Master's Thesis of Public Administration

Effectiveness of climate mitigation aid and climate adaptation aid

기후완화원조와 기후적응원조의 효과성

February 2023

Graduate School of Public Administration

Seoul National University

Public Administration Major

Yunhee Kim

Effectiveness of climate mitigation aid and climate adaptation aid

Academic Advisor: Lee, Sukwon

Submitting a master's thesis of Public Administration

September 2022

Graduate School of Public Administration

Seoul National University

Public Administration Major

Yunhee Kim

Confirming the master's thesis written by

Yunhee Kim

December 2022

Chair	Ko, Kilgon (Seal)
Vice Chair	Dostal, Jörg Michael (Seal)
Examiner	Lee, Sukwon (Seal)

Abstract

In the international community, there has been consistent suggestion that foreign aid should contribute to developing countries' efforts against climate change. In 1998, the Development Assistance Committee of OECD introduced the Rio Markers to measure how much foreign aid is provided for addressing climate change. The Rio Markers divides climate related aid into two types: climate mitigation aid and climate adaptation aid.

This study aims to investigate whether two types of climate aid achieve their intended results. In this study, CO2 emissions is selected as a dependent variable for the effectiveness of climate mitigation aid and the annual change of agricultural output for climate adaptation aid. This study is different from other studies in adopting a new control variable of fossil fuel aid to test its impact on climate change. Panel datasets are compiled for 115 countries from 2011 to 2019.

The key findings of the empirical regression are as follows. First, climate mitigation aid has a negative relation with CO2 emissions, which is the desired result. Fossil fuel aid has no statistically significant relation with CO2 emissions, however, has a role to limit the effectiveness of climate mitigation aid. Second, climate adaptation aid does not show significant relation with the annual change of agricultural output which is a proxy of adaptation capacity. The amount of total aid and FDI have an effect to decreasing the annual change of agricultural output. However, this effect is not found in the countries with large exposure to fossil fuel aid.

Foreign aid recently draws attention in terms of responding to climate change. Thus, it is necessary to set up a proper system for evaluating climate aid. Especially, a systematic framework for evaluating the effectiveness of climate adaptation aid should be designed.

Keyword : aid effectiveness, climate adaptation aid, climate mitigation aid, CO2 emissions, fossil fuel aid
Student Number : 2020-24574

Table of Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1. Study Background

According to Intergovernmental Panel on Climate Change (IPCC) which is the United Nations institute for providing scientific information related to climate change, human activity warmed the earth by 0.87°C between pre-industrial periods (1850–1901) and the decade 2006–2015. If current trends continue, the earth will warm by 1.5°C around 2040 due to human activity.

Climate change has had a direct impact on people's lives by increasing frequency of natural disasters like floods and droughts, as well as changes in the composition of agricultural crops and marine species as a result of global warming. There are various policies and international agendas in place to adapt to the new changed environment and to mitigate negative effects of climate change. These addressing efforts are easily found in daily lives including government subsidies for electric car purchases and increased reliance on renewable energy.

In the international community, there has been consistent suggestion that foreign aid should contribute to developing countries' efforts to address climate change. The first consensus was the adoption of the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Framework Convention to Combat Desertification (UNCCD) and the United Nations Convention on Biological Diversity (CBD) at the United Nations Conference on

Environment and Development in 1992. In 1998, the Development Assistance Committee (DAC) of OECD introduced the Rio Markers to measure how much foreign aid is related to addressing climate change. The Rio Markers indicate whether each project contributes to climate mitigation, desertification, and biodiversity, respectively. In 2008, it became mandatory to indicate the Rio Marker for every aid project when DAC member countries submit aid statistics to OECD DAC. And a second marker, climate adaptation, was added in 2010. By doing so, international community got to have a tool to monitor and evaluate climate aid flows.

While international consensus and methodological instruments for the climate change related aid are building, some studies were made to investigate how effective the climate aid has been addressing the climate change: Do climate aids contribute to reducing CO2 emissions and help people to adopt to the changed environment?

In the course of reviewing the existing studies and data, it was found that aids were also granted to the fossil fuel related sectors. Especially during the years when the price of fossil fuel was stable at the low level, there were lots of aid money flowing into coal or oil-fired power plant. It is significant when the Chinese aid for fossil fuel energy was also taken account. In other words, aids promote mitigation and adaptation for climate change on the one hand and finance fossil fuel energy which may aggravate climate change on the other hand.

1.2 Purpose of Research

This study examines whether the purposes of climate mitigation aid and climate adaptation aid are achieved as intended, respectively. This study is differentiated in that it approaches the effectiveness of aid for climate change more comprehensively by considering both climate aids and fossil fuel aids. In addition, this study tries to separately understand the effectiveness of climate aid in terms of mitigation and adaptation.

Chapter 2. Literature Review

2.1. Emergence of Climate Aid

The necessity of climate aid has been vigorously discussed. At the fifteenth conference of the parties (COP) of the UNFCCC in 2009, developed countries agreed to mobilize 100 billion USD of climate finance a year to support developing countries by 2020. According to UNFCCC, "Climate finance refers to local, national or transnational financing—drawn from public, private and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change." Climate finance comprises of four types, "bilateral public finance, multilateral public finance, officially supported export credit and mobilized private finance" (OECD, 2019). Climate aid in this paper is a sub-group of climate finance in the form of bilateral public finance called as Official Development Aid (ODA) which accounted for 37.6% of the total climate finance in 2020.

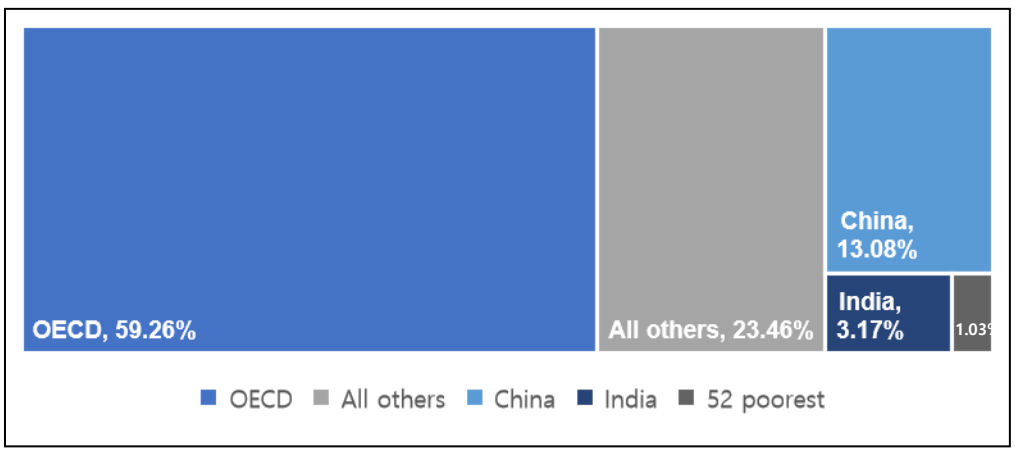
Figure 1. Climate finance provided and mobilized

(billion USD)

Source: OECD(2022a)

According to Baker and Mitchell (2020), OECD member countries have been responsible for 59 percent of the cumulative CO2 emissions since 1751 while the poorest countries produced just 1 percent. However, the impact of climate change is not limited to the most responsible countries but affects the earth as a whole. Many countries are suffering from floods and droughts which have different pattern of the past. Crop and fishery production are also affected by climate change.

Figure 2. Cumulative CO2 emissions, 1751–2017



Source: Baker and Mitchell(2020)

In this context, donors' role as facilitators of climate finance has been underlined. OECD (2009) underlined the importance of donors in supporting developing countries' attempts to align their development policies and programs with a changing climate. The role of foreign aid was emphasized as a catalyst to achieve the global objectives against climate change in Arndt and Tarp (2017). It urged to change the existing aid architecture to address global environmental issues beyond a traditional concentration on poverty reduction. Emphasis of foreign aid

on addressing climate change is also found in Michaelowa and Michaelowa (2007) which stated that the main function of ODA has been changing due to emerging climate change issue.

2.2. Development and Measurement of Climate Aid

In line with emphasis on the role of aid for climate change, OECD DAC started to measure how much foreign aid is injected to addressing climate change by introducing the Rio Markers. The Rio Markers are composed of three types, climate mitigation, climate adaptation and biodiversity. According to OECD (2011), climate mitigation aid indicates the aid contributing "to the objective of stabilisation of greenhouse gas (GHG) concentrations in the atmosphere". Climate adaptation aid means the aid intending "to reduce the vulnerability of human or natural systems to the impacts of climate change and climate-related risks". These two markers are the primary indicators for climate aid.

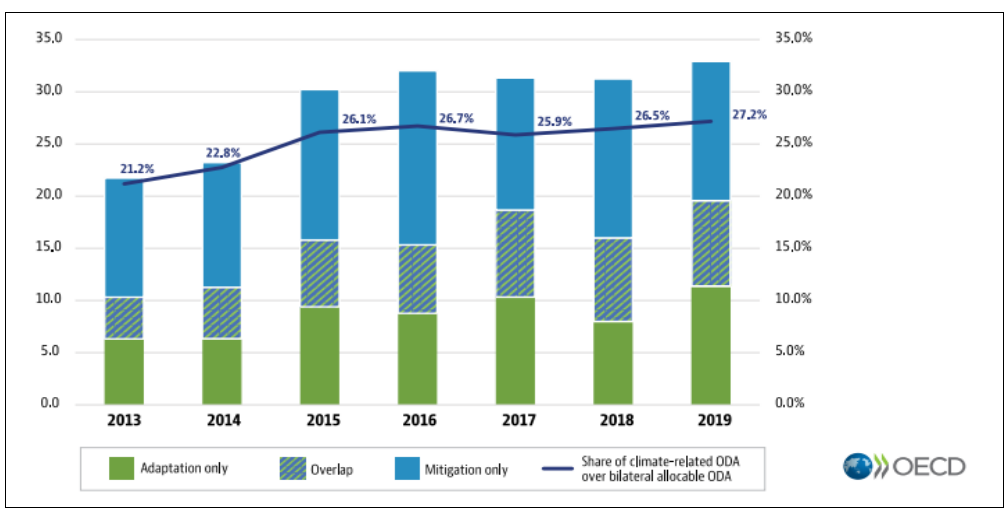
Table 1. Definition of climate mitigation aid and climate adaptation aid

Type	Objective
Climate mitigation aid	Stabilisation of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system by promoting efforts to reduce or limit GHG emissions or to enhance GHG sequestration
Climate adaptation aid	Reduction of the vulnerability of human or natural systems to the impacts of climate change and climate-related risks, by maintaining or increasing adaptive capacity and resilience.

