and many low- to middle-income countries are, on average, more energy intensive than developed countries (Agenda for International Development, 2019).

Climate policies have aimed to achieve a balance between developed and developing country commitments with regard to carbon emission mitigation.[1] The 2015 Paris Agreement and the UN's Sustainable Development Goals (SDGs) have attempted to unite various stakeholders to work toward ensuring low carbon economic development. Developed countries and international organizations such as the United Nations, the World Bank and the Organization for Economic Co-operation and Development (OECD) have been providing aid for sustainable development to developing countries to meet SDGs. Such green aid or green Overseas Development Assistance (ODA) focuses on the reduction of carbon emissions by encouraging increased investment in efficient energy technologies, energy-saving facilities, CO_2 reservoirs and/or the production of renewable energy (World Bank, 2010; OECD, 2011).

Has such green ODA been effective in mitigating carbon emissions in recipient nations? Our paper is an attempt to answer this basic question which achieves even more significance in the current context of compromised aid flows to developing economies. According to the OECD, aid flows in 2018 fell by nearly 3 per cent from their 2017 levels, with the poorest countries being the worst hit (OECD, 2018). In a seminal study, Burnside and Dollar (2000) noted that aid effectiveness was positively associated with institutional quality in recipient countries. In comparable fashion, we ask if the effectiveness of green ODA in mitigating carbon emissions is associated with the quality of institutions in recipient countries. Specifically, does green ODA directed to countries with better institutional quality produce better environmental outcomes? We investigate these questions empirically, utilizing a panel dataset of 86 green ODA recipient countries over 2003–2014 and focusing on three specific indicators of institutional quality – namely, freedom from corruption, rule of law and economic freedom.[2]

The OECD's Development Assistance Committee (DAC) monitors ODA flows that meet the objectives of the Rio convention on biodiversity, climate change and desertification through a creditor reporting system utilizing 'Rio markers'.[3] The DAC classifies aid as 'climate change mitigating' if it contributes to the objective of stabilizing GHG concentrations in the atmosphere and promoting efforts to reduce or limit GHG emissions, or enhancing GHG sequestration. Over 2002–2014, such climate change mitigation aid amounted to US$110.35 billion, roughly 10 per cent of total ODA. Japan and Germany provided over 53 per cent of climate change mitigation aid, with India and Indonesia being the largest recipients, receiving US$17.7 billion and 7 billion respectively. For the

[1]Article 9 of the Paris Agreement states that developed countries would provide climate finance assistance to developing countries for emission mitigation and climate change adaptation (2015 United Nations Framework Convention on Climate Change).

[2]Institutional heterogeneity in donor countries can also affect the effectiveness of green ODA recipient countries. While it would be interesting to investigate the institutional quality of donor countries, it is not possible to collect information on such countries within the current database. We have not analyzed this issue given the scope of this study, but acknowledge this as a future area of research.

[3]The Rio Convention relates to the following three conventions, which are result of the Earth Summit held in Rio de Janeiro in 1992. These are: the United Nations Framework Convention on Climate Change (UNFCCC); the Convention on Biological Diversity (CBD); and the United Nations Convention to Combat Desertification (UNCCD). The Rio marker, established by the DAC and the UNFCCC, tracks aid flows that support the implementation of the Rio convention.

purposes of our study, we specifically consider 'climate change mitigation aid' diverted to the three most carbon intensive sectors – namely, energy, transport and industry – as our proxy for green ODA.[4]

The remainder of this study is organized as follows. Section 2 reviews the relevant literature and presents a conceptual framework for the nexus between green ODA, institutional quality and environmental wellbeing. Section 3 presents the methodology and information utilized in our econometric estimations. Section 4 discusses our empirical results and section 5 summarizes the paper and presents policy implications.

2. Green ODA, institutional quality and environment: linkages and literature

The role of aid in impelling environmental wellbeing has not been well studied. This may be due to the fact that the nature of the association between aid and the environment is multifaceted, as discussed by Arvin *et al.* (2006). Hübler and Keller (2010) observe a positive association between foreign aid and energy efficiency. Indeed, it is through various primary and secondary channels that foreign aid may affect carbon emissions in recipient countries. Scholars have suggested that a more heterogeneous and nuanced view on aid effectiveness is called for (e.g., Harms and Lutz, 2006; Mavrotas and Ouattara, 2006; Dreher *et al.*, 2010). It is against this backdrop that we empirically assess the impact of green ODA on carbon emissions in an institutional context.

Figure 1 illustrates a conceptual framing of the linkages between green ODA, institutional quality and environmental wellbeing. As indicated in the figure 1, green ODA can have a direct effect on CO_2 emissions, which is represented by T1. The linkages between carbon emissions and our indicators of institutional quality – namely, economic freedom, corruption and the rule of law – are represented by T2, T3 and T4 respectively. The dashed lines T5, T6, and T7 represent the *interaction* effect of green ODA associated with our institutional quality indices.

Where literature is concerned, there is limited scholarship on T1 or the direct impact of green ODA on environmental wellbeing. However, these studies provide us with a mixed bag of results as their findings differ with regard to various factors such as measurement of environmental degradation, country sample chosen, and time period under consideration, how researchers measured environmental degradation, country and time-period specifics, and the particularities of the estimation techniques. In a theoretical paper, Chao and Yu (1999) suggest that aid helps the environment only when it is tied to environmental cleanup. Arvin and Lew (2009) examine the relationship between aid and ecological wellbeing in selected Asian countries and Sub-Saharan African countries to conclude that aid helps mitigate CO_2 damage, but contributes to increased water pollution and deforestation. Kretschmer *et al.* (2011) adopt a case study approach to find that green aid reduces the energy intensity of domestic production but has no effect on carbon intensity of energy use. Bhattacharya *et al.* (2015) analyze the effect of energy-related aid on CO_2 and SO_2 emissions for a global panel data set and find no systematic effect of such aid on emissions. Bae *et al.* (2016) utilized joint estimation based on two-stage regressions to analyze the impact of green ODA on CO_2 emissions. They find that green ODA reduces CO_2 emissions directly, but that impact lessens significantly through a positive impact of green ODA on per capita GDP.

