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International transfers for climate justice: determinants, objectives and impacts of climate finance

Lucille Neumann Noel

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International Transfers for Climate Justice: Determinants, Objectives and Impacts of Climate Finance

*Transferts internationaux pour la justice climatique :
déterminants, objectifs et impacts des financements climatiques*

Thèse de doctorat de l'université Paris-Saclay

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Thèse soutenue à Paris-Saclay, le 19 septembre 2023 par

Lucille NEUMANN NOEL

Composition du Jury

Membres du jury avec voix délibérative

Mireille CHIROLEU-ASSOULINE Professeure, Université Paris 1 Panthéon-Sorbonne	Présidente
Inmaculada MARTÍNEZ-ZARZOSO Professeure, University of Göttingen (Allemagne)	Rapporteuse & Examinatrice
Philippe QUIRION Directeur de Recherche, CNRS (EHESS)	Rapporteur & Examinateur
Liam F. BEISER-MCGRATH Maître de Conférences, LSE (Royaume-Uni)	Examinateur
Camélia TURCU Professeure, Université d'Orléans	Examinatrice

Titre : Transferts internationaux pour la justice climatique : déterminants, objectifs et impacts des financements climatiques

Mots clés : Finance Climatique, Justice Climatique, Coopération Internationale, Commerce International, Politiques Climatiques, Économie Politique

Résumé : Du fait du changement climatique, les pays en développement font face à une vulnérabilité environnementale et économique accrue. En termes d'émissions cumulées, ils sont pourtant les moins responsables de la crise traversée aujourd'hui. Les transferts climatiques publics internationaux par les pays développés sont un instrument de la coopération internationale pour à la fois aider les pays en développement à mettre en œuvre leurs politiques climatiques et répondre à leur demande de justice climatique. Lors de la COP15 (2009), les pays développés se sont engagés à mobiliser 100 milliards USD dans ce but. En attendant la révision de cet engagement lors des négociations de 2025, cette thèse propose une étude approfondie des transferts

climatiques publics internationaux depuis 2000.

Le premier chapitre s'intéresse aux déterminants de l'allocation des transferts climatiques et plus particulièrement aux intérêts commerciaux des pays donateurs. Le deuxième chapitre évalue la surestimation des transferts climatiques par les pays donateurs et leurs motivations politiques. Pour cela, nous analysons un large échantillon de projets climatiques déclarés par les pays donateurs. Le troisième et dernier chapitre évalue l'efficacité des transferts climatiques en matière d'atténuation du changement climatique. Il estime l'effet des transferts sur les émissions de CO₂ des pays receveurs.

Title : International Transfers for Climate Justice: Determinants, Objectives and Impacts of Climate Finance

Keywords : Climate Finance, Climate Justice, International Cooperation, Trade, Climate Policies, Political Economy

Abstract : In the context of climate change, developing countries are facing increasing environmental and economic vulnerabilities while bearing the least historical responsibilities. International public climate transfers from developed countries are an instrument of international cooperation to both assist developing countries in implementing climate policies and address their climate justice demand. At COP15 (2009), developed countries pledged to mobilise USD 100 billion per year to this end. As this pledge is set to be scaled up in 2025, this dissertation offers an extensive review of international public climate transfers since 2000. It assesses the challenges surrounding them and

their effectiveness.

The first chapter focuses on the determinants of climate transfer allocation and, specifically, the bilateral trade interests of donor countries. The second chapter assesses the overestimation of climate transfers by donor countries and the political motivations that can explain it. It does so by analysing a large sample of climate projects self-reported by donor countries. The third and final chapter evaluates the effectiveness of climate transfers in terms of climate change mitigation. It estimates the effect of climate transfers on the recipient countries' carbon emissions.

Cette thèse a été encadrée par Basak BAYRAMOGLU (INRAE, PSAE) et Jean-François JACQUES (Université Gustave Eiffel, ERUDITE) et financée par l'INRAE, l'Université Paris-Saclay et l'Université Paris-Dauphine.

Résumé

Face à la crise climatique et ses impacts inégaux sur les pays, les transferts climatiques des économies développées en direction des économies en développement se sont imposés comme un des instruments de la politique climatique internationale. L'objectif de ces transferts est double. Ils doivent à la fois lutter contre le changement climatique en finançant la transition des pays receveurs et répondre aux enjeux de justice climatique. Cette notion fait référence à la responsabilité différenciée des pays dans le processus du changement climatique et à l'inégale répartition de son impact. En effet, les pays développés sont les plus grands émetteurs historiques de gaz à effet de serre à l'origine du changement climatique, pourtant, ce sont les pays en développement qui en supportent les conséquences les plus sévères tout en disposant de ressources limitées pour s'en protéger.

Cette thèse rassemble trois chapitres sur les transferts climatiques publics des pays développés vers les pays émergents et en développement. Elle propose ainsi une évaluation approfondie de la finance climatique internationale, depuis les enjeux politiques et commerciaux de son allocation à son efficacité.

Le premier chapitre, publié avec Basak Bayramoglu, Jean-François Jacques et Clément Nondoncelle, se concentre sur les motivations commerciales de l'allocation d'aides climatiques bilatérales par les pays donateurs.¹ Nous y proposons un modèle théorique simple afin d'illustrer les enjeux commerciaux qui sous-tendent l'octroi d'aide climatique. Ce modèle guide ensuite notre analyse empirique et nous permet d'estimer une relation causale entre l'aide climatique bilatérale et le commerce.

Notre modèle théorique présente d'abord deux effets positifs de l'aide climatique sur le commerce bilatéral via l'amélioration des termes de l'échange et l'augmentation du revenu du

¹*International Climate Aid and Trade, Journal of Environmental Economics and Management, 2023, vol.117*

pays receveur. L'aide climatique permet de protéger la structure productive du pays receveur face aux impacts du changement climatique et d'améliorer sa productivité par des transferts technologiques. Ce gain de productivité permet une amélioration des termes de l'échange avec un effet positif sur les exportations du pays receveur vers le pays donateur. En protégeant la capacité de production du pays receveur, l'aide climatique impacte positivement son revenu et donc sa capacité à importer depuis le pays donateur. Notre modèle pose l'hypothèse que l'allocation de l'aide climatique s'appuie sur des relations commerciales pré-existantes liées aux relations historiques et géopolitiques des pays et menacées par les conséquences du changement climatique. Les pays donateurs transfèrent de l'aide climatique à leurs partenaires commerciaux afin de maintenir leurs échanges par les mécanismes précédemment décrits. Notre modèle prédit donc une relation réciproque simultanée entre l'aide climatique et les exportations et importations du pays donateur vers et depuis le pays receveur.

L'analyse empirique vise à évaluer les motivations commerciales dans l'allocation de l'aide climatique bilatérale par l'estimation de l'impact des exportations et importations du pays donateur sur son allocation d'aide climatique. Pour cela, nous utilisons la base de données Creditor Reporting System (CRS) Rio Markers de l'OCDE qui suit les flux d'aide climatique entre 2002 et 2017 et la base BACI du CEPII rassemblant les flux de commerce au niveau produit. D'après nos résultats théoriques, estimer l'impact causal des relations commerciales sur l'allocation d'aide climatique implique de corriger pour les problèmes d'endogénéité causés par la causalité inverse de l'aide sur le commerce. Nous estimons donc un modèle de panel avec effets fixes donateur, receveur et année à l'aide de la méthode des variables instrumentales avec estimation des moindres carrés en deux étapes (IV-2SLS). Nous construisons un instrument shift-share pour l'aide suivant la contribution de [Bartik \(1991\)](#). Notre stratégie instrumentale utilise des variations de demande mondiale au niveau produit construites sur les schémas commerciaux passés pour identifier les variations du commerce non corrélées avec les décisions des pays donateurs et receveurs. Conformément à notre hypothèse selon laquelle l'octroi de l'aide repose sur des relations commerciales préexistantes fondées sur des facteurs historiques et géopolitiques, notre spécification inclut un ensemble de variables de contrôle bilatérales (liens coloniaux, distance géographique, etc.) ainsi que des variables liées aux besoins et aux mérites du bénéficiaire.

Nos résultats empiriques montrent que les exportations des pays donateurs ont un effet significatif et positif sur les transferts d'aide climatique. Nous trouvons ainsi une élasticité de l'aide climatique proche de 0,3 pour les exportations. Toutefois, nous ne trouvons pas d'impact significatif des importations des pays donateurs sur leur allocation d'aide climatique. Nos résultats sont robustes à différentes spécifications des variables de contrôles, aux potentielles variables

omises et aux changements dans les effets fixes utilisés. Nos résultats ne sont pas non plus sensibles aux violations mineures de la restriction d'exclusion requise pour l'inférence causale, que nous évaluons en suivant la méthodologie de [Borusyak and Hull \(2020\)](#).

L'originalité de notre approche réside dans l'association de deux méthodologies : nous développons d'abord un modèle théorique sur les relations entre le commerce et l'allocation de l'aide climatique, ce modèle guidant ensuite notre analyse empirique. Nous étudions ainsi les relations entre l'aide climatique et le commerce en proposant un portrait complet des effets du commerce. Nous mettons en évidence deux mécanismes économiques à l'origine de deux effets distincts du commerce sur l'aide climatique, que nous estimons ensuite empiriquement. Le fait que les intérêts commerciaux affectent l'allocation de l'aide climatique a des conséquences environnementales et politiques globales. Tout d'abord, en la détournant des pays où elle est le plus nécessaire, cela peut limiter son efficacité. Cela peut également nuire à la confiance déjà fragile des pays en développement dans la coopération internationale en matière de climat.

Suite à la vive contestation des pays en développement sur le montant réel des financements climatiques reçus et en l'absence d'une définition et comptabilisation internationalement reconnues, nous avons décidé d'examiner le contenu des projets déclarés comme étant climatiques. Cette analyse a été menée dans deux articles, regroupés ici dans le deuxième chapitre de cette thèse. Ces travaux ont été réalisés avec Basak Bayramoglu et Aliette Dequet, et l'un a été publié dans la *Revue Française d'Économie*.²

Dans ce second chapitre, nous proposons une évaluation automatisée et à large échelle du contenu des projets d'aide climatique bilatéraux déclarés par les pays donateurs auprès de l'OCDE. Nous utilisons la base de données CRS Rio Markers de l'OCDE et notre analyse porte sur 63 195 projets climatiques déclarés entre 2002 et 2018. Nous évaluons leur contenu climatique à l'aide d'une recherche de mots-clés programmée en Python. Cela nous permet d'identifier deux types d'erreurs en fonction des différents objectifs de l'aide climatique. La première erreur est la sur-déclaration de l'aide climatique qui consiste à déclarer un projet non-climatique comme ayant un objectif climatique. La seconde erreur est la confusion entre les objectifs d'atténuation et d'adaptation. Cette distinction nous permet de calculer plusieurs ratios d'erreurs : le ratio de sur-déclaration pour l'aide climatique totale et les ratios d'erreurs de codification de l'aide à l'atténuation et de l'aide à l'adaptation.

Ce chapitre propose également une analyse descriptive approfondie de la sur-déclaration

²Neumann Noel, L. and Bayramoglu, B. (2022): Where Do Donor Countries Stand in Climate Aid Allocation and Reporting?, *Revue Française d'Économie*, vol. XXXVII.

de l'aide climatique par les pays donateurs, en fonction de la destination de l'aide, de ses objectifs et à travers le temps. Nous constatons ainsi que près de la moitié (48,6 %) des projets déclarés comme climatiques n'ont en réalité aucun lien avec les enjeux climatiques. En outre, 67,8% des projets d'adaptation et 64,3% des projets d'atténuation ont été mal codés, c'est-à-dire qu'ils n'ont pas de lien avec les enjeux climatiques ou ont été codés sous le mauvais objectif. Nous montrons que tous les pays donateurs sur-déclarent leurs projets d'aide climatique, même les plus petits, bien qu'il existe une grande hétérogénéité entre les pays donateurs dans les comportements de sur-déclaration. Il semble toutefois y avoir une légère diminution de cette sur-déclaration depuis 2015.

Conformément à la littérature en économie politique, nous suggérons plusieurs explications potentielles à cette sur-déclaration. Celles-ci sont liées à la stratégie électorale, la réputation internationale et la contrainte budgétaire du pays donateur. Sur la base de ces hypothèses et à l'aide d'un modèle de panel non-linéaire, nous estimons les déterminants de la sur-déclaration de l'aide climatique par les pays donateurs. Nous montrons que le fait de déclarer à tort des projets de développement comme répondant aux enjeux climatiques pourrait être une stratégie électorale pour les pays donateurs ayant des contraintes budgétaires plus fortes et des populations soucieuses de l'environnement. Cela leur permettrait de contribuer officiellement à l'objectif des 100 milliards de dollars annuels de la COP15 sans pour autant ouvrir de nouvelles lignes de financement.

Après avoir étudié les déterminants de l'allocation des transferts climatiques et le contenu des projets financés, le dernier chapitre de cette thèse évalue l'efficacité de la finance climatique publique. Cette analyse se concentre sur l'objectif d'atténuation du changement climatique. Elle vise à estimer si les transferts climatiques ont permis une réduction des émissions de CO₂ des pays bénéficiaires. Ce chapitre contribue tout d'abord à la littérature sur la finance climatique et la coopération internationale en discutant des canaux potentiels par lesquels les transferts climatiques pourraient avoir un impact sur les émissions de CO₂ des pays bénéficiaires. Il contribue également à la littérature sur l'aide au développement en examinant les défis méthodologiques auxquels sont confrontés les chercheurs empiristes dans l'estimation de l'effet agrégé de l'aide.

Sur la base de ces analyses, nous proposons trois stratégies empiriques alternatives pour estimer l'impact des transferts climatiques sur les émissions de CO₂ des pays receveurs. Nous utilisons la base de données *climate-related development finance* récemment publiée par l'OCDE ainsi que la base de données CRS Rio Markers de l'OCDE. Notre analyse couvre la période

2000-2020. Nous évaluons l'efficacité des différents types de financement public pour le climat en fonction de la source du financement, de l'objectif climatique et du type de financement. Les données d'émissions de CO₂ proviennent de la base "Our World in Data (OWID) CO₂ and Greenhouse Gas Emissions Dataset" (Ritchie et al., 2020), dont la principale source est le Global Carbon Project.

Les deux premières stratégies empiriques s'appuient sur des modèles de panel et des méthodes d'estimation qui traitent les potentiels problèmes d'endogénéité de la finance climatique. Les transferts climatiques pourraient en effet favoriser les pays qui ont fait de plus grands efforts d'atténuation. Ils pourraient également être dirigés en priorité vers les pays dont les émissions sont plus élevées, parce que leurs besoins d'atténuation sont plus pressants ou pour bénéficier de coûts marginaux de l'atténuation plus faibles. Ceci impliquerait une relation réciproque entre les transferts climatiques et le niveau d'émissions des pays receveurs.

Dans nos modèles de panel, nous utilisons une somme mobile sur trois ans des transferts climatiques pour mieux capturer leur temps d'action et tenir compte du problème de volatilité des transferts. Un soutien constant sur plusieurs années est ainsi plus susceptible d'avoir un effet que des transferts ponctuels. Nous estimons d'abord un modèle de panel simple avec des effets fixes pays receveur et année en utilisant la méthode IV-2SLS et un instrument shift-share. Notre instrument correspond aux transferts climatiques prédits. Il attribue les variations exogènes dans l'allocation totale de financements climatiques des donateurs - c'est-à-dire les variations non-corrélées aux caractéristiques du pays receveur - aux pays bénéficiaires en fonction de leur importance relative passée dans l'allocation des donateurs. Suivant la littérature sur l'effet de l'aide au développement sur les émissions de CO₂ nous estimons ensuite un modèle de panel dynamique à l'aide de la méthode des moments généralisés (GMM) en système.

Enfin, ce chapitre propose une nouvelle stratégie empirique pour l'analyse macroéconomique de l'efficacité de l'aide et des transferts publics en appliquant les récentes techniques d'évaluation de l'impact des politiques publiques. Notre troisième stratégie empirique propose une approche par doubles différences (DiD) à plusieurs périodes et adoption échelonnée du traitement. La difficulté réside dans l'identification d'un contre-factuel. La plupart des pays en développement ayant reçu, au moins une fois, une forme de financement climatique public, nous ne disposons pas d'un groupe de contrôle de pays n'ayant jamais reçu de transferts climatiques. Nous comparons donc petits et larges bénéficiaires de transferts climatiques à l'aide d'un seuil relatif en utilisant les estimateurs DiD robustes à l'hétérogénéité de Callaway and Sant'Anna (2021). Cette stratégie tient compte des effets hétérogènes des transferts climatiques liés au moment et à la durée de leur allocation.

Dans nos trois stratégies empiriques, les résultats de nos estimations convergent vers une absence d'effet des transferts climatiques publics sur les émissions de CO₂ des pays receveurs ainsi que sur leur intensité énergétique. Ces résultats restent valables lorsque l'analyse est conduite sur différents sous-groupes de pays bénéficiaires, à savoir les principaux bénéficiaires de financements climatiques, les principaux émetteurs de CO₂ et des sous-groupes sur la base du niveau de revenu. L'absence d'effet significatif vaut également pour les différentes mesures des transferts climatiques utilisées.

Une conclusion générale clôture cette thèse. Elle en résume les principaux résultats et discute de leurs implications politiques. Elle explicite également les limites de la thèse et donne un aperçu des futures pistes de recherche.

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“I got to have a plan? really? I can’t just be proactive with pep?”

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General Introduction

“Sorry to barge in. I’m afraid we have a slight apocalypse.”

Buffy the Vampire Slayer – S7E10
Bring on the Night (2002)

As early (or late) as 1990 at the 2nd World Climate Conference held in Geneva, financial and technology transfers from developed countries to developing economies were identified as a potential tool to address both the climate change crisis and the demand for climate justice (UN, 1990).³ Climate justice relates to the fair sharing of efforts in addressing the climate change crisis. This equity issue exists both at the international level, i.e. burden sharing among countries and territories, and at the national level between the different components of a society. Climate justice considerations are rooted in the differentiated responsibilities in causing climate change as opposed to the differentiated bearing of its impacts and the unequal resources to respond to it.

A first motivation for these international climate transfers is the need to foster mitigation policies in developing countries. Though most of the highest emitters of greenhouse gas (GHG) emissions are developed countries, it is also necessary for developing and emerging countries to engage in a sustainable development path in terms of emissions. Several of them are fast-growing economies with as fast-growing trends in GHG emissions. For instance, representing

³*“Recognizing further that the principle of equity and the common but differentiated responsibility of countries should be the basis of any global response to climate change, developed countries must take the lead. [...] To this end, there is a need to meet the requirement of developing countries, that adequate and additional financial resources be mobilized and the best available environmentally-sound technologies be transferred expeditiously on a fair and most favourable basis.”* (Ministerial Declaration of the Second World Climate Conference, I.5, UN (1990), p.16-17)

almost a fifth of the world population, China is the largest emitter of GHG. It represented 24.23% of global emissions in 2020 and its emissions have increased by 24,5% between 2010 and 2020 (Climate Watch, 2022). Other examples include India (6,76% of global emissions), Indonesia (3,94% of global emissions) and Turkey (0,92% of global emissions), whose emissions have increased by respectively 22,87%, 37% and 45,15% between 2010 and 2020 (Climate Watch, 2022). Ecological transition and net zero emissions should therefore be a common target for both developed and developing economies, and commitments are now being taken on both sides. For instance, during the 26th Conference of Parties (COP) in Glasgow in 2021, India pledged to attain net zero emissions by 2070. But financial resources are lacking to fund the transition in lower and middle-income countries, therefore justifying the mobilisation of financial assistance from higher-income countries.

This transfer of resources is also compelled by the principle of climate justice. The ministerial declaration of the 2nd World Climate Conference posits the different responsibilities of countries in the climate change crisis, with developed countries being the largest historical emitters and therefore the most responsible (UN, 1990). Yet, developing countries bear the most considerable impacts of climate change. Their vulnerability to climate change relates to socio-economic fragilities, institutional impediments as well as geographic situations (OECD, 2022a). Arid and semi-arid regions, small island states and low-coastal regions are the most impacted by global warming, desertification, and sea-level rise. Lower-income countries do not have the resources to protect themselves from the climate-change-related increase in natural disasters, which primarily target tropical regions. This stark imbalance in responsibilities and consequences needs to be addressed through climate transfers.

This dissertation questions the capacity of international public climate finance to address the climate change crisis. To do so, it examines the different issues regarding its allocation and effectiveness. In this introduction, we present the main facts and challenges surrounding international public climate finance, as well as the historical background of its implementation. This general overview of international climate finance gives us the necessary perspective to better understand the following chapters of this dissertation.

In Section 1, we start by detailing what the notion of international climate finance covers and why it is a necessary tool for global climate cooperation. We then review the history of international climate negotiations through the lens of climate justice in Section 2. In Section 3, we describe climate finance allocation based on the data used in this dissertation. Finally, Section 4 presents and summarises the three chapters of this dissertation.

1 Definition and imperatives of international climate finance

International climate finance is an umbrella term that covers all transboundary financial flows that address climate-related objectives. Those objectives are the *mitigation* of GHG emissions and the *adaptation* of societies to climate change impacts. International climate finance can be further divided according to the providing source and the financial instruments used. First, we distinguish between public or private finance. Both can be concessional (grants and concessional financial instruments) or non-concessional, meaning loans and financial instruments at market rates and conditions. Public international climate finance can be either bilateral, provided directly by donor countries, or multilateral, provided by multilateral agencies and development banks. This dissertation focuses on international *public* climate finance from developed countries and multilateral agencies towards developing countries in the context of intergovernmental climate cooperation and climate justice. Public climate finance better assesses governmental efforts in this matter. Public providers are also the main source of climate finance for developing and emerging economies (Climate Policy Initiative, 2022; Songwe et al., 2022).⁴ It is worth noting that there is no universally accepted accounting method for climate finance flows, and eligibility criteria may vary from one institution to another (Shishlov and Censkowsky, 2022).

International public climate transfers to developing countries are first motivated by the necessity to fund mitigation and adaptation policies in countries most vulnerable to climate change and with limited financial and institutional resources. It also addresses the fairness issue of the imbalance between responsibilities and vulnerabilities in the climate change crisis.

Climate change is a global public bad caused by anthropogenic GHG emissions that thus requires an also global response. Altogether, developing and emerging economies represented around 72% of global GHG emissions in 2020.⁵ According to Songwe et al. (2022), they will represent most of the world's future incremental energy demand because of their development and energy access needs. Fostering decarbonised development paths without delay is, therefore,

⁴Public climate finance represented 51% of global climate finance in 2019/2020, whereas it amounted to 86% in Sub-Saharan Africa, 63% in South Asia, 60% in Central Asia and Eastern Europe, 56% in the Middle East and North Africa and 51% in Latin America and the Caribbean. These figures include domestic as well as international climate finance. Domestic climate finance represented less than half of total climate finance in the cited regions in 2019/2020 (Climate Policy Initiative, 2022; Songwe et al., 2022).

⁵Calculations based on Climate Watch GHG emissions (including land use, land-use change and forestry (LU-LUCF)) data and the United Nations World Economic Situation and Prospects country classification (UN, 2023)

a necessity to mitigate global GHG emissions and reach the net-zero target. Furthermore, mitigation policies are also development-related policies. For instance, unsustainable use of land and natural resources limits both carbon capture and storage capacity as well as local communities' livelihoods. GHG emissions and carbon-intensive production also cause local pollution issues with severe health-related impacts. According to the 2022 Lancet Countdown report (Romanello et al., 2022), in 2020 in India, more than 3.3 million persons died due to exposure to particulate matter from fossil fuel combustion.

Developing countries are also particularly vulnerable to climate change consequences, both physically and institutionally (OECD, 2022a). Their geographic situation place many of them at the forefront of these consequences. Climate change translates into temperature and sea-level rise, more frequent and severe natural catastrophes and extreme meteorological events (drought, wildfires, tropical storms, extreme precipitation and flooding), biodiversity loss and deterioration of ecosystem structure (soil erosion, ocean acidification) (IPCC (2023), B.1.1, B.1.2). Developing countries are not a monolith but many are located in the southern hemisphere and already subject to warmer climate and water scarcity. They are therefore particularly vulnerable to temperature increase and heatwaves with direct heat-related health consequences and deteriorated agricultural production (IPCC (2023), B.1.1). For instance, in spring 2022, India had recorded its first heatwave as early as of March and temperatures reached up to 49.2°C (Hrishikesh and Sebastian, 2022). The 2022 Lancet Countdown report (Romanello et al., 2022) estimates a 55% rise in deaths due to extreme heat between 2000-2004 and 2017-2021 in India. Globally, they find that extreme heatwaves in 2020 are associated with 98 million more people suffering from food insecurity than annually between 1981 and 2010 (Romanello et al., 2022). Furthermore, small island developing states and coastal areas with aquaculture and fishing-based livelihoods are severely affected by sea-level rise, soil erosion and ocean acidification (IPCC (2023), B.1.3). These processes result in a deterioration of food production related to fisheries and aquaculture. Finally, the 2022 Lancet Countdown report (Romanello et al., 2022) concludes that weather conditions resulting from climate change are becoming more suitable for the spread of infectious diseases. They estimate an increase of 12% in the likelihood of dengue transmission from 1951–1960 to 2012–2021, with dengue outbreaks mainly located in Central and South America, Sub-Saharan Africa, South Asia and Pacific islands. They also estimate that the number of months suitable for malaria transmission have increased by 13.8% in the highland areas of Africa over the same period.

This physical vulnerability is aggravated by socio-economic and institutional fragilities. Low income, fragile state capacity and legal framework prevent the necessary domestic in-

vestments. The population is more vulnerable to climate change impacts because of the lack of social safety nets and public services. Ill-adapted urban designs, fragile health systems, low agricultural productivity, and deficit in water, waste and energy infrastructures prevent resilience to climate change. These socio-economic vulnerabilities are then further increased by climate change, leading to a vicious circle. Climate change provokes losses in economic growth (de Bandt et al., 2021), then restraining the countries' ability to raise financial resources for much-needed mitigation and adaptation policies (Cabrillac et al., 2023).

Yet, international finance does not take over for this deficit in domestic resources. Less favourable economic perspectives and higher financial and geopolitical risks limit developing countries' access to international finance. Capital cost is higher for these countries, and this cost grows with increases in climate vulnerability (Climate Policy Initiative, 2022). Rating agencies are now taking climate vulnerability into account, putting pressure on developing countries' sovereign ratings (de Bandt et al., 2021). This climate risk premium further reduces the financing possibilities of vulnerable countries when they are the most needed, in what de Bandt et al. (2021) describe as a scissor effect. Furthermore, mitigation and adaptation projects have high up-front costs with long time horizons and suffer from regulation uncertainty, all of which deter private investments (Climate Policy Initiative, 2022).

Physical and socio-economic vulnerabilities associated with increasingly difficult access to private finance justify the need for international public actors to step in and channel climate funding toward emerging and developing economies.

Estimating investment needs for mitigation and adaptation policies in developing countries is not an easy task. Obtaining their disbursements is even less easy, despite consistent warnings on the current and future impacts of climate change. It implies distinguishing between gross and net cost of mitigation policies - net cost includes expected future benefits of mitigation and adaptation actions -, estimating the costs of a no-action scenario and obviously determining the appropriate discount rates (Nesje et al., 2023).

Estimations of climate investment needs differ, but they are all well above current observed amounts. Regarding adaptation in developing countries, the United Nations Environment Programme Adaptation Gap report (UNEP, 2021) summarises estimations of annual costs from the literature as lying between USD 140 and 300 billion by 2030 and between USD 280 and 500 billion by 2050. Songwe et al. (2022) estimate that annual adaptation needs in Africa based on Nationally Determined Contributions (NDCs) amount to USD 438 billion by 2030. On the mitigation side, the International Energy Agency (IEA, 2021) estimates that investments in de-

carbonised energy solutions in emerging and developing countries (EMDCs) should reach over USD 1 trillion per year by 2030. Excluding China, [Bhattacharya et al. \(2022\)](#) estimate that total investment in energy system transformation in emerging and developing markets should amount to USD 1.3-1.7 trillion per year by 2030. The United Nations Economic Commission for Africa ([UNECA, 2021](#)) assesses that USD 500 billion will be needed to finance clean energy transition in Africa by 2030.

The current amount of total climate finance – including domestic as well as international flows and public as well as private finance – lies between USD 653 billion ([CPI, 2022](#)) and USD 803 billion ([UNFCCC-SFC, 2022](#)) in 2019/2020. Focusing on international public climate finance from developed countries towards developing countries, the Organisation for Economic Co-operation and Development ([OECD, 2022a](#)) estimates a mobilisation of USD 83.3 billion in 2020.

Table 1 summarises the estimations of climate finance needs and observed amounts for a better comparison of their scope.

Table 1: Climate finance needs versus current amounts

Needs				Observed amounts		
Mitigation						
Amount	1 trillion	1.3-1.7 trillion	500 billion	603 billion	761 billion	54.6 billion
Time	By 2030	By 2030	By 2030	2019/20	2019/20	2020
Scope	EMDCs	EMDCs, excl. China	Africa, clean energy	Total flows	Total flows	EMDCs, public flows
Source	IEA	Bhattacharya et al.	UNECA	CPI	UNFCCC	OECD
Adaptation						
Amount	140-300 billion	280 -500 billion	500 billion	66 billion	75 billion	34.6 billion
Time	By 2030	By 2050	By 2030	2019/20	2019/20	2020
Scope	EMDCs	EMDCs	Africa	Total flows	Total flows	EMDCs, public flows
Source	UNEP	UNEP	Songwe et al.	CPI	UNFCCC	OECD

Amount in USD for annual investments. CPI, UNFCCC and OECD’s observed amounts include cross-cutting activities.

Climate finance still falls short of estimated needs to ensure the transition to net zero and the adaptation of societies to already severe climate change consequences. Yet, these needs have been long recognised in international climate negotiations. In the next section, we review the history of international climate transfers in intergovernmental negotiations.

2 International climate negotiations and the demand for climate justice

The results of early environmental international meetings were mainly the recognition of the anthropogenic causes of climate change. Participants called for further scientific research to reduce uncertainty and identify potential impacts, and argue for a precautionary approach regarding GHG emissions. Along those lines, in 1972, the first United Nations (UN) meeting on global environmental issues, the UN Conference on the Human Environment, took place in Stockholm and closed with the Stockholm Declaration and the establishment of the United Nations Environment Programme (UNEP). Followed the first World Climate Conference in 1979 in Geneva, which created the World Climate Programme to research climate change and led to the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. The IPCC was mandated to assess scientific knowledge about the climate system, climate change, its impacts and possible response strategies. Many intergovernmental conferences were organised in the 1980s, gathering policymakers, scientists and non-governmental organisations (NGOs) to discuss scientific knowledge on climate change processes. Among those, we can cite the Villach Conference in 1985, the Toronto Conference in 1988 following the 1987 Brundtland report, the Tata Conference in New Dehli in 1989 or the Hague Conference and Declaration in 1989, which first called upon the development of a framework convention on climate change.

The main achievement of these meetings was to publicise the existence of a scientific consensus on climate change, its anthropogenic causes and the severity of its future consequences. They were, however, highly limited by their lack of global scale. For instance, the United States, the United Kingdom, China and the Union of Soviet Socialist Republics (USSR) were not a part of the Hague Conference. Though it did not bring forth much change either, the Tata Conference on Global Warming and Climate Change was the first to focus on developing countries' concerns. It was organised at the initiative of the Indian Tata Energy Research Institute,

highlighted the severe impact of climate change on developing countries and reminded that industrialised countries had "*caused the major share of the problem*" (see conference statement 4.10 in [Center for International Environmental Law \(1990\)](#), p.554) and were in possession of the resources to assist developing countries in addressing it. Developing economies were thus taking a major stance in demanding international transfers in the name of equity.

In 1990, the IPCC released its first assessment report, and the second World Climate Conference was organised, gathering representatives from 120 countries. This conference set the basis for the UN Framework Convention on Climate Change (UNFCCC), adopted in Rio in 1992. It put forward principles that would guide the convention negotiations, including the idea of a common but differentiated responsibility toward climate change ([UN \(1990\)](#), General Report III.2.1 and Ministerial Declaration 5). It highlighted the disproportionate impacts of climate change on developing countries and the resulting risk of increasing inequalities with developed economies ([UN \(1990\)](#), General Report I.A.2. and II.6.1). It also recognised the historical responsibilities of developed countries in the crisis that the world was now facing globally and the need for equity in the response strategies ([UN \(1990\)](#), Ministerial Declaration 5). These principles are at the core of the climate justice concept, corresponding to the fair sharing of efforts in addressing the climate change crisis. Following these affirmations, the conference Parties stated the need to mobilise financial resources to support developing countries in taking upon climate change challenges and recommended the establishment of funding facilities to that end ([UN \(1990\)](#), General Report II.7.1, III.2.4, III.2.5 and Ministerial Declaration 5 and 17). For instance, they proposed the creation of a global environmental facility, which was later adopted in 1992. They also admitted that developing countries did not face the same policy challenges as their industrialised counterparts. They thus defended developing countries' needs to maintain economic development as a principal objective, which justified a continued growth of their net emissions ([UN \(1990\)](#), Ministerial Declaration 15.). They, however, encouraged developing countries to leapfrog "*directly from a status of underdevelopment through to efficient, environmentally benign, technologies*", instead of following developed countries' industrialisation path ([UN \(1990\)](#), General Report III.2.2, p.13).

The Second World Climate Conference (1990) only made recommendations, no emissions targets were set, and no funding commitments were taken. However, sectors where actions were needed were already well-identified, and adaptation issues were already discussed, indicating that what was lacking was mainly political will.

Preparation and negotiations for the future framework convention were organised between the second World Climate Conference and the Earth Summit in 1992 in Rio by the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC). The resulting UN Framework Convention on Climate Change (UNFCCC) was signed by 154 countries during the Rio Summit and entered into force in 1994. It was then the largest gathering of countries around an environmental agreement. The Rio Declaration following the summit reminded the common but differentiated responsibility principle and the need to mobilise financial resources towards developing countries to meet the Convention's objectives. The UNFCCC established a financial mechanism to this end, operated by the Global Environment Facility (GEF) up to 2011, relayed then by the Green Climate Fund. The Rio declaration also posited what has since been named the "polluter-pays" principle from [Pigou \(1920\)](#)'s theory ([Ratajczak-Juszko and Nyka, 2022](#)), stating that the "*polluter should, in principle, bear the cost of pollution*" (UN (1992), principle 16 p.4). This principle states the simple ethical concept that the negative consequences of the polluting action should be borne by the perpetrator, implying different obligations among countries.

The Rio Earth Summit and the resulting UNFCCC restated the three guiding principles for climate justice, that is the equity, differentiated responsibility and "polluter-pays" principles, and finally established a financial mechanism to put these principles into action. However, the contribution to the GEF was voluntary, and no binding commitment nor internationally accepted targets were set regarding the provision of financial resources to developing countries.

In 1995, the first Conference of Parties (COP) was organised, and it became the UNFCCC authority while the INC was dissolved. The first COP launched the Berlin Mandate negotiations on additional commitments to the Convention that led to the adoption of the Kyoto Protocol in 1997. The Kyoto Protocol legally bound UNFCCC Annex I Parties (developed countries and some emerging economies such as Russia and Turkey) to emission reduction targets and restated the need for international transfers toward developing countries. However, the Kyoto Protocol mainly relied on market mechanisms to mobilise this international funding. It implemented the Clean Development Mechanism, whose objective was to generate climate-related foreign direct investment to non-Annex I Parties in exchange for emission credits.

In 1998, the Development Assistance Committee (DAC) of the OECD elaborated the Rio markers methodology to track the mainstreaming of the Rio Convention's objectives in Official Development Assistance (ODA). ODA are the OECD standard to assess international development-related aid, often summarised by the term *foreign aid*. DAC member countries

must report all their ODA flows through the Creditor Reporting System (CRS). The Rio markers allow them to identify flows towards biodiversity, desertification and climate-related projects. From 2010, the Rio markers methodology distinguished between mitigation and adaptation projects. The use of the Rio markers in the CRS only became mandatory for DAC member countries in 2007, and it mainly covered bilateral ODA flows, but it allowed for the first public tracking of international climate transfers.

COP7, which took place in 2001 in Marrakesh, established several specialised funds: the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund under the administration of the GEF and the Adaptation Fund under the Kyoto Protocol. These funds were tasked with mobilising additional finance focusing on adaptation issues and the most vulnerable countries.

COPs were organised yearly to assess the implementation of the Convention's objectives, but it was not until the 15th COP in 2009 in Copenhagen that an actual target was set for international climate finance toward developing countries.

COP15 constitutes a milestone regarding international climate transfers. For the first time, developed countries agreed on an actual quantified commitment. They pledged to reach a joint mobilisation target of USD 100 billion per year of new and additional finance by 2020 to meet the mitigation and adaptation needs of developing countries (UNFCCC, 2010). This target included USD 30 billion over 2010-2012, labelled fast-track finance. The "new and additional" dimension was particularly important as it meant current funding for other development-related purposes should not be redirected toward climate projects. The objective was not to just green existing finance at the expense of other needed investments. The means of action for this USD 100 billion mobilisation, the source and the type of funding, were not clearly defined, as the Copenhagen Accord stated it should come from "*a wide variety of sources, public and private, bilateral and multilateral, including alternative sources of finance*" (Copenhagen Accord 8. UNFCCC (2010), p.7). This absence of a clear definition of what should constitute the USD 100 billion made tracking the objective arduous. The OECD has published reports with this aim since 2015. Their data include public concessional and non-concessional finance, bilateral and multilateral, as well as private finance mobilised by the public sector. The Copenhagen Accord also first translated the need for a balanced allocation of funding between adaptation and mitigation objectives and committed to prioritising least developed countries (LDC) and small island developing states (SIDS) regarding adaptation (Copenhagen Accord 8., UNFCCC (2010)).

At COP16 in 2010 in Cancún, the Copenhagen Accord commitment was integrated into the UNFCCC and therefore became binding. The Green Climate Fund was established to succeed the GEF as the operating entity of the UNFCCC financial mechanism. Parties also established the Standing Committee on Finance (SCF) to assist the COP with respect to the UNFCCC's financial mechanism. The SCF was tasked with improving the coordination of climate change finance and measuring, reporting and verifying this support toward developing countries. However, [Michaelowa and Sacherer \(2022\)](#) note that the SCF does not have the resources nor an internationally accepted mandate to do so, and it mainly compiles other sources, such as the OECD, the Climate Policy Initiative (CPI) or the IEA's data, and data reported to the UNFCCC by national and multilateral agencies.

Simultaneously, criticisms from NGOs targeted the CDM of the Kyoto Protocol. They reproached CDM projects for not respecting the additionality rules, which implied that the emission reduction would have been lesser without the CDM intervention. They also denounced the exaggerated carbon benefits of the projects and carbon leakage issues. Following these criticisms, restrictions on the use of CDM credits were adopted, leading to a drastic fall in credit prices and CDM activity. According to [Michaelowa and Sacherer \(2022\)](#), it followed a distrust in the capacity of carbon market mechanisms to channel finance toward vulnerable countries and a shift of emphasis toward international public finance.