Source: OECD(2011)

According to OECD(2022b), the share of climate aid in the total ODA has been stalled around 20~30%. Overall, climate aid with mitigation purpose is provided more than adaptation purpose. OECD(2022a) analyzes that relatively stronger incentives may prioritise climate finance for mitigation purpose. Incentives can be activated in the following three ways. First, financial sustainability and returns are more easily attained in mitigation projects than in adaptation projects. Second, mitigation purpose has been more predominant in international and national climate policy in that mitigation can be achieved by global efforts while adaptation is usually pursued at an individual country level. Third, mitigation projects are more easily and quantitively measured which reinforces political incentives.

Figure 3. Share of ODA for climate aid 2013-2019



Source: OECD (2022b)

The main sectors for climate mitigation aid are energy and transport linked to GHG emissions. Energy sector including renewable energy represents 29% of the total climate mitigation aid provided from 2011 to 2019.

Key sectors for climate adaptation aid are water supply & sanitation and agriculture both of which are related to ecosystem. They account for 20% and 19% of the total climate adaptation aid, respectively. (OECD, 2022)

Table 2. Top five sectors for climate mitigation aid and climate adaptation aid in 2019

(disbursement, million USD)

Climate Mitigation Aid	Amount	Climate Adaptation Aid	Amount
Transport & Storage	1,950	General Environment Protection	712
Energy generation, renewable sources	1,546	Water Supply & Sanitation	548
General Environment Protection	1,419	Other Multisector	516
Energy Policy	990	Agriculture	394
Energy distribution	687	Forestry	144

Source: OECD CRS statistics

In practice, climate mitigation aid is mainly realized in the form of transportation or energy projects. The rationale is that mass transport produces less CO2 emissions than private cars and renewable energy produces no CO2 emissions. Refurbishment or improvement of old thermal power plant is also classified into climate mitigation aid in that it can contribute to reducing CO2 emissions.

Table 3. Top five projects of climate mitigation aid in 2019

(disbursement, million USD)

Project Title	Disbursed amount
Delhi Mass Rapid Transport System Project (Phase 3) (Donor : Japan, Recipient : India)	349
Dedicated Freight Corridor Project (Phase 2) (Donor : Japan, Recipient : India)	256
Turakurgan Thermal Power Station Construction Project (Donor : Japan, Recipient : Uzbekistan)	199
Program for the Promotion of Energy Efficiency and Renewable Energies (Donor : Germany, Recipient : Mexico)	186
Navoi Thermal Power Station Modernization Project (Donor : Japan, Recipient : Uzbekistan)	179

Source: OECD CRS statistics

Climate adaptation aid goes into water-related projects or environment-specific funds. By definition, climate adaptation aid "encompasses a range of activities from information and knowledge generation to capacity development, planning and the implementation of climate change adaptation actions." (OECD, 2011) This broad definition may induce various capital contribution to environment-specific funds rather than a specific project. It also does not target a specific country, but rather a region or an unspecified area.

Table 4. Top five projects of climate adaptation aid in 2019

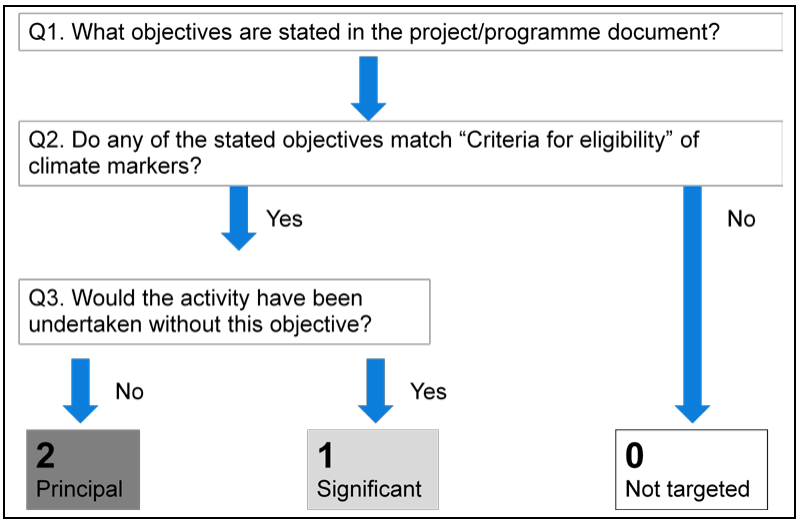
(disbursement, million USD)

Project Title	Disbursed amount
Construction of the Bakheng water treatment plant and extension of the Phnom Penh drinking water network (Donor : France, Recipient : Cambodia)	89
2018 forest public policy project (Donor : France, Recipient : Turkey)	88
Green Climate Fund - Initial Resource Mobilization (Donor : Canada, Recipient : Regional)	83
Canadian Climate Fund for the Private Sector in the Americas II (Donor : Canada, Recipient : Regional)	72
Second amendment to the Global Risk Financing Facility Multi-Donor Trust Fund (Donor : Germany, Recipient : Unspecified)	69

Source: OECD CRS statistics

Rio Markers have three levels of scoring system. When the objective of an aid activity is primarily related to climate change, Rio Marker for that activity is “principal” and gives two (2) points. When the purpose of climate change is not primary but explicitly included, Rio Marker gives one (1) point to that activity and classifies it into “significant”. When an activity is neither principal nor significant, it is classified as “not targeted” with zero point.

Figure 4. Scoring system for Rio Markers



Source: OECD(2011)

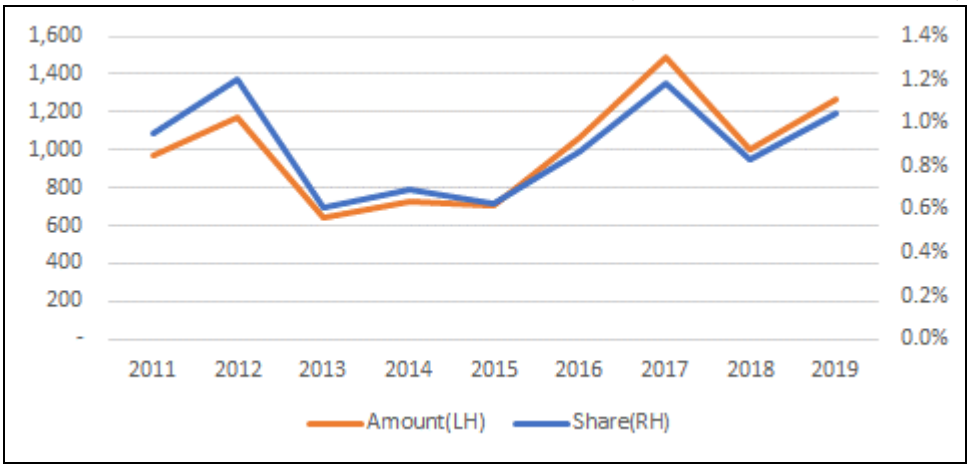
2.3. Fossil Fuel Aid

Fossil-fuel power generation is attractive to developing countries because it is easily accessible with its proven technology and price competitiveness. There have also been aids for fossil fuel energy for decades. The annual disbursed amount has been around 1 billion USD with its share of the total being around 1%.

Besides traditional DAC donors, emerging donors such as China and Middle East countries financed for fossil fuel energy to developing countries. According to China's Global Energy Finance (CGEF) from Boston University, the Export Import Bank of China, a designated institution for concessional loans on behalf of Chinese government, provided 17,895 million USD for fossil fuel projects from 2011 to 2019 which was two times larger than the sum of DAC member countries.

Figure 5. Trend of fossil fuel aid

(disbursement, million USD)



Source: OECD CRS statistics

Table 5. Top five projects of fossil fuel aid in 2019

(disbursement, million USD)

Project Title	Disbursed amount
Matarbari Ultra Super Critical Coal-Fired Power Project (IV) (Donor : Japan, Recipient : Bangladesh)	295
Turakurgan Thermal Power Station Construction Project (Donor : Japan, Recipient : Uzbekistan)	199
Navoi Thermal Power Station Modernization Project (Donor : Japan, Recipient : Uzbekistan)	179
Rades Combined Cycle Power Plant Construction Project (Donor : Japan, Recipient : Tunisia)	138
Nghi Son Thermal Power Plant Construction Project (III) (Donor : Japan, Recipient : Viet Nam)	66

Table 5 shows top five projects of fossil fuel aid disbursed in 2019. Interestingly, four out of five projects were reported with climate mitigation marker having 1 or 2 points. This classification may be based on that assumption that CO2

emission can be reduced by using upgraded technology in construction of thermal power plants or increasing efficiency of old thermal power plants.

Most existing studies confirmed the positive relation between fossil fuel aid and CO2 emissions. Henderson and Sommer (2022) found that CO2 emissions rose as a recipient country receives more fossil fuel energy aid. Mahalik et al. (2021) pointed out that the foreign aid for energy sector increased CO2 emissions because of the effect of fossil fuel energy aid. Both studies support that fossil fuel aid contributes to increasing of CO2 emissions.

2.4. Effectiveness of Climate Aid

2.4.1 Environmental Kutznets Curve

The Environmental Kutznets Curve (EKC) is the most widely recognized model for the relationship between economic growth and environmental degradation. According to the EKC, economic growth initially causes environmental deterioration; however, after reaching a certain level of economic development, environmental quality begins to improve. The pattern between economic growth and environmental degradation showed an inverted U curve as the Kuznets Curve, which explains the relationship between economic growth and income inequality. As a result, it is called as the Environmental Kuznets Curve.