[4]DAC data includes several overlapping dimensions – climate change mitigation, adaptation, desertification and biodiversity. We did not use gross flows due to overlap, concentrating instead on 'climate change mitigation aid' to carbon intensive sectors as it relates more specifically to the focus of our study.

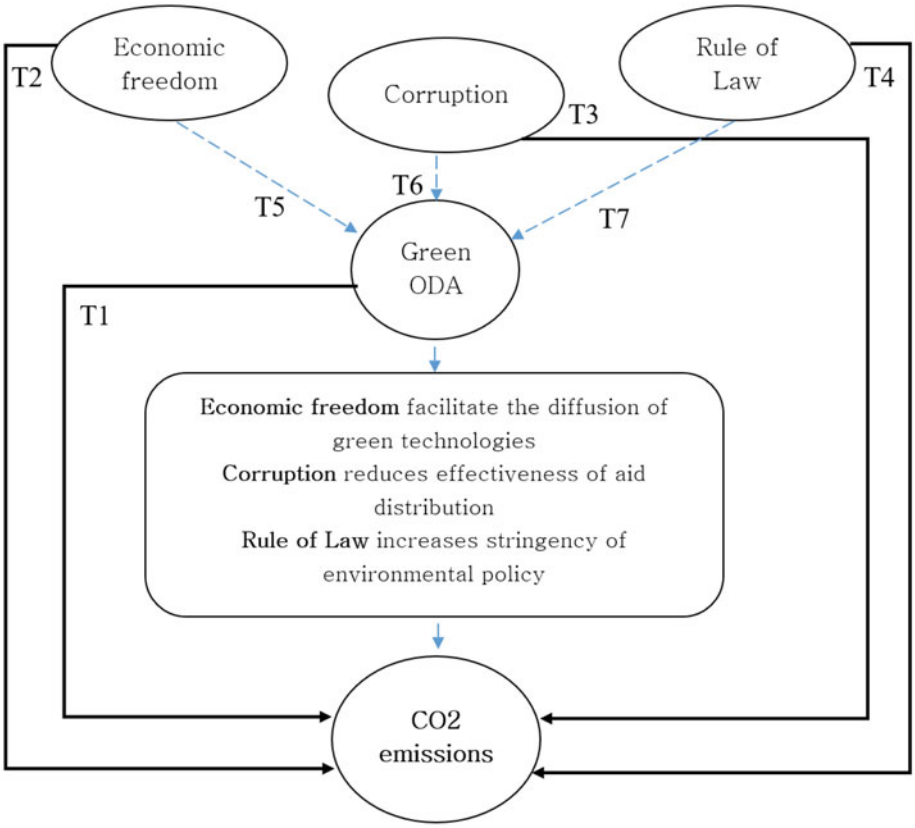

Figure 1. Nexus between green ODA, institutional quality and carbon emissions: a conceptual framework.

Insofar as linkages T2, T3 and T4 are concerned, the literature has documented the channels of association between various indicators of institutional quality and environmental wellbeing. We discuss this literature next, focusing specifically on economic freedom, corruption and the rule of law as our proxies for institutional quality.

2.1 Economic freedom and the environment (Linkage T2)

It is generally accepted that economic freedom provides incentives that can result in an effective use of resources. Several researchers have noted a positive relationship between economic freedom and environmental quality or policy (Barrett and Grady, 2000; Fredriksson and Gaston, 2000; Neumayer, 2002). Bate and Montgomery (2005) suggest that higher levels of economic freedom (the freedom to trade, enter into contracts and start a business) foster the introduction of new and clean energy technologies in developing countries. However, it is also possible that strong intellectual property rights that are associated with greater economic freedom inhibit the diffusion of green technologies (Hall and Helmers, 2010). Similarly, if there are policies in developing countries that distort factor prices, such as subsidies for energy use or protection of domestic industries, the adoption and diffusion of new technology will be hampered.

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Carlsson and Lundström (2001) empirically test three hypotheses to explain the impact of economic freedom on carbon emissions – the efficiency effect, the trade regulation effect and the stability effect. Under the efficiency effect, higher levels of economic freedom lead to efficient and competitive markets, which in turn lead to more efficient political regulation, and reduce carbon emissions. Trade deregulation/liberalization has an indeterminate impact on carbon emissions. On the one hand, trade liberalization can result in more effective resource allocation due to competitive pressures in international markets and thus reduce emissions. On the other hand, in developing countries with less stringent environmental regulations, such liberalization can also result in a pollution haven effect where dirty industries relocate to countries with relatively lax environmental regulations. Finally, the stability effect can lead to more efficient investment and consumption decisions and encourage long-term investment which might have a less than salubrious impact on the environment. In a cross-country study of 75 countries over 1975–1995, Carlsson and Lundström (2001) find that efficiency and trade regulation effects were significantly associated with decreasing carbon emissions and the stability effect had no discernible impact.

Wood and Herzog (2014) estimate the direct causal effect of economic freedom on two indicators of air pollution (fine particulate matter concentrations and CO_2 emissions) for 105 countries. Controlling for income, political institutions and endogeneity in the income-pollution relationship, their results indicate strong evidence of a negative relationship between economic freedom and particulate matter. There is a negative but less robust impact of economic freedom on carbon emissions. Using a system GMM estimator with a panel dataset for 24 African countries over the 1995–2013 period, Adesina and Mwamba (2019) demonstrate that increases in economic freedom are associated with improvements in environmental quality, measured using CO_2 emissions.