COP19 in Warsaw in 2013 was the stage of harsh negotiations on the notion of loss and damage. A coalition of developing countries, the Group of Seventy-Seven (G77), wanted the concept to be defined as climate change impacts beyond adaptation. According to this definition, loss and damage correspond to financial costs of climate change consequences that cannot be avoided even through optimal adaptation ([Mogelgaard and McGray, 2015](#)). The United States and Australia opposed this definition and wanted loss and damage to be integrated into the UNFCCC adaptation framework ([Gabbatiss, 2022](#)). This opposition led to a walkout of the G77 representatives during the negotiations, followed by several NGOs and civil society members (e.g. Oxfam, WWF, Green Peace or ActionAid). Under the G77 pressure, the Parties adopted the Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (WIM). The WIM objectives were to promote knowledge, action and support to address loss and damage, but outside of risk assessment, its outreach was limited, and loss and damage remained under the adaptation framework.

In 2015 in Paris, COP21 led to the adoption of the Paris Agreement with the ambition of succeeding the Kyoto Protocol. Parties set the objective of maintaining global warming between

1.5 and 2°C and achieving net-zero emissions over the second half of the century (UNFCCC (2015), art. 4.1). Countries must submit their Nationally Determined Contributions (NDC) to reach this objective and update them with increased stringency every five years. The achievement of the NDCs is, however, not a legally binding commitment. Several developing countries have included components in their NDCs that are conditional to the reception of climate finance. Michaelowa and Sacherer (2022) estimate that adding this requested finance for the first NDCs amounts to USD 350 billion, more than three times the COP15 commitment. Article 6.4 of the Paris Agreement laid the foundation for the sustainable development mechanism, succeeding the CDM, with the difference that non-Annex I Parties could now access it. Developed countries also reaffirmed their commitment to mobilise USD 100 billion per year by 2020 and extended it until 2025. Pushed by the Alliance of Small Island States (AOSIS) and the LDC group, Parties also finally recognised the concept of loss and damage as a category apart from adaptation. In the Paris Agreement, adaptation and loss and damage correspond respectively to the two distinct articles 7 and 8 (UNFCCC (2015)). The COP21 was also the moment when the absence of a consensus between donors and recipients of climate finance on what the latter covers (definition and accounting) appeared clearly. The OECD 2015 report estimated that, in 2013-2014, USD 57 billion were mobilised for climate purposes by developed countries toward developing ones. This figure was abruptly contested by the Indian Ministry of Finance, which estimated that only USD 2.2 billion had been disbursed (Government of India, 2015). The Indian Department of Economic Affairs secretary, Shaktikanta Das, said in a foreword discourse that the report was "*deeply flawed and unacceptable*" and that the OECD had "*overstated progress*" (Vidal, 2015; The Economic Times, 2015).^{6 7}

The same year, the Third International Conference on Financing for Development took place in Addis Ababa, where the very enticing initiative "From Billions to Trillions" was launched. The initiative aimed to intensify public financial flows and private investments towards developing countries to achieve the UN Sustainable Development Goals (SDG). Suffice it to say that the billions did not make it to trillions and that the gap between funding and needs widened (Le Houérou and Lankes, 2023).

During COP26 in Glasgow in 2021, Parties agreed that a new scaled-up target should be devised by 2025 for international climate transfers, while it already appeared that the USD 100 billion target by 2020 would not be reached. Meanwhile, developing countries' financial needs

⁶indiatimes.com, 29 Nov. 2015.

⁷theguardian.com, 2 Dec. 2015.

to achieve their NDCs by 2030 were for the first time quantified in an SFC report and reached more than 5.8 trillion (Michaelowa and Sacherer (2022) and UNFCCC SFC (2021), chapter 2.2.1.), highlighting the lack of ambition of current target. Since COP23 and considering the failure of the WIM to actually channel funding towards loss and damage, the G77 countries were defending the creation of a loss and damage financial facility. At COP26, they were yet again unsuccessful. The Parties, however, announced the creation of the Just Energy Transition Partnerships (JETP), which are financing cooperation mechanisms to finance energy transition in heavily coal-dependent emerging economies. The first JETP was a financing cooperation between France, Germany, the United Kingdom, the United States, and the European Union towards South Africa for a total amount of USD 8.5 billion (European Commission, 2021). Despite the statements of the Copenhagen Accord and the Paris Agreement, adaptation and loss and damage concerns for the most vulnerable countries thus kept getting put on the back burner.

After decades of pressure, G77 countries finally obtained an agreement on a financing facility for loss and damage during COP27 in Sharm el-Sheikh (UNFCCC, 2022; UNEP, 2022). A working group of representatives from 24 countries was launched to develop an implementation framework for such a facility. Their proposition, which will include the institutional form of the facility, its budget and contributing and recipient countries, will be presented at the COP28 in November 2023 in Dubai. Following COP27, the Group of Seven (G7) and the Vulnerable Group of Twenty (V20) launched the Global Shield against Climate Risks, an initiative for pre-arranged and fast-disbursal funding in the event of natural disasters, but whose initial funding only amounted to USD 200 million (V20, 2022).

Following this relative success, vulnerable countries led by Barbados were also at the initiative of the Paris Summit for a New Global Financing Pact in June 2023. The Summit brought together representatives of 40 countries, the main financial institutions and development banks, as well as private sector and civil society actors. The ambitious stated objective of the Summit was to transform global finance architecture in the context of the developing countries' debt crisis and increased climate vulnerability. As detailed in Section 1, developing countries suffer from high capital costs, and market conditions are degrading with increased vulnerability (scissor effect). Heavy debt services further limit their financial capacity to invest in development and climate policies and to face natural disasters or crises such as the COVID-19 pandemic. Paul et al. (2023) thus assess that the public debt sustainability risk has increased for low and middle-income countries because of the pandemic. The Summit was in line with decades of calls for climate justice as illustrated by the discourse of the president of Brazil, Luiz Inacio Lula da Silva, ahead of the conference, stating that "*those who have really polluted the planet*

over the last 200 years are those who made the industrial revolution. That's why they must pay the historic debt they owe the planet."(Bouissou and Ricard, 2023). Developing countries have been demanding debt service suspension and restructuring and the development of climate-resilient financial mechanisms. On top of grants, several types of financial instruments exist that could be suited for vulnerable countries' specific contexts, but their use is still limited. We can cite debt-for-nature swaps which allow a debt reduction in return for a commitment to spend a share of the reduction on environmental protection (Paul et al., 2023). Other options include state-contingent debt instruments (SCDIs), which have automatic debt rescheduling clauses in case of an external event. For instance, in September 2022, Barbados issued a bond with natural disaster and pandemic clauses. Payments would be automatically suspended in the event of a new global pandemic declared by the World Health Organisation (WHO) (Cabrillac et al., 2023).

Results from the Paris Summit for a New Global Financing Pact remain to be seen. Among the few achievements of the Summit, an agreement on Zambia's debt restructuring has been reached, and the promise of USD 200 billion in additional lending capacity toward developing countries over the next decade was made (Louis, 2023).

The first conclusion that can be drawn in 2023 is that, regardless of increasing pressure from developing countries, the USD 100 billion commitment has not been reached by 2020. According to the latest OECD report, developed countries had only mobilised USD 83.3 billion of climate funding for developing countries in 2020 (OECD, 2022a). This objective also appears increasingly misaligned with the mitigation and adaptation needs of developing countries, as highlighted by their NDCs estimations and the difficulties they face in accessing international capital. The financing of the transition in developing countries cannot produce effective results if recipient countries are plagued with high debt service. Considering public climate finance recorded by the OECD (OECD, 2022a), only 26% of the funding between 2016 and 2020 were grants. Furthermore, as we will detail in the next section, the discrepancy between mitigation and adaptation flows remains large. Mitigation activities are still the dominant target of climate finance, despite a rise in adaptation finance.

In the next section, we describe the allocation and the evolution of international climate finance since 2000. This analysis is based on the main climate finance data used in the following chapters of this dissertation.

3 Who gives what, to whom and when?

In this section, we present an overview of international public climate finance's architecture and trends based on the OECD climate-related development finance database (OECD, 2022d) and the two latest OECD reports on climate finance mobilised and provided by developed countries (OECD, 2022a,b).

3.1 The diversity of data sources

We use two climate transfers databases in the following chapters of this dissertation: the OECD-DAC CRS Rio Markers database (OECD, 2022c) and the OECD climate-related development finance database (OECD, 2022d). The OECD-DAC CRS Rio Markers database tracks climate-related Official Development Assistance (ODA) from 1998 through the Rio Markers methodology. In the following paragraphs, we refer to this database as the *Rio database*. ODA is the OECD standard to identify development aid flows and it has specific concessionality requirements.⁸ The Rio database has been widely used by the literature, especially the aid literature, the grey literature and NGOs work. It covers mostly bilateral flows as only a few multilateral sources report using the Rio markers methodology. The Rio database reports commitments as well as disbursements of climate ODA. The second database, the OECD climate-related development finance database (OECD, 2022d), was only made available recently. We refer to it as the *climate finance database*. It covers a larger scope of climate flows as it includes concessional as well as non-concessional bilateral and multilateral public climate finance, but it does not allow to distinguish flows that meet the ODA standard and only reports commitments. It also collects private philanthropic climate finance.

Finally, the OECD reports from the "Climate Finance and the USD 100 Billion Goal" series (OECD, 2015-2022) are another slightly different sources of information on international public climate finance. It include public bilateral and multilateral climate finance, concessional and non-concessional instruments, as well as private finance mobilised by the public sector.

These explanations highlight once again the difficulty in identifying one standard definition of international public climate finance.

⁸According to the OECD (OECD, 2023), climate-related ODA represented USD 44 billion in 2020 while total public climate finance amounted to 83.3 billion.

In this section, figures and analyses are produced using the previously described climate finance database (OECD, 2022d), which we complete with data from the OECD reports (OECD, 2022a,b). Our database covers 155 recipient countries and 90 providers from 2000 to 2021. Providers include 30 DAC-member countries and the EU institutions (excluding the European Investment Bank), 6 non-DAC member countries⁹, 13 multilateral development banks, 8 multilateral funds or agencies and 32 private philanthropic providers (foundations, private trusts etc.). As our focus is on international public climate finance, we remove these private philanthropic flows from our analysis, which represent very small amounts. All data are expressed in constant 2021 USD.

3.2 Climate objectives

In 2021, international public climate finance amounted to USD 70.1 billion, with USD 40.8 billion targeting mitigation objectives and USD 34.5 billion targeting adaptation objectives. Many activities are cross-objectives, targeting both mitigation and adaptation objectives, so total climate finance is not the sum of mitigation and adaptation finance. The OECD (OECD, 2022a,b) reports a total of USD 83.3 billion for 2020, which in addition to our data, includes USD 1.9 billion in climate-related officially-supported export credits and USD 13.1 billion in private climate finance mobilised by public finance.

Figure 1 shows the evolution of climate finance by objective. Adaptation finance has only been tracked by the OECD since 2010. Climate and mitigation finance, therefore, fully overlap before 2010. All types of climate finance have been increasing over 2000-2021 and at a faster pace since 2009-2010. This could be related to the COP15 in Copenhagen in 2009 and the USD 100 billion commitment. We note a decrease in climate finance allocation between 2020 and 2021 which is also present in the next sections' disaggregated analyses. We believe this drop might be related to the COVID-19 crisis, but this assumption needs to be confirmed by future data on climate finance trends since 2021. Over 2000-2021, the gap between mitigation and adaptation flows has been lessening, but it still remains with USD 6.3 more billion toward mitigation than adaptation activities in 2021.

⁹Some of them are also recipients of climate transfers and their contributions as providers are small.

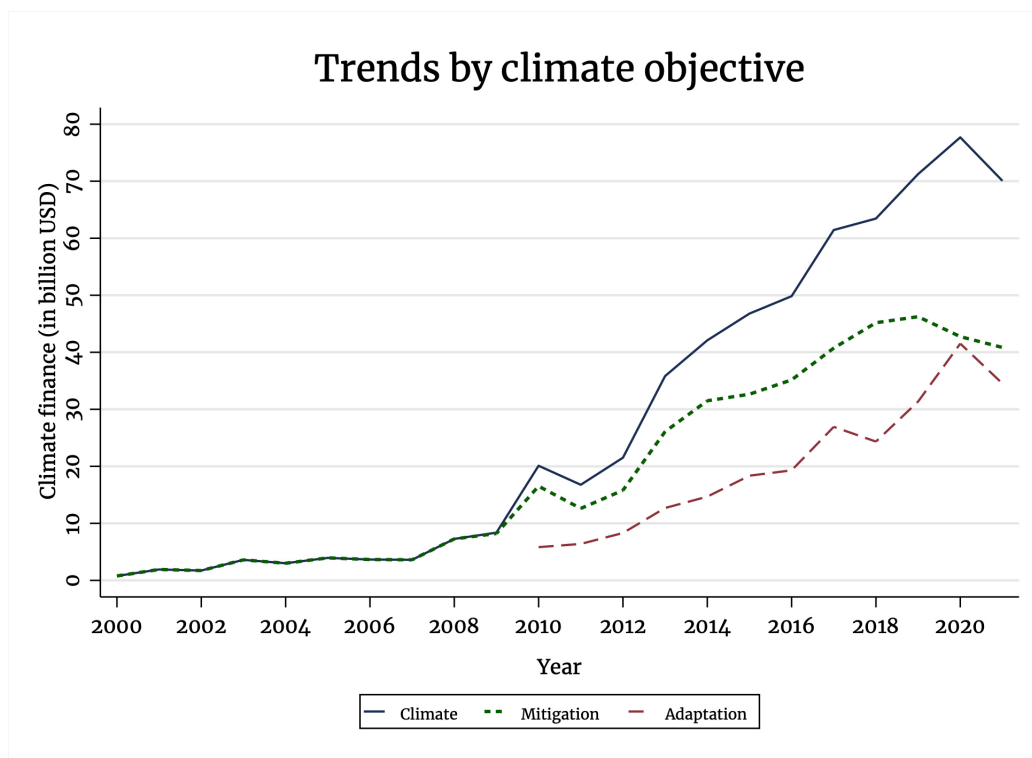


Figure 1: Evolution of climate finance by objective

3.3 Providers of climate finance

Multilateral providers were the major source of climate finance in 2021, with USD 42.9 billion versus USD 27.1 billion of bilateral finance. The gap was smaller in 2020, with USD 44.5 billion in multilateral finance and USD 33.2 billion in bilateral finance. Multilateral donors are the major providers of mitigation finance (26.8 billion USD versus 14 billion for bilateral donors in 2021), but the gap between multilateral and bilateral donors disappears when considering adaptation finance (respectively USD 17.4 billion and 17.1 billion in 2021).

Figure 2 presents the distribution of climate finance per provider type from 2000 to 2021. In the OECD database (OECD, 2022d), bilateral finance was the main source of climate finance, especially for adaptation finance, over the whole period. However, the OECD warns that tracking of multilateral flows was incomplete before 2013.¹⁰ Figure 3 shows the evolution of bilateral and multilateral climate flows between 2000 and 2021 and we indeed observe a strong increase in multilateral flows in 2013, related to the improvement of multilateral climate finance

¹⁰oecd-ilibrary.org

tracking. Since 2016, multilateral donors have been the main providers of total climate finance and mitigation finance. This gap is increasing, meaning multilateral finance grows faster than bilateral finance. However, bilateral and multilateral adaptation flows are of a similar magnitude, with bilateral adaptation finance even exceeding multilateral adaptation finance in 2020.

Distribution of climate finance per provider

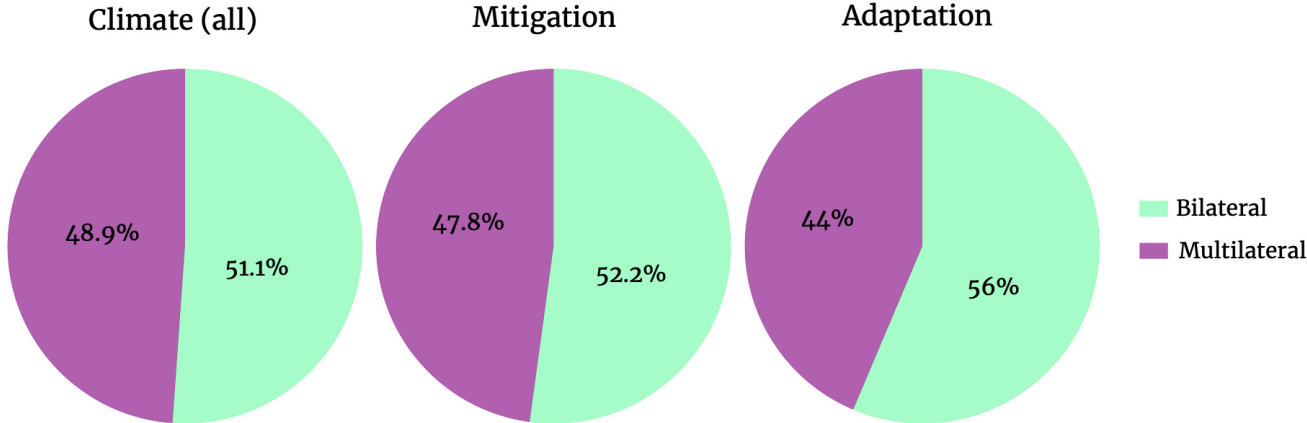


Figure 2: Climate finance distribution per provider

Figure 4 presents the 10 top donor countries of bilateral climate finance from 2000 to 2021. The largest donors are Japan, Germany and France, far ahead of other developed countries like the United States or the United Kingdom. When considering donors’ ranking based on per capita finance, Norway is the biggest donor, followed by, yet again, Japan, Germany and France. It is worth noting that these data only measure bilateral flows from donor countries. They do not take into account donor contributions to multilateral agencies. Donor countries do not all similarly divide their climate finance into bilateral transfers and multilateral contributions. For instance, Japan, the largest donor, uses mainly the bilateral channel (Yeo, 2019).

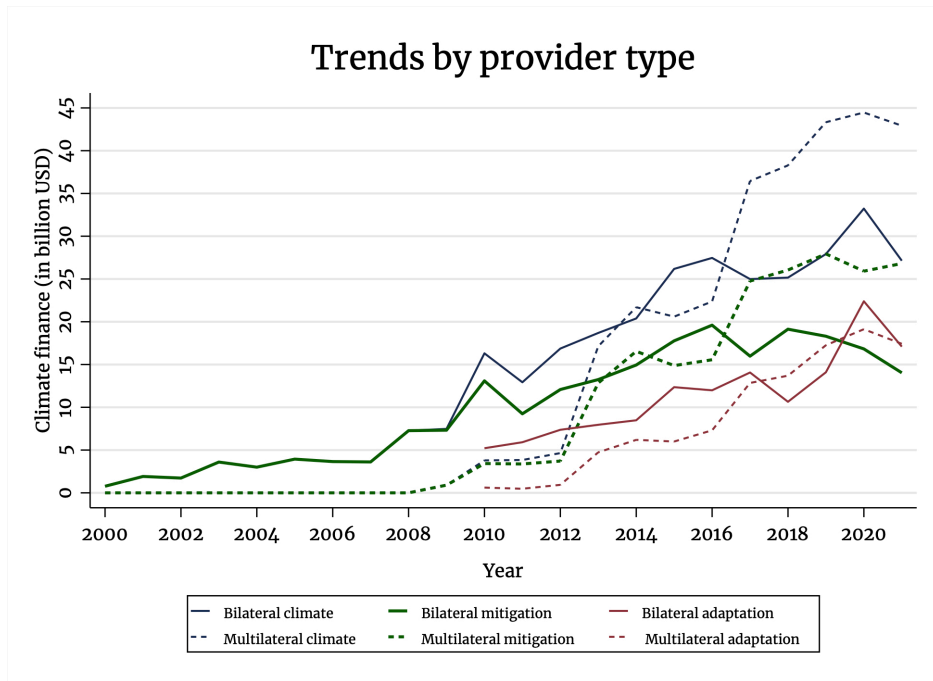


Figure 3: Evolution of climate finance by providing source

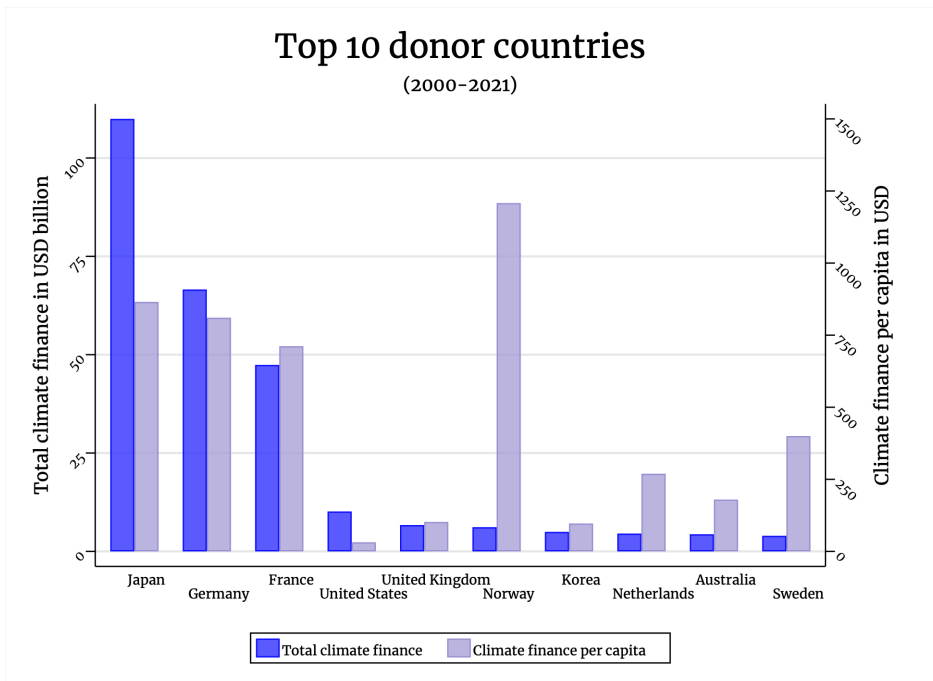


Figure 4: Top donor countries of climate finance over 2000-2021

3.4 Type of funding

The concessional element in climate finance is a key aspect considering the debt crisis developing countries face. A concessional loan offers the recipient country more preferential terms than those of the market, which can include below-market interest rates or extended grace periods. Grants and concessional loans should therefore be favoured, especially in the case of lower-income and vulnerable recipient countries.

In 2021, concessional climate finance represented USD 39.2 billion, including USD 15.9 billion in grants, and non-concessional climate finance amounted to USD 30.8 billion. Considering only mitigation finance, the split between concessional and non-concessional finance is balanced (respectively USD 19.6 billion and USD 21.3 billion). Adaptation finance is, however, mostly concessional (USD 24.4 billion versus USD 10.2 billion for non-concessional) as it mainly targets low-income and vulnerable countries.

Figure 5 details climate finance by instrument type over the period 2000-2021. The main financial instrument for climate transfer was concessional loans, which represented 40.7% of total flows between 2000 and 2021. Summing concessional loans and grants, concessional climate finance represented 65.1% of total climate flows between 2000 and 2021. This distribution per instrument is similar for mitigation finance, with a total of 61% of concessional mitigation finance. When considering adaptation flows, grants are the main instrument representing 40% of total adaptation flows between 2000 and 2021, while concessional loans represented 37.2%. Concessional adaptation finance corresponded to 77.2% of total adaptation flows between 2000 and 2021. Public equity investments remained limited. This is consistent with the higher environmental and economic vulnerability of adaptation finance recipients.

Figure 6 presents the evolution of concessional and non-concessional climate finance by climate objective. Concessional adaptation finance has been increasing more rapidly than non-concessional adaptation finance, likely as an answer to the increasing vulnerability of recipient countries. Mitigation finance presents an inverse trend. Since 2018, concessional mitigation finance has been decreasing and passed below non-concessional mitigation finance in 2021.

The OECD assessment (OECD, 2022a,b) highlights variation in the type of financial instrument according to the recipient region and income group. For instance, grants represented 83% of total climate finance in Oceania, where most SIDS are concentrated and 37% in Africa, while they only accounted for 20% , 17% and 11% of total climate finance in respectively Europe, America and Asia. Lower-income countries receive 61% of their climate finance in the form of grants, while the share of grants for other income groups was comprised between 7% and 13%.

Climate finance providers, therefore, favour the use of grants over loans in the most vulnerable countries.

Distribution of climate finance per instrument

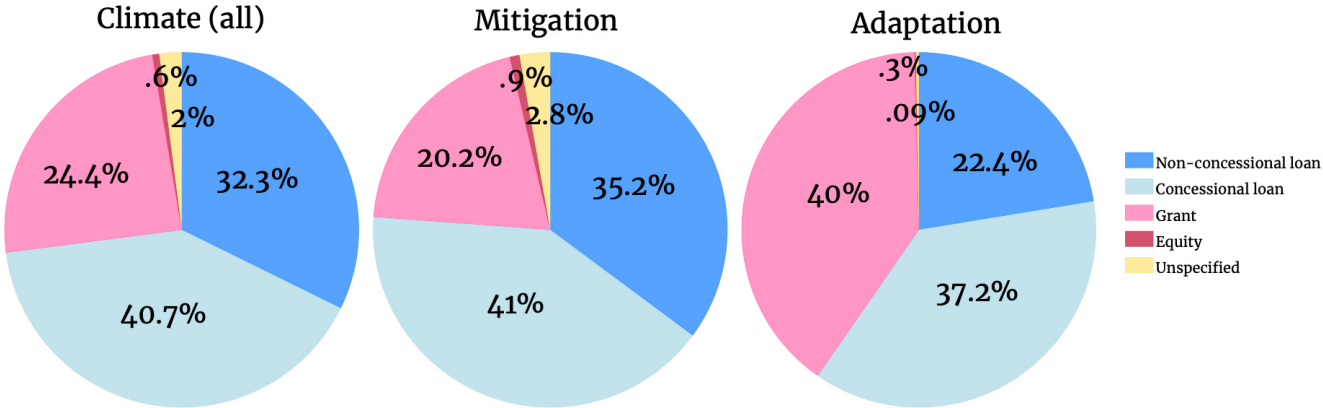


Figure 5: Climate finance distribution per instrument

3.5 Recipients of climate finance

Figure 7 presents the distribution of climate finance per region between 2000 and 2021. Over the whole period, Far East Asia received the most climate and mitigation finance, but it is also the most populated region as it includes China and Indonesia. We note a clear regional division of climate finance by objective. South of Sahara received only 6.6% of total climate finance but 31.1% of adaptation finance, which aligns with these countries’ needs. South of Sahara is thus the largest recipient of adaptation finance. Oceania, whose countries are mostly SIDS, also received a higher share of total adaptation finance (2.1%) than of total mitigation finance (0.8%), while Europe received a larger share of total mitigation finance (11.6%) than of total adaptation finance (5.3%). European recipient countries are mostly emerging and transition economies that are less vulnerable to climate change impacts (e.g., Albania, Moldova, Bosnia and Herzegovina, North Macedonia etc.).

The regional division remained in 2021, but South and Central Asia became the first recipient of climate finance before South of Sahara and Far East Asia.¹¹ In 2021, South of Sahara

¹¹In 2021, South and Central Asia received USD 17.5 billion, South of Sahara USD 17.9 billion, Far East Asia

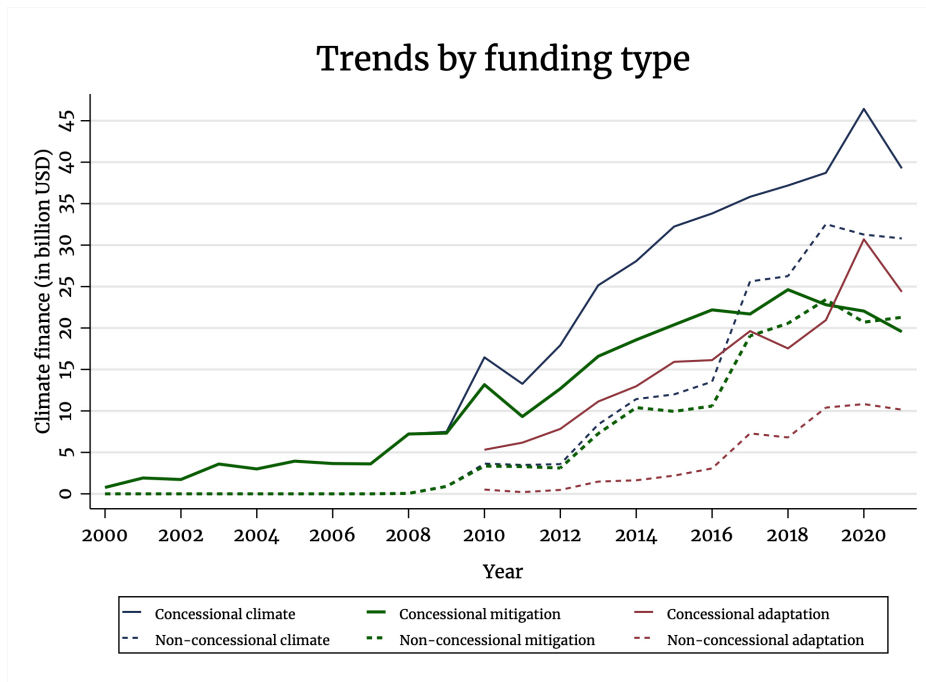


Figure 6: Evolution of climate finance by concessionality

mostly received adaptation finance, while South and Central Asia received more mitigation finance. In Oceania, adaptation objectives represented 93% of total climate finance received. This regional division of climate finance objectives reflects the regional division of climate needs.

Figure 8 displays the evolution of climate finance by continent. Climate finance has increased in all regions, but the growth was stronger in Oceania, Asia and Africa. We can, however, note a large decrease in climate finance towards Asia between 2020 and 2021. The scale of climate finance flows toward Oceania and the Middle East is small, which, regarding Oceania, can be explained by the size of the population, but transfers have also been increasing. Climate finance to the Middle East was multiplied by almost 200 between 2000 and 2021, and it was multiplied by circa 120 towards Oceania. As a comparison, it was multiplied by 80 in Asia. Between 2010 and 2021, the increase in climate finance was the strongest in Oceania (times 12), indicating a higher prioritisation of SIDS in the last decade.

Figure 9 presents the trends in climate finance allocation according to recipient countries' income levels. Middle-income countries are the highest recipients of climate finance, followed by upper-middle-income countries. Note that the upper-income group, which received few cli-

USD 8.2 billion, South America USD 7.7 billion, Europe USD 6.6 billion, Caribbean and Central America USD 4.7 billion, North of Sahara USD 4.5 billion, the Middle East USD 1.8 billion and Oceania USD 1.2 billion.

mate transfers, comprises only 14 countries, most of them with small population sizes.¹² In 2021, lower-income countries received USD 18.6 billion, while middle-income countries received a total of USD 29.3 billion, i.e. 1.6 times more climate finance. Contrary to the other income groups, lower-income countries receive a majority of adaptation finance as per their needs.¹³

Distribution of climate finance per region

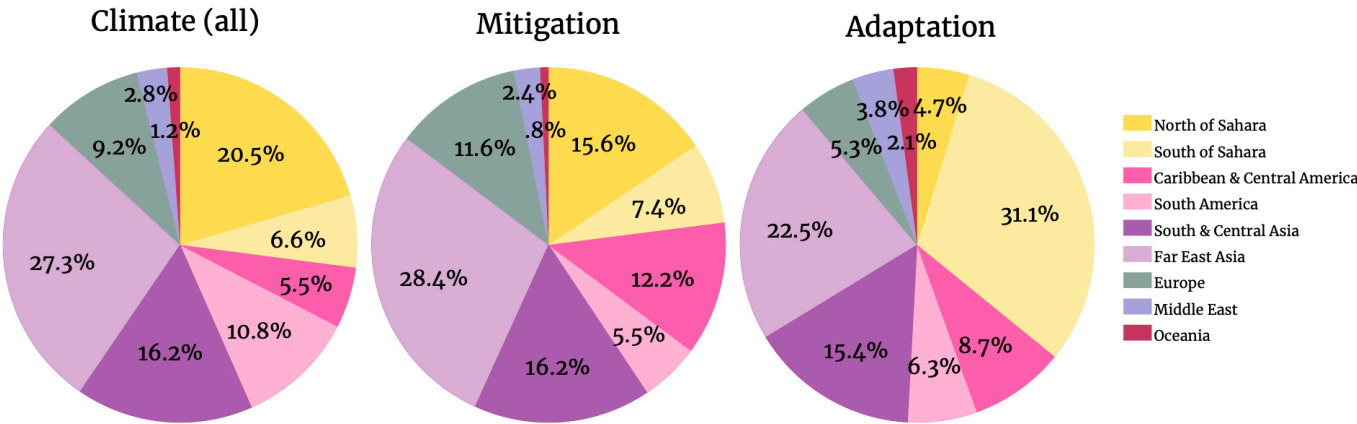


Figure 7: Climate finance distribution per region

According to the OECD assessment (OECD, 2022a,b), between 2016 and 2020, 50% of climate finance was concentrated in 20 countries located in Asia, Africa and America, representing 74% of all developing countries’ population. Figure 10 presents the top ten recipient countries of total climate between 2000 and 2021. As expected, the largest recipients of climate finance are also the largest countries: India, Bangladesh, China, Turkey, Indonesia and Brazil. Apart from Bangladesh, which is classified in the Least Developed Countries (LDC) category by the UN, most of the top recipients are upper-middle to middle-income countries and fast-growing economies. The picture is very much different when considering finance per capita.

¹²Upper-income countries include: Anguilla, Antigua and Barbuda, Bahrain, Barbados, Chile, Cook Islands, Croatia, Oman, Saint Kitts and Nevis, Saudi Arabia, Seychelles, Slovenia, Trinidad and Tobago, Uruguay.

¹³In 2021, lower-income countries received USD 18.6 billion, of which USD 11.9 billion targeted adaptation objectives and USD 8.4 billion targeted mitigation objectives, while middle-income countries received USD 29.3 billion, including USD 14 billion and USD 16.8 billion for adaptation and mitigation objectives. Upper-middle-income countries were allocated USD 22.2 billion in climate finance, USD 15.7 billion towards mitigation activities and USD 8.7 billion toward adaptation activities.

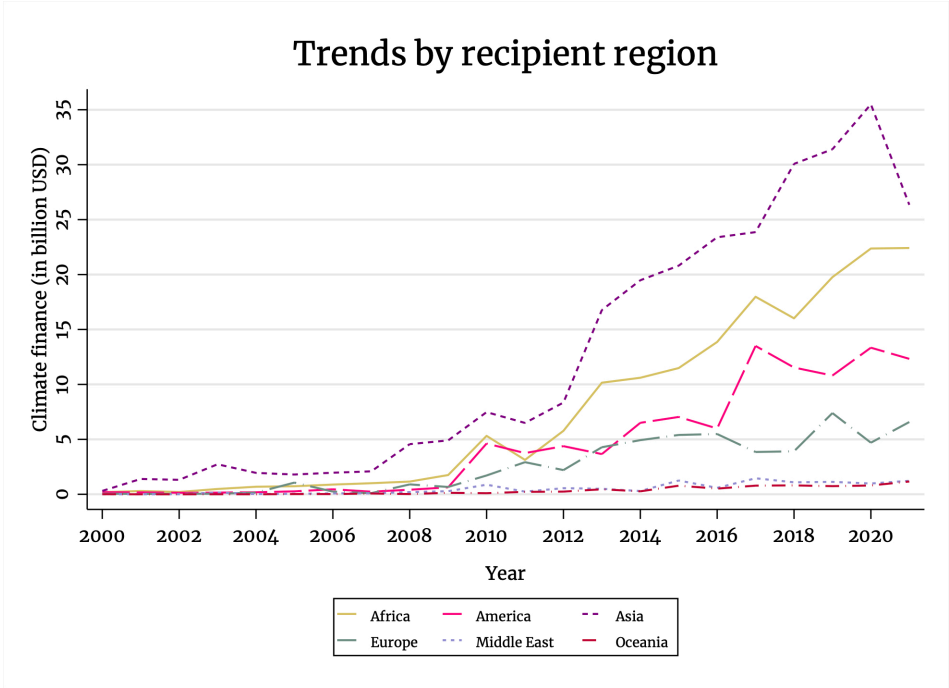


Figure 8: Evolution of climate finance by recipient region

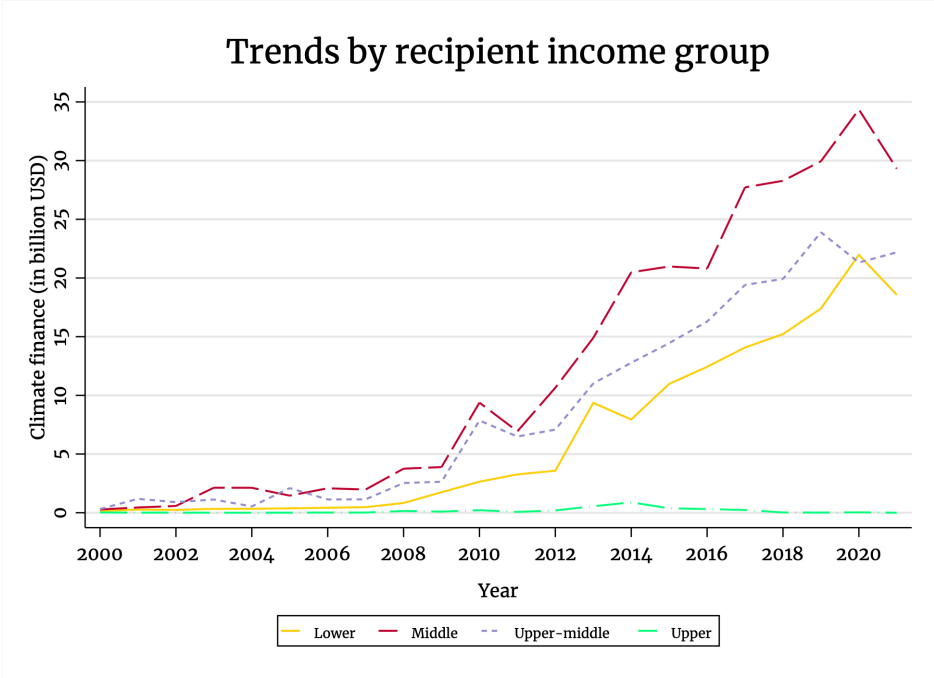


Figure 9: Evolution of climate finance by recipient income group

The top 10 recipients of climate finance per capita are small islands.¹⁴ All of them are classified as SIDS by the UN, and they mainly receive adaptation finance. It is worth noting that, though per capita finance offers a different perspective, not all climate investments are proportional to the population size. The construction of a dike or a power station necessitates, for instance, a minimal investment independent of the population size.