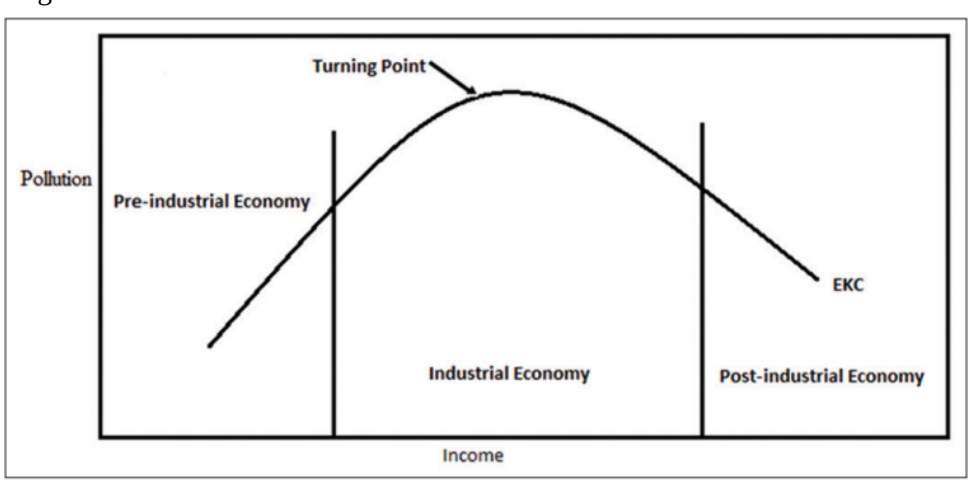
Kim et al. (2015) summarized three explanations for the EKC. First, in general, economic growth causes a shift in economic structure from secondary to tertiary industry. Secondary industry usually consists of labor-intensive and

pollution-inducing business, whereas tertiary industry contributes less to environmental deterioration. Second, economic growth can make it easier to invest in technologies which can reduce pollution. Third, as income increases, so does the need for improved environmental quality.

However, there has been some controversy about whether or not the EKC exists. Issac Doku et al. (2021) examined the role of climate finance for Sub-Sahara African countries to affirm the EKC. It ascertained the inverted U-shaped relationship between GDP per capita and CO2 emissions. It calculated the critical points at which CO2 emissions begin to decline.

In contrast, Kaika and Zervas (2013) pointed out that extensive empirical studies on the EKC did not find an inverted U-shaped relationship between income and CO2 emissions, and that CO2 emissions consistently increased as income level rose. Therefore, the existence of the EKC has not yet been proven.

Figure 6. Environmental Kuznets Curve



Source: Gill, A.(2017)

2.4.2 Foreign Aid and CO2 Emissions

In theory, given that foreign aid seeks to reduce poverty through economic growth in low-income countries that have not yet reached the EKC threshold, it has been hypothesized that foreign aid has a negative impact on environmental quality. According to Arvin, Dabir-Alai, and Lew (2006), the potential link between foreign aid and pollution was found in some countries, although the relationship between aid and pollution has various forms across countries.

Other studies also admitted that it was difficult to identify a meaningful relationship between foreign aid and CO2 emissions. According to Kretschmer, Hubler, and Nunnenkamp (2011) and Boly (2018), aid has no significant relationship with CO2 emissions. Sharma, Bhattarai, and Ahmed (2019) also noted that studies on the effects of aid on CO2 emissions reduction were insufficient.

Some recent studies have found that foreign aid has a positive impact on CO2 emissions. Farooq (2021) supported the positive impact of foreign aid on CO2 emissions since foreign aid can encourage the use of low-emission industrial technology. Mahalik et al. (2021) analyzed foreign aid to India from 1978 to 2014 and discovered that foreign aid greatly reduced CO2 emissions.

To date, there is no established conclusion for the effectiveness of foreign aid on reduction of CO2 emissions.

2.4.3 Energy Aid and CO2 Emissions

On the other hand, as foreign aid has become increasingly emphasized environment-related purposes, some studies have looked into whether sector-specific aid, such as aid for energy sector or climate aid, is effective in reducing CO2 emissions.

Kablan and Chouard (2022) discovered that foreign aid for renewable energy had a slight effect on the reduction of CO2 emissions. Similar but slightly different analysis was presented in Ikegami and Wang (2021). It found that energy aid, whether renewable or non-renewable, contributes to lowering CO2 emissions intensity in recipient countries. Mahalik et al. (2021) argued that energy aid increased CO2 emissions which was different conclusion with Ikegami and Wang (2021).

Bae and Yoo (2021) confined its research scope into foreign aid for renewable energy. It found that renewable energy aid had a significant impact on reducing CO2 emissions, and that its impact was increased in more democratic countries. However, the drop was less obvious in countries where fossil fuel energy was abundant. Moon (2017) also investigated the impact of Korea's mitigation aid in relation with governance. It found that Korea's mitigation aid contributed to reducing CO2 emissions in recipient countries, particularly when coupled with good governance.

Overall, the existing literature states that foreign aid for renewable energy contributes to reducing CO2 emissions.

2.4.4 Foreign Aid and Agricultural Output

There have been various studies on relation between foreign aid and agricultural output. Most of the existing literature favored the role of foreign aid to promote agricultural development.

M.W. Kherallah et al. (1994) investigated the relation between foreign aid and agricultural output growth and concluded that foreign aid had a positive influence on agricultural growth. Karim Barkat (2019) conducted an empirical analysis and found that foreign aid for agriculture sector, as well as total foreign aid, having a minor but positive impact on agricultural output. Sabrine Dhahri (2019), Jian Xu et al. (2020) and Furqan Sikandar et al. (2021) argued that aid for agriculture had positive and significant impacts on agricultural output. Those studies were made in consideration of evaluating the effectiveness of agriculture aid, however, the relation between climate aid and agricultural was not incorporated. This study seeks to fill this gap by estimating the effect of climate adaptation aid on agricultural output.

Chapter 3. Research Design

3.1. Research Model

The purpose of this study is to analyze how effectively climate mitigation aid and climate adaptation aid have responded to climate change.

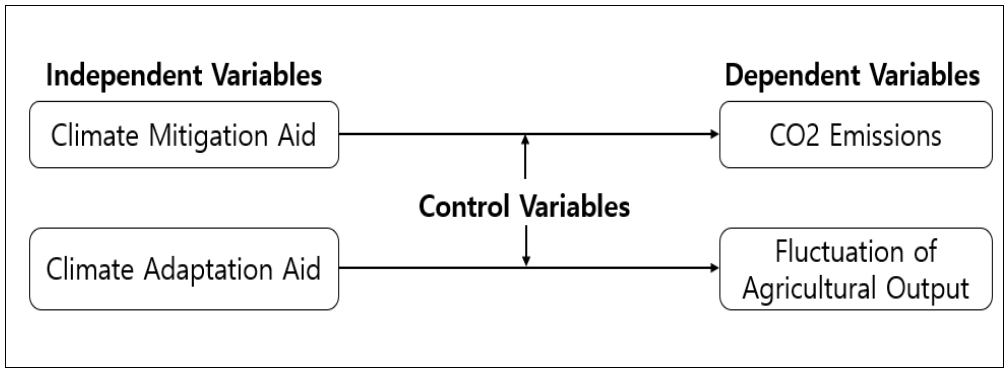
Climate mitigation aid has a purpose of stabilizing GHG concentrations where CO2 emissions are the dominant component. This study investigates whether climate mitigation aid contributes to reducing CO2 emissions.

H1: Climate mitigation aid contributes to reducing CO2 emissions of the recipient countries.

Climate adaptation aid intends to lower the vulnerability of environment to climate change. Climate change incurs various natural calamities such as floods, droughts and abnormal temperatures. In this course, agricultural output is fluctuating every year. This study explores the effectiveness of climate adaptation aid by measuring the annual change in agricultural output of recipient countries.

H2: Climate adaptation aid contributes to reducing the fluctuation of agricultural output of the recipient countries.

Figure 7. Research model



3.2. Data and Variables

3.2.1. Dependent Variables: CO2 Emissions and Agricultural Output

3.2.1.1 CO2 emissions

The main driver for increasing the temperature of the earth is known as GHG including CO2, CH4, N2O and so on. And the most contributing element of GHG is CO2 emissions which account for 77% of GHG. CO2 emissions causes temperature rise as it absorbs solar radiation in the atmosphere (IPCC 2018). CO2 emissions is widely used dependent variable in the model of measuring the effect of climate mitigation aid because climate mitigation aid aims to stabilize GHG concentrations in the atmosphere.

Data for CO2 emissions come from World Development Index (WDI) of

World Bank. Its unit is kilotons of CO2 produced by burning of fossil fuels and manufacturing of cement (World Bank 2017).

3.2.1.2 Agricultural Output

As for estimating the effect of climate adaptation aid, few proxies have been proposed. This study tries to use annual change of agricultural output as a proxy, because agricultural output is vulnerable to change of rainfalls, temperature, and sunshine, etc. If climate adaptation aid works as designed, agricultural output is expected to remain constant.

There are many variables representing agricultural output. Among these, this study uses figures for total crops from statistics of Food and Agriculture Organization of United Nations (FAOSTAT). Total crops are the sum of cereals, fruits, vegetables, etc. FAOSTAT is one of the most widely used statistics for agricultural studies because it provides various indicators such as yield, area harvested and production quantity since 1960.

3.2.2. Independent Variables: Climate Mitigation Aid, Climate Adaptation Aid

This study sets the amount of climate mitigation aid and climate adaptation aid as independent variables. To capture how much climate mitigation aid and climate adaptation aid was provided, this study uses OECD Creditor Reporting

System (CRS) database. Because it includes the Rio Marker which enables data users to identify which aid activity is reported with objectives related to climate change. It is agreed that OECD CRS data with Rio Markers are the most comprehensive and reliable data for study. (Klock, Molenaers and Weiler, 2018)

As this study uses the Rio Markers which are mandatory indicator for DAC statistics, donor countries are limited to 31 countries which are DAC member countries.