2.2 Corruption and the environment (Linkage T3)

Broadly defined as 'the misuse of public office for private gain' (Rose-Ackerman, 1999; Treisman, 2000; Kunicova and Rose-Ackerman, 2005; Transparency International, 2017), corruption plays a significant role in the degradation of the environment. There are two main linkages between corruption and the environment. First, government officials may control access to scarce valuable natural resources and can sell this access. Second, environmental issues such as environmental management, conservation, and enforcement institutions often receive insufficient funding, which creates opportunities for illegal activities. Scholars also argue that corruption can influence environmental degradation via relaxation of stringent environmental regulations (Lopez and Mitra, 2000; Damania *et al.*, 2003; Fredriksson *et al.*, 2004). Winbourne (2002) notes that corruption contributes to the development of environmentally damaging policies and practices, and an inequitable allocation of environmental resources.

Many studies have also looked at the impact of corruption on external inflows such as foreign direct investment (FDI). Alesina and Dollar (2000) point out that almost two-thirds of all foreign aid collected goes to government consumption. These funds are therefore allocated by international sources and end up in the hands of government bureaucrats to be distributed in some form to the general public. Many believe that aid increases the incentives of rent-seeking behavior because there is more rent to divide (Krueger, 1974; Murphy *et al.*, 1993; Svensson, 2000; Torvik, 2002; Hodler, 2007). The enforcement of environmental regulations in Indonesia and Thailand has often been compromised due to rent-seeking behavior by bureaucrats (Cribb, 1998; Riggs and Stott, 1998). Bureaucrats in these developing countries are more inefficient and more corrupt relative to those in developed countries (Lopez and Mitra, 2000).

2.3 Rule of law and the environment (Linkage T4)

Scholars have highlighted the existence of property rights and the rule of law[5] in the management of natural resources (Deacon, 1994; Bohn and Deacon, 2000). Mani and Fredriksson (2002) develop a theoretical framework to examine the linkages between rule of law and environmental policy formation. Their model suggests that an increase in the degree of rule of law has two opposing effects on environmental policy. Policy decisions implemented according to the law increase the stringency of environmental policy. However, a relatively high rule of law incentivizes polluting firms to increase lobbying efforts for favors from corruptible policymakers. Accordingly, they conclude that an increase in corruptibility of policymakers lowers the stringency of environmental policy.

Chen and Chai (2010) and Castiglione *et al*. (2011) have tried to integrate the impact of the rule of law into empirical environmental Kuznets curve (EKC) analyses.[6] Utilizing the rule of law variable from The World Bank's *World Governance Indicators* (at https://databank.worldbank.org/source/worldwide-governance-indicators), the authors find that both income and the rule of law have positive effects on environmental policy stringency in 71 countries. Castiglione *et al*. (2011) find that the rule of law has differential effects on carbon emissions in 28 European countries, partly based on the country's sector composition, and whether or not it had a Socialist past. Gani (2012) examines the relation between different good governance indices and CO_2 emissions for 99 developing countries and finds that political stability, rule of law and control for corruption are negatively correlated with CO_2 emissions. Scott (2016) finds a strong correlation between the Yale environmental performance index and the World Justice Protect Rule of Law index and suggests that environmental advocates should pay attention to strengthening rule of law. The author argues that a strong rule of law increases the public's ability to protect the environment through the procedural rights of access to justice and participatory decision-making.

In sum, while the above-discussed literature documents the association between institutional quality indicators and environmental wellbeing (linkages T2, T3 and T4), there are no studies that focus on the mediating impact of institutional quality on the green ODA-environmental wellbeing association (linkages T5, T6 and T7). Further, as presented above, literature on the *direct* impact of green ODA on the environment is also scant (linkage T1). This caveat motivates our empirical investigation and research question on the environmental impacts of green ODA and whether the efficiency of such aid is mediated by the quality of the institutional environment.

[5] Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police and the courts, as well as the likelihood of crime and violence (from Worldwide Governance Indicators, at https://datacatalog.worldbank.org/rule-law-estimate-0).

[6] The EKC asserts that environmental quality first declines (measured by an increase in pollution) in response to increase in per capita GDP and improves (i.e., pollution levels decline) only after per capita income surpasses a critical threshold. This combination of falling then rising environmental quality (as measured by pollution output) during the course of economic growth results in an inverted U-shaped curve.

3. Model and data

3.1 Model specification

The CO_2 equation that we wish to estimate has the following form:

$$\mathrm{CO}_{2it} = \alpha \mathrm{CO}_{2i,t-1} + \beta_k X_{it} + \gamma \mathrm{INS}_{it} + \delta_k \mathrm{GODA}_{i,t-k} + \mu_k \mathrm{INS} \cdot \mathrm{GODA}_{i,t-k} + \eta_i + \nu_{it}, \quad (1)$$

where CO_{2it} is a per capita CO_2 emission level of country i in time t (hereafter, the subscript it is omitted for all variable explanations); INS proxies institutional quality–corruption, economic freedom and rule of law; $\mathrm{GODA}_{i,t-k}$ is a lagged level of green ODA divided by total population; $\mathrm{INS}\bullet\mathrm{GODA}_{i,t-k}$ is the interaction term between institutional quality and green ODA; k is a lag order for green ODA and interaction term ($k = 0, 1, 2$). The variable X is a vector of exogenous variables that are commonly used as determinants of CO_2 emissions such as per capita level of GDP (the EKC hypothesis mentioned above) and energy intensity (Bae *et al.*, 2017; Shahbaz *et al.*, 2017). η_i is the individual effect and ν_{it} are residual terms.

Concerning the relation between GDP and CO_2 emissions in equation (1), extant literature on the EKC has tested non-linearity between per capita GDP and CO_2 emissions. We utilized a linear term for per capita GDP for two reasons. First, most studies show that the relationship between per capita income and global pollutants such as CO_2 emissions for most developing countries has a linear relationship. Second, including a square term for per capita GDP will not allow us to use system GMM estimation as the variance-covariance matrix does not achieve full rank.