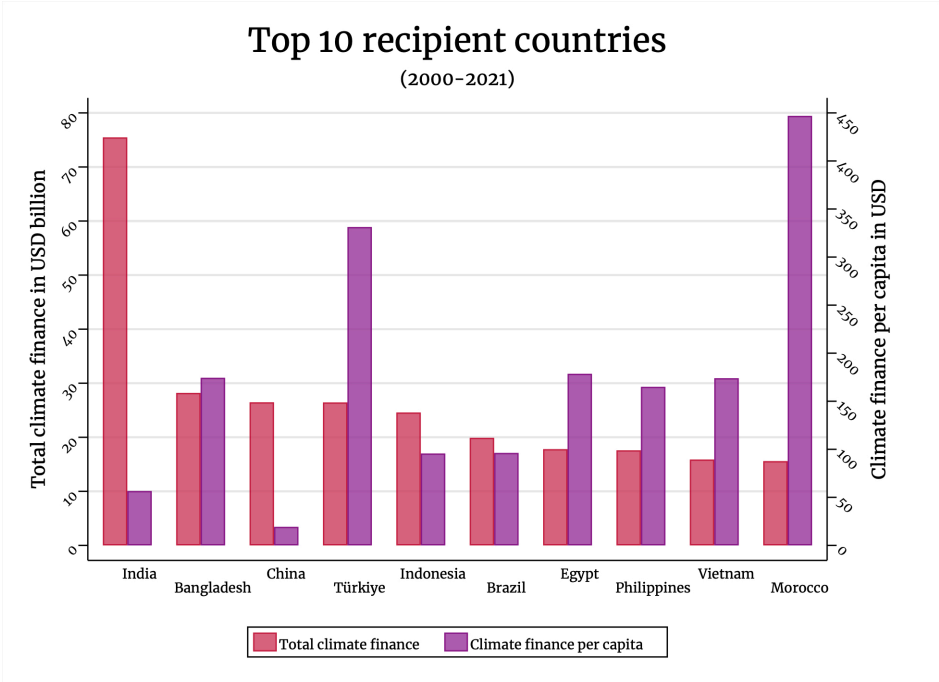


Figure 10: Top recipient countries of climate finance over 2000-2021

¹⁴Top recipient of per capita climate finance are: Tuvalu, Nauru, the Marshall Islands, Dominica, Palau, Tonga, Kiribati, Vanuatu, Samoa and Saint Vincent and the Grenadines.

4 This dissertation

This dissertation gathers three chapters on international public climate finance, corresponding to four papers at different publication stages. It aims to provide an extensive assessment of international public climate finance. It covers the issues of climate finance allocation to recipient countries, the strategic commercial and political motives that surround it and its effectiveness in addressing the climate change crisis. International climate transfers are a strategic response to the climate crisis, but they are also motivated by ethical considerations of climate justice. In this dissertation, we do not discuss what would be the appropriate ethical response to the international climate justice issue. We set out from the demand of developing countries for international climate transfers and take it upon ourselves to assess them.

The first chapter focuses on the strategic motivations behind the allocation of climate-related ODA by donor countries. It is a joint work with Basak Bayramoglu, Jean-François Jacques and Clément Nedoncelle and was published in *the Journal of Environmental Economics and Management* (Bayramoglu et al., 2023). The aid literature has shown that foreign aid allocation by donor countries to developing economies is motivated by the donor country's bilateral trade interests. We thus question whether trade interests also determine the allocation of climate aid. We start from the empirical result of Weiler et al. (2018), who measure a positive correlation between donor countries' exports and bilateral adaptation aid. This correlation is, however, not explained, as the paper does not focus on trade, and it cannot be causally interpreted. To complete this earlier result, we consider how bilateral trade affects donor countries' allocations of bilateral climate aid using a combination of theoretical modelling and empirical analysis.

First, we propose a simple theoretical model to investigate the specific trade mechanisms behind the allocation of climate aid. This model guides our empirical analysis and allows us to estimate a causal relationship between trade and climate aid. Our theoretical trade model illustrates positive terms of trade and income effects of climate aid on trade. Adaptation aid transfers may help restore damaged production structures in recipient countries and protect them from climate change impacts, thus maintaining the production of goods donor countries import. Mitigation aid, through technology transfers, may enhance the recipient countries' productivity. Both mitigation and adaptation aid would therefore have a positive effect on the recipient countries' terms of trade and, so, on its exports to the donor countries. Through these protective and productive effects, climate aid also supports recipient countries' income and

their capacity to import from donor countries. We, therefore, identify two channels through which climate aid increases bilateral trade. Our model posits that the provision of aid is based on pre-existing commercial relations founded on historical and geopolitical factors which are threatened by the effects of climate change on the productive capacity of fragile countries, following a large literature on the historical dependence of trade relations (Eichengreen, 1998; De Sousa and Lochard, 2012; Lavallée and Lochard, 2019). Donor countries allocate climate aid to their trade partners to protect and improve their productive capacities and maintain their bilateral trade relations. This implies that bilateral trade motivates climate aid allocation. Our model thus predicts a positive simultaneous relationship between a donor country's exports to and imports from a recipient country and its climate aid allocation.

In the empirical part of the paper, we provide an econometric evaluation of the predictions of our theoretical model by estimating the impact of trade on aid. We use the OECD-DAC CRS Rio Markers database (OECD, 2022c), described in Section 3.5, that tracks climate-related ODA from 2002 to 2017, and the BACI database from the CEPII (Gaulier and Zignago, 2010) that monitors trade flows at the product level. Following our theoretical results, estimating the causal impact of trade relations on climate aid allocation implies correcting for endogeneity issues due to the reverse causation of aid on trade. We, therefore, estimate a panel data model with donor, recipient, and year fixed effects employing an instrumental variable two-stage least squares (IV-2SLS) method with a shift-share instrument following Bartik (1991)'s contribution. Our instrumental strategy uses variations in world demand at the product level based on previous trade patterns to identify trade variations uncorrelated with donor and recipient countries' decisions and relationships. Following our hypothesis that the provision of aid is based on pre-existing commercial relations founded on historical and geopolitical factors, our specification includes a set of bilateral control variables (e.g. colonial ties, distance) as well as variables related to the recipient's needs and merits.

Our empirical results show that donors' exports have a significant, robust, positive effect on climate aid transfers. We find an elasticity of climate aid close to 0.3 for exports, but we do not find any significant impact of donor imports on climate aid. Our estimates are robust to different specifications of the controls, potential omitted variables, and changes in the set of fixed effects used. Our results are also not sensitive to minor violations of the exclusion restriction required for causal inferences, which we investigate following the methodology of Borusyak and Hull (2020).

The originality of our approach lies in the association of two methodologies: we first develop a theoretical model on the relationships between trade and climate aid allocation, which

then guides our empirical analysis. We also investigate the climate aid and trade relationships by providing a complete picture of the trade effects. We thus highlight two economic mechanisms driving two distinct effects of trade on climate aid which we then estimate empirically. The fact that trade interests affect the allocation of climate aid has global environmental and political consequences. It may render aid less efficient in mitigating climate change and protecting developing countries by deviating it from where it is most needed. It may also hinder the already fragile confidence of developing countries in international climate cooperation.

Following the heated contestation from developing countries on the actual amount of climate finance received and the absence of a clear and internationally accepted definition and accounting methods for climate finance, we decided to dive further into the content of the projects reported as climate finance projects. This analysis was conducted over two papers, regrouped here in the second chapter of this dissertation. These papers are joint works with Basak Bayramoglu and Aliette Dequet, and one was published in the *Revue Française d'Économie* (Neumann Noel and Bayramoglu, 2022).

This chapter builds on an earlier work by Michaelowa and Michaelowa (2011) and a few small-scale analyses (CARE, 2021; Weikmans et al., 2017) that assess the content and alert on misreporting of climate aid projects, i.e. development projects that are falsely reported as being climate-related. We contribute to this literature by offering a large-scale assessment of climate aid projects and proposing a more automated methodology to evaluate climate projects' content. We examine the self-reporting of bilateral climate aid projects to the OECD by donor countries using the OECD-DAC CRS Rio Markers database (OECD, 2022c). Our assessment covers 63,195 climate projects reported by OECD-DAC donor countries between 2002 and 2018, and we evaluate their climate content using a Python-programmed keywords search. We identify two types of errors considering the different objectives of climate aid. The first error is the over-reporting of climate aid, which is reporting a non-climate-related project as climate-related. The second error is the confusion between mitigation and adaptation objectives. This distinction allows us to compute several ratios of misreporting: the over-reporting ratio for total climate aid and miscoding ratios of mitigation aid and adaptation aid.

We also contribute to the literature on climate projects' assessment by proposing an extensive descriptive analysis of over-reporting across donor countries, recipient countries, climate objectives and over time. We find that nearly half (48.6%) of the climate-reported projects analysed were actually not climate-related. Furthermore, 67.8% of adaptation projects and 64.3% of mitigation projects were miscoded, i.e. they were either not climate-related at all or reported

under the wrong objective. We show that all donor countries over-report, even the smaller ones, and that there is considerable heterogeneity among donor countries. There seems, however, to be a slight decrease in over-reporting since 2015.

Following the political economy literature, we suggest several potential explanations for this over-reporting related to electoral strategy, international reputation, and budget constraint. Based on these hypotheses and using a non-linear panel model, we propose an exploratory estimation of the drivers of climate aid over-reporting by donor countries. We show that wrongly reporting development projects as being climate-related might be an electoral strategy for donor countries with tighter budget constraints and environmentally-concerned populations. It allows them to officially contribute to the international commitment of USD 100 billion climate transfer per year without actually opening new lines of funding.

The first two chapters do not depict a very optimistic picture of international public climate finance, as we have shown that bilateral climate aid allocation is driven by donors' strategic interests and that a large share of reported climate aid actually does not target climate objectives. The next logical step and, therefore, the last chapter of this dissertation is to wonder if climate finance meets its objective, i.e. if it is effective.

This last chapter focuses on the mitigation objective of climate finance. It aims at estimating whether climate finance has allowed a reduction in recipient countries' carbon emissions. We choose to focus on mitigation outcomes due to major difficulties in measuring adaptation outcomes and the more recent inclusion of adaptation concerns in climate finance. This chapter first contributes to the literature on climate finance and international cooperation by offering an extensive review of the potential channels through which climate finance could impact recipient countries' carbon emissions. It also contributes to the aid literature by discussing the methodological challenges faced by empirical researchers when estimating aid effectiveness.

Building on these discussions, we propose three alternative empirical strategies to estimate the impact of climate transfers on recipient countries' carbon emissions. Our analysis makes use of the recently published database from the OECD, the climate-related development finance database (OECD, 2022d) (i.e. the previously described *Climate Finance database*), that covers a larger scope of public climate finance beyond climate-related ODA. Following the previous chapters, we also use the OECD CRS database on climate-related ODA (OECD, 2023). Our data range from 2000 to 2020. We, therefore, assess the effectiveness of different types of public climate finance depending on the providing source (bilateral or multilateral), the objective (mitigation or adaptation) and the type of funding (total climate finance and climate ODA). We

use the "Our World in Data (OWID) CO2 and Greenhouse Gas Emissions Dataset" (Ritchie et al., 2020), whose primary source for carbon emissions data is the Global Carbon Project¹⁵, and we compute carbon emissions per GDP.

The first two empirical strategies use panel models and estimation methods that tackle the potential endogeneity concerns of climate finance. Climate finance could be allocated in priority to countries that made higher mitigation efforts, measured by a decrease in their emissions. On the contrary, climate finance could prioritise countries with higher emissions because they concentrate the most pressing mitigation needs or to benefit from lower marginal abatement costs. This would imply a reciprocal relationship between climate transfers and the recipient's carbon emissions. In our panel models, we use a lagged 3-year moving sum of climate finance to capture its deferred effect and take into account the volatility issue. Consistent support over several years is also more likely to have an effect than contemporary transfers. We first estimate a simple panel model with recipient and year fixed effects using the IV-2SLS technique with a shift-share instrument. Our shift-share variable corresponds to expected climate transfers. It allocates exogenous shifts in donor climate transfers, i.e. shifts that are not correlated to the recipient country's characteristics, to the recipient country depending on its past relative importance in the donor climate transfers. Following previous estimations in the literature on the effect of climate or energy-related aid on carbon emissions (Kretschmer et al., 2013; Bhattacharyya et al., 2016; Kablan and Chouard, 2022), we then estimate a dynamic panel model using the two-step system generalised method of moments (GMM).

Finally, we contribute to the aid effectiveness literature by making use of recent policy impact evaluation techniques to offer a new empirical strategy for the macro analysis of aid effectiveness. The difficulty lies in identifying a counterfactual as most developing countries have received a form of climate finance, which means we do not have a control group of developing countries that have never received climate finance. Our third empirical strategy thus proposes a staggered difference-in-differences (DiD) setup comparing small and large recipients of climate finance with a relative threshold and using Callaway and Sant'Anna (2021)'s heterogeneity-robust estimators. This strategy accounts for heterogeneity in climate finance effects related to the time and length of climate finance allocation to the recipient country.

Our estimations converge to the absence of an effect of international public climate finance on the recipient countries' carbon emissions per GDP as well as energy intensity. This result holds when considering different subsamples of recipient countries, namely the top recipients of climate finance, the top emitters of CO2 and groups of countries based on income level. It is

¹⁵globalcarbonproject.org

also consistent across all measures of climate transfers and all estimation strategies.

A general conclusion ends this dissertation by summarising our main findings and discussing the lessons we can draw from them. We also review the dissertation's limitations and provide insights into future research avenues.

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Chapter 1

The Trade Determinants of Bilateral Climate Transfers Allocation

Joint with Basak Bayramoglu, Jean-François Jacques and Clément Nedoncelle¹

“Alright I support you. Go sell more.”

Buffy the Vampire Slayer – S4E13
The I in Team (2000)

Abstract. Foreign aid allocation by donor countries to developing economies is known to be motivated by the donor country’s bilateral trade interests. Does this also apply to bilateral climate aid? In this chapter, we combine theoretical and empirical analyses to investigate how bilateral trade affects donor countries’ allocations of bilateral climate aid. Our theoretical analysis develops a simple model to support our hypothesis that bilateral trade positively impacts climate aid transfers. The model highlights terms-of-trade and positive income effects of climate aid and predicts a positive relationship between donor countries’ exports to and imports from recipient countries and their climate aid transfers. The empirical analysis is based on bilateral climate aid data from 2002 to 2017. We employ fixed effects and instrumental variable two-stage least square estimations (IV-2SLS) with a shift-share instrument to overcome the endogeneity of trade. Our empirical results show that donors’ exports have a significant, robust, positive effect on climate aid transfers.

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1 Introduction

Despite the Paris Agreement (2015), there lacks an international climate treaty setting legally binding caps on greenhouse gas (GHG) emissions for individual countries (Bohringer, 2021). Existing climate agreements are undermined by free-riding behaviour, lack of participation, unambitious targets, and carbon leakage, due mainly to international trade. International aid for climate mitigation and adaptation from developed countries could help to scale up developing countries' climate mitigation efforts and help those countries to adapt to climate change. During the climate change negotiations in Copenhagen in 2009, the developed countries signed up to a joint mobilisation target of \$100 billion per year by 2020 to meet the needs of developing countries. This target was reconfirmed by the Paris Agreement in 2015, which set an amount of aid of at least \$100 billion per year up to 2025. However, the amount of climate aid from the developed countries has fallen well below this target (Roberts et al., 2021). In 2019, these transfers represented \$79.6 billion dollars per year. The need for aid to enable adaptations to climate change is even more urgent than the need for climate mitigation assistance (UNEP, 2021).

This situation highlights the need to investigate the determinants of international climate aid. Empirical evidence in the foreign aid literature (Alesina and Dollar, 2000; Berthelemy, 2006; Dudley and Montmarquette, 1976; McKinlay and Little, 1977) indicates that donors' interests are as important as recipients' needs and merits in the allocation of foreign aid by donor countries. In this chapter, we provide a systematic examination of whether bilateral trade motivates the allocation of bilateral climate aid² by donor countries by proposing a simple theoretical model and providing empirical evidence.

The effectiveness of climate aid is closely related to the allocation of this aid by donor countries and, thus, to the environmental, economic, and geopolitical factors that motivate this allocation. Several works examine the determinants of climate aid (Betzold and Weiler, 2017; Clist, 2011; Halimanjaya, 2015; Halimanjaya and Papyrakis, 2015; Persson and Remling, 2014; Robinson and Dornan, 2017; Stadelmann et al., 2014) by measuring the determinants of the payments and receipt of climate transfers based on aggregate transfers. Except for Weiler et al.

²We focus on bilateral public climate aid as we study bilateral strategic interests. While multilateral public climate finance is larger in value than bilateral public climate finance, the main channel for concessional and developmental transfers is bilateral.

(2018), none of these studies investigates the bilateral relations between countries. These bilateral relations, which consist of commercial, cultural, geographic, and geopolitical ties, are essential and can modify the architecture of climate transfers. An empirical study by [Weiler et al. \(2018\)](#) shows that bilateral adaptation aid is correlated with the donor country's exports to the aid recipient, but the authors do not distinguish between trade flows. We identify the trade flows (exports and imports) that determine bilateral climate aid, provide an economic justification for climate aid, and empirically validate it. We suggest that the provision of aid is based on pre-existing commercial relations, founded on historical, geographic, and geopolitical factors, which are threatened by the effects of climate change on the productive capacity of fragile countries. Specifically, the donor countries are keen to maintain these trade relations to conserve the benefit they provide for both parties. They may provide aid for adaptation to climate change or to reduce GHG emissions (which could also have local negative effects). We propose a simple theoretical model to show how climate aid is determined positively by the donor country's imports and exports vis-à-vis the recipient country. The persistence of old trade relations is investigated in a stream of work initiated by [Eichengreen \(1998\)](#), who highlighted the continuity of trade relations based on old colonial or migratory connections which resist shocks. [Eichengreen \(1998\)](#)'s work gave rise to an extensive empirical literature on this historical dependence of trade relations (see, for instance, [De Sousa and Lochard \(2012\)](#); [Lavallée and Lochard \(2019\)](#)). Our data show that the trade relations analysed predate the signing of the Kyoto Protocol in 1997. However, the effects of climate change have increased with no accompanying threat to trade relations.

The links between foreign aid and international trade have been widely studied in contexts other than climate change (for empirical studies, see for instance [Alesina and Dollar \(2000\)](#); [Berthelemy \(2006\)](#); [Barthel et al. \(2014\)](#); [Fuchs et al. \(2015\)](#); [Turcu and Zhang \(2019\)](#)). [Barthel et al. \(2014\)](#); [Fuchs et al. \(2015\)](#) depart from the fact that there are inefficiencies in current foreign aid systems, with some recipient countries favoured disproportionately and a lack of coordination over aid flows among donor countries. It has been argued that donor countries compete to allocate foreign aid to certain recipient countries in order to increase their share of international trade. [Fuchs et al. \(2015\)](#) show that competition over exports to recipient countries results in inefficient donor allocations that are not based on recipient countries' needs or merit. [Barthel et al. \(2014\)](#) show that if a donor country increases its aid allocation to a certain recipient country, other donor countries in competition with the first donor in terms of exports also increase their aid allocation to that recipient country. However, these studies consider overall foreign aid while we focus specifically on climate aid and propose a theoretical model to guide

our empirical analysis.

Much of the theoretical literature on aid and trade focuses on the aid paradox³ that aid can degrade the recipient country's welfare. The transfer of a good to a country which expresses strong demand for that good will raise the price of that good, which has a negative effect on the welfare of the recipient country (Chichilnisky, 1980; Geanakoplos and Heal, 1983; Yano, 1983; Basu, 2003)). The literature also focuses on improvements to the terms of trade: foreign aid directed towards the export sector of the recipient country improves the recipient country's productivity and lowers the relative price of the exported goods. This, in turn, benefits the donor country. The terms of trade effect of aid has been modelled in the context of climate adaptation aid (Schenker and Stephan, 2014). It highlights two problems. On the one hand, a mechanism similar to the one described above may emerge. If the price of the good whose technology is favoured falls too much, the recipient country may experience a negative income shock and suffer a welfare loss. On the other hand, the other countries importing the good produced by the sector recipient of the aid may also profit from a drop in the international price of the good. These international price externalities inevitably induce strategic and free-rider behaviours. These strategic behaviours may slow aid provision (Schenker and Stephan, 2017).

The objective of our analysis⁴ is to identify the trade determinants of climate aid. Our theoretical model develops a simple trade model to provide an explanation for the existence of climate aid: the maintenance of former trade relations based on colonial ties, geopolitics, etc., which could be degraded by climate change. Indeed, climate change degrades the productivity of exporting industries in developing countries. To maintain the former trade relations (i.e. to keep constant the sum of the utilities of the pair of countries), the donor provides both mitigation and adaptation aid. Climate aid can alleviate the effects of climate change via two channels: a "price effect" and an "income effect". Thanks to climate aid, the price of the good produced by the recipient decreases (the price effect), and the recipient's income increases (the income effect). The price effect increases the donor country's imports, and the income effect increases

³Another stream of theoretical literature focuses on climate funding: see, e.g., Buob and Stephan (2013) for the trade off between mitigation and adaptation funding, Eyckmans et al. (2016) for the separate and combined effects of mitigation aid, adaptation aid and foreign aid, and Gersbach and Winkler (2012); Gersbach and Hummel (2016); Kornek and Edenhofer (2020) for multilateral climate funding. However, none of these papers considers trade relationships between countries.

⁴Our analysis contributes to work on foreign aid which emphasises the effects of trade on aid – our topic of interest. However, there are other explanations for aid, including the altruistic nature of aid as an element of the welfare of the donor country described by Dudley and Montmarquette (1976), which results in a "demand for the supply of aid". This body of work categorises aid depending on the donor country's preferences related to infrastructure, education, health, etc.

the donor country's exports. According to the mechanism highlighted by [Schenker and Stephan \(2014\)](#), climate aid makes it possible to reestablish the terms of trade of the developing country, which could have been degraded by climate change. We are aware that this aid might reduce the recipient country's welfare due to the already mentioned negative income effect. We show that this does not occur if the climate aid has a sufficiently strong income effect (in reducing the adverse impacts of climate change on the recipient country's productive process or in increasing productivity). Rather, the recipient country benefits from aid in terms of welfare. For a given level of the stock of global GHG emissions, if the impact of aid is sufficiently strong, the recipient country's imports and exports improve. In other words, the welfare of both countries increases, which is a necessary condition for the acceptability of aid by both countries. These mechanisms translate into a positive and reciprocal mathematical relationship between the donor country's imports and exports and climate aid. Thus, the empirical analysis aims to validate this relationship and eliminate possible endogeneity biases via an IV method.

In the empirical part of the chapter, we provide an econometric evaluation of the predictions of our theoretical model by estimating the impact of trade on aid. We use the OECD Official Development Assistance (ODA) data relative to climate actions and consider bilateral climate transfers from the OECD Development Assistance Committee (DAC) members between 2002 and 2017. We use a panel data model with donor, recipient, and year fixed effects (FE). We control for the recipient's environmental vulnerability, economic development, and institutional quality, and the historical and political relationships between donors and recipients that we put forward in the theoretical analysis. The main empirical difficulty is the potential simultaneous determination of climate transfers and trade decisions, as our theoretical model emphasises. To overcome endogeneity concerns, we use an instrumental variables strategy in a two-stage least squares estimation (IV-2SLS) where we instrument the level of trade using a shift-share instrument. In particular, we use variations in world demand at the product level based on previous and lagged trade patterns to identify trade variations uncorrelated with country decisions and relationships. This strategy allows *causal* estimates of trade on climate aid transfers. In our methodology, our results are identified from variations in climate aid and trade across country pairs. Our estimation strategy aligns with state-of-the-art estimations of the determinants of foreign aid, which we apply to this specific type of aid transfer.

Our estimations confirm the significant and quantitative role of trade as a determinant of climate aid, which is in line with our theoretical predictions. For a given donor of climate aid, its exports to a specific recipient country increase climate transfers to that country. Our baseline estimates point to an elasticity of aid of around 0.3 for exports. Our estimates are robust to

different controls specifications, potential omitted variables and changes in the set of FE used. Our results are also not sensitive to minor violations of the exclusion restriction required for causal inferences. They are in line with existing evidence regarding the standard determinants of foreign aid in general and climate aid in particular. We, however, find no significant effect regarding donors' imports. Overall, our results show that the strategic export interests of donor countries shape, to a large extent, the allocation of climate aid.

Contributions. This chapter contributes to the literature in several ways. First, we propose an original approach that combines theoretical and empirical analysis of the role played by trade in climate aid allocation. Second, we investigate bilateral trade relationships by providing a complete picture of the trade effects related to the allocation of climate transfers. The existing evidence points to the quantitative role of trade on foreign aid (see among others [Barthel et al. \(2014\)](#) and [Fuchs et al. \(2015\)](#)) and on climate aid ([Weiler et al., 2018](#)). Our theoretical model highlights two economic mechanisms driving two distinct effects of climate aid on trade. These are the terms of trade effect related to the imports of donor countries (in line with the theoretical prediction of [Schenker and Stephan \(2014\)](#)) and the positive income effect related to the exports of the donor country. In our model, the donor country transfers climate aid to maintain trade relations threatened by the impact of climate change on the recipient country. It implies a bi-directional relationship between trade and climate aid. Third, we provide a robust, causal estimate of the trade effect on climate aid, accounting for the bi-directional relationships between aid and trade. We employ an IV-2SLS strategy in which we leverage exogenous trade flow variations across countries to identify the causal effect of trade on climate transfers. This strategy allows the estimation of the causal elasticity of climate aid to trade. It complements the estimates in the literature (such as [Weiler et al. \(2018\)](#)), which may be subject to endogeneity problems. We also contribute to a stream of work in which trade shocks are used as shifters in empirical exercises. Following the seminal contribution of [Bartik \(1991\)](#), this type of strategy has been extensively used at both the aggregate (see, for instance, [Autor et al. \(2013\)](#)) and the microeconomic levels (see, for instance, [Mayer et al. \(2014\)](#) or [Aghion et al. \(2018\)](#)).

This chapter is organised as follows. Section 2 presents the proposed theoretical model. Section 3 presents the data and empirical analysis, and Section 4 presents the empirical results. Section 5 concludes the chapter.

2 Theoretical model

2.1 Model framework

In our proposed theoretical model, climate aid improves the welfare of the recipient country directly through the reduction of negative local environmental externalities, and more importantly, improves the welfare of the donor and recipient countries indirectly through trade.

We develop a simple trade model involving a developed and a developing country, each producing a good (or a basket of goods) according to a linear technology in labour, the only factor of production. The goods produced by each country are substitutable in terms of welfare. Following [Armington \(1969\)](#) approach, countries exchange similar goods with different characteristics, and these trade relations increase the welfare of the countries involved. We assume that country preferences are represented by a constant elasticity of substitution (CES) utility function.

Welfare losses linked to climate change can be either direct through a negative externality (for instance, local air pollution from CO₂ emissions), or indirect through a drop in the consumption of both goods. In our model, local air pollution problems due to GHG emissions degrade the welfare of the recipient country, and more importantly, climate change degrades the trade relations between the donor and recipient countries. We assume for simplicity that there is no negative externality from GHG emissions in the welfare of the donor country. To highlight the trade effects due to climate change, we also assume that climate change negatively affects the production process of only the developing country. It is well known and has been documented that climate change also affects developed countries' production of goods and services but that the magnitude of the effect is smaller than in the case of low-income countries ([Tol, 2018](#))⁵. For example, in the agriculture sector, developing countries have experienced more significant falls in the yields of most crops due to climate change ([World Bank, 2010](#)). A richer model would include lower production losses for the donor country. Our extreme hypothesis simplifies the calculus and represents the asymmetry in production losses due to climate change between countries.

We consider two countries: a donor country denoted 1, which produces the good (or basket

⁵Developing countries will suffer the most from climate change because they are more dependent on climate-sensitive sectors such as agriculture, tend to have hotter climates, and have limited adaptive capacity.

of goods) denoted 1, and a recipient country denoted 2, which produces the good (or basket of goods) denoted 2. Country 1 is assumed to have more resources than country 2 to fight climate change: the exogenous revenue of country 1 is larger than that of country 2, $R_1 > R_2$. The stock of global GHG emissions is denoted P and is thus exogenous to the pair of countries.

We consider two types of climate aid from country 1 to country 2: mitigation aid denoted as T_M and adaptation aid denoted as T_A . We posit that mitigation aid allows the recipient country to adopt more efficient and cleaner technology (energy-saving technology). As for adaptation aid, it helps the recipient country to undertake adaptation actions reducing the adverse effect of GHG emissions on production. For example, drip irrigation, crop diversification, and cyclone shelters are adaptation devices that mitigate some of climate change's effects. The donor funding to the recipient consists of transferring environmental goods manufactured using the domestically produced consumer good.⁶ Hereafter, we present some examples of bilateral mitigation and adaptation projects from the OECD database used in the empirical section of this chapter. Regarding mitigation aid, we can list:

- From Australia to China: aid over five years (1998-2003) for the purpose of energy generation from renewable resources.
- From France to Kenya in 2011: aid to support the development of geothermal energy.
- From France to Mali in 2016: aid to strengthen the photovoltaic and biogas sectors adapted to the Malian rural environment.

Regarding adaptation aid, we find the following examples:

- From Korea to Cambodia in 2010: aid to stabilize agricultural water supply in the Mongkol Borey River basin, reduce the frequent flood damage around the project area, and mitigate a critical power shortage.
- From France to Burkina Faso in 2013: aid to develop drainage and reduce flooding.
- From France to Tunisia in 2017: aid to secure and strengthen the northern water transfer infrastructures for the Sahel and Sfax regions.

These climate projects are likely to improve productivity in the recipient country, and the mitigation projects should reduce emissions from production processes. Note that some of these aid flows involve former trading partners within the same geographical block, such as Korea and Cambodia, or former colonies, such as France and Mali, Tunisia or Burkina Faso.

⁶The model implicitly assumes the existence of a 1 to 1 technology which transforms the consumer good into the environmental good (e.g. air conditioners, dike protection against sea rises, etc.).

The preferences of the representative agents in the two countries are identical. The preferences of donor country 1 are given by:

$$U_1(C_1^1, C_2^1) = [(C_1^1)^\sigma + (C_2^1)^\sigma]^{\frac{1}{\sigma}} \quad (1)$$

where C_r^i is the consumption of good r in country i , and $0 < \sigma < 1$. The elasticity of substitution is $\rho = \frac{1}{1-\sigma} > 1$, meaning that the goods are substitutes.

The production of good 1 is linear with respect to labour:

$$Y_1 = a_1 L_1 \quad (2)$$

with $a_1 > 0$.

The budget constraint of country 1 is written as :

$$C_1^1 + pC_2^1 = R_1 = a_1 L_1 - T_A - T_M \quad (3)$$

where p is the relative price of good 2 assuming good 1 is the numeraire. The donor country provides two types of climate aid which are costly: adaptation aid T_A , and mitigation aid T_M .

The preferences of the recipient country 2 are represented by the following utility function:

$$U_2(C_1^2, C_2^2) = [(C_1^2)^\sigma + (C_2^2)^\sigma]^{\frac{1}{\sigma}} - k\varepsilon \quad (4)$$

where $k > 0$ is the damage parameter, and ε denotes local air pollution from GHG emissions due to productive activities of the recipient country. Parameter k is a disutility parameter. It represents to what extent local air pollution reduces welfare through, for instance, human health problems.

This local pollution can be represented in the following way:

$$\varepsilon = z(T_M)Y_2(T_M) \quad (5)$$

where $z(T_M)$ denotes the emission function. We assume that the GHG emissions of the recipient ε are negligible compared to the stock of global GHG emissions P , which is assumed to be

constant.

The production of good 2 is linear with respect to labour:

$$Y_2(T_M) = a_2(T_M)L_2 \quad (6)$$

As mentioned, mitigation aid allows the recipient country to adopt more efficient and cleaner technology. Consequently, the productivity $a_2(T_M)$ depends positively on mitigation aid T_M , and the emission coefficient $z(T_M)$ depends negatively on mitigation aid T_M . The emission externality can be re-written as:

$$\varepsilon = z(T_M)a_2(T_M)L_2 \quad (7)$$

For the sake of analytical simplicity, we assume the following functional forms: $a_2(T_M) = a_2T_M$ with a_2 a positive constant, and $z(T_M) = (1 - \alpha T_M)$ with α a positive constant. The emission externality can thus be written as $\varepsilon = (1 - \alpha T_M)a_2T_M L_2$. To ensure that the emission externality is reduced by the receipt of climate aid, i.e. $\frac{d\varepsilon}{dT_M} < 0$, we assume that $T_M > \frac{1}{2\alpha}$.

The budget constraint of the recipient country 2 is written as:

$$C_1^2 + pC_2^2 = pR_2 = p[a_2T_M L_2 - (bP - hT_A)] \quad (8)$$

As can be seen from this budget constraint, we assume that due to the stock of global GHG emissions P (assumed to be exogenous and constant), the production in the recipient country drops by $-bP$, with $b > 0$. Adaptation aid helps to reduce this production loss due to climate change by $-hT_A$, with $h > 0$. Parameter h represents the productivity of the adaptation technology acquired with adaptation aid, i.e. to what extent the adaptation technology (for instance, early warning or drip irrigation systems) can reduce the production losses from climate change. We naturally assume that $(bP - hT_A) > 0$.

In the first step, the representative agent in each country maximises its utility with respect to the consumption of the two goods under its budget constraint. This leads to the following relationships for countries 1 and 2 respectively⁷:

⁷Notice that the assumed CES preferences lead to linear demand for goods with respect to income. Therefore, the welfare function we consider can represent the heterogeneity of agents' incomes within countries. Imports

$$C_1^1 = \frac{R_1 p^{\frac{1}{1-\sigma}}}{p + p^{\frac{1}{1-\sigma}}} \quad (9)$$

$$C_2^1 = \frac{R_1}{p + p^{\frac{1}{1-\sigma}}} \quad (10)$$

$$C_1^2 = \frac{R_2 p^{\frac{2-\sigma}{1-\sigma}}}{p + p^{\frac{1}{1-\sigma}}} \quad (11)$$

$$C_2^2 = \frac{R_2 p}{p + p^{\frac{1}{1-\sigma}}} \quad (12)$$

The trade balance is at equilibrium: country 1's imports are equal to country 2's exports, $pC_2^1 = C_1^2$. In a more sophisticated model, which includes several countries producing a specific good or basket of goods, we would not have equality between the exports and imports of two countries taken separately.⁸ Using the condition on the trade balance, the relative price of good 2 produced by recipient country 2 can be expressed as:

$$p = \left(\frac{R_1}{R_2}\right)^{1-\sigma} \quad (13)$$

2.2 Theoretical properties

We now proceed to prove the theoretical properties of the model, which supports our empirical analysis. All of the properties are based on initial calculations provided in Section A in the appendix.

Proposition 1 shows the *positive* effect of both mitigation and adaptation aid on the recipient country's terms of trade.

Proposition 1: The price of good 2 produced by the recipient country 2 is a decreasing function of adaptation and mitigation aid.

from the recipient country may affect only the wealthiest in the population. Although their volume is small, these exports may play an important role in the relations between the two countries.

⁸It would be possible but mathematically difficult to enrich the model by introducing trade relations with other countries to avoid this equality in the value of imports and exports.

Proof: The result $\frac{dp}{dT_A} < 0$ and $\frac{dp}{dT_M} < 0$ is obtained from $\frac{dR_1}{dT_A} = -1 < 0$, $\frac{dR_2}{dT_A} = h > 0$, $\frac{dR_1}{dT_M} = -1 < 0$, and $\frac{dR_2}{dT_M} = a_2L_2 > 0$.

Propositions 2a and 2b show that the terms-of-trade effect allows the recipient country to export more to the donor country if the beneficial impact of the adaptation and mitigation aid on the recipient country's production is sufficiently large.⁹

Proposition 2a: If h is greater than σ , then imports of good 2 by donor country 1 are an increasing function of adaptation aid T_A .

Proof: If $h > \sigma$, then we obtain $\frac{dC_2^1}{dT_A} > 0$ because $\frac{R_1}{R_2} > 1$ and $\sigma < 1$ by assumption.

Proposition 2b: If a_2L_2 is greater than σ , then imports of good 2 by donor country 1 are an increasing function of mitigation aid T_M .

Proof: If $a_2L_2 > \sigma$, then we obtain $\frac{dC_2^1}{dT_M} > 0$ because $\frac{R_1}{R_2} > 1$ and $\sigma < 1$ by assumption.

Propositions 3a and 3b show that if the beneficial impact of adaptation and mitigation aid on production is sufficiently large, the increased production in the recipient country leads to positive income effects. These income effects, in turn, induce an increase in the recipient's imports from the donor country.

Proposition 3a: If h is greater than $\frac{2-\sigma}{\sigma}$, then exports of good 1 by donor country 1 are an increasing function of adaptation aid T_A .

Proof: If $h > \frac{2-\sigma}{\sigma}$, then we obtain $\frac{dC_1^2}{dT_A} > 0$ because $(\frac{R_1}{R_2})^{1+\sigma} > (\frac{R_1}{R_2})^\sigma$.

Proposition 3b: If a_2L_2 is greater than $\frac{2-\sigma}{\sigma}$, then exports of good 1 by donor country 1 are an increasing function of mitigation aid T_M .

Proof: If $a_2L_2 > \frac{2-\sigma}{\sigma}$, then we obtain $\frac{dC_1^2}{dT_M} > 0$.

The findings in Propositions 1, 2 and 3 highlight the "price effect" and the "income effect" induced by climate aid. The greater climate aid, the greater the production benefits in the recipient country. The price of the good produced in the recipient country decreases. According to the mechanism highlighted by [Schenker and Stephan \(2014\)](#), climate aid makes it possible to reestablish the terms-of-trade of the developing country, which could have been degraded by climate change. This corresponds to the price effect, which increases the donor country's imports. This price effect also induces a negative income effect for the recipient country: climate

⁹Since we assume that trade relations are specific to country pairs, we ignore the previously mentioned strategic aspects because no other country can benefit from this price drop.

aid reduces the price of its produced good. At the same time, climate aid leads to a positive income effect for the recipient: climate aid increases the production of the recipient and hence its production value. If climate aid has a sufficiently strong impact (in reducing the adverse impacts of climate change on the recipient country's productive process or in increasing productivity), the positive income effect dominates the negative one. In this case, the positive income effect allows for larger imports by the recipient country.

Consequently, the donor country's climate aid could increase both its imports and exports, which may improve the welfare of the consumers in both countries, a condition necessary for aid acceptability. In the second step, we investigate the conditions under which the transfers increase the welfare of both donor and recipient. To do so, we express the two welfare functions as a function of R_1 and R_2 (without environmental externality for the recipient in a first step):

$$U_1 = R_1^\sigma (R_2^\sigma + R_1^\sigma)^{\frac{1-\sigma}{\sigma}} \quad (14)$$

$$U_2 = R_2^\sigma (R_1^\sigma + R_2^\sigma)^{\frac{1-\sigma}{\sigma}} \quad (15)$$

Proposition 4a: If h is greater than $\frac{3-\sigma}{1-\sigma}$, then the welfare function U_1 of the *donor* increases with adaptation aid T_A .

Proof: If $h > \frac{3-\sigma}{1-\sigma}$, then we obtain $\frac{dU_1}{dT_A} > 0$ because $(\frac{R_1}{R_2})^{1-\sigma} > 1$ and $(\frac{R_2}{R_1})^\sigma < 1$.