Rio marker has three levels of score. The aid activity classified with “principal” is given two points and the activity with “significant” is one point. And the activity indicated as “not targeted” is given zero point. There are various ways to accommodate this scoring system into a single dependent variable. Some studies use “principal” Rio marker only in order to avoid over-reporting tendency of donor countries. (Michaelowa and Michaelowa 2011) Other studies use sum of both markers with discount weight of 50% for “significant”. (Klock, Molenaers and Weiler 2018) (Weiler, Klöck, and Dornan 2018) In other studies, both type of indicators, “principal” and “significant”, are summed up without discount. (Betzeold and Wiler 2017) (Weiler and Sanubi 2019)

This study adopts the sum of the whole amount of “principal” and 50% discounted amount of “significant”. It is reasonable to consider both objectives based on its weight in the aid activity in order to capture the whole picture of the effect of climate aid more comprehensively.

There are two types of data which CRS dataset publishes for aid amount. One

is commitment amount and the other disbursement amount. This study uses disbursement amount for climate aid. Given that the effect of climate aid can be measured not when donor countries decide to provide climate aid but when a specific project or program is implemented using climate aid, it is appropriate to use disbursement amount. In addition, this study adopts one year lag of climate aid disbursement amount (Kablan and Chouard, 2022), because the effect of a specific project or program is usually measurable after a year at least.

3.2.3. Control Variables

3.2.3.1 Fossil-Fuel Aid

The use of fossil fuels contributes to increasing CO2 emissions, because the combustion process of fossil-fuel produces massive amount of CO2. Considering the negative impact of fossil fuel to climate change, it is necessary to include fossil fuel aid as a control variable.

When this study takes into account influence of fossil-fuel aid, the amount of fossil-fuel aid from China also should be considered. However, as China is not a DAC member country, OECD CRS data does not include aid statistics from China. Instead, this study uses data from CGEF from Boston University. CGEF aggregated China's public financing via China Development Bank and the Export-Import Bank of China for energy sector. It is the most reliable database for tracking Chinese aid for energy sector although it has some limitations. (Bertheau and

Linder 2021). One of the limitations is that CGEF does count the commitment amount, not the disbursed amount. Therefore, this study divides the commitment amount into three years equally, considering construction of fossil fuel facilities usually takes three years.

This control variable is lagged one year in consideration of time lag between the completion of a facility and its effect.

3.2.3.2 Income Level: GDP per capita

It is generally supposed that CO2 emissions increase along with the improvement of economic conditions. High GDP per capita is normally based on the vigorous production of good and services which involve more CO2 emissions. In this sense, this study uses GDP per capita as a proxy of economic conditions of a recipient country.

Data for GDP per capita comes from WDI of World Bank. Its unit is US Dollars expressed in constant 2015 USD.

3.2.3.3 Urban Population

This variable is commonly found in the cross-national studies of CO2 emissions. Large share of urban population produces more CO2 emissions as Kasman and Duman (2015) analyzed that urbanization had an increasing effect of CO2 emissions in the long run.

Data for share of urban population comes from WDI of World Bank. Its unit is

percentage of total population.

3.2.3.4 Governance: WGI

It is well known that governance plays a critical role in aid effectiveness. When governance of a recipient country is well established, it helps foreign aid to work more effectively. This tendency also applies to climate aid. Based on this concept, many studies use governance as a control variable in analyzing climate aid effectiveness.

Worldwide governance indicators (WGI) published by the World Bank is a typical proxy of governance. It comprises of six dimensions, Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law and Control of Corruption.

This study uses the aggregate of all six dimensions (Farooq 2021) while other studies use some dimensions selectively (Moon 2017), because all six dimensions are related to the effectiveness of climate aid. Every dimension ranges from -2.5 (weak) to 2.5 (strong). Thus, the aggregate ranges from -15 to 15.

3.2.3.5 Total Amount of Foreign Aid

As for the relation between CO2 emissions and foreign aid, there are various discussions. Given that foreign aid has a purpose to promote economic growth, it can result in increase of CO2 emissions. However, as foreign aid currently emphasizes environment-friendly purposes, some studies have found that it has an

influence of decreasing CO2 emissions.

The impact of overall foreign aid is not necessarily the same as that of climate aid. Mahalik et al. (2021) separately assessed the impact of total foreign aid and foreign energy aid on CO2 emissions in India. In consideration of overall aid's impact on CO2 emission, this study uses the total amount of foreign aid as a control variable.

Data for total aid amount comes from OECD CRS database. This study uses the disbursement amount of each year. Its unit is million US Dollars and one year lagged.

3.2.3.6 Industrial sector

Industrial sector has energy intensive characteristics, because it consumes more electricity which mainly comes from fossil fuels. Thus, it is expected that the greater the share of an economy's industrial sector, the greater the amount of CO2 emissions.

This study uses “Industry (including construction), value added (% of GDP)” indicator from WDI of the World Bank. The indicator includes value addition in manufacturing, mining, construction, water, electricity, and gas.

3.2.3.7 Foreign Direct Investment (FDI)

There are two approaches to discussing the impact of FDI on CO2 emissions.

On the one hand, FDI may contribute to reducing CO2 emissions by

transferring environment-friendly technology. (Kretschmer et al, 2013) It is asserted that foreign companies usually have energy-efficient technologies and can impose pressure on other companies to do the same.

On the other hand, foreign companies may invest developing countries taking advantage of weak environmental regulations. (Mahalik et al. 2021) In this case, FDI contributes to increasing CO2 emissions.

Data for FDI comes from WDI of World Bank with the unit of % of GDP, net inflows.

3.2.3.8 Natural Disasters: Flood, Drought, Cold Wave and Heat Wave

Extreme weather events are one of the determinants of agricultural output. And climate change induces much more weather disasters recently. Patrick Regan et al. (2017) explored how much a country's adaptive capacity can mitigate agricultural losses caused by extreme weather disasters. The study adopted flood, drought, cold wave, and heat wave as extreme weather disasters which were derived from the Emergency Events Database (EM-DAT) provided by the Centre for Research on the Epidemiology of Disasters.

This study also uses four weather events as control variables: flood, drought, cold wave, and heat wave. The value of this variable is annual frequency of the extreme weather events per a country.

3.2.3.9 Agricultural Import and Export

Agricultural exports are commonly acknowledged to improve agricultural output. Mylene Kherallah et al. (1994) stated that agricultural exports fostered agricultural output by generating additional revenues for further investment, absorbing advanced technologies, and enabling economies of scale due to increased market size.

However, there have been no agreed conclusion on the impact of agricultural import on agricultural output. According to Jianxu Liu et al. (2020), agricultural imports effect domestic agricultural output in two opposite ways. On the one hand, it encourages the use of advanced technologies in order to compete with imported items; on the other hand, it results in a loss of human and capital resources in the face of intense competition from importers.

In line with the existing literature, this study also incorporated the parameters of agricultural trade. Agricultural export (import) was represented as the proportion of agricultural export (import) value to GDP using FAOSTAT.

3.2.3.10 Arable Land

Arable land is one of the typical variables for the analysis of agricultural output. This is because agricultural production increases if arable land increases due to large-scale land fill projects. Sabrine Dhahri et al.(2019) and Jianxu Liu et al. (2020) also included this variable into their empirical model.

Data for FDI comes from WDI of World Bank with the unit of % of land area.

Table 6. Variables used in the model (climate mitigation aid)

Variables	Capturing features	Proxy	Sources
Dependent Variable	Effectiveness of climate mitigation aid	Total CO2 emissions	WDI(WB)
Independent Variable	Aid mitigating the effects of climate change	Climate Mitigation Aid	CRS(OECD)
Control Variables	Aid aggravating climate change	Fossil Fuel Aid	CRS(OECD), Boston University (for China)
	Foreign assistance	Total Foreign Aid	CRS(OECD)
	Income level	GDP per capita	WDI(WB)
	Foreign investment affecting energy consumption	FDI	WDI(WB)
	Sector with high energy demand	Industrial Sector	WDI(WB)
	Urbanization	Urban Population	WDI(WB)
	Governance	Worldwide Governance Index	WGI(WB)

Table 7. Variables used in the model (climate adaptation aid)

Variables	Capturing features	Proxy	Sources
Dependent Variable	Effectiveness of climate adaptation aid	Annual Change of Total Crops	FAOSTAT (FAO)
Independent Variable	Aid adapting to the effects of climate change	Climate Adaptation Aid	CRS(OECD)
Control Variables	Same variables used in the climate mitigation aid model		
	Natural disasters	Flood Drought Cold Wave Heat Wave	Emergency Events Database
	Agricultural trade	Agricultural Import Agricultural Export	FAOSTAT (FAO)
	Physical constraint for agricultural activity	Arable Land	WDI(WB)

3.3. Methodology

3.3.1. Methodology Selection

To test the relations between climate aid and reduction of CO2 emissions or vulnerability of agricultural output, this study uses panel regression approach.

Panel data means a dataset which has a time-series and a cross-sectional dimension at the same time. It can be constructed by following the same subjects across time. Data sources of this study such as OECD or World Bank provide data on each variable for the same countries in different year. This makes this study to use panel regression approach.

Panel data enables the regression to be more useful by "controlling for time-constant unobserved features which we think might be correlated with the explanatory variables." (Wooldridge, 2020) CO2 emissions or vulnerability of agricultural output might be influenced by time-constant factors per every country, because every country has intrinsic features according to its geography, climate, history and so on.