3.2 Arellano-Bover/Blundell-Bond estimator

The econometric method in estimating the relations between green ODA and carbon emission levels under different institutional qualities employs the two-step system GMM Arellano-Bover/Blundell-Bond estimator with Windmeijer finite sample correction (Windmeijer, 2005).[7] A system GMM technique is efficient as it allows for more instruments relative to the Arellano-Bond (Arellano and Bond, 1991) estimator. The system GMM can include time-invariant regressors, which would have disappeared in difference GMM estimation. Moreover, the regressors are not required to be strictly exogenous (Roodman, 2009). Several studies have utilized system GMM to analyze the effectiveness of the foreign aid (Armah and Nelson, 2008; Feeny and Ouattara, 2009; Adedokun and Folawewo, 2017).

Soto (2009) notes that the system GMM estimator is the most precise when confronted with small sample bias, which is critical in this study, given our small sample of green ODA recipient countries. However, the moment conditions of the Arellano-Bover/Blundell-Bond estimator should not exhibit significant AR (2) behavior. If a significant AR (2) statistic is encountered, the lags of endogenous variables will not be appropriate instruments for their current values. Accordingly, we test for autocorrelation and provide the results of the Arellano–Bond test for serial correlation in the tables in sections 4.2 and 4.3.

[7] Random effects estimators cannot be used when the time dimension is short and because of potential bias in dynamic panel data models (Nickell, 1981). The GMM approach proposed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) is therefore most effective in empirical analyses where the number of surveyed individuals is relatively large over relatively fewer time periods.

Consider the instruments that the system GMM estimator uses. In the following dynamic equation,

$$y_{it} = \rho y_{i,t-1} + x'_{it}\beta + \alpha_i + \varepsilon_{it}, \quad (2)$$

y_{it} is a dependent variable; x'_{it} is a row vector of explanatory variables; $i = 1, \ldots, N$ is the index for countries; $t = 1, \ldots, T$ is the index for years; ρ is the coefficient of the lagged endogenous variable $y_{i,t-1}$; β is an unknown parameter vector of the k explanatory variables; α_i is the individual effect; and ε_{it} are residual terms. Arellano and Bond (1991) suggest using a difference equation derived from (2) to eliminate the individual effect α_i:

$$y_{it} - y_{it-1} = \rho(y_{i,t-1} - y_{i,t-2}) + (x'_{it} - x'_{it-1})\beta + \varepsilon_{it} - \varepsilon_{it-1}. \quad (3)$$

For equation (3) the previous level values are used as instruments. For example, for the final period T,

$$y_{iT} - y_{iT-1} = \rho(y_{i,T-1} - y_{i,T-2}) + (x'_{iT} - x'_{iT-1})\beta + \varepsilon_{iT} - \varepsilon_{iT-1}. \quad (4)$$

The available instruments are: $y_{i,1}, y_{i2,\ldots,}y_{i,T-2}, x'_{i1}, x'_{i2}, \ldots, x'_{iT-1}$. In addition to the difference equation, Blundell and Bond (1998) suggest using the level equation, where differences are used as valid instruments.

Again, consider the last observation T:

$$y_{iT} = \rho y_{i,T-1} + x'_{iT}\beta + \alpha_i + \varepsilon_{iT}. \quad (5)$$

The available instruments are $\mathrm{d}y_{i,1}, \mathrm{d}y_{i2,\ldots,}\mathrm{d}y_{i,T-1}, \mathrm{d}x'_{i1}, \mathrm{d}x'_{i2}, \ldots, \mathrm{d}x'_{iT}$, where d is a difference operator.

We tested square terms for per capita GDP for our specifications by using a fixed effects model (see online appendix tables B1–B4). The results indicate that the square terms were insignificant, or the estimated turning points were above the maximum value of per capita GDP in our data sample. This is consistent with some EKC studies that indicate that developing countries do not display an EKC relationship between per capita GDP and per capita CO_2 emissions.[8]

3.3 Data and variables

Table A1 in the online appendix provides definitions, data sources and summary statistics for all variables. The total number of green ODA recipient countries in 2011 was 142. However, as green ODA data is combined with the other data, the number of total observations falls to 86 countries and we obtain an unbalanced panel of 86 countries between 2003 and 2014. The list of countries employed in our analysis is presented in table D1 of the online appendix.

Data on green ODA for recipient countries between 2003 and 2014 were collected from the OECD Rio Marker Creditor Reporting System (CRS). As explained above, data on aid flows by sector are monitored by the OECD's creditor reporting system.

[8]Bae *et al.* (2017) mention that Lipford and Yandle (2010) and Shafik (1994) found positive correlation between GDP and CO_2 emissions. Kaika and Zervas (2013) summarized 35 EKC studies that examined the relation between GDP and CO_2 emissions, and showed that in most studies CO_2 emissions tend to rise monotonically as income grows.

The original data include several overlapping dimensions such as climate change mitigation, adaptation, desertification and biodiversity.[9] For the purposes of this paper, we used 'climate change mitigation aid' data as our proxy for green ODA as it relates more specifically to our research focus on carbon emissions. We consider mitigation aid flows directed to the three most carbon intensive sectors, namely, energy, transport and industry. The choice of 'climate mitigation aid' as a proxy for green ODA is based on the fact that such aid is aimed at carbon emission reductions or stabilization of carbon emissions via the application of new and renewable forms of energy. Such aid flows also capture measures to improve the energy efficiency of existing generators, machines and equipment.[10] As reported in tables C1–C3 in the online appendix, we also considered total ODA flows per capita in our estimations. We utilized the real value (2015 US$) for both green ODA and total ODA.