Proposition 4b: If $a_2 L_2$ is greater than $\frac{3-\sigma}{1-\sigma}$, then the welfare function U_1 of the *donor* increases with mitigation aid T_M .

Proof: If $a_2 L_2 > \frac{3-\sigma}{1-\sigma}$, then we obtain $\frac{dU_1}{dT_M} > 0$.

Proposition 5a: If h is greater than $\frac{1-\sigma}{2\sigma}$, then the welfare function U_2 of the *recipient* increases with adaptation aid T_A .

Proof: If $h > \frac{1-\sigma}{2\sigma}$, then we obtain $\frac{d[U_2 + (k(1-\alpha T_M)^{a_2} T_M L_2)]}{dT_A} > 0$ because $\frac{R_1}{R_2} + (\frac{R_1}{R_2})^{1-\sigma} > 2$. As $\frac{d[k(1-\alpha T_M)^{a_2} T_M L_2]}{dT_A} = 0$, this implies $\frac{dU_2}{dT_A} > 0$ if $h > \frac{1-\sigma}{2\sigma}$. To complete the proof, note that the environmental externality $k\varepsilon$ is a decreasing function of T_A .

Proposition 5b: If $a_2 L_2$ is greater $\frac{1-\sigma}{2\sigma}$, then the welfare function U_2 of the *recipient* increases with mitigation aid T_M .

Proof: If $a_2 L_2 > \frac{1-\sigma}{2\sigma}$, then we obtain $\frac{d[U_2 + (k(1-\alpha T_M) a_2 T_M L_2)]}{dT_M} > 0$. As $\frac{d[k(1-\alpha T_M) a_2 T_M L_2]}{dT_M} < 0$, this implies $\frac{dU_2}{dT_M} > 0$ if $a_2 L_2 > \frac{1-\sigma}{2\sigma}$. To complete the proof, the environmental externality $k\varepsilon$ is a decreasing function of T_M .

It is worth noting that to obtain an increase in the donor and recipient countries' welfare, the beneficial impacts of adaptation and mitigation aid on the production of the recipient must be sufficiently large so that the recipient increases its exports and imports. For the recipient country, the positive income effects of receiving aid dominate the substitution effects of the increased price of imports.

Next, we study the motivations for a transfer. For historical and geopolitical reasons (colonial ties, migratory history, etc.) already mentioned in the introduction, we assume that the donor country wants to maintain its trade relations with the recipient country, which are damaged by climate change. It can be easily shown that the welfare of the donor and recipient countries $U_1 = R_1^\sigma (R_2^\sigma + R_1^\sigma)^{\frac{1-\sigma}{\sigma}}$ and $U_2 = \left[R_2^{\frac{\sigma^2}{1-\sigma}} (R_1^\sigma + R_2^\sigma) \right]^{\frac{1-\sigma}{\sigma}} - k\varepsilon$ depend negatively on the stock of global GHG emissions P , through R_1 and R_2 .

As the objective of the donor country is to maintain its former trade relations with the recipient country, we assume that the donor country wants to keep the *sum* of their welfare $U_1 + U_2$ *constant*, independently of how its level was determined in the past:

$$U_1 + U_2 = \left[C_2^1 (1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}} \right] + \left[C_1^2 (1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}} - k\varepsilon \right] \quad (16)$$

Our theoretical model is in line with the trade agreements literature, which is based on the maximisation of the sum of the welfare functions of the signatory countries. This approach was proposed originally by [Bagwell and Staiger \(1999\)](#) and developed by [Limão \(2005\)](#), [Antràs and Staiger \(2012\)](#) and [Grossman et al. \(2021\)](#) among others. We observe that countries have signed similar trade agreements in the past and posit that they want to maintain these relations through climate aid, considering how climate change might impact them. This situation can be illustrated by the relations between France and its former protectorate Tunisia. The European Commission Tunisia Euro-Med Association Agreement (1995) trade agreement to which France is a signatory resulted in the provision by France of climate aid to Tunisia in 2017: aid for securing and strengthening the northern water transfer infrastructures for the Sahel and Sfax regions. An example of long-term trade relations based on geographical proximity is the 2006 and 2007 trade agreements between South Korea and the Association of Southeast Asian Na-

tions (ASEAN) member countries such as Cambodia, which joined ASEAN in 1999. The trade agreements between South Korea and Cambodia resulted in 2010 in the provision of climate aid from South Korea to Cambodia: aid to stabilise the supply of agricultural water in the Mongkol Borey River basin, to reduce the frequent flood damage around the project area, and mitigate a critical power shortage. We have shown theoretically that if climate change has a negative effect on the two countries' welfare, then climate transfers work to improve them. We believe that this is why the two countries agree to use climate transfers to counteract the effects of climate change and keep the sum of their welfare constant. Thus, following any increase in the stock of global GHG emissions leading to climate change, the developed country will increase the amount of its aid since it knows that this aid will have a positive impact on the welfare of the recipient country - directly and indirectly via consumption.

We can show that at equilibrium there is a positive relationship between the donor country's imports and exports and the level of its climate aid.

Prediction: At equilibrium, mitigation and adaptation aid (or their variation) depend positively on the donor country's imports (or their variations) and on the donor country's exports (or their variations).

Proof: If we consider the total differential of $U_1 + U_2 + k\varepsilon$ with respect to adaptation aid T_A , the stock of global GHG emissions P , imports of good 2 by donor country C_2^1 , and exports of good 1 by donor country C_1^2 , we obtain:

$$\begin{aligned}
& dC_2^1(1 + p^{\frac{\sigma}{1-\sigma}}) + dC_1^2(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}} + \\
& C_2^1 \left[\frac{1}{\sigma}(1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} \frac{\sigma}{1-\sigma} (p)^{\frac{\sigma}{1-\sigma}-1} \left[\frac{\partial p}{\partial P} dP + \frac{\partial p}{\partial T_A} dT_A \right] \right] + \\
& C_1^2 \left[\frac{1}{\sigma}(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} \frac{\sigma}{\sigma-1} (p)^{\frac{\sigma}{\sigma-1}-1} \left[\frac{\partial p}{\partial P} dP + \frac{\partial p}{\partial T_A} dT_A \right] \right] \\
& = 0
\end{aligned} \tag{17}$$

By replacing C_1^2 with pC_2^1 and rearranging the terms, we obtain:

$$\begin{aligned}
& dT_A \left[C_2^1 \frac{1}{\sigma} \frac{\sigma}{1-\sigma} \frac{\partial p}{\partial T_A} \left((1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{1-\sigma}-1} - p(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{\sigma-1}-1} \right) \right] \quad (18) \\
& = -dC_2^1 (1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} - dC_1^2 (1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} + \\
& \quad -dP \left[C_2^1 \frac{1}{\sigma} \frac{\sigma}{1-\sigma} \frac{\partial p}{\partial P} \left((1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{1-\sigma}-1} - p(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{\sigma-1}-1} \right) \right]
\end{aligned}$$

The term associated with dT_A is negative because $\frac{\partial p}{\partial T_A} < 0$, and $(1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{1-\sigma}-1} - p(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{\sigma-1}-1} > 0$ because $p > 1$ (as $R_1 > R_2$). This shows that if we regress dT_A with the imports and exports of the donor country, we would obtain positive coefficient estimates.

With mitigation aid, we obtain the same result, but an additional term appears in the coefficient associated with T_M because we now take into account the negative externality of local pollution from GHG emissions in the utility function. The first line of Equation 18 becomes:

$$dT_M \left[C_2^1 \frac{1}{\sigma} \frac{\sigma}{1-\sigma} \frac{\partial p}{\partial T_M} \left((1 + p^{\frac{\sigma}{1-\sigma}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{1-\sigma}-1} - p(1 + p^{\frac{\sigma}{\sigma-1}})^{\frac{1}{\sigma}-1} (p)^{\frac{\sigma}{\sigma-1}-1} - ka_2 L_2 (1 - 2\alpha T_M) \right) \right] \quad (19)$$

The bracketed term is negative if the damage parameter k is sufficiently low, because $ka_2 L_2 (1 - 2\alpha T_M) < 0$.

Why is the mathematical relationship between trade variables and climate aid positive? If trade variables (imports and exports) increase, then *ceteris paribus*, the welfare of both donor and recipient increases. Keeping the sum of the welfare constant requires transfers to reduce the donor's revenue. As the donor's initial revenue is larger than the recipient's initial revenue, the sum of the welfare remains constant. Here, only the revenue effects are at work.

From an econometric point of view, we can conclude that there is a simultaneous and positive relationship between the donor country's transfers (variation in transfers) and its imports (variation in imports) and exports (variation in exports). This simultaneity bias occurs because the variations in imports and exports also depend on the variation in climate transfers. For causal inference, we need to use an instrumental variable strategy to identify the true parameters.

What is the true relationship between climate aid and pollution? The "true" unbiased relationship is written for $T = T_M$ or $T = T_A$:

$$-dT\left(\frac{\partial U_1}{\partial T} + \frac{\partial U_2}{\partial T}\right) = dP\left(\frac{\partial U_1}{\partial P} + \frac{\partial U_2}{\partial P}\right) \quad (20)$$

The terms in parentheses are positive for dT and negative for dP , which means that when the stock of global GHG emissions P increases, aid T also increases in line with the objective of climate transfers to compensate for the welfare losses through trade. If the stock of global GHG emissions increases, then consumption decreases, and the donor will increase its aid allocation to its trading partner. This, in turn, will increase the donor's imports and exports because the price of the good produced by the recipient country decreases while its income increases. Trade and aid flows move in the same direction because the cumulative effects of the aid outweigh the effects of climate change. Two mechanisms are at work: the price effect, which improves the donor country's imports, and the income effect, which improves the recipient country's imports.

2.3 From theory to data

Our empirical analysis aims to identify the trade determinants of climate aid. We explain the allocation of climate aid by the donor countries' will to maintain historical trade relations based on colonial ties, geopolitics, etc., which could be degraded by climate change. Donor countries allocate climate aid to their trade partners to protect and improve their productive capacities and thus maintain their bilateral trade relations. Indeed, our theoretical model shows that climate aid can alleviate the effects of climate change via two channels: the price effect, which increases the donor country's imports, and the income effect, which increases the recipient country's imports. These mechanisms translate into a reciprocal positive mathematical relationship between the donor country's imports and exports and its allocation of climate aid. Our empirical analysis aims to estimate the trade determinants of climate aid and must therefore eliminate possible biases due to this reverse causation. This requires an IV method, which we detail in the next section.

3 Empirical strategy

In this section, we empirically estimate the theoretical model's alternative predictions using the OECD-DAC Creditor Reporting System (CRS) Rio Markers database (OECD, 2020b). In particular, we check whether trade (exports and imports) affects the allocation of climate aid. We first present our data in Subsection 3.1 and detail our empirical strategy in Subsection 3.2.

3.1 Data

We gather data on climate aid, trade flows, and some control variables, for the period 2002-2017.

Climate aid. The OECD-DAC CRS Rio Markers database (OECD, 2020b) includes bilateral environmental aid from OECD-DAC member countries at the project-level. It distinguishes among four types of environmental actions corresponding to the four so-called Rio markers: mitigation, adaptation, biodiversity, and desertification. However, the adaptation Rio marker was only introduced in 2010. The projects' relevance relative to the Rio markers is evaluated as "principal", "significant", or "not targeted". We use the aggregate of principal and significant mitigation and adaptation aid flows. Following the advice accompanying the database, we use project-level data and merge them appropriately to obtain total bilateral climate aid per year without double counting projects targeting both adaptation and mitigation objectives. We also screen for identical bilateral transfers registered more than once by donor countries for different purposes. The data considered in our analysis refer to 154 recipient countries and 27 donor countries from 2002 to 2017. All the donor countries are DAC members. We exclude aid transfers from EU institutions as we consider donor countries' strategic trade motivations, and we observe no climate aid transfers from Hungary. We also merge Luxembourg's and Belgium's transfers to enable matching with our trade data that identify both countries under Benelux. We correct aid values for inflation using the US Consumer Price Index (CPI) (base 2010) from the World Bank World Development Indicators (WB-WDI)(World Bank, 2021a). We also build a database which accounts for null transfers by rectangularising the data at the donor, recipient, and year levels. If no bilateral transfer is observed, we record it as a null value transfer. The rectangularised dataset is used to check for potential selection bias (across donors and recipi-

ents) in the empirical estimation. This second set of data thus includes all climate aid transfers, including null transfer, for each country pair in each year.

Trade. To measure trade flows, we use the CEPII BACI database (Gaulier and Zignago, 2010), which gathers bilateral trade data at the product-importer-exporter-year level. We matched these data to our period of analysis (2002-2017) and our countries. We aggregate all product-specific trade flows at the bilateral-year level and correct them for inflation using the US CPI (base 2010). This allows us to measure both exports and imports at the country-pair level.

Control variables. We include in our analysis a set of macroeconomic control variables. In line with much of the foreign aid literature, we control for the following three categories of variables (Alesina and Dollar, 2000): recipients' needs, recipients' merits, and donors' interests. To account for the recipients' needs, we include GDP and population (WB-WDI), environmental vulnerability (Notre Dame Global Adaptation Initiative indicators (ND-GAIN, 2022)¹⁰), and per capita greenhouse gas (GHG) emissions (Ritchie et al. (2020)). To measure the recipients' merits, we include indicators of institutional quality from the World Bank World Governance Indicators (WB-WGI) (World Bank, 2021b).¹¹ We create an indicator for average institutional quality by computing the mean of the five WGI.

To control for bilateral relationships, we include distance and a dummy variable representing past colonial ties between donor and recipient countries (CEPII Gravity database (Head et al., 2010; Conte et al., 2020)) in line with our theoretical model. We also include an index of voting similarity at the UN General Assembly (Voeten et al., 2009).¹² We also control for the donors' GDP (WB-WDI). In robustness check, we control for omitted variables and selection bias using the share of green party seats in the donor countries' parliament to proxy for the donor population's interest in environmental issues (Armingeon et al., 2020), total foreign aid (ODA) (OECD, 2020a), language similarity (CEPII Gravity database (Head et al., 2010; Conte et al., 2020)), and a dummy for whether donor and recipient countries are signatories to a regional trade agreement (RTA) (De Sousa, 2012). Monetary variables are in USD millions corrected for inflation using the 2010 US CPI.

¹⁰The ND-Gain Index ranks from 0 to 100, with the lowest scores representing the most vulnerable countries.

¹¹The WGI score between -2.5 and 2.5, with the lower values corresponding to countries with the lowest outcomes. The five WGI measure: voice and accountability, political stability and absence of violence, government effectiveness, regulatory law, the rule of law and control of corruption.

¹²The voting similarity index is a bilateral-year variable (between 0 and 1) which indicates voting similarity practices between two countries in the UN General Assembly where 1 indicates perfect similarity. Abstention is counted as a half-agreement with a yes or no vote.

Table 1.1 provides the descriptive statistics of the dataset with only positive climate transfers. The full dataset, including the null transfers, consists of 66,528 observations. Separate mitigation and adaptation aid data are provided from 2010. Thus, the observations for these two variables cover 2010 to 2017.

Table 1.1: Descriptive statistics

Variable	Mean	SD	Min	Max	N
Climate aid	15.20	94.27	1.36e-07	3,458.51	12,077.00
Mitigation aid	11.61	81.80	0.00	2,804.69	12,077.00
Adaptation aid	5.29	29.81	0.00	1,025.13	12,077.00
Donor exports	1,684.16	9,932.48	1.66e-03	211,326.7	11,789.00
Donor imports	2,290.08	17,484.5	1.09e-03	535,979.4	11,627.00
Distance (km)	7,534.39	3,665.79	394.75	19,447.35	11,860.00
Colony (dummy)	0.08	0.28	0.00	1.00	11,860.00
UN vote Similarity	0.69	0.13	0.05	1.00	11,696.00
Donor GDP	2.83e06	4.02e06	1.55e04	2.19e+07	12,077.00
Recipient GDP	2.69e05	1.09e+06	15.38	1.37e+07	11,839.00
Recipient Pop.	76.61	229.59	0.01	1,386.39	11,985.00
WGI	2.49	0.54	0.55	4.33	11,998.00
ND-Gain Index	41.98	7.57	15.93	62.18	11,476.00
Donor GHG	725.09	1,325.53	0.00	6,601.13	12,077.00
Recipient GHG	330.92	1,248.77	-85.62	11,592.12	12,064.00
ODA	64.49	203.13	-16.65	5,194.44	11,956.00

Aid, trade and GDP in USD million. Distance in km. Population in million.

GHG emissions in million tons CO₂-eq.

3.2 Empirical strategy

Baseline model To estimate the impact of trade relationships on the level of positive climate aid across years and pairs of countries, we estimate a multivariate linear regression with fixed effects (FE):

$$\text{Climate Aid}_{ijt} = \alpha_X \text{Exports}_{ijt} + \alpha_M \text{Imports}_{ijt} + \beta Z_{ij} + \theta Y_{ijt} + \gamma W_{it} + \eta X_{jt} + \mathbf{FE} + \epsilon_{ijt} \quad (21)$$

where ClimateAid_{ijt} is our general measure of climate aid from country i to country j in year t . We consider total climate aid. In the additional results section, mitigation and adaptation aid are estimated separately (see Subsection 4.2.3).

To assess the impact of trade on climate aid, we focus on two measures of trade, consistent with the implications of our theoretical model. We estimate the impacts of both the exports from country i (aid donor) to destination j (aid recipient) and the imports of country i from country j in year t (trade flows go in the opposite direction to climate aid flows). Our objective is to estimate both α_M and α_X , which *ceteris paribus* capture the impact of imports and exports on climate aid. Based on our theoretical model, we expect these parameters to be positive.

Our specification includes a set of bilateral time-invariant control variables (Z_{ij}), such as distance, and a set of bilateral time-varying control variables (in Y_{ijt}), such as voting similarity in the UN General Assembly. These variables are particularly important as they are direct confounding factors with respect to the trade variables. Also, as additional controls, we include donor-year (W_{it}) and recipient-year (X_{jt}) variables, such as GDP, vulnerability, and quality of governance.

Finally, we include a set of FE to control for unobserved heterogeneity. As alternatives to donor, recipient, and year FE, we include two-dimensional FE. We consider donor-year and recipient-year FE to provide a quasi within-estimation. Given the size of our sample, this is a very demanding estimation. We first include donor-year FE, which control for all changes in the donor country and hold constant the total amount of aid provided by this country to all recipients. The inclusion of these donor-year FE allows our main coefficient to be interpreted as the effect of trade on the share of aid to country j with respect to other recipients. The FE, in this case, allow us to study the allocation of aid across recipients for a given donor(-year). When included, all donor-year control variables are absorbed and cannot be identified. The FE

also exclude donor-year groups with only one recipient. Next, we introduce recipient-year FE to control for all changes in the destination country. Similar to the donor-year FE, the recipient-year FE hold constant the total amount of aid received by a country and study the relative origin of all aid received. If we include these FE, we need to exclude recipients that receive climate aid from only one donor country (there is no variance for these observations), and we cannot identify the effect of changes in the (unilateral) recipient's economic characteristics over time.

Endogeneity issues. We can estimate equation 21 with a standard ordinary least square (OLS) estimation. However, we cannot exclude endogeneity problems which could lead to biased estimation of both α_X and α_M . In particular, both the trade variables and aid could be determined simultaneously, resulting in an aid-to-trade outcome, as we have underlined theoretically. On the one hand, climate aid might influence the recipient country's aggregate revenue, which would affect the donor's exports by increasing demand. On the other hand, climate aid, and especially adaptation aid, might affect local production in the recipient country. It could lead to shifts in the recipient country's firms' production technology, specialisation, or market power, which, in turn, would affect the donor country's imports. Finally, since external factors such as political conflicts and resulting changes in both trade and aid flows might influence both variables, we omit them from our main specification.

To overcome endogeneity issues, we use an instrumental variables (IV) strategy in a two-stage least squares (2SLS) estimation. In the first stage, we instrument the levels of both bilateral exports and imports using their expected levels and employ the predictions as the regressors in the second stage. Our IV strategy should identify the sources of variations in bilateral trade that are exogenous to climate aid and the exporting and importing countries' decisions. It allows us to exclude simultaneous variations in aid and trade. Identifying the relationship requires instruments which (i) are related (and relevant) to trade, and (ii) are orthogonal to country pair decisions about trade or aid allocation.¹³

We use two shift-share instruments of exports and imports at the bilateral-year level. Our work is in line with a large literature which uses trade shocks as shifters in empirical exercises. Following the seminal contribution of [Bartik \(1991\)](#), this type of strategy has been used exten-

¹³Following the advice of one of the referees, we have investigated the possibility to use weather shocks as an exogenous trade shifter. Even though we are interested in these trade variations from weather/climate issues, we believe that these variations lead to additional problems. We have identified that weather variations are only weakly correlated to trade flows and are, thus, potentially weak instruments. They are also plausibly endogenous to climate aid. Finally, weather variations could be of particular importance for the identification of the relationship. They are implicitly included in the estimation via the country-year fixed effects and via the vulnerability of the recipient country.

sively at both the aggregate (see, e.g. Autor et al. (2013)) and microeconomic (see, e.g. Mayer et al. (2014) or Aghion et al. (2018)) levels.

Bilateral exports are instrumented by world demand (WD) for the products previously exported by country i to country j . Our baseline instrument is constructed using BACI product-level information at the HS4 level. Specifically, we start by computing WD by aggregating all trade flows for a given product p over all trade partners, except exporter i and importer j . We denote it WD_{ijpt} :

$$WD_{ijpt} = \sum_{i' \neq i} \sum_{j' \neq j} X_{i'j'pt} \quad (22)$$

Next, we aggregate all product-level (quasi) world demand in a bilateral-year variable to account for the importance of exports from country i to country j in the total world flows of product p five years earlier. We denote this share by s_{ijpt}^X :

$$s_{ijpt}^X = \frac{X_{ijpt-5}}{X_{pt-5}}. \quad (23)$$

This variable captures the importance of a specific export flow compared to world exports of a traded product. We obtain a shift-share variable where shifts in world demand are allocated to pairs of countries depending on their relative importance in total trade flows.

$$\text{Predicted Exports}_{ijt} = \sum_p s_{ijpt}^X \times WD_{ijpt} \quad (24)$$

For example, suppose that exports involving two countries account for 70% of the total exports of a given product. We argue that if world exports of that product double (but not based on increased supply from country i or increased demand from country j), it is likely that exports from country i to country j will also increase proportionally to the overall shift in exports and to the initial share.

We perform a similar exercise to obtain the predicted imports of country i from country j . Our instrument measures the total demand for the product that previously was imported by country i from country j . In practical terms, we use the same product-level WD shifts (again excluding country i and country j flows) but aggregate them using the share of the imports of country i from country j in the total world flows of product p :

$$s_{ijpt}^M = \frac{M_{ijpt-5}}{X_{pt-5}} \quad (25)$$

where M_{ijpt-5} is the level of imports of i from j in year $t - 5$. Aggregating world flows at the product and the import-driven shares levels gives the predicted imports of country i from country j in year t :

$$\text{Predicted Imports}_{ijt} = \sum_p s_{ijpt}^M \times WD_{jipt}. \tag{26}$$

For example, suppose the same 70% increase in the total flows of a specific product. If the imports of country i from country j represent a minor fraction of the total flows, the predicted imports will likely be small. However, if the imports of country i from country j represent a major fraction of the total flows, the predicted imports will be quantitatively important.

Figure 1.1 depicts the first-stage relationship between exports and predicted exports (Figure 1.1-A) and between imports and predicted imports (Figure 1.1-B). Both plots show a strong correlation between the variable of interest and the instrument.

Equation 21 remains the key equation to estimate the impact of both trade flows on climate aid using the variables for the two predicted flows as instruments in the first stage. We estimate all the equations using linear estimators. The variables are log-transformed, and standard errors are clustered at the exporter-importer level. The robustness checks use alternative estimators and clustering levels.

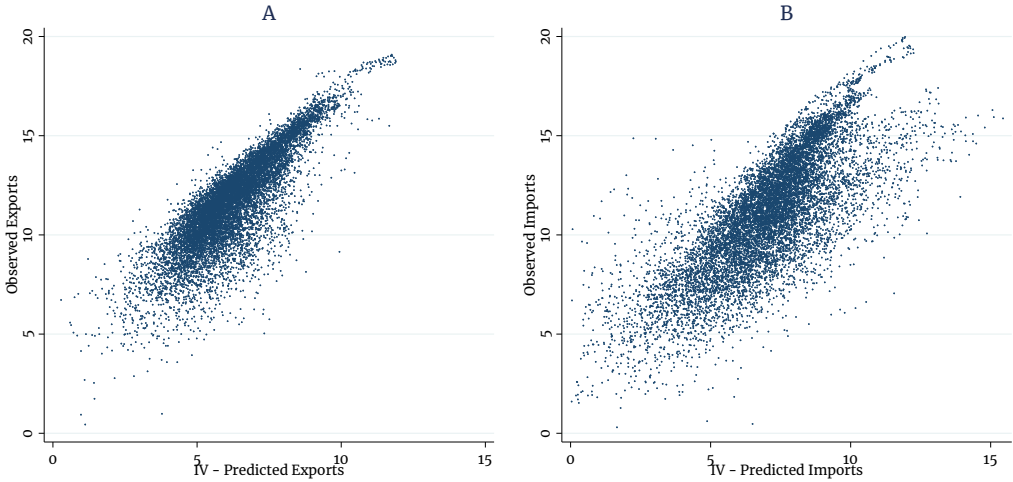


Figure 1.1: Relationship between endogenous trade flows and instruments

4 Results

We present our baseline results in the following Subsection **4.1** and several robustness checks and additional analyses in Subsection **4.2**. We propose a summary of the main results of our empirical analyses in Subsection **4.3**

4.1 Baseline results

IV results. Table **1.2** provides the baseline IV results of equation **21** based on several alternative specifications. We can interpret them as causal since, by construction, we ensured that variations in trade were uncorrelated to countries' decisions. In all the specifications, which differ in terms of FE, the observed import and export levels are instrumented as described in the previous section. Regarding the quality of the instrumentation strategy, Table **1.2** provides the Kleibergen-Paap Wald F-statistic. The validity of the IV strategy is described in detail in Appendix **C.1**.

Columns 1 and 2 in Table **1.2** include only donor, recipient, and year FE. Column 1 includes the baseline set of controls which affect climate aid. Column 2 includes additional climate-related determinants of climate aid. Columns 3 and 4, respectively, include donor-year and recipient-year FE. Column 5 accounts for both of these FE. In all the columns, standard errors are clustered at the donor-recipient level.

First, we find that climate aid is not affected by the donor's imports from the recipient. Regardless of the control variables included, the coefficient of imports is never significant. Also, regardless of the standard errors, the point estimates are all close to zero, suggesting no effect of the import channel.

Second, we find that exports have a positive effect on climate aid allocation. In all columns, the coefficient of exports is close to 0.3. We estimate that a 10% increase in the exports from country i to country j increases climate aid by around 3%. The coefficient is stable across specifications, control variables, and the FE included. In particular, this pro-aid effect is not affected by controls for unobserved heterogeneities in donor-year and recipient-year. The counterpart is that the main variation used to identify this effect is across country pairs, not within a country

Table 1.2: Baseline IV results

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.295*** (0.081)	0.284*** (0.086)	0.259*** (0.081)	0.300*** (0.082)	0.279*** (0.084)
Imports	0.020 (0.039)	0.006 (0.042)	0.019 (0.037)	0.041 (0.044)	0.029 (0.043)
Distance	-0.692*** (0.151)	-0.700*** (0.162)	-0.741*** (0.153)	-0.713*** (0.160)	-0.749*** (0.165)
Colony	0.956*** (0.201)	0.850*** (0.211)	0.953*** (0.198)	0.970*** (0.215)	0.942*** (0.216)
UN Vote Simi.	1.262*** (0.241)	1.255*** (0.247)	0.887*** (0.336)	1.531*** (0.297)	1.604** (0.629)
Donor GDP	2.157*** (0.253)	2.038*** (0.265)		2.298*** (0.265)	
Recip. GDP	0.017 (0.186)	-0.046 (0.199)			
Recip. Pop.	3.075*** (0.669)	3.263*** (0.745)			
WGI		2.084*** (0.673)			
Vulnera. GAIN		-3.924** (1.614)			
Recip. GHG		0.151 (0.102)			
Observations	10542	9269	10601	10344	10327
R^2	0.073	0.068	0.067	0.080	0.076
K.P. Wald F-stat.	288.695	236.333	288.994	321.390	312.161
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

pair over time. For instance, the results in columns 4 and 5 can be interpreted as follows: for a given donor, increasing the exports to one destination country is correlated to an increase in bilateral climate aid to that country, controlling for aid and trade in the other potential destination countries, and controlling for the recipient country's average imports (i.e. the exports of other potential donors). We interpret these results as causal because we instrument for the level of trade between countries: our results show that this effect accounts for the joint determination of aid and trade. Exogenous changes in export possibilities have a quantitative impact on climate aid.

How confident can we be in this result? First, our F-statistics are large and well above standard levels of confidence, confirming that our instruments are not weak.

Second, most control variables have the expected signs, suggesting that the IV estimator is efficient. On average, the distance between the donor and recipient deters climate aid. More importantly, as we underlined in our theoretical analysis, former colonial ties increase climate aid. Common political concerns (measured by UN vote similarity) also increase climate aid. Higher donor's GDP is associated with higher amounts of climate aid, but the recipient country's GDP and the recipient country's GHG emissions seem to have no impact on the level of climate aid allocated. However, the size of the recipient country measured by the number of inhabitants and its institutional quality do determine climate aid allocation. Concerning the recipient countries' vulnerability, we estimate that climate aid is directed toward countries with higher levels of environmental vulnerability (the higher the environmental vulnerability index, the less vulnerable the country). This result is in line with most of the literature (Betzold and Weiler, 2017; Robinson and Dornan, 2017; Weiler et al., 2018; Peterson and Skovgaard, 2019; Mori et al., 2019), which estimates vulnerability as a potential determinant of climate aid using either the ND-GAIN index or the Climate Risk Index. However, case studies on the Adaptation Fund (Stadelmann et al., 2014; Persson and Remling, 2014) find less optimistic results. For instance, Stadelmann et al. (2014) evaluated 39 adaptation project proposals using four vulnerability indices. They find that the Adaptation Fund board has selected projects in countries with low vulnerability and high income per capita. These contrasting results may be due to the lack of a common definition of vulnerability and the diversity of vulnerability indicators.

Third, in Appendix C.1, Table C.4 presents the first-stage results for each of the endogenous regressors. They show that the observed exports are mainly explained by the variable for predicted exports (not predicted imports). The results are reversed for imports. Overall, the predicted exports and imports variables provide a good explanation of the variance in the observed

trade flows. Appendix **B** provides a check of the properties of the IV estimations.

OLS results Table **1.3** presents the OLS estimation results for the relationship between trade and climate aid. The results of the OLS are similar to the IV results: similar magnitudes (around 0.3 for the exports, 0 for imports) and significance (exports affect climate aid, imports do not). However, the OLS results are more precise. Across specifications, we estimate smaller standard errors (still clustered at the country pair level). Since the IV results seem to add some noise to the estimator, we assume that endogeneity is of minor importance concerning the export channel. The quantitative conclusions regarding the effects of exports and imports are similar for both estimation types.

4.2 Robustness checks

In the present section, we check the robustness of our results and offer some additional results to support our baseline estimates.

4.2.1 Correcting for selection bias

First, we show that our results are robust to correcting for sample selection. Since our baseline results are estimated on a sample which only includes positive climate aid flows, we develop a two-stage model to account for this potential selection bias, also known as a Heckman correction.

In the first stage, we estimate the probability to receive climate aid using the following model on the rectangularised dataset which includes null aid flows:

$$Pr(\textit{ClimateAid}_{ijt} > 0) = \phi(\gamma W_{it} + \theta Y_{ijt} + \alpha Z_{ij}) \quad (27)$$

where $\textit{ClimateAid}_{ijt}$ is a binary variable indicating whether or not climate aid was transferred from country i to country j in the year t .

Table 1.3: Baseline OLS results

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.219*** (0.036)	0.207*** (0.039)	0.231*** (0.035)	0.230*** (0.040)	0.253*** (0.041)
Imports	0.015 (0.020)	-0.001 (0.022)	0.017 (0.020)	0.018 (0.023)	0.013 (0.023)
Distance	-0.772*** (0.114)	-0.789*** (0.121)	-0.760*** (0.116)	-0.809*** (0.124)	-0.773*** (0.130)
Colony	0.974*** (0.184)	0.878*** (0.194)	0.914*** (0.180)	0.988*** (0.201)	0.916*** (0.199)
UN Vote Simi.	1.240*** (0.231)	1.233*** (0.242)	0.931*** (0.318)	1.466*** (0.287)	1.535** (0.595)
Donor GDP	2.102*** (0.242)	1.925*** (0.255)		2.243*** (0.253)	
Recip. GDP	0.036 (0.176)	-0.019 (0.188)			
Recip. Pop.	2.652*** (0.644)	2.689*** (0.723)			
WGI		2.033*** (0.643)			
Vulnera. GAIN		-4.061*** (1.550)			
Recip. GHG		0.150 (0.101)			
Observations	11180	9724	11274	11057	11042
R^2	0.069	0.064	0.064	0.074	0.070
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In our model, the provision of climate aid is determined by the existence of a foreign aid (ODA) relationship between the two countries and by the share of green party seats in the parliaments. We believe these two variables mainly determine the existence of a climate aid flow and, to a lesser extent, determine the amount of climate aid. For robustness, we include additional covariates which quantitatively do not provide additional information – see the information criteria statistics (AIC) in Table C.8 in Appendix C.2. Conditional on this set of determinants, we run OLS estimations with country-pair and year FE, OLS with country-year FE, and probit estimations, and choose the specification with the highest information (AIC) statistics. The results are presented in Table C.8 in Appendix C.2. In the second stage, we estimate our baseline equation, including the inverse Mills ratio (λ_{ijt}) computed from the first-stage estimation. We do so for both IV and OLS estimations:

$$\text{Climate Aid}_{ijt} = \alpha_X \text{Exports}_{ijt} + \alpha_M \text{Imports}_{ijt} + \beta Z_{ij} + \theta Y_{ijt} + \gamma W_{it} + \eta X_{jt} + \lambda_{ijt} + \mathbf{FE} + \epsilon_{ijt} \quad (28)$$

The results of the modified second stage with an IV-2SLS strategy are presented in Table 1.4, and the modified OLS results in Table 1.5. Overall, the coefficients are close to the baseline results, which removes concern over sample selection issues. The inverse Mills ratio is large and significant in both estimations but does not affect the size or precision of the results.

Table 1.4: Selection bias correction: second-stage IV results

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.315*** (0.087)	0.290*** (0.091)	0.274*** (0.087)	0.317*** (0.088)	0.287*** (0.091)
Imports	0.021 (0.042)	0.012 (0.044)	0.016 (0.040)	0.037 (0.048)	0.023 (0.047)
Inv. Mills Ratio	-0.544*** (0.180)	-0.352** (0.176)	-0.631*** (0.203)	-0.386* (0.198)	-0.471** (0.232)
Distance	-0.693*** (0.169)	-0.706*** (0.179)	-0.773*** (0.170)	-0.732*** (0.182)	-0.801*** (0.186)
Colony	0.941*** (0.205)	0.848*** (0.213)	0.945*** (0.202)	0.964*** (0.219)	0.952*** (0.220)
UN Vote Simi.	1.304*** (0.246)	1.280*** (0.251)	0.884** (0.346)	1.622*** (0.305)	1.711*** (0.646)
Donor GDP	2.292*** (0.267)	2.218*** (0.278)		2.441*** (0.281)	
Recip. GDP	-0.029 (0.192)	-0.059 (0.205)			
Recip. Pop.	3.145*** (0.689)	3.325*** (0.767)			
WGI		2.037*** (0.697)			
Vulnera. GAIN		-3.888** (1.674)			
Recip. GHG		0.101 (0.102)			
Observations	9957	8782	10014	9734	9717
R^2	0.074	0.068	0.067	0.080	0.076
K.P. Wald F-stat.	261.802	217.486	262.652	288.165	280.569
Donor FE	x	x		x	
Recipient FE	x	x	x		
Year FE	x	x			
Donor-Year FE			x		x
Recipient-Year FE				x	x
Donor-Rec. Cluster	x	x	x	x	x

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.5: Selection bias correction: second stage, OLS results

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.212*** (0.037)	0.195*** (0.041)	0.223*** (0.036)	0.217*** (0.042)	0.235*** (0.043)
Imports	0.013 (0.021)	0.001 (0.023)	0.012 (0.021)	0.011 (0.025)	0.004 (0.025)
Distance	-0.821*** (0.124)	-0.827*** (0.132)	-0.830*** (0.127)	-0.882*** (0.137)	-0.867*** (0.144)
Colony	0.987*** (0.185)	0.893*** (0.195)	0.930*** (0.181)	1.014*** (0.203)	0.950*** (0.201)
UN Vote Simi.	1.273*** (0.238)	1.251*** (0.246)	0.920*** (0.329)	1.544*** (0.298)	1.600** (0.631)
Donor GDP	2.198*** (0.254)	2.084*** (0.265)		2.326*** (0.267)	
Recip. GDP	0.002 (0.181)	-0.027 (0.193)			
Recip. Pop.	2.715*** (0.661)	2.779*** (0.743)			
Inv. Mills Ratio	-0.763*** (0.177)	-0.565*** (0.181)	-0.882*** (0.204)	-0.654*** (0.210)	-0.821*** (0.261)
WGI		1.976*** (0.667)			
Vulnera. GAIN		-3.969** (1.604)			
Recip. GHG		0.102 (0.100)			
Observations	10559	9215	10650	10412	10397
R^2	0.071	0.065	0.066	0.076	0.072

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2.2 Alternative IVs

In Appendix C.1, Tables C.5, C.6 and C.7 present the second-stage results of our IV estimations using alternative IVs. The results in Table C.5 are for the predicted flows computed using a 1-year instead of a 5-year lag. Table C.6 presents the results for the predicted flows computed using quantities rather than values. Table C.7 presents the results for exports and imports instrumented by 1-year lagged exports and imports. Overall, the coefficients are close to those in the baseline estimates, around 0.3, but the precision of the estimations is lower, especially in Table C.6.

4.2.3 Adaptation vs mitigation

We also replicate our estimations separately for mitigation aid in Table 1.6 and for adaptation aid in Table 1.7.

Imports have no effect on either adaptation or mitigation aid, but exports are a significant determinant of both, with a higher coefficient for mitigation aid. We estimate that a 10% increase in the exports from country i to country j increases mitigation aid by around 3% and increases adaptation aid by around 1.5%. The quantitatively larger reaction of mitigation aid, with respect to donor country's exports, compared to adaptation aid is puzzling. According to our theoretical model, mitigation aid increases productivity to a larger extent than adaptation aid. Thus, the income effects may be larger in the case of mitigation aid and may induce more imports of the recipient from the donor country. More generally, it is conceivable that the effects of mitigation aid are more persistent than adaptation aid because the technological change enabled by mitigation assistance may have longer-term impacts. These dynamic aspects are not taken into account in our model, which is static.