There are two ways for estimating unobserved effects of panel data models, random effects model and fixed effects model. Panel data is a collection of observations for the same entity repeatedly. Thus, it can be expected that there is something in its own characteristics that may affect the independent variables and it should be controlled. This is the basic rationale for the fixed effects model. Using

the fixed effects model can remove the effect of time-invariant characteristics. In addition, the fixed effects model allows for correlation between unobserved effect and the independent variables in any period. In contrast, the random effects model assumes that the unique characteristics in one entity are random and uncorrelated with all the independent variables. (Wooldridge, 2020)

3.3.2. Regression Equation for Panel Data Analysis

The regression equation for estimating the effect of climate mitigation aid is as follows.

$$CO2_{r,t} = \beta_0 + \beta_1 MA_{r,t-1} + \beta_2 FA_{r,t-1} + \beta_3 TA_{r,t-1} + \beta_4 GDP_{r,t} + \beta_5 FDI_{r,t-1} + \beta_6 IND_{r,t} + \beta_7 URB_{r,t} + \beta_8 WGI_{r,t} + \mu$$

Where, CO2 stands for total CO2 emissions, MA stands for climate mitigation aid, FA stands for fossil fuel aid, TA stands for total foreign aid, GDP stands for GDP per capita, FDI stands for Foreign Direct Investment, IND stands for industrial sector, URB stands for urban population, WGI stands for Worldwide Governance Index and μ stands for an error term.

The effect of CO2 reduction can be measured after a certain period of time from investment. Thus, money-related variables such as mitigation aid, fossil fuel aid, total aid and FDI are lagged by one year.

The regression equation for estimating the effect of climate adaptation aid is as follows.

$$TC_{r,t} = \beta_0 + \beta_1 AA_{r,t-1} + \beta_2 FA_{r,t-1} + \beta_3 TA_{r,t-1} + \beta_4 GDP_{r,t} + \beta_5 FDI_{r,t-1}$$
$$+ \beta_6 IND_{r,t} + \beta_7 URB_{r,t} + \beta_8 WGI_{r,t} + \beta_9 Flood_{r,t+} \beta_{10} Drought_{r,t}$$
$$+ \beta_{11} ColdWave_{r,t} + \beta_{12} HeatWave_{r,t} + \beta_{13} AgriImport_{r,t}$$
$$+ \beta_{14} AgriExport_{r,t+} \beta_{15} ArLand_{r,t} + \mu$$

Where, TC stands for annual change of total crops in absolute value, AA stands for climate adaptation aid, Flood stands for annual frequency of flood, Drought stands for annual frequency of drought, ColdWave stands for annual frequency of cold wave, HeatWave stands for annual frequency of heat wave, AgriImport stands for agricultural import, AgriExport stands for agricultural export, ArLand stands for arable land and μ stands for an error term.

This study transformed aid-related variables and monetary variables into a log form. According to Wooldridge (2020), using logarithms has advantages because it can justify reporting even when there is a significant percentage change and can "make OLS estimates less sensitive to outlying" by narrowing its range. Based on this characteristics, monetary terms and population is commonly transformed into logarithms in the regression analysis.

However, taking logarithms can not be used if a variable is zero or negative values. When a variable y is not negative but can have the value 0, Wooldridge (2020) recommends to use log (1+y) instead. In line with this, this study adds 1 to

all aid-related variables which can have value of 0 and uses logarithms.

In addition, total CO2 emissions and annual change of total crops are turned into logarithms because those variables have large and skewed values.

Chapter 4. Results of Analysis and Interpretation

4.1. Descriptive Statistics

Descriptive statistics of all variables are provided in Table 8.

This study uses a panel data of 115 countries from 2011 to 2019. OECD CRS statistics provide data for 249 recipient countries, however, 115 countries were selected in this empirical model due to availability of data from other sources. The list of recipient countries included in this empirical model is shown in Appendix 1. The panel data covers from 2011 when the climate adaptation markers were first published to 2019 which is the most recent year for CO2 emission statistics published in the WDI of the World Bank.

Table 8. Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Total CO2 emissions(ln)	1,035	9.241	2.218	4.605	16.186
Annual Change of Total Crops(ln)	1,035	15.779	2.298	0	21.320
Mitigation Aid(ln)	1,035	2.451	1.699	0	7.803
Adaptation Aid(ln)	1,035	2.238	1.494	0	5.989
Fossil Fuel Aid(ln)	1,035	0.552	1.434	0	7.686
Total Aid(ln)	1,035	5.449	1.558	0	8.736
GDP per capita(ln)	1,030	7.874	1.001	5.628	9.728
FDI(ln)	982	6.616	2.026	0.054	12.581
Industrial Sector	1,021	26.026	10.339	4.556	66.580
Urban Population	1,035	50.015	20.107	10.915	95.426

WGI	1,035	-2.966	3.628	-13.656	7.184
Flood	1,035	0.929	1.701	0	14
Drought	1,035	0.105	0.310	0	2
Cold Wave	1,035	0.062	0.278	0	3
Heat Wave	1,035	0.013	0.120	0	2
Agricultural Import	1,034	0.065	0.103	0.003	1.284
Agricultural Export	1,035	0.039	0.042	0	0.367
Arable Land	1,026	14.691	13.547	0.086	61.205

However, it is helpful to look over the numerical quantity of each aid because aid amounts used in the regression model are logarithm terms. The statistical characteristics of each type of aid are shown in Table 9. From 2011 to 2019, the average amount of climate mitigation aid per a recipient country is 53.929 million USD which is more than double the amount of climate adaptation aid or fossil fuel aid. Standard deviation of climate adaptation aid is one third that of climate mitigation aid, which means climate adaptation aid is more evenly spread among recipient countries than climate mitigation aid.

Table 9. Descriptive statistics of original numbers of each aid

(million USD)

Variable	Obs	Mean	Std. dev.	Min	Max
Mitigation Aid	1,035	53.929	161.625	0	2,445.850
Adaptation Aid	1,035	27.205	51.692	0	398.192
Fossil Fuel Aid	1,035	23.747	141.087	0	2,177.405
Total Aid	1,035	570.740	782.250	0	6,223.944

In contrast, fossil fuel aid is not common for all donors and recipient countries. Some donor countries provide fossil fuel aid for limited numbers of recipient countries. A half of donor countries were engaged in fossil fuel aid and most active donors – Japan, Germany, and France – make up more than 94% of the total fossil fuel aid. And only one-third of recipient countries receive fossil fuel aid. Specifically, Bangladesh, Bosnia and Herzegovina, China, India, Indonesia, Iraq, Serbia and Viet Nam have received fossil fuel aid every year during the study period.

Table 10. Numbers of donor countries and recipient countries for fossil fuel aid

	total	2011	2012	2013	2014	2015	2016	2017	2018	2019
donor countries	22	15	17	18	18	17	14	11	11	10
recipient countries	82	27	44	46	40	41	36	37	37	24

4.2. Result of Panel Regression Analysis

4.2.1 Effectiveness of Climate Mitigation Aid

Table 11 presents the results of the panel regression analysis. The results of the pooled OLS model are reported in the first column. Results from the random effects model and the fixed effects model are shown in the following two columns (column 2 and column 3). The results of the pooled OLS model are shown for comparison purposes although it is a simple regression of all the data without taking panel data features into account.

The hausman test is used to assess which of the random effects model or the fixed effects model is statistically significant. The p value of hausman test is calculated as 0.0000 which can reject the null hypothesis at a significance level of 0.01. The fixed effects model is therefore preferred to the random effects model.

In the fixed effects model, climate mitigation aid has negative effect on total CO2 emissions and the coefficient is statistically significant. This means the purpose of climate mitigation aid is achieved as planned and “H1. Climate mitigation aid contributes to reducing CO2 emissions” is confirmed.

However, total aid has an influence of increasing total CO2 emissions at a significance level of 0.05. This can be explained by the hypothesis that foreign aid contributes to economic growth, which increases CO2 emissions. However, this result does not support the hypothesis that foreign aid can contribute to reducing

CO2 emissions by emphasizing environment-friendly purposes after passing a certain threshold.

Table 11. Estimated effect of variables on total CO2 emissions

	Total CO2 emissions(ln)		
VARIABLES	Pooled OLS	Random Effects	Fixed Effects
Mitigation Aid(ln)	0.165***	-0.00405	-0.0225***
	(0.0329)	(0.00915)	(0.00772)
Fossil Fuel Aid(ln)	0.103***	-0.00211	-0.00266
	(0.0216)	(0.00571)	(0.00473)
Total Aid(ln)	0.486***	0.0593***	0.0299**
	(0.0399)	(0.0155)	(0.0130)
FDI(ln)	0.382***	0.0265***	0.00551
	(0.0223)	(0.00948)	(0.00798)
GDP per capita(ln)	1.054***	0.762***	0.804***
	(0.0598)	(0.0851)	(0.0836)
Industrial Sector	0.0243***	0.00967***	0.00961***
(% of GDP)	(0.00370)	(0.00214)	(0.00184)
Urban Population	0.00431**	0.0367***	0.0540***
(% of total population)	(0.00218)	(0.00449)	(0.00500)
Worldwide Governance	-0.148***	-0.0155	0.00541
Index	(0.0130)	(0.0102)	(0.00878)
Constant	-5.938***	0.639	-0.163
	(0.475)	(0.582)	(0.551)
Observations	979	979	979
R-squared	0.809		0.417
Number of countries		114	114

Note: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Other control variables such as GDP per capita, industrial sector, and urban population have a statistically significant influence on CO2 emissions as analyzed in Moon (2017), Ikegami and Wang (2021), Isaac Doku et al. (2021), etc.

According to Table 11, fossil fuel aid is not statistically significant for total CO2 emissions. To further investigate the effect of fossil fuel aid, another panel regression was carried out by dividing the recipient countries into two groups. In Table 12, the first group includes countries receiving less than 100 million USD in fossil fuel aid from 2011 to 2019, while the second group includes countries receiving more than 100 million USD in fossil fuel aid for the same period. The first group consists of 91 countries and the second group consists of 22 countries. The regression results show that climate mitigation aid is statistically significant only in the first group countries.