Data on per capita CO_2 emissions was collected from the World Bank's *World Development Indicators*[11] for the period between 2003 and 2014 and measured in metric kilos per capita. The data for per capita GDP in constant 2010 US$ and energy intensity were also collected from *World Development Indicators*. Data on economic freedom was obtained from the Heritage Foundation (at https://www.heritage.org/index/explore). The rule of law index and control of corruption index were collected from Worldwide Governance Indicators (at https://databank.worldbank.org/source/worldwide-governance-indicators). All institutional indices were rescaled from 0 to 1, where a higher value implies better institutional quality.

The interaction term (GODA*INS) in equation (1) is of special interest to our analysis. Specifically, green ODA multiplied by different institutional quality indices will enable us to investigate whether the effectiveness of green aid is mediated by the quality of the institutional environment. Since all indices are scaled from 0 to 1, a lower level of institutional quality index connotes a reduction in the value of the interaction term.

4. Results

4.1 Unit root test

Table 1 shows the panel unit root test results. In our analysis we use a set of unit root tests, namely tests with common unit root processes. We use the Levin–Lin–Chu (hereafter LLC) test (Levin *et al.*, 2002), as well as tests with individual unit root processes: the Im, Pesaran and Shin test (hereafter IPS) (Im *et al.*, 2003); the Fisher augmented Dickey–Fuller (hereafter ADF) test (Maddala and Wu, 1999; Choi, 2001); and the Phillips and Perron (hereafter PP) test (1988). The null hypothesis for all tests is that the panel contains unit roots.

According to the estimation results of the IPS and ADF tests for CO_2 emissions and GDP variables, the null hypothesis of a unit root cannot be rejected at levels. However, all the tests show that these variables are strongly stationary at first difference. All other variables, such as ODA variables, institutional indices and energy intensity, reject the

[9] The data is available at https://stats.oecd.org/Index.aspx?QueryId{\mathsurround=\opskip$=$}58196#.

[10] The data is available in the 'Aid activities targeting Global Environmental Objectives' subsection of 'Flows based on individual CRS project'. See the CRS database website at https://stats.oecd.org/Index.aspx?QueryId{\mathsurround=\opskip$=$}58196#.

[11] The data is available at https://databank.worldbank.org/reports.aspx?source=world-development-indicators#.

Table 1. Unit root test results

Variables		LLC	IPS	ADF	PP
CO_2 emissions	Level	−4.528***	1.368	194.5	251.97***
	1st difference	−26.057***	−16.992***	598.1***	762.01***
GDP	Level	4.958	8.167	134.39	233.11***
	1st difference	−22.906***	−11.136***	402.45***	434.15***
Energy intensity	Level	−13.889***	−3.100***	243.17***	332.61***
Green ODA	Level	−12.412***	−7.694***	378.47***	439.19***
Economic freedom index	Level	−11.95***	−5.053***	283.27***	295.07***
Control of corruption	Level	−6.478***	−2.006**	220.04***	247.45***
Rule of law index	Level	−6.022***	−1.539*	213.42**	231.37***
Total ODA	Level	−15.176***	−8.219***	358.99***	391.04***

Notes: *Denotes statistical significance within 10%, **within 5% and ***within 1%. LLC – Levin, Lin & Chu test; IPS – Im, Pesaran & Shin test; ADF – Fisher Augmented Dickey-Fuller test; PP – Phillips-Perron test. The null for LLC is: common unit root. The null for IPS, ADF and PP is: individual unit root.

null hypothesis of a unit root at levels. Thus, we assume that these variables are stationary. As some variables are nonstationary, the estimation of the OLS estimation might lead to spurious regression. For difference GMM (Arellano and Bond, 1991), the instruments become extremely weak once the process approaches a unit root. In this case, the Arellano-Bover/Blundell-Bond estimator (system GMM) is often used. Mehic (2017) used Monte Carlo simulations and showed that the absolute bias of the system GMM due to non-stationary data is low for most combinations of N (panels) and T (time periods).

4.2 Green ODA and carbon emissions (Linkage T1)

We first examine whether green ODA and institutional quality have a direct impact on CO_2 emissions in recipient countries. Table 2 provides parameter estimates for three specifications with different institutional quality indices. We construct ODA_FREE which employs the economic freedom index; ODA_CORR that utilizes the freedom from corruption index; and ODA_RL that contains the rule of law index.[12] As displayed, none of our institutional quality indices appears to have a significant direct impact on mitigation of carbon emissions. Our findings on the lack of a direct relationship between institutions and the environment are in accord with other empirical studies (Scruggs, 1998; Roberts and Parks, 2007; Wood and Herzog, 2014).

As explained for equation (1), we have also considered lagged per capita CO_2 emissions, per capita GDP, energy intensity and per capita green ODA as explanatory variables. Table 2 indicates that current year emissions are positively affected by an increase in CO_2 emissions in the former year. Per capita GDP is also positively associated with CO_2 emissions.

[12]We also considered estimating a model that included all of our institutional quality indices. However, the estimation indicated multicollinearity problems among the institutional indices (variance inflation factors (VIFs) were above 30). Accordingly, we report results that employ only one institutional index per specification.

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Table 2. Parameter estimates: direct effects of institutional quality on CO_2 emissions

CO_2 emissions		ODA_FREE	ODA_CORR	ODA_RL
L1(CO_2)		0.624***	0.635***	0.633***
		(0.072)	(0.070)	(0.073)
GDP		0.499***	0.486***	0.488***
		(0.114)	(0.113)	(0.110)
Energy intensity		15.794***	15.461***	15.605***
		(3.754)	(3.829)	(3.920)
Green ODA		0.457	−0.266	−0.181
		(2.191)	(2.542)	(2.310)
Economic freedom		3,121.136		
		(2,681.939)		
Control of corruption			1,512.820	
			(1,869.042)	
Rule of law				941.989
				(2,018.635)
Constant		−5,395.181***	−4,075.631***	−3,853.701***
		(1,978.504)	(1,182.424)	(1,160.242)
Arellano-Bond test for zero autocorrelation	AR(1)	−1.82*	−1.91*	−1.82*
	AR(2)	0.58	0.63	0.57

Notes: *Denotes statistical significance within 10% and ***within 1%. Standard deviations of parameter estimates in brackets. L1 is a lag operator and represents the first lag.