The control variables have the same signs as in the baseline estimations for both adaptation and mitigation aid, with the recipient's GDP still not a significant determinant of adaptation or mitigation aid. However, in the case of adaptation aid, we estimate a significant positive coefficient of the recipient's GHG emissions which contrasts with the baseline and mitigation aid estimations. We also observe that the recipient's environmental vulnerability seems to be a stronger determinant of mitigation aid, while historical colonial relationships have a bigger impact on adaptation aid allocation.

Table 1.6: IV results on mitigation aid

	Dep. Variable: log Aid - Mitigation				
	(1)	(2)	(3)	(4)	(5)
Exports	0.286*** (0.093)	0.301*** (0.097)	0.257*** (0.092)	0.342*** (0.096)	0.331*** (0.097)
Imports	-0.001 (0.041)	0.001 (0.043)	0.006 (0.040)	0.007 (0.049)	0.010 (0.049)
Distance	-0.672*** (0.171)	-0.621*** (0.180)	-0.690*** (0.174)	-0.657*** (0.183)	-0.648*** (0.188)
Colony	0.683*** (0.202)	0.551*** (0.211)	0.699*** (0.197)	0.681*** (0.219)	0.652*** (0.216)
UN Vote Simi.	1.304*** (0.273)	1.428*** (0.274)	0.807** (0.405)	1.678*** (0.331)	1.609** (0.771)
Donor GDP	2.589*** (0.274)	2.485*** (0.290)		2.696*** (0.298)	
Recip. GDP	-0.038 (0.198)	-0.070 (0.210)			
Recip. Pop.	2.139*** (0.697)	2.004*** (0.760)			
WGI		2.264*** (0.726)			
Vulnera. GAIN		-5.039*** (1.710)			
Recip. GHG		0.079 (0.098)			
Observations	9086	8063	9119	8832	8811
R^2	0.058	0.059	0.050	0.066	0.059
K.P. Wald F-stat.	225.659	191.280	231.649	249.167	247.961
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1.7: IV results on adaptation aid

	Dep. Variable: log Aid - Adaptation				
	(1)	(2)	(3)	(4)	(5)
Exports	0.190** (0.084)	0.170* (0.092)	0.153* (0.083)	0.178** (0.086)	0.153* (0.086)
Imports	0.026 (0.047)	0.016 (0.053)	0.023 (0.045)	0.048 (0.051)	0.047 (0.050)
Distance	-0.804*** (0.166)	-0.755*** (0.177)	-0.840*** (0.165)	-0.830*** (0.177)	-0.841*** (0.179)
Colony	1.483*** (0.231)	1.413*** (0.250)	1.457*** (0.222)	1.470*** (0.240)	1.421*** (0.235)
UN Vote Simi.	0.562** (0.281)	0.516* (0.286)	0.984*** (0.367)	0.325 (0.410)	1.220* (0.717)
Donor GDP	3.064*** (0.363)	2.890*** (0.387)		3.149*** (0.381)	
Recip. GDP	-0.067 (0.244)	-0.320 (0.292)			
Recip. Pop.	2.509** (1.257)	3.174** (1.531)			
WGI		1.268 (0.969)			
Vulnera. GAIN		-2.282 (2.484)			
Recip. GHG		0.358*** (0.135)			
Observations	6502	5447	6554	6448	6443
R^2	0.086	0.076	0.077	0.090	0.082
K.P. Wald F-stat.	257.656	215.265	253.413	292.482	286.771
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4.2.4 Omitted variables

The other threat to the identification of the impact of trade on climate aid is omitted variables which jointly determine aid and trade. Table 1.8 checks for these possible biases. First, the correlation between climate aid and exports could be the result of a correlation among foreign aid (ODA), climate aid, and exports. We can expect a persistent effect on bilateral aid relations such that donor countries allocate climate aid to countries who are already recipients of their foreign aid. Then, since foreign aid is significantly larger than climate aid, the coefficient identified might be the result of the effect of foreign aid through climate aid. Column 1 in Table 1.8 excludes this bias but provides similar results.

Second, the main result abstracts from the potential trade agreements between donor and recipient countries. Consequently, the observed correlation could be the outcome of a preferential trade agreement. Column 2 uses RTA data from De Sousa (2012). The results show that the effect of exports on aid is not driven by the existence of an (omitted) trade agreement between the donor and the recipient of aid.

Third, language is a determinant of trade (Melitz, 2008) and might be a driver of (climate) aid. The results in columns 3 and 4 show that this additional control does not threaten the significance of the pro-aid effect of exports.

4.2.5 Heterogeneity across products

Our baseline results show a robust positive effect of the donor's exports on its allocation of climate aid but no significant effect of its imports. A potential explanation for this might be the different product composition of the donor's exports and imports to and from recipient countries.¹⁴ While donor countries' exports consist mostly of specialised manufactured goods with high levels of differentiation, recipient countries tend to export more homogeneous raw products and commodities. On average, in our sample, more than half of the recipients' exports (i.e. donors' imports) consist of homogeneous products, while these represent around 33% of donors' exports.

Homogeneous products might be more easily substitutable than differentiated manufactured goods. Therefore, a donor country might have fewer incentives to maintain its import flows from

¹⁴We thank one of the reviewers for this suggestion.

Table 1.8: Omitted variables: IV results

	Dep. Variable: log Aid			
	(1)	(2)	(3)	(4)
Exports	0.337*** (0.113)	0.224** (0.090)	0.254*** (0.084)	0.326*** (0.112)
Imports	0.029 (0.058)	0.038 (0.047)	0.032 (0.043)	0.031 (0.057)
Distance	-0.674*** (0.207)	-0.678*** (0.169)	-0.783*** (0.165)	-0.692*** (0.205)
Colony	0.902*** (0.250)	0.829*** (0.228)	0.420* (0.232)	0.359 (0.272)
UN Vote Simi.	1.990** (0.937)	1.660*** (0.624)	1.391** (0.631)	1.870** (0.931)
L.ODA	-1.708 (1.165)			-1.720 (1.199)
RTA		0.318* (0.186)		
Language			0.834*** (0.161)	0.817*** (0.193)
Observations	6838	8352	10327	6838
R^2	0.077	0.069	0.084	0.086
K.P. Wald F-stat.	211.853	247.049	301.066	205.730
Donor-Year FE	✓	✓	✓	✓
Recipient-Year FE	✓	✓	✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

a specific recipient country than to maintain its export flows to the same country through climate aid allocation. For instance, a donor country might be more able to substitute its commodity imports using another recipient country. However, if the donor country exports specialised products designed for the recipient country j 's market, it might be more difficult to redirect this production to another recipient country j' .

We first test this hypothesis using the variation in product types. Specifically, we use product-level characteristics following Rauch (1999), highlighting the difference between homogeneous and differentiated products. We replicate our IV-2SLS strategy on subsamples of product types. We run the estimations, instrumenting both exports and imports using shift-share instruments for each product type. Table 1.9 presents the results. Column 1 focuses on differentiated products. Similar to our baseline results, we find no effect of imports on climate aid allocation. The point estimates are close to zero and are not significant for imports. For donors' export flows of differentiated products, the results are similar to our baseline results, with a significant coefficient close to 0.3. Column 2, which includes only homogeneous products, provides a different picture. A donor's exports of homogeneous products have no impact on its climate aid allocation, which supports the trade specialisation hypothesis. Donor countries have a higher incentive to maintain their differentiated compared to their homogeneous trade flows since the former are less substitutable.

Second, we leverage the variation in the intensity of differentiated products in donors' exports and imports. For exports, we identify – across donor-year observations– sellers that export relatively more differentiated products compared to other donors. We built a dummy variable ("*High Share Diff.*") for each donor country, indicating whether their exports include higher shares of differentiated products compared to the sample average.¹⁵ Columns 3 and 4 in Table 1.9 show that the trade effect on climate aid is shaped by the importance of differentiated products. Column 3 introduces the interaction between exports and our previously defined measure *High Share Diff.*. The results suggest that differentiated exports are quantitatively more important for climate aid allocation than all exports taken together. All other things being equal and controlling for the level of exports, highly-differentiated exports from country i to country j are correlated with higher levels of climate aid allocation compared to more homogeneous-product

¹⁵In formal terms, we first compute the share of differentiated products in each donor's exports: $\omega_{it}^{diff,X} = X_{it}^{diff} / X_{it}$, then we compute the average share over all donor-years: $\bar{\omega}_{it}^{diff,X}$. We identify exporters that sell relatively more differentiated products by comparing the observed share to the average share: *High Share Diff.* = $1\{\omega_{it}^{diff,X} > \bar{\omega}_{it}^{diff,X}\}$. We conduct a similar exercise for donors' imports.

exports. Column 4 includes the interaction between imports and *High Share Diff.*¹⁶ We find that imports determine climate aid only in the case of highly differentiated products. A large share of differentiated products is correlated with larger amounts of climate aid compared to other importers.

We interpret these results as follows: conditional on trade levels, product differentiation is a plausible mechanism determining how trade affects climate aid. Differentiated products, which are more difficult to substitute than homogeneous goods, seem to be a driver of the observed trade effect on aid.

Table 1.9: Role of product specialisation (IV estimations)

	Dep. Variable: log Aid			
	(1)	(2)	(3)	(4)
Imports	0.010 (0.041)	0.041 (0.029)		-0.009 (0.032)
Exports	0.271*** (0.070)	0.049 (0.051)	0.150** (0.067)	
Distance	-0.804*** (0.155)	-1.014*** (0.141)	-0.833*** (0.141)	-1.066*** (0.120)
Colony	0.970*** (0.210)	1.171*** (0.211)	0.982*** (0.205)	1.206*** (0.200)
UN Vote Simi.	1.413** (0.614)	1.497** (0.642)	1.312** (0.601)	1.491** (0.609)
Exports × 1 (High Share Diff.)			0.177*** (0.042)	
Imports × 1 (High Share Diff.)				0.132*** (0.046)
Observations	10105	9853	10692	10692
R^2	0.075	0.069	0.079	0.066
Sample	Differentiated	Homogeneous	Full	Full

Column 1 focuses on differentiated products (see [Rauch \(1999\)](#)). Column 2 focuses on homogeneous products.

Columns 3 and 4 use the full sample. All columns include donor-year and recipient-year FE.

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

¹⁶For each donor country, this measure indicates whether the country's imports include a higher share of differentiated products compared to the sample average.

4.2.6 Other checks

Plausibly exogenous IV The validity of our IV results relies on the validity of the excluded instrument we used. Appendix **B** checks the validity of world import demand as an instrument and provides insights into identification of the source of the shift-share instrument.

Alternative clustering level While the main results are derived from the standard errors clustered at the country-pair level, the results in Tables **C.9**, **C.10** and **C.11** are for standard errors clustered at the donor-year level and do not affect inferences.

4.3 Conclusion of the empirical analysis

Our estimations confirm the important role of exports from donor countries to recipient countries as a determinant of climate aid. The estimates point to an elasticity of 0.3 for exports which is robust to endogeneity issues and omitted variables and across specifications and FE included in the estimation. The separate estimations for mitigation and adaptation aid again show that imports have no impact but that exports are a significant determinant of both, with respective elasticities of 0.15 and 0.3. Our estimate of 0.15 for adaptation aid elasticity is larger than the elasticity of per capita adaptation aid of 0.03 for exports in [Weiler et al. \(2018\)](#) for the period 2010-2015.

Our estimations show that the import channel emphasised in the theoretical model seems not to have an effect. We did not find a significant impact of the donor's imports on its allocation of climate aid to a specific recipient. Compared to the results in the literature, we estimate that the trade effect emphasised by [Weiler et al. \(2018\)](#) is only an export-driven channel: the more a donor exports to a specific country, the higher the relative amount of aid allocated to that country.

In addition, our results are in line with existing evidence regarding the standard determinants of foreign aid in general and climate aid in particular. However, after accounting for trade interests, our results cast doubt on the role of the recipient country's GDP and GHG emissions on bilateral climate aid allocation.

5 Conclusion

Given the importance of climate aid for developing countries and the general objective of increasing funding for climate objectives, understanding their determinants is important for both academics and policymakers. Our work offers some information on the quantitative role of trade on climate aid. We conducted both theoretical and empirical analyses of the role played by trade on climate aid. We investigated the theoretical trade channels of climate aid and provided an empirical assessment of them, also accounting for endogeneity concerns.

We have provided a set of theoretical insights based on a simple trade model. Our model highlights the terms-of-trade and positive income effects of climate aid and predicts a positive relationship between the donor's exports to and imports from the recipient country and its climate aid transfers. The empirical assessment provides a robust and causal estimate of the effects of trade on climate aid, accounting for the bi-directional relationships between aid and trade. For a given donor, climate aid is positively determined by its exports to a specific country but is unaffected by its imports from a potential aid recipient. Our baseline estimates suggest an elasticity of aid of around 0.3 for exports. We show that the impact of trade on climate aid is mainly export rather than import-driven. We interpret this result as follows: climate aid may be used by donors to increase their exports through the establishment of stable and friendly relations with potential importers. While imports might be expected to have some influence triggered by a terms-of-trade effect, we found no evidence of this over the period 2002-2017. The low levels of climate aid, which are the subject of complaints from recipient countries, might explain their negligible influence on exchange rates. If climate aid increases in the future in line with donors' pledges from COP15, the import channel may begin to have some influence. Overall, this chapter reveals some empirical regularities which should be informative for policymakers about the determinants of climate aid. In particular, we show that trade interests are important quantitatively in the allocation of climate aid. As a result, any special trade interests may affect the allocation of aid with not just local but global environmental consequences.

Some limitations of this chapter must be underlined. First, our empirical results are based only on bilateral climate aid data, while at the aggregate level, multilateral aid is more important in value than bilateral aid. Our focus on bilateral aid is motivated by a greater presence of strategic behaviour for this type of aid on the part of donor countries to maintain their bilateral trade relations with their historical partners. Second, the empirical distinction between adaptation and mitigation aid is only available since 2010. For future work, it would be interesting to

analyse whether the behaviour of donor countries in terms of climate aid allocation has changed in the recent period following the ratification of the Paris Agreement (2015) and whether trade motives are less important than the needs of recipient countries in the allocation of climate aid by donor countries since then. Another avenue for future research could be to study the implications of trade-related measures, such as carbon border adjustments in the European Union on the allocation of climate aid by EU countries as mitigation aid may help to green the exports of recipient countries.

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Appendix

A Theoretical model - the preliminaries

Once we have expressed the levels of the relative price of good 2 and the consumption as a function of R_1 and R_2 , we can express their total differentials as a function of dR_1 and dR_2 :

$$dp = (1 - \sigma) \left(\frac{R_1}{R_2} \right)^{-\sigma} \left(\frac{dR_1 R_2 - dR_2 R_1}{(R_2)^2} \right) \quad (\text{A.1})$$

$$dC_2^1 = - \left[-\sigma \left(\frac{R_2}{R_1} \right)^{1+\sigma} dR_1 + (\sigma - 1) \left(\frac{R_2}{R_1} \right)^\sigma dR_2 - dR_2 \right] (R_2)^{-2} \quad (\text{A.2})$$

$$dC_1^2 = - \left[-\sigma \left(\frac{R_1}{R_2} \right)^{1+\sigma} dR_2 + (\sigma - 1) \left(\frac{R_1}{R_2} \right)^\sigma dR_1 - dR_1 \right] (R_2)^{-2} \quad (\text{A.3})$$

The utility of the donor country as a function of R_1 and R_2 is given by:

$$U_1 = C_2^1 \left(1 + \left(\frac{R_2}{R_1} \right)^{-\sigma} \right)^{\frac{1}{\sigma}} = R_1^\sigma (R_2^\sigma + R_1^\sigma)^{\frac{1-\sigma}{\sigma}} \quad (\text{A.4})$$

The utility of the recipient country (without the emissions externality) as a function of R_1 and R_2 is given by:

$$U_2 + k(1 - \alpha T_M) a_2 L_2 T_M = C_1^2 \left(1 + \left(\frac{R_1}{R_2}\right)^{-\sigma}\right)^{\frac{1}{\sigma}} = R_2^\sigma (R_2^\sigma + R_1^\sigma)^{\frac{1-\sigma}{\sigma}} \quad (\text{A.5})$$

The sign of the total differential of the donor country's utility dU_1 is the sign of the following expression:

$$dR_1 \left(1 + \left(\frac{R_2}{R_1}\right)^\sigma\right) + (1 - \sigma) \left[\left(\frac{R_1}{R_2}\right)^{1-\sigma} dR_2 + dR_1\right] \quad (\text{A.6})$$

The sign of $d[U_2 + (k(1 - \alpha T_M) a_2 T_M L_2)]$ is the sign of the following expression:

$$\frac{\sigma^2}{1 - \sigma} dR_2 + \frac{\sigma dR_1}{\frac{R_1}{R_2} + \left(\frac{R_1}{R_2}\right)^{1-\sigma}} + \sigma \frac{dR_2}{1 + \left(\frac{R_1}{R_2}\right)^\sigma} \quad (\text{A.7})$$

We now investigate the positivity of the expressions $\frac{dC_2^1}{dT_A}$, $\frac{dC_2^1}{dT_M}$, $\frac{dC_1^2}{dT_A}$, $\frac{dC_1^2}{dT_M}$, $\frac{dU_1}{dT_A}$, $\frac{dU_1}{dT_M}$, $\frac{d[U_2 + (k(1 - \alpha T_M) a_2 T_M L_2)]}{dT_A}$ and $\frac{d[U_2 + (k(1 - \alpha T_M) a_2 T_M L_2)]}{dT_M}$, and the negativity of the expressions $\frac{dp}{dT_A}$ and $\frac{dp}{dT_M}$.

Regarding the effects of adaptation aid, we have $\frac{dR_1}{dT_A} = -1$ and $\frac{dR_2}{dT_A} = h$. Regarding the effects of mitigation aid, we have $\frac{dR_1}{dT_M} = -1$ and $\frac{dR_2}{dT_M} = a_2 L_2$.

These properties together with the assumptions of the model, that is $\frac{R_1}{R_2} > 1$ and $\sigma < 1$, allow us to obtain the results contained in Propositions 1-5.

B Plausibly exogenous IV

The validity of our IV results relies on the validity of our excluded instrument. We now check the validity of the world import demand as an instrument and assess the sensitivity of the second-stage results. We proceed in 3 steps.

Quasi-random instrument (country observables and instrument)

The IV strategy uses sources of variations in trade that should be uncorrelated to the trade partners and thus allow for causal inference. Our excluded instrument should, in particular, be uncorrelated to the trade partners' observables. Table B.1 shows that there is no strong and quantitatively important correlation between our baseline instruments and the set of observables. We regress the excluded instrument on the set of observables used in the exercise. In particular, we hardly estimate a significant and robust correlation independently of the fixed effects we use. Despite being sometimes significant, we argue that the instrument is plausibly exogenous given the small F-stats obtained regarding the correlation between the predicted exports and vulnerability and between expected imports and the recipient's population. We thus estimate that the instruments are quasi-randomly distributed across observations in our sample, to the exclusion of distance, which appears to be a major determinant of the value of the instruments.

Table B.1: Quasi-random instrument

	GDP(i)	GDP(j)	Pop.(j)	WGI(j)	Vuln.(j)	GHG(j)	Dist.	Colony	UN Simi.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Predicted Exports	0.005 (0.003)	0.008 (0.006)	-0.000 (0.001)	0.002 (0.002)	0.002*** (0.001)	0.014 (0.010)	-0.206*** (0.018)	0.035*** (0.007)	0.000 (0.002)
Observations	10692	10829	10906	10913	10609	9610	11010	11010	10900
R^2	0.996	0.995	1.000	0.949	0.988	0.987	0.705	0.415	0.962
F-stat	2.604	1.918	0.048	1.207	6.962	1.934	124.394	26.495	0.044
Cluster Level	ij	ij	ij	ij	ij	ij	ij	ij	ij
Fixed Effects	ij jt	ij it	ij it	ij it	ij it	ij it	jt it	jt it	jt it
	GDP(i)	GDP(j)	Pop.(j)	WGI(j)	Vuln.(j)	GHG(j)	Dist.	Colony	UN Simi.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Predicted Imports	0.002 (0.002)	0.006* (0.003)	-0.001 (0.001)	0.000 (0.002)	0.001 (0.001)	0.003 (0.004)	-0.069*** (0.008)	0.011*** (0.003)	-0.001 (0.001)
Observations	10160	10357	10420	10422	10211	9205	10462	10462	10367
R^2	0.996	0.995	1.000	0.947	0.988	0.985	0.676	0.414	0.964
F-stat	0.821	3.036	1.114	0.036	1.225	0.683	72.040	9.414	0.681
Cluster Level	ij	ij	ij	ij	ij	ij	ij	ij	ij
Fixed Effects	ij jt	ij it	ij it	ij it	ij it	ij it	jt it	jt it	jt it

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Quasi-random product-level Demand Shocks

The instrument we use in the present paper leverages foreign demand shocks at the HS6 product level (denoted WD_{ijpt} in the paper). The key to identification is that these demand shocks are uncorrelated to observables at the country pair-year level: identification would hence arise from random shocks to demand. Table B.2 shows that foreign demand shocks *at the product level* are mostly uncorrelated to country-level observables (as dependent variables in the table). On top of that, the table displays low F-stats.

Table B.2: Quasi-random product-level demand shocks

	GDP(i) (1)	GDP(j) (2)	Pop.(j) (3)	WGI(j) (4)	Vuln.(j) (5)	GHG(j) (6)	Dist. (7)	Colony (8)	UN Simi. (9)
Product Shock	0.001** (0.000)	-0.000 (0.001)	0.003*** (0.000)	-0.000 (0.000)	-0.001*** (0.000)	-0.001 (0.001)	-0.016*** (0.002)	0.003*** (0.001)	0.000** (0.000)
Observations	11625692	11462914	11556589	11562673	11447479	10718176	11625709	11625709	11551249
R^2	0.995	0.992	0.999	0.929	0.981	0.977	0.647	0.297	0.962
F-stat	4.352	0.041	117.063	0.375	59.140	0.367	104.206	29.806	5.811
Cluster Level	ij	ij	ij	ij	ij	ij	ij	ij	ij
Fixed Effects	ij jt p	ij it p	ij it p	ij it p	ij it p	ij it p	jt it p	jt it p	jt it p

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Non-random exposure of country pairs to foreign shocks

By construction, our shift-share instrument combines foreign exogenous demand shocks with exporter-specific exposure to these shocks. Previous results showed that foreign shocks can hardly be correlated to partners' observables. Yet, a remaining concern is that trade partners are non-randomly exposed to those quasi-random export shocks. For instance, we could imagine that some countries have an export structure which is oriented towards specific foreign markets, in former colonies, countries sharing the same language or close countries, for instance. In other words, the non-random exposure to the random shock may lead to a bias in our estimations. Our results should thus be insulated from this non-random exposure of trade partners to foreign demand shocks.

[Borusyak and Hull \(2020\)](#) develop a general econometric framework for shift-share settings that allows for the possibility that shock exposure is non-random. They also provide a set of guidelines to implement this strategy in empirical applications. We follow these guidelines and use a re-centring process, i.e. we control for the random average exposure of trade partners based on unobservables. In formal terms, we compute a set of 20 random counterfactual country-product-year level demand shocks, replicating the average distribution of the observed demand shocks. Armed with these 20 random shifts, we combine them with the observed

weights, creating a set of 20 counterfactual instruments (i.e. country-specific trade shifts). We thus compute an average exposure of exporters to foreign shocks out of random shocks. Following the idea in [Borusyak and Hull \(2020\)](#), this average instrument should capture the differential (and potential non-random) exposure of the country to random shocks.

We include this average instrument (only for exports) in the second-stage estimation. Results are presented in Table **B.3**. Overall, controlling for the average random exposure of firms to foreign shocks, we obtain close estimates compared to baseline results. Then, we also do not estimate a significant impact of the correction we implement here regarding the import channel. Our instruments thus do a good job of capturing the demand shifts abroad without being contaminated by non-random exposure to these demand shifts.

Table B.3: Controlling for the average instrument

	Dep. Variable: log Climate Aid, (ln Aid_{ijt})				
	(1)	(2)	(3)	(4)	(5)
Exports	0.102** (0.048)	0.175** (0.078)	0.122*** (0.052)	0.209*** (0.065)	0.167*** (0.069)
Imports	0.026 (0.041)	0.012 (0.044)	0.024 (0.043)	0.045 (0.047)	0.038 (0.047)
Distance	-0.811*** (0.196)	-0.841*** (0.207)	-0.873*** (0.212)	-0.818*** (0.196)	-0.867*** (0.201)
Colony	1.035*** (0.232)	0.947*** (0.243)	0.945*** (0.245)	1.016*** (0.243)	1.003*** (0.244)
UN Vote Simi.	1.355*** (0.257)	1.345*** (0.265)	1.002** (0.416)	1.504*** (0.304)	1.556** (0.667)
Donor GDP	2.095*** (0.257)	1.928*** (0.268)		2.250*** (0.272)	
Recip. GDP	0.122 (0.215)	0.069 (0.223)	0.082 (0.216)		
Recip. Pop.	2.640*** (0.704)	2.834*** (0.776)	2.840*** (0.745)		
Mean Shock	0.124 (0.082)	0.125 (0.086)	0.154* (0.087)	0.137 (0.089)	0.172* (0.092)
WGI		2.369*** (0.707)	2.188*** (0.699)		
Vulnera. GAIN		-3.988** (1.743)	-3.191* (1.646)		
Recip. GHG		0.121 (0.109)	0.123 (0.106)		
Observations	9764	8608	8594	9560	9544
R^2	0.068	0.064	0.059	0.074	0.067
K.P. Wald F-stat.	85.211	75.160	75.442	103.749	101.816
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

C Additional empirical results

C.1 Additional IV results

Table C.4: IV: first-stage results

	Dep. Variable: log Exports				
	(1)	(2)	(3)	(4)	(5)
Predicted Exports	0.561*** (0.023)	0.550*** (0.025)	0.562*** (0.023)	0.622*** (0.025)	0.621*** (0.025)
Predicted Imports	0.033*** (0.009)	0.034*** (0.010)	0.038*** (0.009)	0.038*** (0.010)	0.037*** (0.010)
	Dep. Variable: log Imports				
	(1)	(2)	(3)	(4)	(5)
Predicted Exports	0.125*** (0.024)	0.124*** (0.025)	0.124*** (0.024)	0.122*** (0.026)	0.123*** (0.026)
Predicted Imports	0.541*** (0.016)	0.535*** (0.017)	0.547*** (0.016)	0.559*** (0.017)	0.562*** (0.017)
Observations	10542	9269	10601	10344	10327
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.5: Alternative IV: 1-year lag in shares

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.217*** (0.059)	0.208*** (0.062)	0.210*** (0.058)	0.222*** (0.065)	0.225*** (0.067)
Imports	0.010 (0.027)	0.010 (0.028)	0.004 (0.027)	0.022 (0.030)	0.008 (0.031)
Distance	-0.803*** (0.132)	-0.785*** (0.139)	-0.822*** (0.134)	-0.838*** (0.145)	-0.841*** (0.151)
Colony	1.016*** (0.192)	0.894*** (0.201)	0.988*** (0.188)	1.055*** (0.210)	0.996*** (0.209)
UN Vote Simi.	1.265*** (0.235)	1.262*** (0.243)	0.901*** (0.327)	1.491*** (0.289)	1.496*** (0.600)
Donor GDP	2.100*** (0.248)	1.904*** (0.259)		2.256*** (0.258)	
Recip. GDP	0.061 (0.181)	-0.011 (0.191)			
Recip. Pop.	2.668*** (0.657)	2.745*** (0.736)			
WGI		2.077*** (0.656)			
Vulnera. GAIN		-3.975** (1.579)			
Recip. GHG		0.150 (0.101)			
Observations	10880	9519	10946	10708	10692
R^2	0.070	0.065	0.064	0.078	0.073
K.P. Wald F-stat.	739.153	642.650	790.543	712.821	702.416
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Second-stage IV results. Exports and imports are instrumented by predicted exports and predicted imports.

Predicted flows are computed using a 1-year lag, instead of a 5-year lag as in baseline results.

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.6: Alternative IV: using quantities in the IV

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.184* (0.099)	0.128 (0.106)	0.147 (0.101)	0.204** (0.104)	0.189* (0.107)
Imports	0.041 (0.050)	0.046 (0.056)	0.045 (0.048)	0.052 (0.057)	0.044 (0.056)
Distance	-0.815*** (0.164)	-0.859*** (0.174)	-0.858*** (0.168)	-0.829*** (0.174)	-0.850*** (0.180)
Colony	1.055*** (0.207)	0.975*** (0.217)	1.046*** (0.206)	1.059*** (0.223)	1.019*** (0.224)
UN Vote Simi.	1.271*** (0.240)	1.261*** (0.246)	0.910*** (0.338)	1.525*** (0.295)	1.598*** (0.628)
Donor GDP	2.125*** (0.252)	1.980*** (0.263)		2.267*** (0.264)	
Recip. GDP	0.094 (0.187)	0.054 (0.198)			
Recip. Pop.	2.905*** (0.668)	3.111*** (0.741)			
WGI		2.060*** (0.675)			
Vulnera. GAIN		-3.766** (1.628)			
Recip. GHG		0.146 (0.103)			
Observations	10536	9264	10595	10338	10321
R^2	0.073	0.068	0.065	0.079	0.074
K.P. Wald F-stat.	195.187	159.460	185.363	203.897	193.063
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Second-stage IV results. Exports and imports are instrumented by predicted exports and predicted imports.

Predicted flows are computed using quantities instead of values as in baseline results.

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.7: Alternative IV: lagged exports and imports

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.342*** (0.059)	0.304*** (0.064)	0.351*** (0.058)	0.351*** (0.068)	0.362*** (0.070)
Imports	-0.006 (0.035)	-0.028 (0.036)	-0.009 (0.034)	-0.012 (0.039)	-0.018 (0.040)
Distance	-0.676*** (0.148)	-0.735*** (0.156)	-0.661*** (0.150)	-0.715*** (0.164)	-0.703*** (0.169)
Colony	0.860*** (0.216)	0.819*** (0.232)	0.792*** (0.212)	0.920*** (0.232)	0.881*** (0.230)
UN Vote Simi.	0.743*** (0.288)	0.674** (0.299)	1.065** (0.439)	0.872** (0.408)	2.165** (0.870)
Donor GDP	2.316*** (0.318)	2.110*** (0.334)		2.655*** (0.350)	
Recip. GDP	-0.155 (0.225)	-0.269 (0.241)			
Recip. Pop.	2.687*** (0.855)	2.580*** (0.985)			
WGI		2.843*** (0.875)			
Vulnera. GAIN		-5.195*** (1.988)			
Recip. GHG		0.153 (0.111)			
Observations	7481	6417	7513	7185	7168
R^2	0.070	0.066	0.065	0.079	0.077
K.P. Wald F-stat.	1256.896	1186.308	1278.121	1378.212	1410.387
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Rec. Cluster	✓	✓	✓	✓	✓

Second-stage IV results. Exports and imports are instrumented by 1-year lagged exports and imports. Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

C.2 Other additional results

Table C.8: Selection bias correction: initial stage

	Dep. Variable: Pr(Aid > 0)					
	(1)	(2)	(3)	(4)	(5)	(6)
ODA	0.123*** (0.005)	0.113*** (0.005)	0.087*** (0.006)	0.080*** (0.006)	2.932*** (0.103)	2.856*** (0.104)
Share Green	0.009*** (0.001)	0.009*** (0.001)			0.033*** (0.005)	0.035*** (0.005)
UN. Vote Simi.		-0.000 (0.018)		-0.031** (0.015)		-0.094 (0.067)
Distance						0.044 (0.039)
Colony						0.898*** (0.088)
Constant	0.078*** (0.004)	0.088*** (0.008)	0.128*** (0.003)	0.126*** (0.007)	-3.978*** (0.107)	-4.371*** (0.363)
Observations	64064	59216	64064	59216	64064	59216
R^2	0.016	0.014	0.558	0.562		
AIC	19023.656	19356.902	6483.236	7216.401	37557.109	35848.979
Estimator	OLS	OLS	OLS	OLS	Probit	Probit
Fixed Effects	✓	✓	✓	✓		

Standard Errors are clustered at the country-pair level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.9: IV: main results, second stage – alternative clustering level

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Exports	0.295*** (0.063)	0.284*** (0.066)	0.259*** (0.059)	0.300*** (0.065)	0.279*** (0.064)
Imports	0.020 (0.030)	0.006 (0.033)	0.019 (0.029)	0.041 (0.033)	0.029 (0.032)
Distance	-0.692*** (0.118)	-0.700*** (0.127)	-0.741*** (0.112)	-0.713*** (0.123)	-0.749*** (0.121)
Colony	0.956*** (0.190)	0.850*** (0.197)	0.953*** (0.183)	0.970*** (0.200)	0.942*** (0.196)
UN Vote Simi.	1.262*** (0.301)	1.255*** (0.313)	0.887*** (0.281)	1.531*** (0.373)	1.604*** (0.501)
Donor GDP	2.157*** (0.499)	2.038*** (0.529)		2.298*** (0.509)	
Recip. GDP	0.017 (0.152)	-0.046 (0.160)			
Recip. Pop.	3.075*** (0.554)	3.263*** (0.649)			
WGI		2.084*** (0.649)			
Vulnera. GAIN		-3.924*** (1.350)			
Recip. GHG		0.151* (0.083)			
Observations	10542	9269	10601	10344	10327
R^2	0.073	0.068	0.067	0.080	0.076
K.P. Wald F-stat.	593.101	504.709	562.926	699.358	678.155
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Yr. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the donor-year level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.10: IV: first-stage results – alternative clustering level

	Dep. Variable: log Exports				
	(1)	(2)	(3)	(4)	(5)
Predicted Exports	0.561*** (0.016)	0.550*** (0.018)	0.562*** (0.017)	0.622*** (0.017)	0.621*** (0.018)
Predicted Imports	0.033*** (0.007)	0.034*** (0.008)	0.038*** (0.007)	0.038*** (0.007)	0.037*** (0.007)
Observations	10542	9269	10601	10344	10327
R^2					
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Yr. Cluster	✓	✓	✓	✓	✓

	Dep. Variable: log Imports				
	(1)	(2)	(3)	(4)	(5)
Predicted Exports	0.125*** (0.020)	0.124*** (0.019)	0.124*** (0.020)	0.122*** (0.021)	0.123*** (0.021)
Predicted Imports	0.541*** (0.012)	0.535*** (0.013)	0.547*** (0.012)	0.559*** (0.013)	0.562*** (0.014)
Observations	10542	9269	10601	10344	10327
R^2					
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Yr. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the donor-year level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table C.11: OLS: main results – alternative clustering level

	Dep. Variable: log Aid				
	(1)	(2)	(3)	(4)	(5)
Distance	-0.772*** (0.084)	-0.789*** (0.092)	-0.760*** (0.083)	-0.809*** (0.089)	-0.773*** (0.090)
Colony	0.974*** (0.177)	0.878*** (0.180)	0.914*** (0.170)	0.988*** (0.190)	0.916*** (0.183)
UN Vote Simi.	1.240*** (0.289)	1.233*** (0.303)	0.931*** (0.276)	1.466*** (0.376)	1.535*** (0.491)
Donor GDP	2.102*** (0.519)	1.925*** (0.545)		2.243*** (0.513)	
Recip. GDP	0.036 (0.144)	-0.019 (0.148)			
Recip. Pop.	2.652*** (0.521)	2.689*** (0.606)			
Exports	0.219*** (0.029)	0.207*** (0.033)	0.231*** (0.027)	0.230*** (0.033)	0.253*** (0.032)
Imports	0.015 (0.016)	-0.001 (0.017)	0.017 (0.015)	0.018 (0.018)	0.013 (0.017)
WGI		2.033*** (0.635)			
Vulnera. GAIN		-4.061*** (1.456)			
Recip. GHG		0.150* (0.082)			
Observations	11180	9724	11274	11057	11042
R^2	0.069	0.064	0.064	0.074	0.070
Donor FE	✓	✓		✓	
Recipient FE	✓	✓	✓		
Year FE	✓	✓			
Donor-Year FE			✓		✓
Recipient-Year FE				✓	✓
Donor-Yr. Cluster	✓	✓	✓	✓	✓

Standard Errors are clustered at the donor-year level. All variables are in logs.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Chapter 2

Are International Climate Transfers Really Climate-Related? Extent and Determinants of Donor Countries' Miscoding

Joint with Basak Bayramoglu and Aliette Dequet¹

“That’s why they call it the secret forces, Will. ’Cause they kind of keep the whole lying thing to themselves.”

Buffy the Vampire Slayer – S4E14
Goodbye Iowa (2000)

Abstract. Contrary to donor countries’ declarations, actual climate assistance received is deemed incomplete by recipient countries. The existing literature indicates that donor countries overestimate the climate change content of their international aid projects. In this chapter, we consider new data corresponding to bilateral climate aid projects between 2002 and 2018 using the OECD-DAC Creditor Reporting System database. First, we assess the share of projects wrongly reported as climate-relevant through a textual analysis with Python programming and complementary hand-coding. We find that out of the 63,195 projects reported as climate-relevant by donor countries, nearly half (48.6%) were not climate-related. Second, using country-level data for 28 donor countries from 2002 to 2018, we estimate the factors that may affect the miscoding of climate projects. Adding to the results of the literature, we find that the political-economy argument stating that miscoding could be an electoral strategy for donor governments is only valid for less wealthy donor countries.

¹Part of this chapter was published in Neumann Noel, L. and Bayramoglu, B. (2022): Where Do Donor Countries Stand in Climate Aid Allocation and Reporting?, *Revue Française d’Économie*, vol. XXXVII.

1 Introduction

During the climate negotiations of the Copenhagen Conference of the Parties (COP15) in 2009, developed countries collectively committed to providing USD 30 billion of new climate aid (fast-track climate finance) for the period 2010-2012 in addition to existing aid and pledged to reach a joint mobilisation target of US\$100 billion per year by 2020 to meet the needs of developing countries. Far from being reached, this target has been extended to 2025 by the Paris Agreement (COP21) in 2015. Indeed, the latest assessment from the Organisation for Economic Cooperation and Development (OECD) (OECD, 2022) shows that in 2020, five years after the Paris Agreement, donors had only mobilised USD 83.3 billion toward developing countries, a figure that includes mobilised private finance. Public climate finance only amounted to USD 68.3 billion that year.

In past negotiations, developed countries have also committed to registering their pledges with the United Nations Framework Convention on Climate Change (UNFCCC) (1992), but in the absence of an international definition of climate assistance, contributing countries have had some latitude as to what they can report as such. The Rio Markers methodology was elaborated by developed countries in 1998 under the Development Assistance Committee (DAC) of the OECD "to help members in their preparation of National Reports to the Rio Conventions, by identifying activities that mainstream the Conventions' objectives into development cooperation" (OECD (2020a), p.2). The Rio markers methodology distinguishes four categories (or markers) for environmental actions: 1) biodiversity, 2) desertification, 3) climate change mitigation and 4) climate change adaptation. Through the Creditor Reporting System (CRS), DAC donor countries indicate whether development projects they are financing target the environmental objectives corresponding to the Rio markers. Most donor countries have used data from the OECD-DAC Rio marker CRS to self-report their bilateral climate aid commitments to the UNFCCC Secretariat.