In addition, it is necessary to analyze the effect of fossil fuel aid from China on total CO2 emissions. The average amount of fossil fuel aid project supported by China is 526 million USD, which is enough to differentiate the recipient countries by two groups: one with no fossil fuel aid from China and the other with fossil fuel aid from China. The list of fossil fuel aid projects financed by Chinese ODA is attached in Appendix 2. The regression results presented in the third and fourth columns of Table 12 suggest that climate mitigation aid is effective for the country group that received no fossil fuel aid from China.

To sum up, the results indicate that climate mitigation aid can be effective for reducing CO2 emissions in the recipient countries with little exposure to fossil fuel aid.

Table 12. Estimated effect of variables on total CO2 emissions by country group

	Total CO2 emissions(ln)			
VARIABLES	Fossil fuel aid < 100 million USD	Fossil fuel aid ≥100 million USD	No fossil fuel aid from China	Fossil fuel aid from China
Mitigation Aid(ln)	-0.0281***	-0.00232	-0.0182**	-0.0225
	(0.00913)	(0.0139)	(0.00902)	(0.0155)
Total Aid(ln)	0.0475***	-0.0917**	0.0473***	-0.136***
	(0.0145)	(0.0429)	(0.0146)	(0.0440)
FDI(ln)	0.00203	0.0397*	0.000722	0.0603***
	(0.00887)	(0.0212)	(0.00897)	(0.0209)
GDP per capita(ln)	0.848***	1.257***	0.873***	0.958***
	(0.0938)	(0.198)	(0.0981)	(0.173)
Industrial Sector (% of GDP)	0.00774***	0.0140***	0.00725***	0.0203***
	(0.00206)	(0.00378)	(0.00216)	(0.00330)
Urban Population (% of total population)	0.0596***	-0.00268	0.0524***	0.0316**
	(0.00547)	(0.0126)	(0.00549)	(0.0135)
Worldwide Governance Index	0.0179*	-0.0709***	0.00794	-0.0281
	(0.00977)	(0.0189)	(0.00971)	(0.0210)
Constant	-1.287**	1.154	-0.957	1.285
	(0.636)	(1.147)	(0.644)	(1.099)
Observations	785	184	789	180
R-squared	0.431	0.560	0.417	0.564
Number of countries	91	22	92	21

Note: Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

4.2.2 Effectiveness of Climate Adaptation Aid

Three regression models—the pooled OLS model, the random effects model, and the fixed effects model—are used to examine how climate adaptation aid affects the fluctuation of agricultural output of the recipient countries. Table 13 displays the outcomes of panel regression analysis for each of the three models. The fixed effects model outperforms the random effects model, according to the hausman test.

In the fixed effects model, climate adaptation aid has no statistically significant impact on annual change of total crops. Thus, the regression results reject "H2. Climate adaptation aid contributes to reducing the fluctuation of agricultural output of the recipient countries."

Among control variables, total aid amount and FDI have positive influences on keeping constant volume of total crops. Control variables relating to natural disasters do not demonstrate any significance. Agriculture-related control variables do not either.

As was done in examining the effects of climate mitigation aid, additional regressions were made to further look into the influence of fossil fuel aid. Table 14 displays the results of additional regressions. Climate adaptation aid does not demonstrate any statistical significance for all groups. However, two variables, total aid and FDI, show their significance only for the group with little exposure to fossil fuel aid. This result is in line with regression results of climate mitigation aid as shown in Table 12.

Table 13. Estimated effect of variables on annual change of the total crops

	Annual change of total crops(ln)		
VARIABLES	Pooled OLS	Random Effects	Fixed Effects
Adaptation Aid(ln)	-0.125**	-0.00930	-0.0590
	(0.0572)	(0.0604)	(0.0670)
Fossil Fuel Aid(ln)	0.00970	0.0279	0.0392
	(0.0349)	(0.0380)	(0.0387)
Total Aid(ln)	0.589***	0.372***	-0.283***
	(0.0656)	(0.0816)	(0.106)
FDI(ln)	0.443***	0.284***	-0.134**
	(0.0434)	(0.0550)	(0.0670)
GDP per capita(ln)	-0.116	-0.0993	0.216
	(0.102)	(0.182)	(0.689)
Industrial Sector	-0.00501	0.0105	0.0209
(% of GDP)	(0.00627)	(0.00994)	(0.0151)
Urban Population	0.00431	0.0103	-0.0402
(% of total population)	(0.00366)	(0.00698)	(0.0408)
Worldwide Governance	-0.0928***	-0.108***	-0.0361
Index	(0.0207)	(0.0364)	(0.0715)
Flood	0.0835**	0.0410	-0.0248
(annual frequency)	(0.0354)	(0.0383)	(0.0397)
Drought	0.100	0.108	0.0265
(annual frequency)	(0.168)	(0.147)	(0.139)
Cold Wave	0.240	0.198	0.216
(annual frequency)	(0.183)	(0.168)	(0.164)
Heat Wave	-0.419	-0.167	-0.198
(annual frequency)	(0.430)	(0.407)	(0.394)
Agricultural Import	-13.14***	-9.899***	2.880
(% of GDP)	(1.316)	(1.990)	(2.854)
Agricultural Export	12.21***	7.592***	-3.403
(% of GDP)	(1.417)	(2.350)	(3.564)
Arable Land	0.0211***	0.0311***	0.0563
	(0.00422)	(0.00819)	(0.0516)
Constant	7.253***	8.229***	14.07***
	(0.845)	(1.450)	(4.679)
Observations	959	959	959
R-squared	0.616		0.028
Number of countries		112	112

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 14. Estimated effect of variables on annual change of the total crops by country group

	Annual change of total crops(ln)			
VARIABLES	Fossil fuel aid < 100 million USD	Fossil fuel aid ≥100 million USD	No fossil fuel aid from China	Fossil fuel aid from China
Adaptation Aid(ln)	-0.0358	-0.161	-0.0315	-0.0946
	(0.0769)	(0.149)	(0.0748)	(0.164)
Total Aid(ln)	-0.275**	-0.513	-0.302***	-0.168
	(0.112)	(0.375)	(0.110)	(0.391)
GDP per capita(ln)	0.0367	2.559	0.158	2.298
	(0.768)	(2.038)	(0.790)	(1.822)
FDI	-0.138*	0.0621	-0.158**	0.140
	(0.0717)	(0.212)	(0.0707)	(0.221)
Industrial Sector	0.0218	0.0323	0.0205	0.0251
(% of GDP)	(0.0168)	(0.0377)	(0.0173)	(0.0350)
Urban Population	-0.0244	-0.215	-0.0237	-0.328**
(% of total population)	(0.0442)	(0.130)	(0.0431)	(0.157)
Worldwide Governance	-0.0763	0.0435	-0.0623	-0.0290
Index	(0.0794)	(0.196)	(0.0770)	(0.219)
Flood	0.00322	-0.0376	-0.0341	0.0201
(frequency per year)	(0.0597)	(0.0547)	(0.0483)	(0.0764)
Drought	0.114	-0.413	0.101	-0.472
(frequency per year)	(0.161)	(0.291)	(0.154)	(0.339)
Cold Wave	0.0677	0.304	0.143	0.337
(frequency per year)	(0.243)	(0.222)	(0.210)	(0.289)
Heat Wave	0.732	-0.519	-0.389	0.0687
(frequency per year)	(0.905)	(0.428)	(0.485)	(0.737)
Agricultural Import	3.186	2.304	2.624	2.713
(% of GDP)	(3.010)	(11.73)	(2.933)	(13.26)
Agricultural Export	-2.798	-9.918	-2.653	-10.62
(% of GDP)	(3.701)	(18.75)	(3.640)	(17.84)
Arable Land	0.0549	0.0948	0.0593	0.142
	(0.0548)	(0.184)	(0.0532)	(0.239)
Constant	14.03***	5.056	13.61**	7.715
	(5.373)	(11.78)	(5.348)	(11.33)
Observations	775	184	779	180
R-squared	0.026	0.100	0.032	0.070
Number of countries	90	22	91	21

Note: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4.3. Interpretation

According to the result of panel regression analysis, climate mitigation aid has a negative relation on CO2 emissions while total aid has positive relation with CO2 emissions. This indicates that more emphasis on climate mitigation aid could be a feasible strategy to effectively reduce CO2 emissions in developing countries.

In terms of the relationship between fossil fuel aid and CO2 emissions, the regression results show that climate mitigation aid can be effective in reducing CO2 emissions in recipient countries that have minimal exposure to fossil fuel aid. It suggests that fossil fuel aid might act as a controlling factor for the effectiveness of climate mitigation aid. In addition, the regression results demonstrate that CO2 emissions have a positive relation with GDP per capita, FDI, urbanization and industrialization. It might mean that economic growth induces the increase of CO2 emissions.

Climate adaptation aid does not have a significant effect on keeping the stable volume of agricultural output. It suggests that climate adaptation aid does not contribute to strengthening adaptive capacity of recipient countries. However, the amount of total aid and FDI contribute to stabilizing the fluctuation of agricultural output. Those two variables may represent the openness of the economy. Because large amount of total aid and FDI can be achieved with active communication and exchange of other countries. Thus, it can be inferred that the more open an economy is, the less fluctuating the agricultural output is.

In Table 14, it is notable that positive effect of total aid and FDI on the annual

change of agricultural output can be found in the country group with little exposure to fossil fuel aid. Just as in the analysis of climate mitigation aid, fossil fuel aid may limit the effectiveness of total aid and FDI on the annual change of agricultural output.

Chapter 5. Conclusions

5.1. Summary of Findings

According to OECD, foreign aid has a purpose of promoting and specifically targeting the economic development and welfare of developing countries. Today climate change considerably undermines welfare of developing countries. In this context, it is asserted that foreign aid should reduce negative impact of climate change on recipient countries, thereby pave the way for sustainable economic development.

As the importance of climate aid continues to grow, OECD DAC devised two indicators for measuring how much climate aid are provided. One is climate mitigation aid which aims to stabilize GHG concentrations and the other is climate adaptation aid with a purpose of reducing the vulnerability to the impacts of climate change.