Results show that energy intensities are associated with higher CO_2 emissions, which is in line with other studies that considered energy intensity as a determinant for CO_2 emissions (Shahbaz *et al.*, 2015; Bae *et al.*, 2017). However, green ODA does not have a statistically significant association with CO_2 emissions.

As shown in table 2, the Arellano-Bond test for autocorrelation indicates zero autocorrelation in the first-differenced errors at order 1 for all models but accepts a null hypothesis of no autocorrelation for order 2, implying that the instruments are valid.

4.3 Interaction effects of green ODA and institutional quality indices

The parameter estimation of interaction terms between green ODA and the institutional quality indices can help us discern the mediating impact of institutions on the green ODA-carbon emissions linkage. Accordingly, we extend our specifications by including an interaction term between green ODA and institutional quality indices. We also used the lagged terms for green ODA and interaction terms to account for time delays in the execution of green ODA projects. Thus, for the economic freedom index (EF), we construct three additional specifications EF, EF_L(1) and EF_L(2). As indicated in table 3, specification EF contains our explanatory variables from table 2 *plus* the interaction term GODA*EF. This is replicated in models EF_L(1) and EF_L(2) by the inclusion

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Table 3. Indirect effects of institutional quality on CO_2 emissions: Economic Freedom Index and green ODA

CO_2 emissions		EF	EF_L(1)	EF_L(2)
L1(CO_2)		0.623***	0.621***	0.602***
		(0.072)	(0.073)	(0.074)
GDP		0.502***	0.509***	0.527***
		(0.113)	(0.115)	(0.118)
Energy intensity		15.731***	15.338***	16.135***
		(3.769)	(3.841)	(3.944)
Green ODA		33.777*	41.909*	60.874*
		(19.876)	(23.993)	(35.788)
GODA*EF		−51.155*	−62.973*	−90.074*
		(29.415)	(35.819)	(52.151)
Economic freedom		3,152.643	3,300.997	4,182.229
		(2,704.673)	(2,876.841)	(3,126.003)
L1(GODA)			36.873	55.445*
			(33.410)	(33.032)
L2(GODA)				43.049
				(49.520)
L1(GODA*EF)			−56.866	−82.155*
			(50.247)	(49.172)
L2(GODA*EF)				−59.118
				(67.337)
Constant		−5 419.515***	−5,452.820***	−6,134.918***
		(2,003.220)	(2,080.369)	(2,256.594)
Arellano-bond test for zero autocorrelation	AR(1)	−1.82*	−1.80*	−1.90*
	AR(2)	0.55	0.46	0.53
Joint test		1.05	15.97***	7.95

Notes: *Denotes statistical significance within 10% and *** within 1%. Standard deviations of parameter estimates in brackets. L1 and L2 are lag operators and represent the first and second lag respectively.

of L1(GODA*EF) and L2(GODA*EF) which augment the interaction specifications by a one period and a two-period lag respectively.

As indicated in table 3, current year coefficients for green ODA and its interaction with economic freedom for all model specifications are statistically significant at the 10 per cent level, but with opposite signs. It is worth noting that green ODA coefficients – β_k in equation (1) – are positive, while the interaction terms – μ_k in equation (1) – are negative and have a higher absolute value.

In order to explain the impact of institutional quality indices on effectiveness of green ODA, we rearranged equation (1) as follows:

$$\mathrm{CO}_{2it} = \alpha \mathrm{CO}_{2i,t-1} + \beta_k X_{it} + \gamma \mathrm{INS}_{it} + (\delta_k + \mathrm{INS} \cdot \mu_k)\mathrm{GODA}_{i,t-k} + \eta_i + \nu_{it}. \quad (6)$$

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According to equation (6), the impact of green ODA on CO_2 emissions might be positive or negative, depending on the sign of the expression in parentheses ($\delta_k + \text{INS} \cdot \mu_k$). To estimate the threshold level of the impact of green ODA on carbon emissions, we set the term $(\delta_k + \text{INS} \cdot \mu_k)\text{GODA}_{i,t-k}$ of equation (6) to zero and solved for *INS* which in our case is represented by economic freedom. Thus

$$\text{INS} = -\left(\frac{\delta_k}{\mu_k}\right). \tag{7}$$

Accordingly, for model EF, green ODA reduces CO_2 emissions in recipient countries where the economic freedom index is higher than 0.66 (= 33.77/51.15). This implies that in countries with an economic freedom index below this threshold level, green ODA may be associated with an increase in emissions. Although the coefficients of first lags of green ODA and the interaction term are found to be statistically insignificant in model EF_L(1), these coefficients are significantly different from zero in EF_L(2) model and have the same signs as the unlagged coefficients. The coefficients for the second lags of green ODA (L2(GODA)) and the interaction term (L2(GODA*EF)) also display the same signs as the coefficients for the first lags L1(GODA) and L1(GODA*EF) respectively, but they do not achieve statistical significance. As calculated above, the economic freedom threshold estimates for models EF_L(1) and EF_L(2) are 0.66 and 0.67 respectively. Overall, the three specifications in table 3 indicate that green ODA recipient countries with relatively more economic freedom are more likely to mitigate CO_2 emissions compared to other green ODA recipients.