Contrary to donors' self-declarations, actual climate assistance received for climate change mitigation and adaptation is deemed incomplete by recipient countries. The credibility of the Rio markers data has also been questioned by the academic and grey literature (Michaelowa and Michaelowa, 2011; Junghans and Harmeling, 2012; Weikmans et al., 2017; CARE, 2021). These studies show that donor countries, in their self-reports of bilateral Official Development

Assistance (ODA) through the Rio Markers CRS, misrepresent a considerable number of their development projects as climate-relevant. All these studies lead to the same conclusion: too many aid projects are mislabelled as climate-relevant, which leads us to suspect that these classification errors cannot be random, solely due to misunderstandings of project contents or rapid coding mistakes. This miscoding precludes proper assessment of the nature of climate aid and undermines confidence in international negotiations.

Most of the existing literature examining the climate content of international climate aid projects focus either on adaptation projects, on specific samples and case studies (Junghans and Harmeling, 2012; Donner et al., 2016; Weikmans et al., 2017; CARE, 2021) or on older projects (Michaelowa and Michaelowa (2011), projects coverage: 1998-2008). The recent report by the non-governmental organisation (NGO) CARE (2021) focuses on a more recent period from 2013 to 2017 but provides a detailed assessment for only 112 projects launched in six countries in Africa and Asia. Toetzke et al. (2022) use a more recent database to estimate the climate-related content of development aid from 2000 to 2019 using a machine learning classification, but they do not specifically focus on the miscoding of climate aid. In this chapter, we first analyse whether the miscoding of climate projects persists since those earlier studies by assessing the share of miscoded projects in a systematic way. We propose an extensive descriptive analysis of miscoding over donor countries, recipient countries and years. We then estimate the determinants of donor countries' miscoding. We do so using a large set of bilateral climate ODA projects (63,195 projects) carried out all over the world from 2002 to 2018 using the OECD-DAC CRS Rio Markers database (OECD, 2020c). To assess projects' climate content, the literature uses a classification of the projects' purposes or a keyword search in the projects' descriptions through hand coding or programming. In order to capture the advantages of each method and increase the coverage of projects, we first analyse the projects' purposes and then undertake a systematic textual search of keywords using Python programming. Unlike the literature, we assess the share of miscoded projects for climate projects overall as well as for adaptation and mitigation projects separately.

In line with Michaelowa and Michaelowa (2011), we also provide an empirical analysis of the factors that may explain donor countries miscoding on the content of their climate aid projects. Michaelowa and Michaelowa (2011) use the project-level foreign aid database from AidData, which includes bilateral aid from 21 DAC donor countries to developing countries from 1995 to 2008. To determine whether a project is truly climate-relevant, the authors undertake a keyword search in the description and title of each project. Then, they estimate the

factors that could influence the number of miscoded projects. Estimates show that certain political variables, such as the share of votes for green political parties or the composition of the government, play a key role in determining the number of miscoded projects. We estimate different hypotheses and propose new specifications (for instance, alternative measures of environmental policy stringency and a richer set of fixed effects). Furthermore, we estimate the drivers of the miscoding of climate projects overall and separately for adaptation and mitigation projects, including additional coding errors.

We empirically evaluate three sets of potential determinants of climate aid miscoding corresponding to three hypotheses. The first hypothesis refers to the political-economy argument concerning politically-motivated donors: we expect more miscoding of climate projects from governments with an electoral strategy to serve an environmentally concerned population. The second hypothesis states that greater environmental involvement of the government is associated with less miscoding. The third hypothesis posits that a better economic situation eases the budget constraint of the government and leads to less miscoding. To estimate these hypotheses, we use two alternative econometric models, a logit model and a linear probability model, both with fixed effects and clustered standard errors, and conduct several robustness checks.

Our climate projects' assessment converges with the literature in estimating a large amount of miscoded climate aid. We also show that all donor countries miscode, even the smaller ones, but the extent to which they do so is heterogeneous among donors and years. There seems, however, to be a slight decrease in over-reporting since 2015. While we confirm some of the results of [Michaelowa and Michaelowa \(2011\)](#), we also obtain new ones. For instance, the political-economy argument that donors could have an electoral motivation in miscoding climate aid is only valid for less wealthy donor countries. The effect of the government's environmental commitment is confirmed by two out of our three variables for environmental policy stringency. We estimate a consistent negative effect of the number of International Environmental Agreements (IEAs) in force on the probability of miscoding and a consistent positive effect of the evolution of greenhouse gas (GHG) emissions. The effect of the budget constraint is consistently supported by our results concerning the unemployment rate but other variables have more mitigated results across our different specifications.

This chapter is organised as follows. Section 2 reviews and compares the methods used by the literature on the assessment of aid projects' climate content. Sections 3 and 4 present our own methodology and detail the results of our climate projects assessment. Finally, Sections 5 and 6 present our research hypotheses on the determinants of miscoding and our empirical

results.

2 Literature review

A small strand of the academic and grey literature examines the climate content of international climate aid projects. They analyse the climate projects reported by donor countries and reassess their relevancy toward climate change objectives. We present the methods used by this literature in Subsection 2.1 and detail its findings in Subsection 2.2.

2.1 Main assessment methods

Three main approaches of projects evaluation are used in the literature, either separately or mixed:

1. *A classification based on the projects' purposes.* A project's purpose is a variable from the OECD CRS database that takes 206 modalities. To evaluate aid projects, [Donner et al. \(2016\)](#) assess the climate-relevancy of the projects' purposes. This method has the advantage of being fast and efficient. Since all purposes are in English, the method avoids language-related issues. However, some purposes are not easy to categorise as mitigation-relevant, adaptation-relevant or not climate-relevant. The method is also dependent on the accurate coding of projects' purposes by donor countries.
2. *A search for keywords in the projects' title and description.* This method has first been used by [Michaelowa and Michaelowa \(2011\)](#) through hand-coding and then by [Junghans and Harmeling \(2012\)](#) with an Excel Macro. Textual search are also used in machine-coding algorithm ([Donner et al., 2016](#)) and machine learning analyses ([Toetzke et al., 2022](#)). It allows for a distinction between adaptation and mitigation and for an individual analysis of projects, contrary to the projects' purposes classification. It needs, however, to rely on a comprehensive selection of keywords.
3. *A manual check of all projects.* This method, used by [Weikmans et al. \(2017\)](#), has the advantages and disadvantages of relying entirely on human control. The accuracy of the

classification is better than what is obtained from a keyword search, but as the method is very time-consuming, the project coverage cannot be very large.

In the following sections, we distinguish two types of coding errors. The first error corresponds to non-climate-related projects that have been reported as climate-related, and the second error is the confusion error between mitigation and adaptation projects. For the sake of clarity, we propose three definitions:

Definition 1: An *over-reported* project is a non-climate-related project that has been reported as a climate-related one.

Definition 2: A *misreported* project is a climate-related project whose content has been mis-coded, i.e. a mitigation project coded as an adaptation project, and vice versa.

Definition 3: An *overcoded* project is a project that is either misreported or over-reported. The term overcoding thus covers both coding errors together.

The next subsection presents the results of the literature on climate projects evaluation.

2.2 Literature results

Small-scale assessments. Assessments with a small coverage of projects have focused on adaptation projects only.

[Junghans and Harmeling \(2012\)](#) use the OECD-DAC CRS Rio Markers database ([OECD, 2020c](#)) on bilateral aid and analyse 6,107 adaptation projects reported in 2010. They search for 49 keywords in English in the long description of the projects using an Excel Macro. The selected projects are then manually assessed to verify the context in which the keywords are used, and mismatched projects are reviewed as a double check. [Junghans and Harmeling \(2012\)](#) also recode some of the projects' scores when they deem the adaptation relevancy to be significant (score 1) instead of principal (score 2) and then evaluate the amount of real adaptation finance applying a 50% ratio to significant adaptation projects. They find that, out of 6,107 projects reported as adaptation-relevant by the donors, about 35% were actually adaptation-relevant, 20% were undetermined, and 45% had no link with climate change adaptation. They also find that among those adaptation-relevant projects, 38% had their score wrongly coded as principal instead of significant. The five donors with the highest proportion of overcoded projects in 2010 were in descending order: Greece, France, the United Kingdom, Portugal and Spain. The

authors also show that one-sixth of the 6,107 projects had a null budget and that the ten most expensive projects, which represent one-third of all the reported adaptation aid, were wrongly coded, either not climate-related or with only a significant score. As a whole, when considering aid in value, they find 55-69% of adaptation aid to be overcoded, the higher ratio corresponding to the 50% discount applied to significant adaptation aid.

Weikmans et al. (2017) also use the OECD-DAC CRS Rio Markers database (OECD, 2020c) and focus on the 5,201 bilateral adaptation projects reported in 2012. They undertake a systematic hand-coding of the projects to avoid the shortcomings related to the use of limited keywords and recode the projects following the scoring system of the Rio Markers methodology (principal, significant, not related). They find that out of the 5,201 projects coded as adaptation-relevant by the donors (27% as principal and 73% as significant), about 17% actually targeted adaptation as a principal objective, 8.5% targeted adaptation as a significant objective, 8.5% were undetermined and 66% had no link with climate change adaptation. Considering aid in value, it corresponds to 76% of overcoded adaptation aid (USD 7.7 billion). Weikmans et al. (2017) find that Portugal, Greece, Luxembourg, Japan and France were the countries with the highest ratios of overcoded projects. Note that the United States did not report any adaptation aid activity in 2012.

The NGO CARE (2021) provides a detailed assessment of 112 projects launched in six countries in Africa and Asia from 2013 to 2017, extracted from the OECD-DAC CRS Rio Markers database (OECD, 2020c). The total adaptation aid reported for these projects by donor countries is worth USD 6.2 billion. The findings of the NGO CARE (2021) reveal that USD 2.6 billion of this adaptation finance is actually not adaptation-related, indicating an overcoding ratio of 41% in terms of projects' value.

Large-scale assessments. Three studies evaluate large sample of aid projects: Michaelowa and Michaelowa (2011), Donner et al. (2016) and Toetzke et al. (2022).

Michaelowa and Michaelowa (2011) use the AidData database (Tierney et al., 2011), which includes bilateral foreign aid from 21 DAC donor countries from 1995 to 2008. In a first step, they carry out keyword-based hand-coding to evaluate 636,962 development projects (including 10,414 climate-reported projects through the Rio Markers). They restrict their textual analysis to English, but for each project showing a keyword, they assess its context manually. In a second step, they manually evaluate the climate-reported projects that do not include one of the keywords. They classify the projects as climate-relevant, adaptation-relevant, mitigation-relevant, undetermined, over-reported or under-reported. Climate-relevant projects are not the

exact sum of adaptation and mitigation-relevant projects. They also include projects whose climate relevance was clear but not detailed enough to allow for a distinction between mitigation and adaptation. Over-reported projects are projects that were wrongly reported as climate-relevant according to their analysis, while under-reported projects are climate-relevant projects that were not reported as such. Undetermined projects are climate-reported projects whose information is missing for a proper evaluation. They find that out of 10,414 projects reported as climate-relevant by the donors, about 41% were actually climate-relevant, 28% were undetermined, and 31% were not climate-relevant. Thus, the percentage of projects over-reported as climate-relevant is between 31% and 59% (when including undetermined projects). As the Rio Marker for adaptation was not yet introduced, they cannot estimate overcoding for mitigation and adaptation separately.

Donner et al. (2016) also use the AidData database (Tierney et al., 2011) but focus on 30,794 development projects and adaptation objectives in Small Island Developing States (SIDS) of Oceania, which are particularly vulnerable to climate change, between 1992 and 2012. They develop a machine coding algorithm after a manual pilot study on a sample of 2000 projects. They first search for the keywords "climate" and "adaptation" in the title and description of the projects and define these projects as "explicit adaptation" projects. The remaining projects are classified based on their purposes using three different definitions of "implicit" adaptation, each one corresponding to a more or less broad definition of what adaptation to climate change is. Contrary to Michaelowa and Michaelowa (2011) and our analysis, they do not estimate the over-reporting of climate aid but the share of adaptation aid among all ODA. They find that total explicit adaptation transfer towards SIDS of Oceania represented 3-4% of annual aid flows (USD 79.7 million per year), while implicit adaptation represented 30% of annual aid flows (using their largest definition of implicit adaptation projects). Smaller countries received a higher amount of total aid and adaptation aid per capita: for instance, Niue (1,190 people), Tokelau (1,137 people), and Tuvalu (10,782 people) received respectively, USD 430, USD 234 and USD 118 per capita in explicit adaptation funding from 2008 to 2012.

Toetzke et al. (2022) use a machine-learning classifier to estimate bilateral climate aid among bilateral ODA. As Donner et al. (2016), they estimate the amount of climate-relevant (resp. *adaptation-relevant*) projects in reported ODA, not the extent of miscoding in reported climate aid. They use the OECD-DAC CRS database (OECD, 2020b), which gathers all ODA projects, and evaluate 2.7 million bilateral ODA projects between 2000 and 2019. Their machine-learning model includes two subsequent classifiers. The first assesses the relevance of the projects for mitigation, adaptation or environmental objectives. The second classifies relevant

projects into ten detailed categories corresponding to either mitigation or adaptation objectives. Though projects can target multiple purposes, their process can only attribute a project to a single category. They also do not include environmental projects with climate co-benefits and therefore consider their estimations as conservative and best compared to the principal Rio markers. As we detail in the next section, Rio markers distinguish between a significant and principal impact of activities. Text inputs are translated into English via the Google Translate API. The two classifiers are trained independently on 1,500 descriptions of ODA projects. They build on the pre-trained model ClimateBERT, which is a domain-specific version of the Bidirectional Encoder Representations from Transformers (BERT) language model. The first classifier of their model presents a 96% accuracy, and the second classifier presents a 95% accuracy. Among the 2.7 million ODA projects evaluated, they find 82,023 bilateral climate aid projects (48% mitigation and 52% adaptation) worth USD 80 billion (65% mitigation and 35% adaptation). This estimation of bilateral climate aid is lower than that of the OECD-DAC CRS Rio Markers database (OECD, 2020c). Comparing their results to the Rio Markers estimations, they find that their estimate of bilateral climate aid is 21% below the estimate of the principal Rio markers and 64% below the principal and significant Rio Markers. Their estimate of bilateral climate aid, therefore, represents 36% of reported bilateral climate aid via the Rio markers.

The following section describes the methodology we chose to assess climate projects over-coding.

3 Climate projects assessment

3.1 Climate aid data

We use climate aid data from the project-level OECD CRS Rio Markers database (OECD, 2020c), which gathers bilateral environmental ODA projects from OECD-DAC member countries.² For each project, four dummy variables indicate whether the project targets the following Rio Markers: mitigation, adaptation, biodiversity, and desertification. Since the climate change adaptation marker was only introduced in 2010, from 1998 to 2010, there was only one marker

²No data are available for Hungary, and we exclude the European Union as a donor from our analysis since we focus on country-specific miscoding.

related to climate change. For each of these markers, the funded project is given a score: 2 if the main objective of the project is targeting the Rio objective, 1 if the project has a significant impact on the Rio objective, or 0 if the project does not meet the Rio objective. We use the aggregate of both principal and significant mitigation and adaptation aid. We consider total climate aid commitments³ from 28 donor countries to 154 recipient countries between 2002 and 2018. In total, our database comprises 63,195 projects.

3.2 Methodology

After identifying the main methods used in the literature (project purpose analysis, keyword search, text mining, hand-coding), we propose an original methodology by mixing these different approaches. Following [Donner et al. \(2016\)](#), we distinguish between an explicit and an implicit definition of climate aid, but, unlike them, we do so for both adaptation and mitigation projects. We thus classify the 63,195 climate-reported projects into four categories: 1) mitigation explicit, 2) mitigation implicit, 3) adaptation explicit, and 4) adaptation implicit. The categories mitigation explicit and adaptation explicit (*resp.* implicit) include projects which have a direct (*resp.* indirect) link with actions and policies on climate change mitigation or on climate change adaptation. Implicit mitigation and adaptation projects correspond to a broader definition of what mitigation and adaptation can cover. As a first step, we evaluate the projects' purposes. The project purpose is a variable included in the Rio Markers CRS database that takes 206 modalities. We define 20 of these purposes as matching one or several of our four categories. For the projects whose purposes were deemed undetermined, we use a Python-coded algorithm to carry out a keyword analysis of the projects' title, short description, and long description using the five main languages found in the database (English, French, Spanish, German, and Dutch) and classify them according to our four categories or as not climate-related. The keywords are detailed in Section C in the appendix. The keywords are chosen to reflect as much as possible the diversity of adaptation and mitigation projects. The keyword search is then also carried out on the projects whose purpose was defined as climate-relevant in order to refine their classification. For example, a project which was classified as mitigation-relevant after the purposes' evaluation can also be labelled as adaptation-relevant after the keyword search. The word "climate" is not used in the keyword search because it does not allow for differentiation

³Most papers in the aid literature use aid commitments rather than aid disbursements because commitments better reflect donors' intentions and are not affected by the recipient capacity.

between mitigation and adaptation actions. Therefore, we manually evaluate 1,620 projects that include the word "climate" in their title or descriptions but none of the other keywords.

4 Descriptive analysis

In the present section, we offer an extensive descriptive analysis of our climate projects' assessment results.

4.1 Overall results

Out of 63,195 projects from 2002 to 2018, we find 13,087 explicit mitigation projects, 4,336 implicit mitigation projects, 10,736 explicit adaptation projects, and 5,214 implicit adaptation projects. Projects can be both mitigation and adaptation-related, but they cannot be both implicit and explicit for the same marker. We also find 5,722 projects whose titles and descriptions lack sufficient information for a proper evaluation of their climate content. To ensure that we precisely measure overcoding, we do not include those 5,722 projects in the count of overcoded projects. These projects amount to a total of 1,943 MUSD and around 1% of total climate aid. 32,048 projects are therefore considered not climate-relevant according to our methodology, which means that about 48.6% of the projects were over-reported. This result is close to the conservative (59%) estimations of [Michaelowa and Michaelowa \(2011\)](#). [Toetzke et al. \(2022\)](#) find a 64% gap between the amount reported as climate aid and their estimation of actual climate aid based on development aid projects data. In addition to the literature, we measure two other overcoding errors: false mitigation error and false adaptation error, which include misreported projects. We estimate these additional errors over 2010-2018 as the adaptation Rio Marker was only introduced in 2010. We find that 67.8% of adaptation projects were overcoded, which is consistent with the literature ([Junghans and Harmeling \(2012\)](#), 65%; [Weikmans et al. \(2017\)](#), 66%) and that 64.3% of mitigation projects were overcoded.

Considering aid in value, the percentage of over-reported climate aid is even higher and amounts to 60.7%. This means that over-reported projects are relatively more expensive than correctly coded projects. The ratio of overcoded aid is 71.5% for adaptation aid and 61.1% for

mitigation aid. When defining only explicit climate projects as being climate-relevant, we find 67% of over-reported climate projects, 78.5% of overcoded adaptation projects and 71.3% of overcoded mitigation projects, and respectively 65%, 77.6% and 63.5% for aid in value. These figures indicate that the number and value of miscoded projects increase when a more restrictive definition of climate objectives is considered.

As an additional analysis, we also investigate whether the underestimation of climate projects is as significant as their overestimation, which would suggest that miscoding by donor countries is mainly due to human errors in project coding and not due to political and strategic motives. We here consider all ODA projects from the OECD-DAC CRS database in 2018 and assess climate aid underestimation that year using the same keyword search. We thus identify projects that have not been reported as climate-relevant but should have been. We find that 8.5% of the 138,686 development projects in 2018 had not been reported as climate-relevant when they should have been. This represents 7.5% of aid in value. The underestimation ratios of climate aid clearly fall short of overestimation ones.

To verify the reliability of our assessment method, we randomly select 200 climate projects that we manually analyse, and we compare our results with those of our complete assessment process. We find an 8% error size, meaning 16 projects were not correctly assessed by our method. The errors are balanced between the two potential directions: 8 projects were classified as climate-relevant by our assessment method while they were not, and 8 projects were classified as not climate-relevant while they were. We conclude that our assessment process is accurate at 92%.

Table 2.1 summarises our results with those from the literature. These results are difficult to compare as they do not cover the same temporal and geographical scope and do not estimate the same type of error. Nevertheless, most results converge towards 60 to 70% of overcoding.

Table 2.2 sums up basic descriptive statistics on climate aid allocation and overcoding.⁴ Aid

⁴"Reported" corresponds to aid as reported by donor countries in the OECD database. "Over-reported climate aid" are non-climate-related projects reported as mitigation and/or adaptation projects. Overcoded mitigation and adaptation aid correspond to mitigation and adaptation-reported aid that was evaluated as either not climate-related or misreported (confusion between adaptation and mitigation). "Actual" corresponds to aid that was evaluated as climate-related (resp. mitigation/adaptation-related). Note that reported climate aid is not the exact sum of reported mitigation aid and reported adaptation aid because the two categories overlap: some projects target both adaptation and mitigation objectives. Over-reported climate aid is not the sum of overcoded mitigation aid and overcoded adaptation aid either because the latter two include confusion errors between mitigation and adaptation objectives.

Table 2.1: Comparison between the results of the literature

Overcoding ratios	Number of projects	Amount of aid
Climate aid over-reporting ratio	Bayramoglu et al. [2022]: 48.6-67% Michaelowa and Michaelowa [2011]: 31-59%	Bayramoglu et al. [2022]: 60.7-65%
Mitigation aid overcoding ratio	Bayramoglu et al. [2022]: 64.3-71.3%	Bayramoglu et al. [2022]: 61.1-63.5%
Adaptation aid overcoding ratio	Bayramoglu et al. [2022]: 67.8-78.5% Junghans and Harmeling [2012]: 65% Weikmans et al. [2017]: 66%	Bayramoglu et al. [2022]: 71.5-77.6% Junghans and Harmeling [2012]: 55-69% Weikmans et al. [2017]: 76% CARE [2021]: 41%

Table 2.2: Descriptive statistics on climate aid (MUSD)

Variable	Sum	Mean	Std. Dev.	Min.	Max.	N	Time
Reported climate aid	197,048.85	3.12	27.61	4.38e-20	1,846.06	63,195	2002-2018
Reported mitigation aid	152,199.00	3.72	32.58	4.38e-20	1,846.06	40,914	2002-2018
Reported adaptation aid	67,785.97	1.71	12.51	9.63e-19	852.65	39,630	2010-2018
Over-reported climate aid	125,127.98	3.90	34.78	4.38e-20	1,846.06	32,048	2002-2018
Overcoded mitigation aid	95,836.04	3.53	35.57	4.38e-20	1,846.06	27,177	2002-2018
Overcoded adaptation aid	48,493.04	1.80	13.50	9.63e-19	852.65	26,872	2010-2018
Actual climate aid	71,920.87	2.31	17.33	1.12e-18	863.76	31,147	2002-2018
Actual mitigation aid	59,900.95	3.44	22.91	1.40e-18	863.76	17,417	2002-2018
Actual Adaptation aid	25,250.85	1.58	10.93	1.12e-18	638.68	15,942	2002-2018

is in USD million (hereafter MUSD) and covers 2002-2018. No adaptation aid was reported before 2010, as the adaptation marker was only introduced in 2010. There is, therefore, no overcoded adaptation aid over 2002-2010, but we can estimate actual adaptation aid before 2010 (adaptation projects coded as mitigation ones).

Regarding reported aid, the numbers of adaptation and mitigation projects are close. Still, the total amount of mitigation aid is 2.3 times higher than the amount of adaptation aid, and the average value of mitigation projects is 2.2 times higher than adaptation projects' average value. These gaps are quite similar when considering overcoded and actual mitigation and adaptation aid. It is worth noting that the average over-reported climate project is more expensive than the average reported climate project. While this property also holds for overcoded and reported adaptation projects, it does not apply to mitigation projects. It explains why the overcoding ratio is lower for mitigation aid in value than for the number of mitigation projects and reversely for adaptation aid. The literature on adaptation overcoding finds similar results (see Table 2.1). On average, overcoding happens for more expensive adaptation projects and cheaper mitigation projects. This difference might be explained by the fact that more expensive mitigation projects are easier to identify and less likely to be confused with adaptation projects. Indeed, in our database, we find the most expensive mitigation-reported projects to be related to renewable

energy generation, public transport and sustainable transportation system. When considering the over-reporting of total climate projects, we also find that more expensive projects are over-reported on average.

Note that these figures are aggregated and do not show the heterogeneity of climate aid over-coding among donors, recipients and over time which we discuss in the following subsections.

4.2 Disaggregated results

4.2.1 Dynamics of climate aid overcoding

Figure 2.1 represents the evolution of climate aid overcoding through three overcoding and over-reporting ratios (computed for aid in value). The total climate aid over-reporting ratio measures the share of over-reported climate aid in all reported climate aid. The mitigation overcoding ratio accounts for the share of over-reported and misreported mitigation aid in reported mitigation aid. A similar definition applies to the adaptation overcoding ratio. Adaptation and mitigation overcoding ratios, therefore, include the confusion error between adaptation and mitigation projects (misreporting).

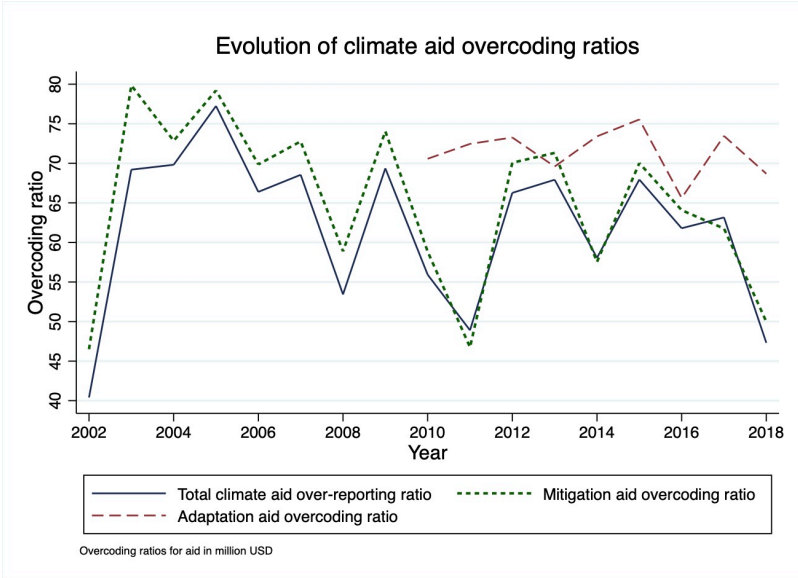


Figure 2.1: Evolution of climate aid overcoding ratios (aid in value)

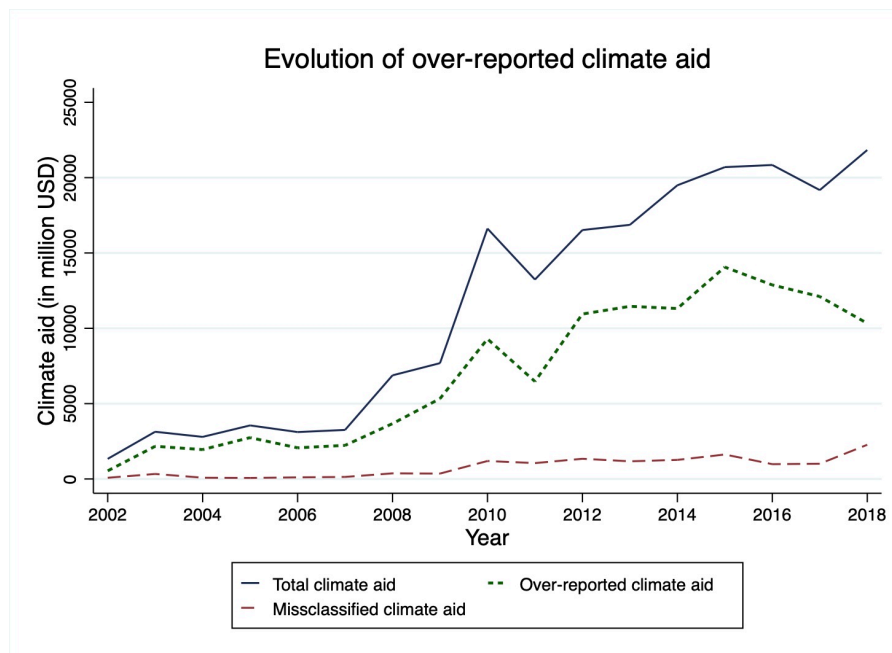


Figure 2.2: Evolution of over-reported climate aid

Figure 2.2 shows the evolution of climate aid alongside over-reported and misclassified climate aid. As total climate aid has been multiplied by 2 between 2002 and 2004, over-reported climate aid has been multiplied by 3.6. The climate aid over-reporting ratio, therefore, rose from 40.4% to 69.8%. A large decrease to 49% occurred in 2011, one year after COP16 in Cancun and the implementation of the adaptation Rio Marker, but this decrease did not last, and the total over-reporting ratio rose back to 66.3% in 2012. Total over-reporting of climate aid seems to have been decreasing since 2015, which could be related to the Paris Agreement (COP21). Over 2015-2018, the climate aid over-reporting ratio has decreased by 20 percentage points to reach 47.3% and over-reported climate aid has decreased from 15,688 MUSD to 12,602 MUSD. During COP21, developing countries again expressed their need for climate funding and how current funding was insufficient. This international pressure and the higher expectations from civil society that followed the Paris Agreement could have had an impact on donors' over-reporting. The negotiations could also have been an opportunity for a better understanding of developing countries' climate needs.

The introduction of the adaptation Rio Marker, however, does not seem to have impacted the confusion error between adaptation and mitigation activities. As can be seen in Figure 2.2, mis-reported aid kept increasing after 2010 (misreported aid amounted to 1,193.7 MUSD in 2010, three times the amount in 2009). Misreported aid represented 4.7% of total reported climate aid

in 2009, 7.2% in 2010 and 8% in 2011. It could be explained by insufficient information from the OECD regarding what should be defined as an adaptation-related activity.

The evolution of the mitigation overcoding ratio closely followed that of the total climate aid over-reporting ratio, as mitigation aid represented 77% of total climate aid over the period. The adaptation overcoding ratio was, however, almost always higher and fluctuated between 65% and 75% from 2012 to 2018. It is well known that adaptation projects are more difficult to identify as adaptation actions have no common metric contrary to mitigation efforts. This is why the literature has mainly focused on the overcoding of adaptation aid.

The overcoding ratios for the number of climate-reported projects are less volatile over time, as can be seen in Figure **B.4** in the appendix. We choose to present mainly the results for aid in value as it more accurately depicts the gap with recipients' needs but annual results can be skewed by a few very expensive projects.

To complete this descriptive analysis, we study the time-series properties of our over-reporting and overcoding ratios. We first investigate whether the series are stationary. We perform the augmented Dickey-Fuller test that verifies if a variable follows a unit-root process. The null hypothesis is that the variable contains a unit root, and the alternative is that the variable was generated by a stationary process. The test results indicate that climate aid over-reporting and mitigation aid overcoding display non-stationary time series properties, while the adaptation aid overcoding series is stationary. These results need to be considered with caution as the sample size is very short (16 years for climate aid over-reporting and mitigation overcoding and 9 years for adaptation overcoding).

We next study whether the series exhibit a structural break in a given year. To address this question, we have undertaken different tests for the three overcoding and over-reporting ratios. For instance, we have performed the statistical test based on the cumulative sum of recursive residuals that was introduced in [Brown et al. \(1975\)](#). This test allows us to investigate whether the coefficients in a time-series regression are stable over time. For each type of overcoding, we fail to reject the null hypothesis of a constant mean at the 1% significance level. We also examine the cusum plots. In the appendix, Figures **A.1**, **A.2**, **A.3** show that the plots of the recursive cusum process never cross the 99% confidence bands, which implies that the mean of the regression model is stable at the 1% significance levels. It turns out that there is no structural break for the period 2002-2018, despite the introduction of the adaptation marker in 2010. This supports the idea that over-reporting and overcoding problems persist over time despite countries' experience in reporting and the introduction of the adaptation marker in 2010.

4.2.2 Heterogeneity in climate aid overcoding

Figure 2.3 displays the ranking of climate aid over-reporting by donor countries. There is a clear heterogeneity among donor countries as the over-reporting ratio ranks from 23.5% for Norway to 89.6% for Poland. Poland, Luxembourg, Japan, Iceland and the Netherlands are the countries that most over-report their climate aid. It is also noticeable that the largest donors do not necessarily over-report more. Figures B.5 and B.6 in the appendix shows over-reporting ratios alongside the share of total climate aid allocation by donor countries. Japan, the top donor of climate aid, has a high over-reporting ratio of 86.3%, but Germany, the second donor of climate aid, has a far lower over-reporting ratio of 38.6%. According to Yeo (2019), Japan often declares coal-based projects as climate aid projects. Meanwhile, Luxembourg and Poland have provided a low level of aid, respectively 237 MUSD and 76 MUSD over 2002-2018, but both have an over-reporting ratio of almost 90%. In the appendix, Figure B.7 shows the evolution of over-reporting for the top three donor countries.

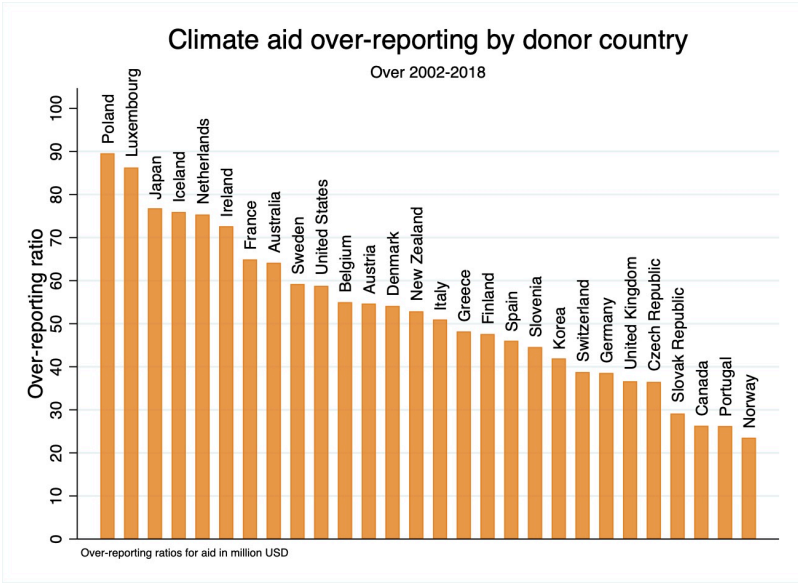


Figure 2.3: Climate aid over-reporting ratio by donor country (aid in value)

Junghans and Harmeling (2012) find that the donors with the highest proportion of over-coded adaptation projects in 2010 were Greece, France, the United Kingdom, Portugal and Spain, while Weikmans et al. (2017) observe the highest overcoding of adaptation projects among Portugal, Greece, Luxembourg, Japan and France in 2012. Previous results from Michaelowa and Michaelowa (2011) show the donor countries with the highest over-reporting of climate

projects over 1995-2008 to be the United States, the Netherlands, Norway, Portugal and Germany. These results are difficult to compare with ours as they do not cover the same period and type of miscoding (see Figure **B.8** in the appendix for the overcoding ratio by donor country for the number of projects). We can, however, note that some countries are present in at least two rankings from the literature: France, Greece, Japan, Luxembourg, Portugal, and the Netherlands.

Several factors might explain the heterogeneity of over-reporting behaviour among donor countries. [Michaelowa and Michaelowa \(2011\)](#) show that donor countries' governments with environmentally concerned populations might increase their over-reporting due to political-economy motives. We explore different hypotheses to explain this heterogeneity in Section **5**. According to [Weikmans et al. \(2017\)](#), some countries⁵ have been more careful ex-post and commissioned reports on the quality of their climate aid reporting.

Figures **2.4**, **2.5** and **2.6** represent the over-reporting ratio for aid in value by recipient country, region and income group. The over-reporting ratio by recipient indicates the share of over-reported climate aid on the total reported climate aid received by the recipient over 2002-2018. The average over-reporting ratio by recipient country is 51.7% with a standard deviation of 23.3. This indicates a large heterogeneity, though, once again, we find less variation when considering the over-reporting ratio for the number of projects, with an average of 46.5% and a standard deviation of 14. The over-reporting ratio in value by recipient country ranks from 0% for Wallis and Futuna and Trinidad and Tobago to 100% for Anguilla and Bahrain. These four countries are very small recipients of climate aid, Bahrain being the smallest recipient, with only USD 7,000 received over 2002-2018. Extreme figures of over-reporting are more likely to be observed among very small recipients as they only have a few projects implemented. We observe less discrepancy in over-reporting among larger recipients, as can be seen in Figure **2.4**, which compares climate aid allocation and over-reporting for the 10 top recipient countries. Among them, the over-reporting ratio for aid in value ranks from 39.9% for Brazil to 77% for India, while the over-reporting ratio for the number of projects ranks from 37.9% for China to 53.4% for Morocco.

Figure **B.9** in the appendix plots climate aid received by recipient countries against the associated over-reporting ratio. As seen in Figure **B.9**, there seems to be no correlation between the amount of climate aid received by the recipient country and the share of over-reported climate aid. Heterogeneity in over-reporting among recipients might partly come from donors' over-

⁵Sweden, Finland, Switzerland, Belgium and Austria.