This study tries to investigate whether two types of climate aids achieve their intended results. In this study, CO2 emissions is selected as a dependent variable for the effectiveness of climate mitigation aid and the annual change of agricultural output for the effectiveness of climate adaptation aid. Other control variables are chosen in accordance with the existing literature. Panel datasets are compiled from 2011 to 2019 from various sources such as OECD CRS, WDI and FAOSTAT.

The key findings of the empirical regression are as follows.

First, panel regression analysis shows that climate mitigation aid has a negative relation with CO2 emissions which is consistent with previous studies. This suggests that climate mitigation aid has achieved its goal as intended. Fossil fuel aid has no statistically significant relation with CO2 emissions, however, has a role to limit the effectiveness of climate mitigation aid.

Second, it is found that climate adaptation aid does not show significant relation with the annual change of agricultural output which is a proxy of adaptation capacity. This can be explained in three ways. The first is that climate adaptation aid does not actually work. The second is that climate adaptation aid has not been provided enough to affect the adaptation capacity of the recipient countries. And the third is that the dependent variable does not adequately represent the effectiveness of climate adaptation aid. This result cannot be compared with the existing studies because there are little empirical studies for the effectiveness of climate adaptation aid.

Although climate adaptation aid does not influence the vulnerability of recipient countries, the amount of total aid and FDI show some decreasing effect on the annual change of agricultural output. This suggests that the openness of an economy can contribute to reduce vulnerability to climate change. It is noteworthy that this effect is found in the country groups where little fossil fuel aid was provided.

Overall, this study contributes to previous research in aid effectiveness with the following distinctions. First, this study tries to evaluate the effectiveness of

climate adaptation aid. Unlike the established dependent variable for climate mitigation aid, there has been no agreed proxy for climate adaptation aid. This study sets the annual change of agricultural output as a proxy for climate adaptation aid. Although no statistically significant relation was found between annual change of agricultural output and climate adaptation aid, it is worth noting that this study presented a new indicator, the annual change of agricultural output, for the effectiveness of climate adaptation aid.

Second, this study is different from other studies in adopting a new additional control variable of fossil fuel aid to test its impact on climate change. It is found that fossil fuel aid put some limit on the effectiveness of other variables. The effectiveness of climate mitigation aid was not found in the country group having a large exposure to fossil fuel aid. It implies that fossil fuel aid has a negative indirect impact on the aid effectiveness.

5.2. Limitations

This study is not free of limitations. First, this study has not found a suitable proxy representing the effectiveness of climate adaptation aid. Logically and theoretically the annual change of agricultural output was considered as a proper dependent variable. However, the empirical model indicates that climate adaptation aid does not have a significant impact on the annual change of agricultural output.

Second, due to data unavailability and imperfections, this study does not fully incorporate the influence of China's foreign aid. It is well known that China does

not make its aid-related data public. Based on CGEF from Boston University, fossil fuel aid from China is included in the empirical model of this study. However, other sectors for Chinese aid are not included in the model.

Third, it should be noted that the magnitude of climate aid can be over or under aggregated. Michaelowa and Michaelowa (2011) pointed out the risk that Rio Markers can be over-coded due to politico-economic factors or simple misunderstanding. So-called "Greenwashing" phenomenon can be found in foreign aid. Since OECD CRS dataset is based on the voluntary entry by donor countries, accuracy and objectivity are not guaranteed. More correct method for estimating the exact magnitude of climate aid should be explored.

5.3. Policy Implications and Recommendations

At the last COP27 in Sharm El-Sheikh, Egypt, a new "Loss and Damage" fund for vulnerable countries is agreed. It is a new arrangement for helping developing countries in responding to loss and damage incurred by climate change. A similar attempt was also made in the past. At the COP15 in Copenhagen in 2009, developed countries agreed to mobilize 100 billion USD a year for addressing climate change in developing countries. As such, the responsibility of developed countries has been emphasized in providing financial resources to cope with climate change in developing countries.

Foreign aid, as a traditional means to addressing difficulties of developing countries, recently draws attention in terms of responding to climate change.

However, it is not fully investigated whether climate aid has been effective to addressing climate changes in developing countries. As William Easterly (2006) pointed out, the feeling that “something is being done” by the rich people is not sufficient. It is necessary to set up a proper framework for evaluating climate aid. And based on lessons learned, climate aid should evolve into more effective and more efficient framework.

Recently increased emphasis is placed on the importance of adaptation to climate change given that, except for China and India, developing countries negligibly contribute CO2 emissions on the globe. What most developing countries need might be to strengthen their capabilities to cope with various impact of climate change. In this regard, an appropriate proxy for the effectiveness of climate adaptation aid should be devised.

Bibliography

Arndt, C., & Tarp, F. (2017). Aid, environment and climate change. *Review of Development Economics*, *21*(2), 285-303.

Arvin, B. M., Dabir-Alai, P., & Lew, B. (2006). Does foreign aid affect the environment in developing economies?. *Journal of Economic Development*, *31*(1), 63.

Baker, A., & Mitchell, I. (2020). Projecting Global Emissions for Lower-Income Countries. *Centre for Global Development Note. London: Center for Global Development*.

Bertheau, P., & Lindner, R. (2022). Financing sustainable development? The role of foreign aid in Southeast Asia's energy transition. *Sustainable Development*, *30*(1), 96-109.

Betzold, C., & Weiler, F. (2017). Allocation of aid for adaptation to climate change: Do vulnerable countries receive more support?. *International Environmental Agreements: Politics, Law and Economics*, *17*(1), 17-36.

BOLY, M. (2018). CO2 mitigation in developing countries: The role of foreign aid. *IDEAS Working Paper Series from RePEc*, 2018.

Dhahri, S., & Omri, A. (2020). Does foreign capital really matter for the host country agricultural production? Evidence from developing countries. *Review of World Economics*, 156(1), 153-181.

Doku, I., Ncwadi, R., & Phiri, A. (2021). Examining the role of climate finance in

the Environmental Kuznets Curve for Sub-Sahara African countries. *Cogent Economics & Finance*, *9*(1), 1965357.

Easterly, W. (2006). *The White Man's Burden : Why the West's Efforts to Aid the Rest Have Done so Much Ill and so Little Good / William Easterly.*

Farooq, U. (2022). Foreign direct investment, foreign aid, and CO2 emissions in Asian economies: does governance matter?. *Environmental Science and Pollution Research*, *29*(5), 7532-7547.

Gill, A., Viswanathan, K., & Hassan, S. (2017). Is environmental kuznets curve still relevant? International Journal of Energy Economics and Policy, 7(1), 156-165.

Henderson, K. E., & Sommer, J. (2022). Aiding fossil fuel dependency: a cross-national analysis of energy sector aid, national autonomy, and CO2 emissions in 122 nations. *International Journal of Sociology*, 52(1), 25-48.

Ikegami, M., & Wang, Z. (2021). Does energy aid reduce CO2 emission intensities in developing countries?. *Journal of Environmental Economics and Policy*, 10(4), 343-358.

IPCC (2018) Special Report on the impacts of global warming. Geneva: IPCC

Liu, J., Wang, M., Yang, L., Rahman, S., & Sriboonchitta, S. (2020). Agricultural productivity growth and its determinants in south and southeast Asian countries. *Sustainability* (Basel, Switzerland), 12(12), 4981.

Kablan, S., & Chouard, V. (2022). Does climate aid matter for reducing CO2 emissions? The case of foreign aid for renewable energy. *Applied Economics*, 1-16.

Kaika, D., & Zervas, E. (2013). The Environmental Kuznets Curve (EKC) theory—Part A: Concept, causes and the CO2 emissions case. *Energy policy*, *62*, 1392-1402.

Kasman, A., & Duman, Y. S. (2015). CO2 emissions, economic growth, energy consumption, trade and urbanization in new EU member and candidate countries: a panel data analysis. *Economic modelling*, *44*, 97-103.

Kherallah, M., Beghin, J., Peterson, E., & Ruppel, F. (1994). Impacts of official development assistance on agricultural growth, savings and agricultural imports. *Agricultural Economics,* 11(2), 99-110.

Kim, J. (2019). Sustainable energy transition in developing countries: The role of energy aid donors. Climate Policy, 19(1), 1-16.

Klöck, C., Molenaers, N., & Weiler, F. (2018). Responsibility, capacity, greenness or vulnerability? What explains the levels of climate aid provided by bilateral donors?. *Environmental Politics*, 27(5), 892-916.

Kretschmer, B., Hübler, M., & Nunnenkamp, P. (2013). Does foreign aid reduce energy and carbon intensities of developing economies?. *Journal of International Development*, *25*(1), 67-91.

Mahalik, M. K., Villanthenkodath, M. A., Mallick, H., & Gupta, M. (2021). Assessing the effectiveness of total foreign aid and foreign energy aid inflows on environmental quality in India. *Energy Policy*, 149, 112015.

Michaelowa, A., & Michaelowa, K. (2007). Climate or development: Is ODA diverted from its original purpose?. *Climatic change*, 84(1), 5-21.

Michaelowa, A., & Michaelowa, K. (2011). Coding Error or Statistical Embellishment? The Political Economy of Reporting Climate Aid. *World Development*, 39(11), 2010-2020.

OECD (2009). Integrating Climate Change Adaptation into Development Cooperation. Paris: OECD

OECD (2011). Handbook on the OECD-DAC Climate Markers. Paris: OECD

OECD (2022a), Climate Finance Provided and Mobilised by Developed Countries in 2016-2020. Paris: OECD

OECD (2022b). Climate-related Official Development Assistance: A snapshot, Paris: OECD

Regan, P., Kim H., & Maiden E. (2017). Climate Change, Adaptation, and Agricultural Output, University of Notre Dame

Sarkar, M. S. K., Sadeka, S., & Sikdar, M. M. H. (2018). Energy consumption and CO2 emission in Bangladesh: trends and policy implications. *Asia Pacific Journal of Energy and Environment*, *5*(1), 41-48.