Table 4 replicates the above exercise for the corruption dimension of institutional quality. Specifications CC, CC_L(1) and CC_L(2) were constructed analogous to specifications EF, EF_L(1) and EF_L(2) as described above. As indicated in table 4, the direct and indirect effect (GODA*CC) of green ODA are not significant in sub-specification CC. However, for CC_L(1) and CC_L(2), we note that the direct impact of green ODA in the current and previous year is associated with increased CO_2 emissions as these coefficients are significant and positive. However, the indirect impact of green ODA through the interaction terms (GODA*CC) in current year and its first lag are negative and significant. The second lags for both green ODA and the interaction term in model CC_L(2) are not significant, analogous to the results obtained for economic freedom. Taken together, these results suggest that while green ODA facilitates the reduction of CO_2 emissions in recipient countries with a relatively higher level of transparency, such aid is also associated with an increase in emissions for relatively more corrupt countries.

Table 5 presents our estimations for the rule of law dimension of institutional quality. As with tables 3 and 4, our specification RL includes only current levels for green ODA and the interaction term between green ODA and the rule of law index. The RL_L(1), RL_L(2) models include one and two lags respectively for green ODA and the GODA*RL interaction term. Although the signs of the coefficients for green ODA and its interaction with the rule of law index were similar to those for economic freedom and control for corruption indices, they are not significant in all specifications. In short, as econometrically demonstrated in our sample, a stronger rule of law index has no impact on the effectiveness of green ODA in mitigating carbon emissions.

In sum, the estimation results from tables 3–5 suggest that the salubrious environmental impact of green ODA is most significant for countries with higher economic freedom and more transparency in recipient countries.

Table 4. Indirect Effects of institutional quality on CO_2 emissions: Control of Corruption Index and green ODA

CO_2 emissions		CC	CC_L(1)	CC_L(2)
L1(CO_2)		0.633***	0.632***	0.607***
		(0.069)	(0.070)	(0.071)
GDP		0.491***	0.493***	0.510***
		(0.112)	(0.114)	(0.116)
Energy intensity		15.592***	15.441***	16.995***
		(3.823)	(3.772)	(4.017)
Green ODA		19.020	25.139**	34.094*
		(12.353)	(10.150)	(19.773)
GODA*CC		−41.541	−51.813**	−69.519*
		(25.285)	(21.379)	(38.540)
Control of corruption		1,520.268	1,584.105	2,236.186
		(1,836.903)	(1,875.524)	(1,952.530)
L1(GODA)			32.454**	40.835**
			(15.944)	(17.886)
L2(GODA)				36.242
				(42.081)
L1(GODA*CC)			−70.548**	−83.973**
			(35.453)	(37.702)
L2(GODA*CC)				−67.323
				(79.656)
Constant		−4,127.301***	−4,123.984***	−4,630.026***
		(1,158.767)	(1,179.070)	(1,230.676)
Arellano-bond test for zero autocorrelation	AR(1)	−1.90*	−1.89*	−1.92*
	AR(2)	0.61	0.51	0.61
Joint test		0.86	6.24**	3.04*

Notes: *Denotes statistical significance within 10%, **within 5% and ***within 1%. Standard deviations of parameter *estimates* in brackets. L1 and L2 are lag operators and represent the first and second lag respectively.

4.4 The net effect of green ODA on CO_2 emissions

Table 6 summarizes the estimated coefficients of the direct impact of green ODA and its indirect impact on CO_2 emissions. To calculate the net (direct + indirect) impact of green ODA and its 95 per cent confidence interval for point estimates, we used coefficients for green ODA and interaction terms for current year coefficients. We omitted the models with the rule of law index due to insignificance of green ODA and interaction terms. The table also contains the threshold index levels as defined by equations (6) and (7). The results could be interpreted in the following manner. In model EF for example, the impact of the green ODA on CO_2 emissions might be positive or negative depending on the value of the economic freedom index in the recipient country, and can vary from

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Table 5. Indirect effects of institutional quality on CO_2 emissions: Rule of Law Index and green ODA

CO_2 emissions		RL	RL_L(1)	RL_L(2)
L1(CO_2)		0.631***	0.629***	0.603***
		(0.073)	(0.074)	(0.073)
GDP		0.492***	0.496***	0.512***
		(0.112)	(0.112)	(0.114)
Energy intensity		15.673***	15.725***	17.294***
		(3.900)	(3.971)	(4.061)
Green ODA		19.224	24.958	35.242
		(15.668)	(16.831)	(28.036)
GODA*RL		−38.672	−47.553	−67.383
		(31.387)	(33.544)	(53.328)
Rule of law		954.059	940.035	1,695.078
		(1,960.848)	(1,922.843)	(1,847.237)
L1(GODA)			22.637	32.479
			(18.370)	(20.581)
L2(GODA)				32.792
				(33.736)
L1(GODA*RL)			−45.060	−60.151
			(38.247)	(40.917)
L2(GODA*RL)				−57.421
				(57.379)
Constant		−3,887.377***	−3,893.311***	−4,446.977***
		(1,122.728)	(1,152.970)	(1,167.911)
Arellano-bond test for zero autocorrelation	AR(1)	−1.87*	−1.86*	−1.95*
	AR(2)	0.46	0.34	0.66
Joint test		0.33	7.44**	3.38*

Notes: *Denotes statistical significance within 10%, **within 5% and ***within 1%. Standard deviations of parameter estimates in brackets. L1 and L2 are lag operators and represent the first and second lag respectively.

−36.87 to 2.11. Moreover, for this model, green ODA is positively associated with CO_2 emissions if the economic freedom index is lower than 0.66 and negatively associated with emissions if the index is above the threshold level.

Based on the estimates from table 6, the average abatement cost per ton of CO_2 for the EF model is calculated as US$57.50 (1000/17.4). Notice that these are very static calculations averaged across a wide set of countries and the abatement costs might vary significantly across countries. By way of comparison with Sandbag's data, the average carbon market price of the European Union Emissions Trading System during the 2009–2018 period was about €10 and increased rapidly up to €25 in 2019.[13] Stern *et al.*

[13] The data is available at https://sandbag.org.uk/carbon-price-viewer/.