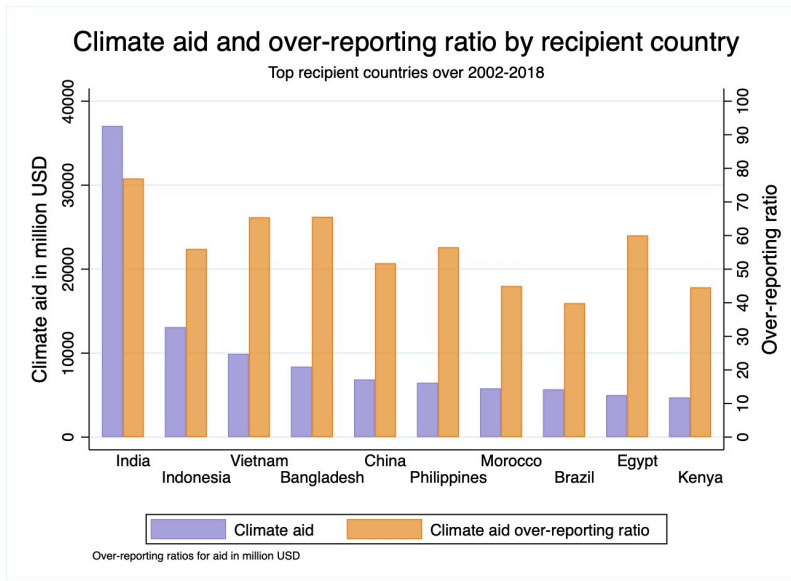


Figure 2.4: Allocation of climate aid and over-reporting ratio by recipient country (aid in value)

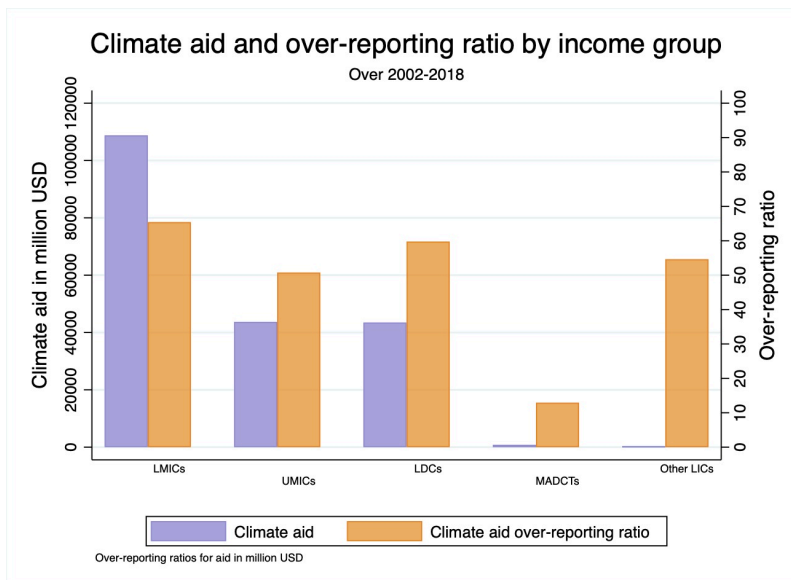


Figure 2.5: Allocation of climate aid and over-reporting ratio by recipient income group (aid in value)

reporting heterogeneity. Bilateral relations play an important role in the allocation of climate aid (Bayramoglu et al., 2023), and donor countries do not allocate aid equally among potential recipients. For instance, India received 77% of its climate aid from Japan which over-reported 86.3% of its climate aid, while Brazil received 62.4% of its climate aid from Germany and Norway, which have lower over-reporting ratios (see figure 2.3). There might also be differences among recipient countries in the type of projects implemented and the clarity of the projects’ descriptions provided when applying for funding. Some recipient countries might carry out more ambiguous projects, thus resulting in higher over-reporting and misreporting.

Figure 2.5 compares climate aid and over-reporting ratio by recipient income group. Figure B.10 in the appendix presents those results with aid per capita. We use the income groups of the OECD-DAC CRS database.⁶ LMICs received the highest amount of climate aid (10,876.9 MUSD) with a 65.4% share of over-reported aid. Other income groups have an over-reporting ratio comprised between 50% and 70%, except for MADCTs whose over-reporting ratio is equal to 13%. MADCTs also received the lowest amount of climate aid (822 MUSD). However, MADCTs’ over-reporting ratio for climate aid in number of projects is 36% indicating that correctly reported projects to MADCTs were more expensive than over-reported projects.

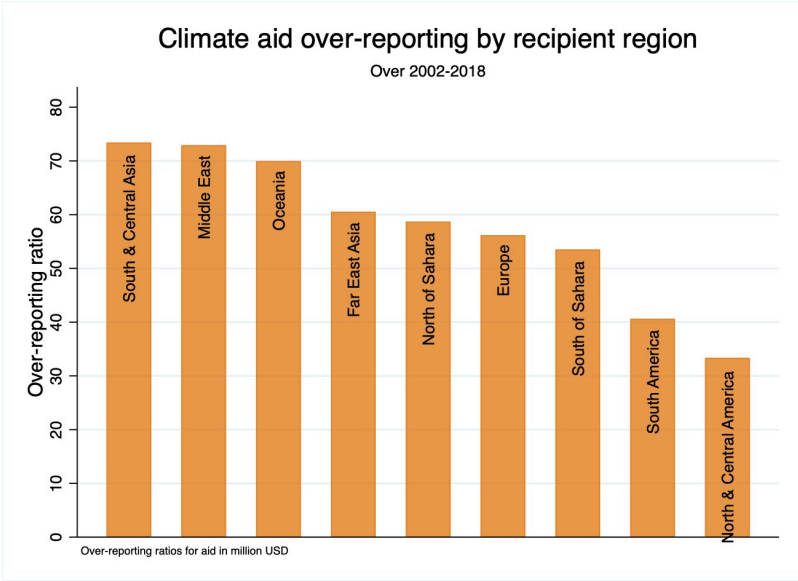


Figure 2.6: Climate aid over-reporting ratio by recipient region (aid in value)

Finally, Figure 2.6 introduces the over-reporting ratio by recipient region. We use here the regional categories of the OECD-DAC CRS database. The over-reporting ratio varies from 34%

⁶LDCs: least developed countries; LICs: low-income countries; LMICs: lower-middle-income countries; UMICs: upper middle-income countries; MADCTs: more advanced developing countries and territories.

for North and Central America to 78% for South and Central Asia, which received 68.6% of its climate aid from Japan. Over-reporting is very high for Asia, the Middle East and Oceania and smaller for America, whose top donor is Germany. Then again, there does not seem to be a correlation between the amount of climate aid received by the regions and the amount of over-reporting. Heterogeneity in over-reporting by recipient regions might be explained by the differences in over-reporting and allocation behaviour from donor countries.

The two following sections of this chapter aim to explain the differences in climate projects overcoding by donor countries.

5 Empirical strategy

In this section, we present our empirical strategy to estimate the determinants of climate projects overcoding by donor countries. In Subsection 5.1, we posit three hypotheses to explain the heterogeneity we have observed in Section 4. In Subsection 5.2, we present our empirical strategy to estimate these hypotheses.

5.1 Research hypotheses and data

We believe political and diplomatic interests may affect the over-reporting of climate aid. More specifically, we believe developed countries have a conflicted interest in upholding their climate aid promises on the one hand while not increasing their Official Development Aid (ODA) flows on the other hand. [Nakhooda et al. \(2015\)](#) and [Bose \(2012\)](#) estimated that a large share of climate aid is actually recycled Official Development Aid. Since the UNFCCC (1992), developed countries have started to publicly set the fight against climate change as a priority. Twenty-seven Conference of Parties have already been organised, and the International Environmental Agreements (IEA) Database Project ([Mitchell, 2021](#)) lists 2296 Bilateral Environmental Agreements and 1402 Multilateral Environmental Agreements. Environmental discourses and actions do not only fall within ecological concerns. Diplomatic relations and countries' reputations are also at stake. Since COP16 (2010), article 4.3 of the UNFCCC states that "new and additional" funds must be sent to developing countries by their developed coun-

terparts to address climate change with the quantified objective of reaching USD 100 billion per year by 2020. Meanwhile, ODA allocation follows a voluntary approach. This allows for a loophole through which developed countries could try to achieve their climate aid objectives by reorienting already existing ODA (Khan and Munira, 2021) or by misreporting it.

Following these observations, we suggest three hypotheses to explain donor countries' over-coding behaviour:

H1. Taking up the argument of Michaelowa and Michaelowa (2011), our first hypothesis states that donor governments with an environmentally-concerned population may use over-reporting of development aid as climate aid as an electoral strategy with no budget constraint. Therefore, a greater degree of concern in the population for the environment is expected to be associated with more frequent over-reporting. The government of the donor country is incentivised to highlight a high amount of climate aid to rally public support. Over-reporting development projects as climate-related is the only option with no budget constraints, so we expect it to be chosen by donor countries. To measure the donor population's interest in environmental issues, we use the share of green party votes in parliamentary elections (computed from the Comparative Political Data Set (Armingeon et al., 2020) as used in Michaelowa and Michaelowa (2011).

H2. Our second hypothesis posits that donor governments with higher environmental preferences are more likely to be virtuous in regard to climate aid, implying less frequent climate aid over-reporting. For simplicity, as in Michaelowa and Michaelowa (2011), we discard principal-agent problems here; hence, the administrative and political parts of the government are assumed to be one unique entity. A government with low environmental preferences will more likely choose to over-report its development aid as climate aid to uphold its international commitments with no budget constraint. To measure government environmental preferences and estimate this hypothesis, we use several indicators of environmental policy stringency. We first use the relative evolution of national GHG emissions (excluding land use, land use change and forestry) since the adoption of the Kyoto Protocol in 1997 (computed using data from UNFCCC GHG Data (UNFCCC, 2021)), the number of International Environmental Agreements (IEAs) in force for the donor country (including terminated IEAs) from the International Environmental Agreements Database Project (Mitchell, 2021) and the cumulative number of climate-related laws and policies from the Climate Change Laws of the World database (Grantham Research Institute on Climate Change and the Environment and Sabin Center for Climate Change Law, 2021). As an alternative measure of environmental policy stringency, we use the Protected Ar-

as Representative Index (PARI) from the Environmental Performance Index (Wendling et al., 2020), which is the only EPI sub-index that allows for cross-sectional comparison. The PARI measures the proportion of biologically scaled environmental diversity included in a country's terrestrial protected areas.

H3. Our third hypothesis concerns the budget constraint of the donor country. We assume that a stricter constraint leads to more frequent over-reporting of climate aid. We measure the budget constraint with GDP per capita, GDP growth, government debt as a percentage of GDP (World Bank, 2021a), unemployment rate (Armingeon et al., 2020) and with the amount of ODA excluding climate aid (OECD, 2020b). We believe the unemployment rate will measure the behaviour of the donor government in the face of a worsening economic situation.

Controls. Finally, we control for the total number of projects reported annually by the donor country, the total amount of annual climate aid and the project's value. Concerning the factors that may impact human coding errors, we expect that the more projects that must be coded, the more likely that there will be coding errors. We also expect that greater care is taken to report more expensive projects and, thus, fewer coding errors, as overcoding a large-scale project is less likely to go unnoticed. We also control for the efficiency of the development agency of the donor with the Bureaucratic Quality Index from Institute for Democracy and Electoral Assistance (2021). We alternatively use another proxy for the efficiency of the development agency of the donor with the Governance Effectiveness Index from the World Bank (World Bank, 2021b). As Halimanjaya and Papyrakis (2015), we assume that the more transparent and effective the governance of a donor country, the more likely that the government will uphold its commitments to climate change protection.

Table 2.3 summarises the descriptive statistics for our independent variables. All monetary variables are corrected for inflation using the 2010 US inflation index. GDP per capita is expressed in USD. ODA, total climate aid, and project value are expressed in million USD. The Bureaucratic Quality Index ranks from 0 to 1, and the Government Effectiveness Index ranks from -2.5 to 2.5, where higher values correspond to better governance. Data are missing for South Korea for unemployment, the share of green votes, and the evolution of GHG emissions.

Table 2.3: Descriptive statistics: controls

Variable	Mean	SD	Min	Max	Obs
GDP growth	1.81	2.27	-8.07	25.18	63,195
GDP per capita	50,219.51	19,020.27	10,620.91	134,270.30	63,195
Government debt	1.79	4.65	-14.47	16.18	63,157
Unemployment	7.78	4.90	2.20	27.50	60,370
Share of green votes	4.01	4.34	0.00	21.70	60,370
GHG emissions evolution	-7.42	12.63	-39.90	32.92	60,370
Climate change laws	14.06	7.00	1.00	36	63,172
IEA in force	336.21	77.35	121.00	507.00	63,195
ODA	12,392.01	11,608.65	27.50	40,722.61	63,184
Number of projects	435.16	300.35	1.00	1,478	63,195
Amount of climate aid	1,725.42	2,643.45	4.33e-04	11,001.12	63,195
Project's value	3.302	29.56	4.92e-20	2,006.58	63,195
Bureaucratic quality	.93	.12	0.63	1.00	63,195
Government effectiveness	1.50	.35	0.16	2.35	63,195
PARI	40.40	14.28	13.11	69.58	63,195

5.2 Empirical model

We estimate the validity of our hypotheses using the following logit model with unconditional fixed effects:

$$Pr[Overcoding_{pijt} = 1 | \mathbf{X}] = Pr[Overcoding^*_{pijt} > 0 | \mathbf{X}] = F(\beta X_{it} + \theta Z_{pijt} + \lambda_i + \mu_j + \nu_t) \quad (2.1)$$

$$\text{with } Overcoding^*_{pijt} = \beta X_{it} + \theta Z_{pijt} + \lambda_i + \mu_j + \nu_t + \epsilon_{pijt}$$

where $Overcoding_{pijt}$ is a dummy variable indicating if the project p financed by country i in country j during year t has been overcoded (1) or not (0).

We include donor country, recipient country, and year fixed effects to control for unobserved heterogeneity. Indeed, our descriptive analysis of overcoding shows that donor countries have specific individual behaviours regarding the overcoding of climate aid. These descriptive statistics also show heterogeneity in overcoding among recipients, which might be related, for instance, to geopolitical reasons regarding a donor's dependency on imports of natural resources or intermediate goods from certain recipient countries. Finally, year fixed effects allow us to take into account the impact of global economic events or international climate negotiations. We believe the incidental parameter problem is limited here as our model includes up to 199

individual effects (17 years, 28 donors and 154 recipients) for 63,195 observations. We correct for heteroskedasticity and autocorrelation by using clustered standard errors at the donor, recipient and year level (ijt). We use a set of donor-year independent variables (X_{it} , see Section 5.1) and one project-related independent variable (Z_{pijt} , the project value). Independent variables defined in \mathbb{R}_+ are log-transformed.⁷ Independent variables defined in \mathbb{R} are transformed using the *asinh* function.^{8 9}

In Section 6.1, we consider all climate-reported projects from 2002 to 2018, and our over-coding dependent variable indicates if the project is over-reported (i.e. falsely reported as climate relevant (1) or not (0)). In Section 6.2, we consider adaptation and mitigation projects separately over the 2010-2018 period, as the adaptation marker was only introduced in 2010. Our two overcoding variables then indicate whether the project is overcoded and therefore include the confusion error between adaptation and mitigation objectives. Section 6.3 presents our additional specifications for robustness check. We first estimate equation 2.1 using a linear probability model with clustered standard errors at the donor-recipient level. We also estimate equation 2.1 using a logit model with different fixed effects. Finally, we estimate the determinants of the share of over-reported projects funded by donor i to recipient j in year t using aggregated data.¹⁰ We estimate a linear regression model with donor, recipient and year fixed effects using Ordinary Least-Squares (OLS) with clustered standard errors at the donor-recipient level.

Observations for South Korea as a donor country are dropped because of missing data for several explanatory variables.

⁷GDP per capita, unemployment, climate change laws and policies, IEAs, ODA, number of projects, amount of climate aid, project value, Bureaucratic Quality Index, Government Effectiveness Index and PARI.

⁸GDP growth, government debt, the share of green votes, and the evolution of GHG emissions.

⁹ $\forall x \in \mathbb{R} : \text{asinh}(x) = \ln(x + \sqrt{x^2 + 1}) = \sinh^{-1}(x)$.

¹⁰Over-reporting ratio $_{ijt} = \frac{\text{Number of Over-reported Projects from } i \text{ to } j \text{ in } t}{\text{Number of Reported Projects from } i \text{ to } j \text{ in } t} * 100$

6 Empirical results

We first present our estimations' results for climate projects overall in Subsection 6.1. We then replicate our estimations on mitigation and adaptation projects separately in Subsection 6.2. Additional specifications are presented in Subsection 6.3.

6.1 Results for climate projects over-reporting

Table 2.4 presents the baseline results of equation 2.1 for all climate projects. Results are presented as odds ratios.¹¹

Our first hypothesis states that donor governments with an environmentally-concerned population may use over-reporting of development aid as climate aid as an electoral strategy with no budget constraint. Therefore, a greater degree of concern in the population for the environment is expected to be associated with more frequent over-reporting. We measure the degree of concern in the population for the environment by the share of green votes in parliamentary elections. The share of green votes is only significant when we add the interaction effect of green votes and GDP per capita. It has then the expected positive effect on the probability of over-reporting, with a corresponding odds ratio greater than one. This effect decreases when GDP per capita increases, as indicated by the interaction variable having an odds ratio of less than one. As GDP per capita increases, the budget constraint is reduced, and governments might be less inclined to over-report aid as an electoral strategy. We compute the marginal effects of the share of green votes on the probability of over-reporting for several values of GDP per capita and present them in Table 2.5. Figure 2.7 plots those results. The marginal effect of the share of green votes is null for the average GDP per capita but becomes negative as GDP per capita increases and positive for less-than-average values of GDP per capita. This supports our first hypothesis on the interaction effect of budget constraint and electoral strategy.

Our second hypothesis posits that donor governments with higher environmental preferences are more likely to be virtuous in regards to climate aid, implying less frequent climate aid over-reporting. Governments environmental preferences are measured through the relative

¹¹An odds ratio greater than 1 indicates a positive effect of the variable on Y and an odds ratio less than 1 indicates a negative effect.

Table 2.4: Logit model: determinants of climate aid over-reporting

	(1)	(2)	(3)
Dep. Var: Over-reporting			
GDP growth	0.958* (0.023)	0.963 (0.023)	0.966 (0.022)
GDP per capita	0.819 (0.201)	1.196 (0.295)	1.088 (0.272)
Gov. debt (% GDP)	0.985 (0.019)	0.973 (0.019)	1.022 (0.020)
Unemployment	1.937*** (0.161)	1.997*** (0.167)	2.022*** (0.174)
Share of green votes	0.979 (0.028)	34.448*** (20.969)	24.007*** (14.343)
GHG evolution (since Kyoto)	1.140*** (0.019)	1.136*** (0.019)	1.121*** (0.019)
CC laws and policies	1.829*** (0.161)	1.971*** (0.174)	
IEA	0.003*** (0.002)	0.001*** (0.001)	0.003*** (0.003)
ODA	0.768*** (0.059)	0.851** (0.067)	0.880 (0.070)
No. of projects	1.407*** (0.051)	1.410*** (0.052)	1.509*** (0.055)
Total climate aid	0.859*** (0.026)	0.848*** (0.025)	0.823*** (0.024)
Project's value	0.989* (0.006)	0.989* (0.006)	0.988** (0.006)
Bureaucratic quality	0.000*** (0.000)	0.001*** (0.001)	
Green votes x GDP per cap.		0.720*** (0.040)	0.742*** (0.041)
PARI			2.331** (0.878)
Gov. effectiveness			0.593*** (0.094)
<i>N</i>	60290	60290	60313
pseudo <i>R</i> ²	0.109	0.110	0.108

Exponentiated coefficients (odd ratios); Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Table 2.5: Marginal effects of green votes

Mean(GDP per capita)	Min(GDP per capita)	Max(GDP per capita)
-0.0005	0.0932***	-0.0693***
(0.006)	(0.015)	(0.011)

Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

evolution of GHG emissions since the Kyoto Protocol, the number of climate change related laws and policies, the number of IEAs in force, and the EPI Protected Areas Representativeness Index. Our results are mixed. Variations in GHG emissions and IEAs odds ratios are significant with the expected effects. Donor countries whose GHG emissions have increased since the Kyoto Protocol are more likely to over-report aid as climate-related. In contrast, the more donor countries participate in IEAs, the less likely they are to over-report aid. Contrary to our expectations, a greater number of climate-related laws and policies and higher values of the Protected Areas Representativeness Index are associated with more over-reporting. This might be explained by the difficulty of measuring actual government environmental preferences.¹² The number of climate-related laws and policies is a quantitative measure that only approximately reflects the stringency of the country's climate policy. It does not indicate the actual content of these laws and cannot hierarchise laws with different levels of stringency (e.g. tax level). Furthermore, the EPI Protected Areas Representativeness Index is not specifically linked to the stringency of a country's climate policy. The evolution of GHG emissions since the Kyoto Protocol seems to be a more reliable indicator than the climate policy stringency indicator based on means of action without guarantee of results. Our results on GHG emissions variation support our hypothesis that donor governments with higher environmental preferences are less likely to over-report their climate projects.

In our third hypothesis, we assume that a stricter budget constraint is associated with higher over-reporting. However, GDP per capita and government debt are not significant, and GDP growth is only significant in our first specification, with a negative effect on the probability of over-reporting. Higher growth reduces the probability of over-reporting. We find that higher unemployment consistently increases the probability of over-reporting in all specifications. A worsening economic situation may induce donor governments to increase project over-reporting. Contrary to [Michaelowa and Michaelowa \(2011\)](#) hypothesis, the effect of unemploy-

¹²Several other measures of environmental policy stringency exist ([Galeotti et al., 2020](#)), but they are not available for our whole sample.

ment is likely to measure here the behaviour of the government in the face of an economic crisis. We also find that higher amounts of ODA are associated with less over-reporting. As the total amount of climate aid also has a negative effect on over-reporting, this may reflect more virtuous behaviour in general regarding aid. It seems that development aid and climate aid are not necessarily substitutes for donor countries.

Our control variables are significant with the expected effects on over-reporting. Donor countries with higher scores in bureaucratic quality and government effectiveness are less prone to over-report development aid as climate-related. More expensive projects are less likely to be over-reported, and a greater number of climate projects leads to more over-reporting, likely due to human coding error.

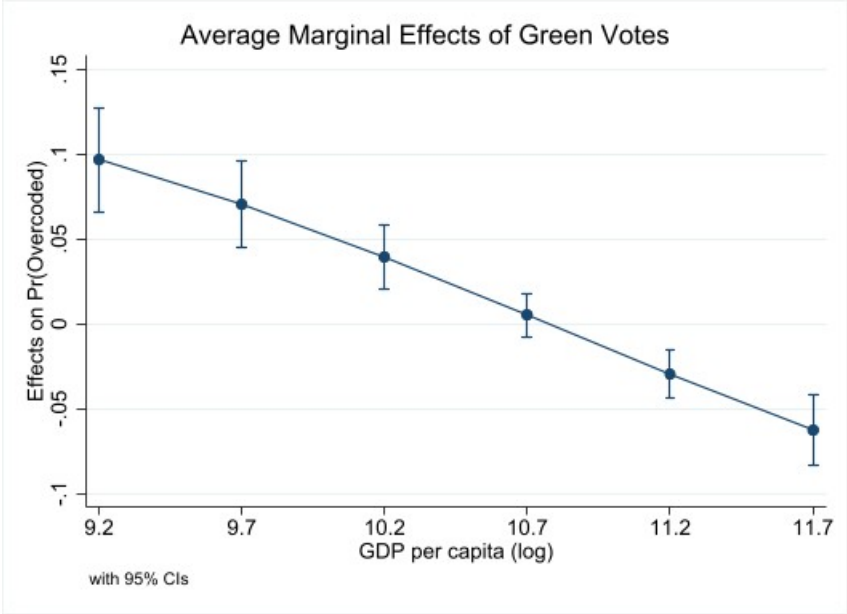


Figure 2.7: Average marginal effects of green votes

6.2 Results for mitigation and adaptation projects overcoding

Tables 2.6 and 2.7 present baseline results of equation 2.1 for respectively mitigation and adaptation projects overcoding from 2010 to 2018. Our dependent variables are false mitigation and false adaptation, as defined in Section 2.

Concerning the share of green votes, we find the same positive effect for total climate projects and mitigation projects when we include the interaction variable with GDP per capita but not when we consider adaptation projects only. It seems that the overcoding of climate and mitigation projects by politically-motivated donors only happens for less wealthy donor countries.

We still find mitigated results concerning government environmental preferences. Contrary to our expectations, the number of climate change laws is associated with a higher probability of overcoding, but we do find the expected positive effect for the evolution of GHG emissions when considering adaptation aid and total climate aid. They are, however, no longer significant for mitigation projects overcoding. IEAs have a consistently negative effect on the probability of overcoding for both mitigation and adaptation aid, indicating that international pressure is efficient.

Our budget constraint hypothesis is partly confirmed when considering adaptation and mitigation separately. GDP growth and GDP per capita have the expected negative effect on the probability of overcoding, meaning richer donor countries are less likely to overcode climate aid. However, the effect of government debt has opposite signs for adaptation projects and mitigation ones. Unemployment does not have a consistent effect on the probability of overcoding; rather, it has a significant negative effect on mitigation overcoding in Table 2.6 and is not significant for adaptation overcoding in Table 2.7.

Finally, most control variables are significant with the expected signs: donor countries with better bureaucratic quality and government effectiveness are less prone to overcode mitigation and adaptation projects. More expensive projects are less likely to be overcoded, and a greater number of climate projects leads to more overcoding, likely due to human coding errors.

Table 2.6: Logit model: determinants of mitigation aid overcoding

	(1)	(2)	(3)
Dep. var : False Mitigation			
GDP growth	0.866*** (0.030)	0.863*** (0.029)	0.891*** (0.030)
GDP per capita	0.130*** (0.056)	0.162*** (0.071)	0.176*** (0.079)
Gov. debt (% GDP)	0.934** (0.032)	0.919** (0.031)	0.944* (0.033)
Unemployment	0.589*** (0.120)	0.660** (0.137)	0.749 (0.160)
Share of green votes	1.050 (0.046)	49.743*** (59.233)	33.182*** (39.128)
GHG evolution (since Kyoto)	1.014 (0.028)	1.008 (0.028)	1.003 (0.029)
CC laws and policies	4.150*** (0.701)	4.203*** (0.704)	
IEA	0.000*** (0.000)	0.000*** (0.000)	0.001*** (0.002)
ODA	0.682*** (0.073)	0.761** (0.087)	0.686*** (0.081)
No. of projects	1.363*** (0.082)	1.414*** (0.087)	1.569*** (0.096)
Total climate aid	0.851*** (0.040)	0.825*** (0.040)	0.796*** (0.039)
Project's value	0.907*** (0.007)	0.907*** (0.007)	0.907*** (0.007)
Bureaucratic quality	0.000** (0.000)	0.000** (0.000)	
Green votes x GDP per cap.		0.702*** (0.076)	0.723*** (0.078)
PARI			0.659 (0.328)
Gov. Effectiveness			1.374 (0.451)
<i>N</i>	30408	30408	30408
pseudo <i>R</i> ²	0.142	0.142	0.139

Exponentiated coefficients (odd ratios); Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Table 2.7: Logit model: determinants of adaptation aid overcoding

	(1)	(2)	(3)
Dep. var: False Adaptation			
GDP growth	0.895*** (0.029)	0.894*** (0.028)	0.942* (0.030)
GDP per capita	0.127*** (0.052)	0.152*** (0.064)	0.145*** (0.065)
Gov. debt (% GDP)	1.085*** (0.032)	1.079** (0.032)	1.136*** (0.034)
Unemployment	1.024 (0.189)	1.064 (0.196)	0.992 (0.194)
Share of green votes	0.948 (0.037)	5.046 (5.178)	2.878 (3.018)
GHG evolution (since Kyoto)	1.145*** (0.028)	1.143*** (0.028)	1.093*** (0.027)
CC laws and policies	4.210*** (0.690)	4.218*** (0.689)	
IEA	0.031** (0.049)	0.027** (0.042)	1.945 (3.159)
ODA	0.940 (0.088)	0.979 (0.095)	1.056 (0.106)
No. of projects	1.518*** (0.086)	1.535*** (0.088)	1.687*** (0.098)
Total climate aid	0.915* (0.043)	0.902** (0.043)	0.866*** (0.041)
Project's value	0.934*** (0.009)	0.934*** (0.009)	0.937*** (0.009)
Bureaucratic quality	0.048 (0.257)	0.045 (0.241)	
Green votes x GDP per cap.		0.858 (0.081)	0.899 (0.087)
PARI			3.586*** (1.404)
Gov. effectiveness			0.484** (0.137)
<i>N</i>	37475	37475	37475
pseudo <i>R</i> ²	0.098	0.098	0.095

Exponentiated coefficients (odd ratios); Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

6.3 Additional specifications

Table **2.8** presents our results using a linear probability model with the same fixed effects as in our baseline model (donor, recipient and year fixed effects). Tables **2.9** and **2.10** present our results using a logit model with alternative fixed effects: we add recipient region fixed effects (Table **2.9**) and project sector fixed effects (Table **2.10**) to the donor and year fixed effects.¹³ As in Table **2.4**, we are using the whole sample of climate projects from 2002 to 2018, and the dependent variable indicates whether the climate project has been over-reported. Standard errors are clustered at the donor-recipient level.

Finally, Table **F.8** presents our results for the share of over-reported projects from 2002 to 2018 using a linear regression model with donor, recipient and year fixed effects and clustered standard errors.

The results of our linear probability model are similar to that of our baseline model, except the project value is no longer significant. Alternative fixed effects do not drastically alter the main results of our baseline logit model. Under sector fixed effects, GDP growth becomes significant with a negative effect, and ODA is no longer significant. Our estimations of the determinants of the over-reporting ratio also confirm our baseline results, but the variables related to our budget constraint hypothesis are now significant. Higher GDP growth slightly increases the over-reporting ratio, while higher GDP per capita and lower unemployment decrease it.

¹³Results are presented as odds ratios.

Table 2.8: Linear probability model : determinants of climate aid over-reporting

	(1)	(2)	(3)
Dep. Var: Over-reporting			
GDP growth	-0.008 (0.005)	-0.007 (0.005)	-0.006 (0.005)
GDP per capita	-0.083 (0.053)	0.007 (0.054)	-0.017 (0.056)
Gov. debt (% GDP)	-0.003 (0.004)	-0.005 (0.005)	0.005 (0.005)
Unemployment	0.141*** (0.019)	0.149*** (0.019)	0.152*** (0.020)
Share of green votes	-0.005 (0.006)	0.778*** (0.136)	0.700*** (0.137)
GHG evolution (since Kyoto)	0.028*** (0.004)	0.027*** (0.004)	0.025*** (0.004)
CC laws and policies	0.133*** (0.021)	0.150*** (0.020)	
IEA	-1.266*** (0.170)	-1.407*** (0.177)	-1.230*** (0.182)
ODA	-0.060*** (0.018)	-0.037** (0.018)	-0.028 (0.018)
No. of projects	0.074*** (0.009)	0.075*** (0.009)	0.090*** (0.009)
Total climate aid	-0.030*** (0.007)	-0.033*** (0.007)	-0.040*** (0.007)
Project's value	-0.002 (0.002)	-0.003 (0.002)	-0.003 (0.002)
Bureaucratic quality	-1.606*** (0.230)	-1.404*** (0.230)	
Green votes x GDP per cap.		-0.072*** (0.013)	-0.066*** (0.013)
PARI			0.186** (0.094)
Gov. effectiveness			-0.117*** (0.037)
Observations	60295	60295	60318
R^2	0.139	0.140	0.138

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

Table 2.9: Logit model with regional fixed effects

	(1)	(2)	(3)
Dep. Var : Over-reporting			
GDP growth	0.956* (0.023)	0.961* (0.023)	0.963 (0.022)
GDP per capita	0.797 (0.200)	1.170 (0.296)	1.070 (0.275)
Gov. debt (% GDP)	0.983 (0.019)	0.972 (0.019)	1.020 (0.020)
Unemployment	1.933*** (0.162)	1.995*** (0.168)	2.020*** (0.175)
Share of green votes	0.983 (0.029)	35.727*** (22.076)	24.508*** (14.886)
GHG evolution (since Kyoto)	1.143*** (0.020)	1.138*** (0.020)	1.124*** (0.020)
CC laws and policies	1.811*** (0.161)	1.954*** (0.174)	
IEA	0.003*** (0.002)	0.001*** (0.001)	0.003*** (0.003)
ODA	0.758*** (0.058)	0.840** (0.066)	0.867* (0.069)
No. of projects	1.421*** (0.052)	1.425*** (0.052)	1.524*** (0.056)
Total climate aid	0.859*** (0.026)	0.848*** (0.025)	0.823*** (0.024)
Project's value	0.990* (0.006)	0.989* (0.006)	0.989* (0.006)
Bureaucratic quality	0.000*** (0.001)	0.001*** (0.001)	
Green votes x GDP per cap.		0.718*** (0.041)	0.741*** (0.041)
PARI			2.162* (0.856)
Gov. effectiveness			0.599*** (0.096)
<i>N</i>	60298	60298	60321
pseudo <i>R</i> ²	0.103	0.104	0.102

Exponentiated coefficients; Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

Table 2.10: Logit model with project's sector fixed effects

	(1)	(2)	(3)
Dep. Var: Over-reporting			
GDP growth	0.906*** (0.025)	0.910*** (0.025)	0.916*** (0.024)
GDP per capita	1.026 (0.291)	1.574 (0.450)	1.630* (0.477)
Gov. debt (% GDP)	1.024 (0.023)	1.010 (0.023)	1.043* (0.023)
Unemployment	2.140*** (0.202)	2.231*** (0.212)	2.357*** (0.231)
Share of green votes	0.937** (0.030)	47.705*** (32.359)	25.550*** (17.179)
GHG evolution (since Kyoto)	1.148*** (0.022)	1.143*** (0.022)	1.138*** (0.022)
CC laws and policies	1.783*** (0.175)	1.940*** (0.191)	
IEA	0.006*** (0.005)	0.003*** (0.002)	0.005*** (0.004)
ODA	0.936 (0.081)	1.046 (0.092)	1.042 (0.095)
No. of projects	1.334*** (0.053)	1.335*** (0.054)	1.408*** (0.056)
Total climate aid	0.818*** (0.027)	0.806*** (0.027)	0.785*** (0.026)
Project's value	0.985** (0.006)	0.984** (0.006)	0.984** (0.006)
Bureaucratic quality	0.025*** (0.036)	0.064* (0.098)	
Green votes x GDP per cap.		0.696*** (0.043)	0.735*** (0.045)
PARI			2.122* (0.969)
Gov. effectiveness			0.953 (0.163)
<i>N</i>	55389	55389	55412
pseudo <i>R</i> ²	0.176	0.177	0.175

Exponentiated coefficients (odd ratios); Standard errors in parentheses
 * p<0.1, ** p<0.05, *** p<0.01

Table 2.11: Linear model: determinants of climate aid over-reporting ratios

	(1)	(2)	(3)
Dep. Var: Over-reporting ratio			
GDP growth	0.060* (0.031)	0.073** (0.032)	0.056* (0.032)
GDP per capita	-0.787** (0.342)	-0.362 (0.361)	-0.611* (0.369)
Gov. debt (% GDP)	-0.057** (0.029)	-0.064** (0.029)	-0.006 (0.029)
Unemployment	0.750*** (0.124)	0.780*** (0.124)	0.764*** (0.128)
Share of green votes	-0.030 (0.039)	3.152*** (0.884)	2.830*** (0.879)
GHG evolution (since Kyoto)	0.184*** (0.024)	0.178*** (0.024)	0.175*** (0.024)
CC laws and policies	0.465*** (0.115)	0.523*** (0.116)	
IEA	-8.570*** (0.830)	-9.233*** (0.859)	-8.141*** (0.876)
ODA	-0.395*** (0.109)	-0.299*** (0.112)	-0.277** (0.113)
No. of projects	0.434*** (0.049)	0.434*** (0.050)	0.503*** (0.049)
Total climate aid	-0.136*** (0.040)	-0.143*** (0.041)	-0.149*** (0.039)
Bureaucratic quality	-9.247*** (1.593)	-8.514*** (1.606)	
Green votes x GDP per cap.		-0.295*** (0.082)	-0.270*** (0.082)
PARI			-0.093 (0.452)
Gov. effectiveness			-1.069*** (0.191)
Observations	12686	12686	12704
R^2	0.236	0.237	0.233

Standard errors in parentheses

* p<0.1, ** p<0.05, *** p<0.01

7 Conclusion

In this chapter, we have analysed the international climate aid projects funded between 2002 and 2018 using project-level climate aid data from the OECD CRS Rio Markers database, and we have assessed the share of overcoded projects in a systematic way using Python programming and complementary hand coding. Using country-level economic, environmental and political data for 28 DAC donor countries from 2002 to 2018, we have estimated the factors that may affect the overcoding of climate projects by donors. We have undertaken the estimations for overall climate projects, but also for adaptation and mitigation projects separately with different definitions of overcoding.

Our empirical analysis provides two important findings. First, our assessment of the content of climate projects indicates that the share of over-reported projects is still very high between 2002 and 2018. Out of the 63,195 projects reported as climate-relevant by donor countries, nearly half (48.6%) are not climate-related. Furthermore, we find that 67.8% of adaptation projects and 64.3% of mitigation projects are overcoded. Our descriptive results also show that all donor countries overcode climate projects, even small donors. However, the extent to which they overcode is heterogeneous among donors and years. There seems to be a slight decrease in overcoding since 2015, potentially related to the Paris Agreement.

Our second finding, obtained from the econometric analysis, is that economic, environmental, and political factors influence overcoding by donor countries. National policies and actions to fight climate change have the characteristics of a public good giving countries a free-rider incentive in the funding of these actions. Donor countries are therefore inclined not to increase their aid allocation toward additional climate projects but to simply relabel their already existing foreign aid as climate-related. Overcoding development aid as climate-related could be an electoral strategy with no budget constraint for donors with environmentally-concerned populations. Our estimates indicate that donor countries' electoral motivations in overcoding climate aid are only confirmed for less wealthy donor countries. The positive effect of the budget constraint on overcoding is consistently supported by our results concerning the unemployment rate, but other variables have more mitigated results across our different specifications.

The impact of the government's environmental preferences is confirmed by two out of our three variables for environmental policy stringency. We estimate a consistent negative effect of the number of IEAs in force on the probability of overcoding across all our models and spec-

ifications. International pressure thus seems to be efficient in restraining donor countries from overcoding. We also estimate that donor countries whose GHG emissions have increased since the Kyoto Protocol are more likely to overcode aid. Other environmental policy stringency indicators, i.e. the number of climate-related laws and policies and the EPI PARI Index, do not appear to accurately measure the stringency of a country's climate policy. In the absence of data on countries' actual abatement efforts, the evolution of GHG emissions since the Kyoto Protocol is a more reliable indicator of governments' climate actions than indicators based on means of action without guarantee of results.

The miscoding of climate projects with the Rio marker methodology is a long-known issue, as highlighted by various scholars (Michaelowa and Michaelowa, 2011; Junghans and Harmeling, 2012; Weikmans et al., 2017) and by the OECD DAC Secretariat itself (Weikmans et al., 2017). Our assessment of 63,195 projects up to 2018 shows that donor countries persist in over-reporting the climate change content of their development aid projects: slightly less than half of the projects investigated are over-reported. The poor quality of aid reporting by donor countries has several negative consequences. First, it undermines the efforts toward international climate justice between developed and developing countries. It also compromises trust in international climate negotiations, which is already tarnished by the fact that donor countries have failed to meet their USD 100 billion climate aid pledges. Consequently, it reduces the capacity and willingness of developing countries to undertake mitigation and adaptation actions. According to the United Nations Environmental Program (UNEP, 2021), current international adaptation aid flows largely fall short of the adaptation needs of developing countries. Over-reporting of adaptation aid thus further increases the gap between developing countries' needs and the funding they receive. Accurate data on climate aid are also necessary to evaluate the efficiency of past climate aid projects and to design more efficient aid schemes in the future.

In line with the existing literature, our research reiterates the need for third-party control of donor countries' climate aid reporting and for a robust climate finance accounting methodology (Weikmans et al., 2017). Greater transparency in this reporting process could help build trust between the different parties in the negotiations and provide impetus to increase the ambition of the pledges in international climate change negotiations.

Additional work will include further estimations at the donor-recipient-year level and at the donor-recipient-year and project type level. Theoretical modelling of the strategic political motives of the donor countries in overcoding could provide an interesting extension to this chapter.