Sharma, K., Bhattarai, B., & Ahmed, S. (2019). Aid, growth, remittances and carbon emissions in Nepal. *The Energy Journal*, *40*(1).

Weiler, F., Klöck, C., & Dornan, M. (2018). Vulnerability, good governance, or donor interests? The allocation of aid for climate change adaptation. *World Development*, *104*, 65-77.

Weiler, F., & Sanubi, F. A. (2019). Development and climate aid to Africa: comparing aid allocation models for different aid flows. *Africa spectrum*, *54*(3), 244-267.

World Bank (2017) World Development Indicators 2017. Washington, DC: World Bank.

Wooldridge, J. (2020). *Introductory Econometrics : A Modern Approach / Jeffrey M. Wooldridge.*

강문수, 정민지, & 박규태. (2022). 기후 변화가 아프리카 농업 및 분쟁에 미치는 영향과 시사점. *세계지역전략연구, 21-05*

김재혁, 신동현, & 조하현. (2015). 패널 이항모형을 이용한 환경쿠즈네츠곡선(EKC)의 결정요인 분석. *응용경제*, *17*(4), 105-137.

문승민. (2017). 한국의 기후변화 완화 원조는 수원국의 이산화탄소 배출 감축에 기여하는가?: 환경 쿠즈네츠 곡선과 거버넌스의 관점을 중심으로. *국제개발협력연구*, 9(2), 29-56.

배유진, & 유태환. (2021). 재생에너지 공적개발원조(ODA)가 이산화탄소 감축에 미치는 영향. *환경정책*, *29*(3), 175-199.

Appendix 1. List of Recipient Countries

Country Name	Income Group	Country Name	Income Group
Afghanistan	LDC	China (People's Republic of)	UMIC
Albania	UMIC	Colombia	UMIC
Algeria	UMIC	Comoros	LDC
Angola	LDC	Congo	LMIC
Antigua and Barbuda	UMIC	Costa Rica	UMIC
Argentina	UMIC	Côte d'Ivoire	LMIC
Armenia	LMIC	Cuba	UMIC
Azerbaijan	UMIC	Democratic Republic of the Congo	LDC
Bangladesh	LDC	Djibouti	LDC
Belarus	UMIC	Dominica	UMIC
Belize	UMIC	Dominican Republic	UMIC
Benin	LDC	Ecuador	UMIC
Bhutan	LDC	Egypt	LMIC
Bolivia	LMIC	El Salvador	LMIC
Bosnia and Herzegovina	UMIC	Ethiopia	LDC
Botswana	UMIC	Fiji	UMIC
Brazil	UMIC	Gabon	UMIC
Burkina Faso	LDC	Gambia	LDC
Burundi	LDC	Georgia	LMIC
Cambodia	LDC	Ghana	LMIC
Cameroon	LMIC	Grenada	UMIC
Central African Republic	LDC	Guatemala	LMIC
Chad	LDC	Guinea	LDC
Chile	UMIC	Guinea-Bissau	LDC

Country Name	Income Group	Country Name	Income Group
Guyana	UMIC	Namibia	UMIC
Honduras	LMIC	Nepal	LDC
India	LMIC	Nicaragua	LMIC
Indonesia	LMIC	Niger	LDC
Iran	UMIC	Nigeria	LMIC
Iraq	UMIC	North Macedonia	UMIC
Jamaica	UMIC	Pakistan	LMIC
Jordan	LMIC	Panama	UMIC
Kazakhstan	UMIC	Papua New Guinea	LMIC
Kenya	LMIC	Paraguay	UMIC
Kyrgyzstan	LMIC	Peru	UMIC
Lao People's Democratic Republic	LDC	Philippines	LMIC
Lebanon	UMIC	Rwanda	LDC
Lesotho	LDC	Saint Vincent and the Grenadines	UMIC
Madagascar	LDC	Sao Tome and Principe	LDC
Malawi	LDC	Senegal	LDC
Malaysia	UMIC	Serbia	UMIC
Maldives	UMIC	Sierra Leone	LDC
Mali	LDC	Somalia	LDC
Mauritania	LDC	South Africa	UMIC
Mauritius	UMIC	Sri Lanka	LMIC
Mexico	UMIC	Sudan	LDC
Montenegro	UMIC	Suriname	UMIC
Morocco	LMIC	Syrian Arab Republic	LMIC
Mozambique	LDC	Tajikistan	LMIC
Myanmar	LDC	Tanzania	LDC

Country Name	Income Group
Thailand	UMIC
Timor-Leste	LDC
Togo	LDC
Turkey	UMIC
Turkmenistan	UMIC
Uganda	LDC
Ukraine	LMIC
Uruguay	UMIC
Uzbekistan	LMIC
Vanuatu	LMIC
Viet Nam	LMIC
Yemen	LDC
Zambia	LDC
Zimbabwe	LDC

Appendix 2. The list of fossil fuel aid projects financed by Chinese ODA

Year	Recipient Country	Amount (M USD)	Sector	Project Title
2019	Brazil	714	Oil	Petrobras Line of Credit
2018	Sri Lanka	1,000	Gas	Hambantota Natural Gas-Powered Electrical Station
2018	Mongolia	52	Coal	Expansion Project of Erdenet Thermal Power Station
2017	Bosnia	732	Coal	Tuzla 7 Lignite Power Plant
2017	Indonesia	700	Coal	Indonesia Morowali Industrial Park Captive Coal-Fired Power Plant
2017	Uzbekistan	90	Coal	Modernizing Baisun and Shargun coal deposits
2016	Bangladesh	2,000	Coal	Payra 1320 (2x660) MW Thermal Power Plant Project
2016	Zimbabwe	998	Coal	Hwange Thermal Power Station Expansion (Unit 7-8)
2016	Brazil	900	Oil	Unspecified Oil Export; Debt Financing Petrobras
2016	Indonesia	98	Coal	Cilacap Sumber Power Station (Phase II)
2016	Maldives	75	Oil	STELCO 5th Power Development
2015	Indonesia	1,300	Coal	Bangko Tengah, aka South Sumatra 8 or Sumsel-8
2015	Eritrea	99	Oil	Hirgigo thermal power plant upgrade
2014	Indonesia	373	Coal	Pangkalan Susu Unit 3 & 4 Coal Fired Power Plant
2014	Indonesia	241	Coal	Takalar Steam Coal-Fired Power Plant (200MW)
2014	Serbia	608	Coal	Kostolac B2 (retrofit), Kostolac B3 (new), and Expansion of Drmno Mine
2014	Tajikistan	332	Coal	Dushanbe-2 Combined Heat and Power (CHP) Plant
2014	Morocco	300	Coal	Jerada Power Station Extension

2013	Mexico	1,000	Oil	Vessels and Offshore Oilfield Equipment
2013	Kyrgyzstan	386	Coal	Bishkek Power Station Units 12 and 13
2013	Bangladesh	129	Coal	Kodda Power Plant
2013	Uzbekistan	74	Gas	Gas Network Modernization Project
2012	Tanzania	1,200	Gas	Mtwara–Dar es Salaam Natural Gas Pipeline
2012	Uzbekistan	166	Coal	Angren Power Station with Uzbekenergo
2012	Kazakhstan	200	Oil	On-lending for KazMunayGas Atyrau Refinery, Advanced Oil Refining
2012	Indonesia	133	Coal	Parit Baru Power Station
2011	Angola	2,000	Oil	Sonangol Development
2010	Vietnam	1,000	Coal	Duyen Hai 1
2010	Chad	330	Oil	N'Djamena Refinery and Pipeline
2010	Serbia	293	Coal	Kostolac B Power Plant, Phase 1
2010	Pakistan	155	Gas	Guddu Combined Cycle Power Plant
2010	Indonesia	126	Coal	Tanjung Kasam Power Station with Sinosure
2010	Bolivia	60	Oil	Equipment Procurement
2010	Turkmenistan	31	Oil	Oil, Gas, and Pipeline Equipment Acquisition for Turkmenneft

Source: CGEF from Boston University

국문초록

서울대학교 행정대학원
행정학 전공
김윤희

국제사회에서는 대외원조가 개발도상국의 기후변화 대응노력에 기여해야 한다는 주장이 꾸준히 제기되어 왔다. 1998년 OECD 개발원조위원회는 기후변화 대응과 관련된 대외원조 규모를 측정하기 위해 리우 마커를 도입했다. 리우 마커는 기후 관련 원조를 기후 완화 원조와 기후 적응 원조의 두 가지 유형으로 나누었다.

본 연구의 목적은 두 가지 유형의 기후원조가 의도한 성과를 달성하였는지를 알아보는 것이다. 본 연구에서는 기후완화원조의 효과에 대한 종속변수로 CO2 배출량을 선정하고, 기후적응원조의 효과에 대해서는 농업생산량의 변동성을 선정하였다. 본 연구는 화석연료 관련 원조를 통제변수로 추가했다는 점에서 다른 연구들과 차별화된다. 패널 데이터는 2011년부터 2019년까지 115개국을 대상으로 구축되었다.

패널회귀분석의 주요 결과는 다음과 같다. 첫째, 기후완화원조는 이산화탄소 배출을 감소시키는데 영향을 미친다. 화석연료원조는 CO2 배출과 통계적으로 유의미한 관계는 없으나, 기후완화원조의 효과를 제한한다. 둘째, 기후적응원조는 개도국의 적응역량을 대표하는 농업생산량의 변동성과 유의미한 관계를 보이지 않는다. 총 원조액과 FDI는 농업생산량의 변동성을 완화하는데 영향을 미치나, 화석연료원조를 많이 받는 수원국에서는 그 효과가 발견되지 않는다.

최근 기후변화 대응 측면에서 대외원조가 주목받고 있다. 이에 기후원조를 평가하기 위한 적절한 시스템이 마련될 필요가 있다. 특히, 기후적응원조의 효과를 평가하기 위한 체계적인 프레임워크가 설계되어야 할 것이다.

주제어 : 기후완화원조, 기후적응원조, 원조효과성, 화석연료원조, CO2 배출량
학번 : 2020-24574