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Table 6. The net impact of green ODA on CO_2 emissions

Model	EF	EF_L(1)	EF_L(2)	CC	CC_L(1)	CC_L(2)
GODA	33.777	41.909	60.874	19.020	25.139	34.094
GODA*INS	−51.155	−62.973	−90.074	−41.541	−51.813	−69.519
Net impact	−17.378*	−21.064*	−29.199*	−22.521*	−26.673**	−35.426*
	(9.944)	(12.244)	(16.935)	(13.494)	(11.745)	(19.251)
Threshold level	0.66***	0.665***	0.676***	0.458***	0.485***	0.49***
	(0.045)	(0.041)	(0.040)	(0.065)	(0.046)	(0.045)

Notes: *Denotes statistical significance within 10%, **within 5% and ***within 1%. Brackets contain standard deviations of linear and nonlinear combinations of estimators.

(2011) estimated that under the assumption of a common global carbon dioxide price of US$50 per ton, developing countries such as China and India might reduce emissions during the 2010–2020 period relative to the business-as-usual (BAU) scenario by 27 and 30 per cent respectively. The Carbon Pricing Leadership Coalition (High-Level Commission on Carbon Prices, 2017) stated that the carbon price level consistent with achieving the goal of the Paris Agreement is at least US$40–80 per ton of CO_2 by 2020 and US$50–100/$TCO_2$ by 2030. Wang and Wei (2014) estimated that the average abatement cost per ton of CO_2 emissions for the industrial sector of Chinese major cities over 2006–2010 was US$56.61, which is quite close to our estimated results. Only 18.5 per cent of our data sample is associated with a control of corruption index above the threshold level of 0.49. For the economic freedom index, the percentage of the sample with an index value over the threshold is even lower and accounts for only about 14.8 per cent. These results imply that only a small portion of recipient countries effectively use green ODA for mitigation of carbon emissions.

5. Conclusions

Climate change poses a serious risk to lives and livelihoods, particularly for developing economies. During the last two centuries, human activities have increased the concentration of GHGs in the atmosphere considerably. The most significant increase has been that of carbon dioxide. The COP21 conference held in Paris in December 2015 called for GHG emissions at a level consistent with an average global temperature rise of 2°C (possibly 1.5°C) above pre-industrial average temperature. Developed nations and international organizations have traditionally supported emissions reductions by way of green ODA that is designed to assist recipient countries in cleaning up existing energy infrastructure, reducing energy intensity, and switching from a fossil fuel-based energy mix to a renewables-based energy mix. This paper examines whether green ODA plays a significant role in mitigating carbon emissions in recipient countries, and if institutional quality affects the effectiveness of green ODA. Our research is especially relevant in the current context of compromised aid flows to developing economies in the wake of the financial crisis (OECD, 2018).

A novelty of our analysis is the application of dynamic panel modelling to explore the nexus between green ODA, institutions and carbon emissions. Utilizing a panel dataset of 86 green ODA recipient countries over the period 2003 to 2014 and employing a two-step system GMM Arellano-Bover/Blundell-Bond estimator with Windmeijer finite sample correction, we find that green ODA overall has no direct association with the mitigation of carbon emissions. However, when institutional quality indices such as economic freedom, rule of law and control of corruption are included, we found a significant effect of institutional quality on the effectiveness of green ODA. In general, green ODA is associated with higher carbon emissions in countries with poor institutions. In particular, green ODA is effective in mitigating carbon emissions when channeled to countries that enjoy higher economic freedom as well as more freedom from corruption. The results are mixed the rule of law is considered.

Our findings are robust to the inclusion of other exogenous variables such as per capita level GDP and energy intensity as controls. We have not analyzed institutional heterogeneity in donor countries in our paper given our data constraints, but acknowledge this as a future area of research. Moreover, it is very difficult to identify causality between green ODA and CO_2 emissions due to the possibility of endogeneity between two variables. In this regard, our findings on 'direct incremental effect of green ODA on CO_2 emissions' regardless of institutional quality indices should be very carefully interpreted.

From a policy perspective, our findings on the mediating role of institutional quality in determining the effectiveness of green ODA are significant. Our findings should not be taken to imply that cutting green aid to countries with poor institutions would mitigate carbon emissions. Instead, our results call for a nuanced look at green ODA and the significance of the institutional environment in countries receiving green ODA. Our results also place emphasis on the role of information collection, organization, analysis and dissemination. Such flows need to be directed, monitored and evaluated more thoroughly, perhaps by international institutions such as the World Bank, UNDP or OECD. Combatting global carbon emissions does entail a short-term financial cost. However, what are the costs of the alternative? As the twenty-fifth Conference of the Parties (COP25) meetings get underway, policymakers and politicians might want to explicitly consider the cost of doing nothing; of their economic and political inertia; and of ignoring the perils imposed by a rapidly warming planet. Advocates are pushing COP25 to establish some form of loss and damage financing tool, to create a task force on delivering new funding. Our analysis suggests that at the very least, policymakers need to be cognizant of the institutional environment while considering climate finance initiatives to combat carbon emissions.

It must be noted that green ODA recipient countries are still on the positive slope of their environmental Kuznets curves – per capita GDP is positively associated with CO_2 emissions. Indeed, for most developing economies, the EKC turning point is not attainable any time soon. Heightened energy demand by developing countries is a contributing factor behind the recent rise in global carbon emissions. In the present conjuncture, it is imperative that developed nations continue their commitments in Paris to help developing countries abate future carbon emissions without sacrificing the economic growth needed to combat poverty. Our results also show that a higher energy efficiency (or lower energy intensity) can mitigate CO_2 emissions significantly. Thus, donor nations can better guide their green ODA flows to the use of more efficient energy utilization in recipient countries.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355770X20000170.

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