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Appendix

A Time series properties

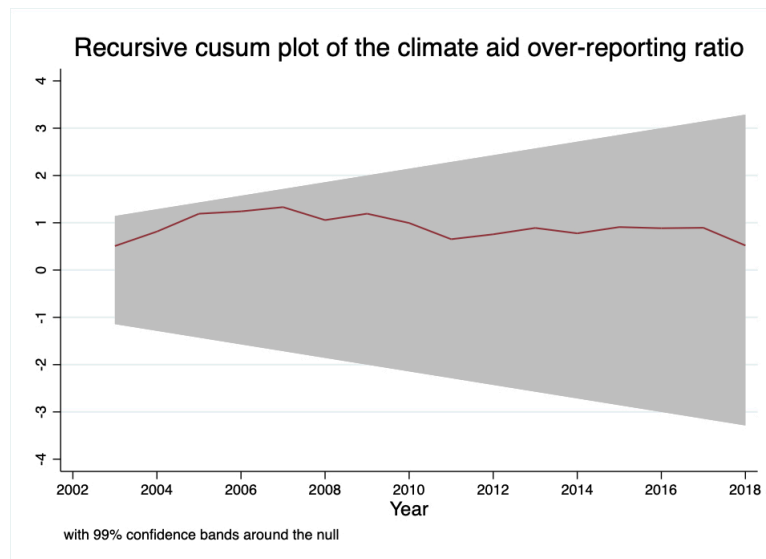


Figure A.1: Test of structural break for the climate projects over-reporting ratio

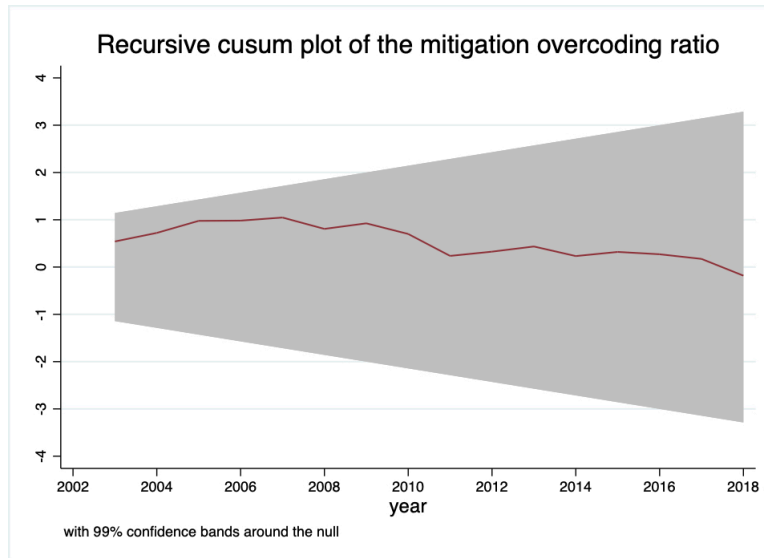


Figure A.2: Test of structural break for the mitigation projects overcoding ratio

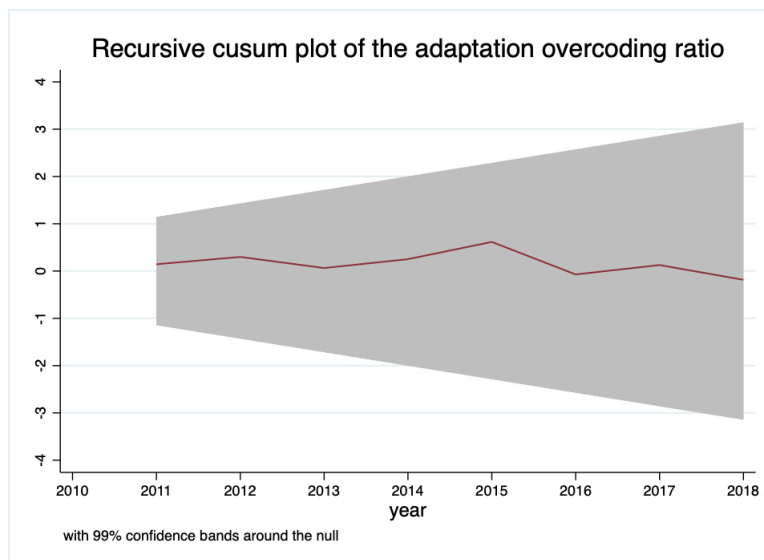


Figure A.3: Test of structural break for the adaptation projects overcoding ratio

B Additional analyses

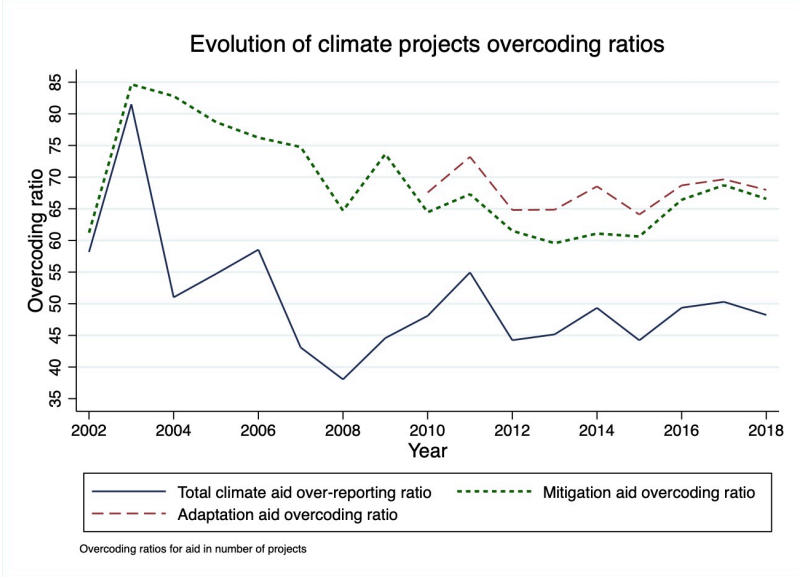


Figure B.4: Evolution of climate aid overcoding ratios (aid in number of projects)

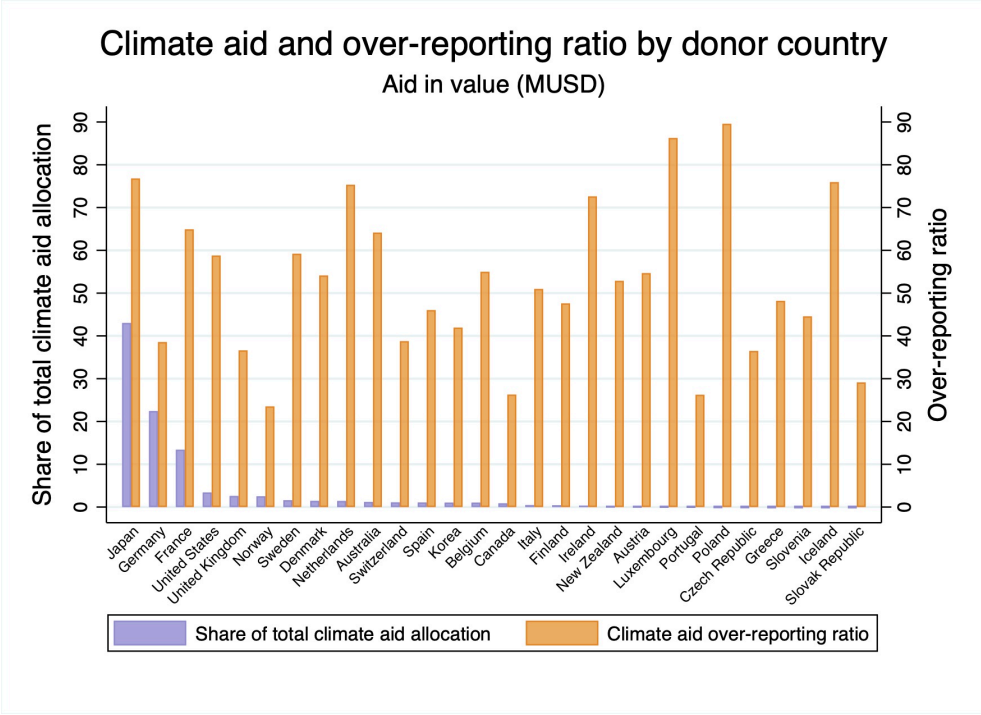


Figure B.5: Climate aid and over-reporting ratios by donor country (aid in value)

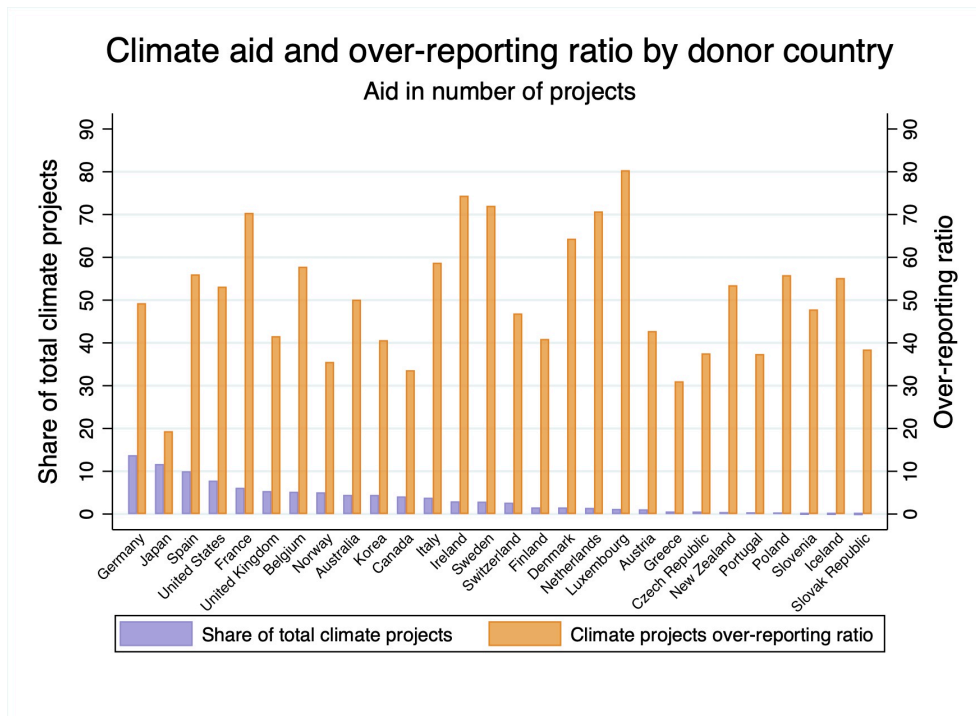


Figure B.6: Climate aid and over-reporting ratios by donor country (aid in number of projects)

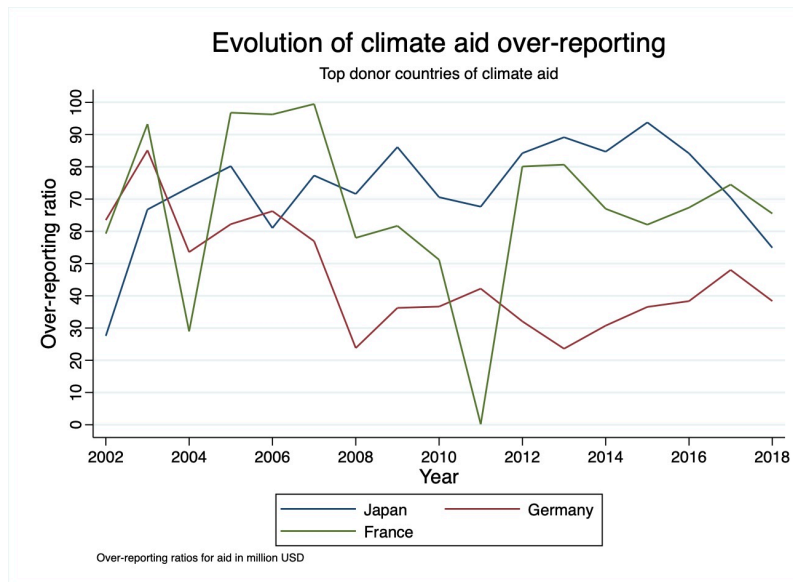


Figure B.7: Evolution of climate aid over-reporting for Japan, Germany and France (aid in value)

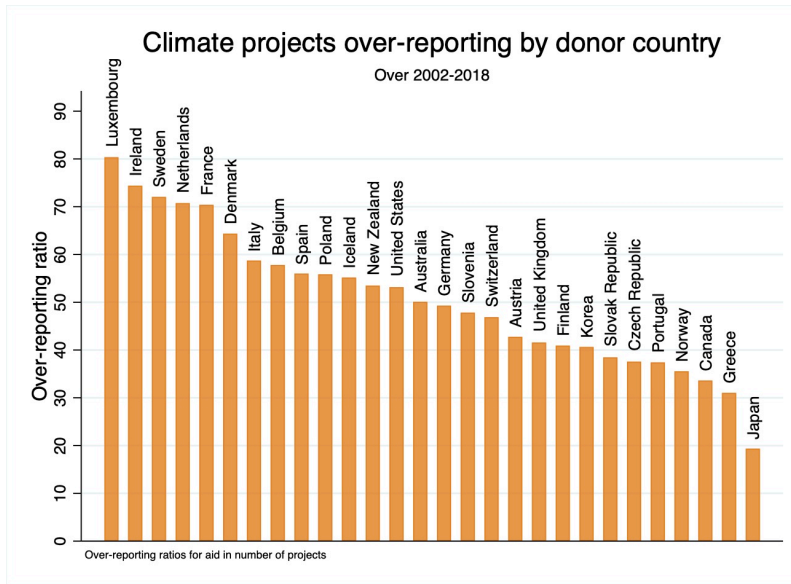


Figure B.8: Climate aid over-reporting ratio by donor country (aid in number of projects)

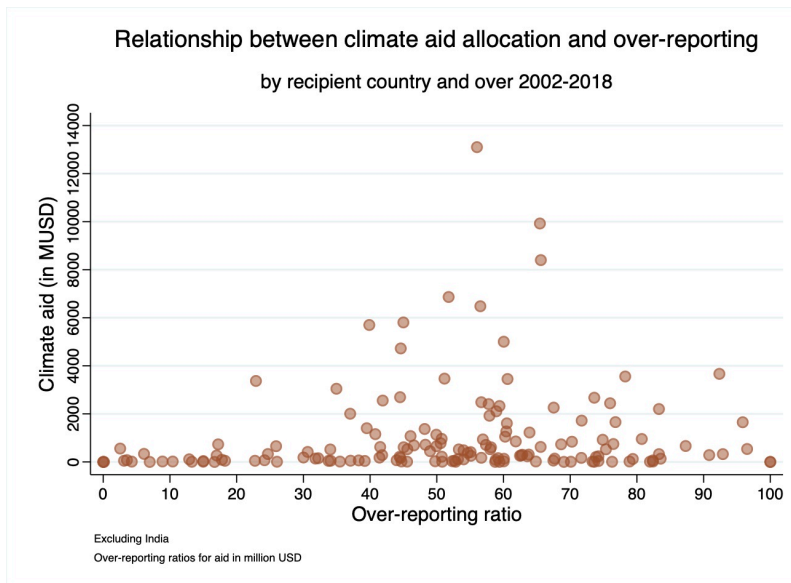


Figure B.9: Relationship between climate aid allocation and over-reporting ratio for recipient countries (aid in value)

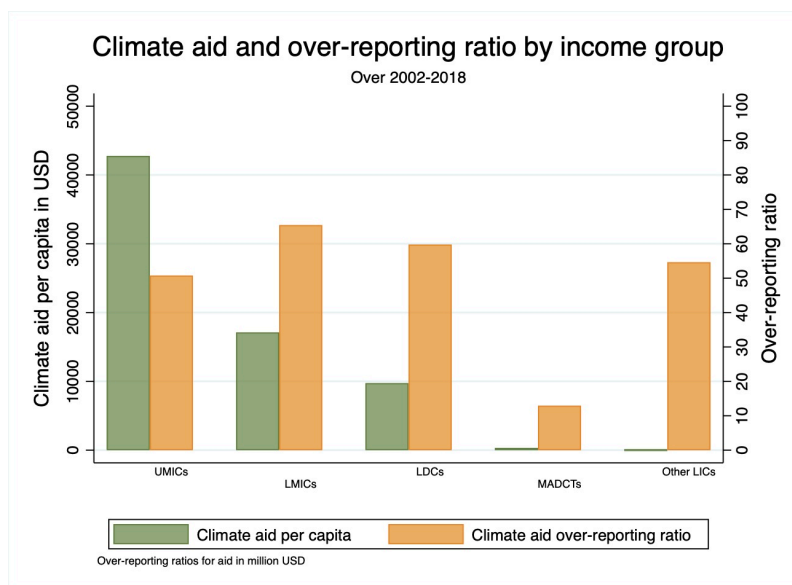


Figure B.10: Allocation of climate aid per capita and over-reporting ratio by recipient income group (aid in value)

C Keywords list

List of explicit mitigation keywords : 'air quality', 'biomass', 'capture and storage', 'carbon sink', 'co2 sink', 'carbon management', 'clean energy', 'climate smart', 'climate-smart', 'climate action', 'climate efforts', 'climate technology', 'climate protection', 'climate-friendly', 'climate friendly', 'emission', 'energy efficiency', 'energy reduction', 'energy savings', 'green technology', 'geothermal', 'hybrid energy', 'hydro-electric', 'hydro electric', 'hydrolic', 'hydro power', 'low carbon', 'low-carbon', 'biogaz', 'nuclear', 'photovoltaic', 'renewable', 'alternative energy', 'solar', 'stove', 'wind energy', 'sustainable energy', 'resource efficient', 'forest management', 'forest sustainability', 'forest conservation', 'forest protection', 'deforestation', 'forest rehabilitation', 'reforestation', 'mangrove', 'cloud forest', 'wetland', 'redd', 'redd', 'ccs', 'mitigation', 'mitigate climate change', 'recycl', 'sustainable waste management', 'pollution management', 'air pollution', 'agroecology', 'agro ecology', 'agro-ecology', 'agro ecological', 'agro-ecological', 'agro forestry', 'agroforestry', 'agro-forestry', 'organic farming', 'green logistic', 'green transport', 'green growth', 'sustainable economic growth', 'green economy', 'public transport', 'land rehabilitation', 'land management', 'land use', 'soil improvement', 'improve soil', 'soil quality', 'soil rehabilitation', 'degraded soil', 'soil degradation', 'sustainable agricultural practice', 'biological fertilizer', 'organic fertilizer', 'low-impact agri', 'low impact agri', 'ecological agriculture', 'ecological agriculture', 'sustainable rural development', 'sustainable urban development', 'nationally determined contribution', 'climate policy', 'climate change policy', 'national action plan on climate change', 'national strategy for climate change', 'climate fund', 'fund for climate change', 'calidad del aire', 'biomasa', 'captura y almacenamiento de carbono', 'sumidero de carbono', 'sumidero de co2', 'manejo de carbono', 'energía limpia', 'climáticamente inteligente', 'acción climática', 'protección climática', 'protección del clima', 'amigable con el clima',

'emisión', 'eficiencia energética', 'reducción de energía', 'ahorro de energía', 'tecnología verde', 'tecnologías verdes', 'geotérmica', 'geotermia', 'energía híbrida', 'sistemas híbridos de energía', 'hidroeléctric', 'hidráulic', 'bajo en carbono', 'biogas', 'nuclear', 'fotovoltaic', 'renovable', 'solar', 'estufa', 'eólica', 'viento', 'eficiencia en los recursos', 'eficiente de los recursos', 'eficiencia de los recursos', 'conservación forestal', 'conservación de los bosques', 'protección forestal', 'protección de los bosques', 'proteger los bosques', 'redd', 'reforestación', 'manglar', 'deforestación', 'rehabilitación forestal', 'bosque nuboso', 'humedal', 'mitigación', 'mitigar el cambio climático', 'reciclaje', 'gestión sostenible de residuos', 'manejo de la contaminación', 'contaminacion del aire', 'agroecología', 'agroecológico', 'silvicultura', 'agroforestería', 'agro forestería', 'agro-forestería', 'agricultura orgánica', 'logística verde', 'transporte sostenible', 'transporte público', 'transportes públicos', 'rehabilitación de tierras', 'rehabilitación de las tierras', 'gestion de tierras', 'uso del suelo', 'mejoramiento de suelo', 'calidad del suelo', 'regeneración del suelo', 'regenerar el suelo', 'degradación del suelo', 'suelo degradado', 'prácticas agrícolas sostenibles', 'prácticas en agricultura sostenible', 'fertilizantes orgánicos', 'fertilizantes biológicos', 'agricultura de bajo impacto', 'política climática', 'política de acción climática', 'plan de acción nacional sobre el cambio climático', 'estrategia nacional ante el cambio climático', 'fondo climático', 'fondo para el cambio climático', 'energía sostenible', 'qualité de l'air', 'biomasse', 'séquestration du carbone', 'puits de carbone', 'puit de co2', 'gestion du carbone', 'énergie propre', 'énergies propres', 'climato-intelligent', 'climato-intelligent', 'action climatique', 'actions climatiques', 'protection du climat', 'respectueux du climat', 'respectueuse du climat', 'émissions', 'efficacité énergétique', 'économies d'énergie', 'technologie verte', 'technologies vertes', 'technologie propre', 'géothermale', 'géothermique', 'énergie hybride', 'énergie durable', 'énergies durables', 'énergies hybrides', 'hydro-électrique', 'hydro électrique', 'hydraulique', 'bas carbone', 'bas-carbone', 'biogaz', 'nucléaire', 'photovoltaïque', 'renouvelable', 'solaire', 'réchaud', 'foyers améliorés', 'éolienne', 'mangrove', 'économe en ressource', 'conservation de la forêt', 'protection de la forêt', 'réhabilitation de la forêt', 'conservation des forêts', 'protection des forêts', 'réhabilitation des forêts', 'zones humides', 'forêt humide', 'forêt de nuage', 'recycl', 'redd', 'reforestation', 'déforestation', 'atténuation du changement climatique', 'gestion des déchets', 'pollution atmosphérique', 'pollution de l'air', 'agroécologi', 'agro écologi', 'agro-écologi', 'agroecologi', 'agro-ecologi', 'agro ecologi', 'agroforesteri', 'agro foresteri', 'agro-foresteri', 'agriculture biologique', 'logistique verte', 'transport vert', 'croissance verte', 'économie verte', 'transport écologique', 'transports publics', 'réhabilitation des sols', 'usage des sols', 'sols pollués', 'sites pollués', 'dégradation des sols', 'qualité des sols', 'pratiques agricoles durables', 'pratiques agricoles soutenables', 'engrais organique', 'fertilité des sols', 'réduction des intrants', 'engrais biologique', 'agriculture à faible impact', 'politique climatique', 'politique du climat', 'plan d'action national contre le changement climatique', 'fond climatique', 'fond pour le climat', 'luftqualität', 'biomasse', 'kohlenstoffspeicher', 'kohlenstoffsenke', 'co2-senke', 'co2 senke', 'kohlenstoffmanagement', 'saubere energie', 'nachhaltige energie', 'klimamaßnahmen', 'klimaschutz', 'klima schutz', 'klimafreundlich', 'emissionen', 'energieeffizienz', 'energieeinsparung', 'energiereduzierung', 'grüne technologie', 'geothermie', 'geothermisch', 'erdwärme', 'hybridenergie', 'wasserkraft', 'hydraulisch', 'kohlenstoffarm', 'biogas', 'nuklear', 'photovoltaik', 'erneuerbare', 'solar', 'gaskocher', 'windenergie', 'kernkraft', 'ressourceneffizient', 'walderhaltung', 'waldschutz', 'schutz des waldes', 'abholzung', 'waldsanierung', 'wiederaufforstung', 'mangroven', 'wolkenwald', 'feuchtgebiet', 'minderung', 'klimawandel zu stoppen', 'recycl', 'wiederaufbereitung', 'recycling', 'nachhaltige abfallwirtschaft', 'luftverschmutzung', 'agrarrökologie', 'agroforstwirtschaft', 'agrarrforstwirtschaft', 'ökologischer landbau', 'agroökologisch', 'grüne logistik', 'grüner verkehr', 'öffentlicher verkehr', 'landsanierung', 'bodenmanagement', 'bodennutzung', 'bewirtschaftung des bodens', 'bodenverbesserung', 'boden zu verbessern', 'bodenqualität', 'bodensanierung', 'de-

gradiertes boden', 'bodendegradation', 'nachhaltige landwirtschaftliche praxis', 'biologischer dünger', 'organischer dünger', 'klimapolitik', 'nationaler aktionsplan zum klimaschutz', 'klimafonds', 'fonds für den klimawandel', 'luftqualität', 'biomassa', 'koolstofafvang en opslag', 'koolstofput', 'co2 gootsteen', 'carbon gootsteen', 'schone energie', 'klimaat-slim', 'klimaatactie', 'klimaatbescherming', 'klimaatvriendelijk', 'emissie', 'energie-efficiëntie', 'energiebesparing', 'groene technologie', 'geothermische', 'geothermie', 'hybride energie', 'duurzame energie', 'hydro-elektrisch', 'hydroelektrisch', 'hydrolisch', 'koolstofarm', 'biogas', 'nucleair', 'fotovoltaïsch', 'recyclen', 'hernieuwbaar', 'zonne-energie', 'gasfornuis', 'windenergie', 'efficiënt gebruik van hulpbronnen', 'bosbehoud', 'bosbescherming', 'bosherstel', 'ontbossing', 'bosherstel', 'herbebossing', 'mangrove', 'wolken bos', 'wetland', 'nat gebied', 'redd', 'mitigatie', 'klimaatverandering verminderen', 'recyclen', 'gerecycled', 'duurzaam afvalbeheer', 'beheer van vervuiling', 'luchtvervuiling', 'agro-ecologi', 'agrobosbouw', 'biologische landbouw', 'groene logistiek', 'groen transport', 'openbaar vervoer', 'groen vervoer', 'landherstel', 'landbeheer', 'landgebruik, bodemverbetering', 'bodem verbeteren', 'bodemkwaliteit', 'bodemsanering', 'gedegradeerde bodem', 'aantasting van de bodem', 'duurzame landbouwpraktijken', 'biologische meststof', 'organische meststof', 'landbouw met lage impact', 'klimaatbeleid', 'nationaal actieplan klimaatverandering', 'klimaatfonds', 'fonds voor klimaatverandering'.

List of implicit mitigation keywords : 'clean development mechanism', 'paris agreement', 'unfccc', 'united nations conference on climate change', 'conference on climate', 'climate negotiation', 'climate expert', 'fishery research', 'marine conservation', 'sea protection', 'sustainable fisher', 'sustainable fishing', 'ecosystem service', 'natural resource', 'sustainable river basin management', 'climate change advocacy', 'climate change awareness', 'climate change education', 'climate education', 'sustainable development', 'sustainable economic development', 'sustainable corporate', 'sustainable governance', 'sustainable agriculture', 'mecanismo de desarrollo limpio', 'acuerdo de paris', 'cmnucc', 'experto en clima', 'investigación pesquera', 'conservación marina', 'pescador sostenible', 'servicios del ecosistema', 'servicios ecosistémicos', 'servicios ambientales', 'recursos naturales', 'sensibilización contra el cambio climático', 'agricultura sostenible', 'desarrollo sostenible', 'desarrollo económico sostenible', 'corporativo sostenible', 'gobernanza sostenible', 'negociaciones climáticas', 'negociaciones de cambio climático', 'conferencia sobre el clima', 'educación sobre el cambio climático', 'mécanisme de développement propre', 'accord de paris', 'accords de paris', 'accord de paris', 'accords de paris', 'ccnucc', 'conférence sur le changement climatique', 'conférence sur le climat', 'négociations climatiques', 'expert climat', 'expert du climat', 'recherche sur la pêche', 'conservation marine', 'pêche durable', 'pêcherie durable', 'services écosystémiques', 'service écosystémique', 'ressources naturelles', 'gouvernance des ressources', 'sensibilisation au changement climatique', 'éducation au changement climatique', 'agriculture durable', 'développement durable', 'économie durable', 'gouvernance durable', 'mechanismus für umweltverträgliche entwicklung', 'paris-abkommen', 'paris-abkommen', 'klimarahmenkonvention', 'klimakonferenz', 'klimaverhandlungen', 'klima expert', 'fischereiforschung', 'erhaltung des meeres', 'nachhaltige fischerei', 'meeresschutz', 'ökosystemleistung', 'sensibilisierung für klima', 'aufklärung für den klima', 'klimawandels sensibilisier', 'klimawandels zu sensibilisier', 'natürliche ressource', 'nachhaltige landwirtschaft', 'nachhaltige entwicklung', 'nachhaltiges regieren', 'nachhaltiges unternehmen', 'schoon ontwikkelingsmechanisme', 'overeenkomst van parijs', 'raamverdrag van de verenigde naties inzake klimaatverandering', 'klimaatonderhandeling', 'onderhandeling over klimaatverandering', 'klimaatconferentie', 'conferentie over klimaatverandering', 'klimaatverdrag', 'klimaat expert', 'visserijonderzoek', 'behoud van de zee', 'duurzame visserij', 'duurzame visvangst', 'ecosysteemdienst', 'natuurlijke hulpbron', 'natuurlijke bronnen', 'bodemrijkheid', 'sensibilisering voor klimaat', 'duurzame ontwikkeling', 'duurzame

landbouw’.

List of explicit adaptation keywords : ‘climate change impact’, ‘climate impact’, ‘climate change effect’, ‘climate effect’, ‘threat of climate change’, ‘effects of climate’, ‘impact of climate’, ‘impacts of climate’, ‘consequences of climate’, ‘changing climate’, ‘climate change resilient’, ‘resilience of public’, ‘climate change risk’, ‘climate change prediction’, ‘climate monitoring’, ‘climate change monitoring’, ‘climate prediction’, ‘climate resilient’, ‘climate resilience’, ‘climate risk’, ‘climate variability’, ‘climate change adaptation’, ‘climate adaptation’, ‘adaptation to climate change’, ‘climatology’, ‘meteorological’, ‘climatic shock’, ‘climate shock’, ‘climatic event’, ‘climate hazard’, ‘climatic hazard’, ‘environmental hazard’, ‘climate change adversities’, ‘resilience to climate change’, ‘climate victims’, ‘climate tolerant’, ‘protection from climate’, ‘endangered by climate’, ‘threatened by climate’, ‘climate threat’, ‘climatic threat’, ‘climate vulnerability’, ‘vulnerable to climate’, ‘vulnerable to climatic’, ‘dam’, ‘bush fires’, ‘cyclone’, ‘desertification’, ‘dike’, ‘disaster relief’, ‘disaster risk’, ‘drought’, ‘dyke’, ‘environmental catastrophe’, ‘environmental disaster’, ‘flood’, ‘inundation’, ‘disaster-resilient’, ‘disaster resilient’, ‘disaster response’, ‘disaster management’, ‘climate-sensitive’, ‘climate sensitive’, ‘water security’, ‘sustainable river basin management’, ‘monsoon’, ‘natural catastrophe’, ‘natural disaster’, ‘natural risk’, ‘natural hazards’, ‘resilient infrastructure’, ‘sea level’, ‘sea-level’, ‘storm’, ‘tsunami’, ‘typhoon’, ‘maritime disaster’, ‘warning system’, ‘water management’, ‘water conservation’, ‘water resources’, ‘erosion’, ‘resilient agri’, ‘resilient crop’, ‘agroclimatic crop’, ‘sustainable crop’, ‘seed bank’, ‘sustainable livelihood’, ‘climate policy’, ‘climate change policy’, ‘national action plan on climate change’, ‘national strategy for climate change’, ‘climate fund’, ‘fund for climate change’, ‘impactos del cambio climático’, ‘impacto del cambio climático’, ‘efectos del cambio climático’, ‘resiliencia del cambio climático’, ‘resiliente al cambio climático’, ‘riesgo de cambio climático’, ‘riesgos de cambio climático’, ‘riesgo climático’, ‘riesgos climáticos’, ‘vulnerabilidad climática’, ‘vulnerabilidad al cambio climático’, ‘vulnerabilidad a los cambios climáticos’, ‘amenaza del cambio climático’, ‘predicción climática’, ‘predicciones climáticas’, ‘monitoreo del clima’, ‘monitoreo climatico’, ‘variabilidad climática’, ‘adaptación al cambio climático’, ‘adaptarse al cambio climático’, ‘resiliencia frente al cambio’, ‘climatología’, ‘meteorológico’, ‘choque climático’, ‘fenómenos meteorológicos’, ‘fenómenos climático’, ‘eventos climáticos’, ‘riesgo ambiental’, ‘adversidades climática’, ‘víctimas del clima’, ‘protección contra el cambio climático’, ‘peligro por el cambio climático’, ‘amenazado por el cambio climático’, ‘represa’, ‘ciclón’, ‘desertificación’, ‘dique’, ‘alivio de desastre’, ‘riesgo de desastre’, ‘sequía’, ‘catastrofia ambiental’, ‘desastre ambiental’, ‘inundación’, ‘monzónica’, ‘catastrofia natural’, ‘desastre natural’, ‘riesgo natural’, ‘infraestructura resiliente’, ‘nivel del mar’, ‘tormenta’, ‘tsunami’, ‘tifón’, ‘sistema de advertencia’, ‘conservación del agua’, ‘gestión del agua’, ‘recursos hídricos’, ‘agricultura resiliente’, ‘cultivo resiliente’, ‘cultivos resilientes’, ‘banco de semillas’, ‘banco de germoplasma’, ‘semillas resistentes’, ‘medios de vida sostenibles’, ‘política climática’, ‘política de acción climática’, ‘plan de acción nacional sobre el cambio climático’, ‘estrategia nacional ante el cambio climático’, ‘fondo climático’, ‘fondo para el cambio climático’, ‘erosión’, ‘impacts du changement climatique’, ‘impact du changement climatique’, ‘impact des changements climatiques’, ‘impacts des changements climatiques’, ‘effets du changement climatique’, ‘effet du changement climatique’, ‘résilience au changement climatique’, ‘résilience climatique’, ‘risques liés au changement climatique’, ‘risques climatiques’, ‘risque climatique’, ‘résilience face au changement climatique’, ‘résilience face aux changements climatiques’, ‘conséquences du changement climatique’, ‘menace du changement climatique’, ‘surveillance du changement climatique’, ‘surveillance du climat’, ‘prévisions climatiques’, ‘prévision du changement climatique’, ‘évolutions climatiques’, ‘variabilité du climat’, ‘variabilité climatique’, ‘adaptation au changement climatique’, ‘adaptation aux changements climatiques’, ‘adaptation climatique’, ‘climatologie’,

'météorologique', 'chocs climatiques', 'choc climatique', 'événements climatiques', 'événement climatique', 'aléa climatique', 'aléas climatiques', 'aléa naturel', 'aléas naturels', 'victimes du changement climatique', 'victimes du climat', 'résistant au changement climatique', 'résistante au changement climatique', 'résistants au changement climatique', 'résistantes au changement climatique', 'protection contre le changement climatique', 'menacé par le changement climatique', 'menacée par le changement climatique', 'menacés par le changement climatique', 'menacées par le changement climatique', 'menacé par les changements climatiques', 'menacées par les changements climatiques', 'menacés par les changements climatiques', 'menace climatique', 'menace du changement climatique', 'menace des changements climatiques', 'menacées par les changements climatiques', 'vulnérabilité au changement climatique', 'vulnérabilité aux changements climatiques', 'vulnérabilité climatique', 'vulnérables aux changements climatiques', 'vulnérables au changement climatique', 'vulnérable aux changements climatiques', 'vulnérable au changement climatique', 'digue', 'feux de brousse', 'cyclone', 'désertification', 'secours aux sinistrés', 'désastre environnemental', 'désastres environnementaux', 'désastre naturel', 'désastres naturels', 'sécheresse', 'catastrophe environnementale', 'catastrophe naturelle', 'catastrophes naturelles', 'inondation', 'mousson', 'infrastructures résilientes', 'infrastructures résistantes', 'niveau de la mer', 'tempête', 'tsunami', 'typhon', 'système d'alerte', 'gestion de l'eau', 'conservation de l'eau', 'ressources en eau', 'agriculture résiliente', 'adaptation de l'agriculture aux changements climatiques', 'adaptation de l'agriculture au changement climatique', 'adaptation de l'agriculture aux enjeux climatiques', 'adaptation de l'agriculture aux effets du changement climatique', 'résilience agricole', 'semences résistantes', 'semences plus résistantes', 'semences pour une agriculture durable', 'plants pour une agriculture durable', 'banque de graines', 'banque de semences', 'moyens de subsistance durable', 'politique climatique', 'politique du climat', 'plan national d'action contre le changement climatique', 'plan national d'adaptation au changement climatique', 'fond climatique', 'fond pour le climat', 'auswirkungen des klimawandels', 'klimaauswirkungen', 'klimaresilienz', 'klimarisik', 'überwachung des klimawandels', 'klimaüberwachung', 'vorhersage des klimawandels', 'klimavorhersage', 'klimawandelrisik', 'klimaschwankungen', 'klimaresistent', 'klima-prognose', 'klimavariabilität', 'anpassung an den klima', 'klimatologi', 'meteorologisch', 'klimaschock', 'klimaereignis', 'klimagefährdung', 'klimlagefah', 'umweltgefah', 'naturgefah', 'widerstandsfähigkeit gegen den klimawandel', 'klimaopfer', 'opfer des klimawandels', 'klimatolerant', 'schutz vor klima', 'durch den klimawandel gefährdet', 'vom klimawandel bedroht', 'damm', 'buschfeuer', 'zyklon', 'desertifikation', 'deich', 'katastrophenhilfe', 'katastrophenrisiko', 'trockenheit', 'umweltkatastrophe', 'flut', 'überschwemmung', 'überhäufung', 'überflutung', 'katastrophenresistent', 'monsun', 'naturkatastrophe', 'belastbare infrastruktur', 'meereshöhe', 'sturm', 'tsunami', 'taifun', 'warnsystem', 'wasserverwaltung', 'wasserschutz', 'wasservorräte', 'widerstandsfähige landwirtschaft', 'widerstandsfähige ernte', 'resistente ernte', 'samenbank', 'resistente samen', 'nachhaltiger lebensunterhalt', 'klimapolitik', 'nationaler aktionsplan zum klimaschutz', 'klimafonds', 'fonds für den klimawandel', 'impact van klimaatverandering', 'klimaatimpact', 'klimaatverandering effecten', 'klimaateffect', 'weerbaarheid tegen klimaatverandering', 'klimaatbestendigheid', 'klimaatverandering risico', 'klimaatrieco', 'klimaatverandering voorspelling', 'monitoring van klimaatverandering', 'klimaat monitoring', 'klimaat voorspelling', 'klimaatvariabiliteit', 'aanpassing aan de klimaatverandering', 'klimatologie', 'meteorologisch', 'klimaatschock', 'klimaatgebeurtenis', 'klimatologische gebeurtenis', 'klimaatgevaar', 'klimatologisch gevaar', 'milieugevaar', 'tegenslagen tegen klimaatverandering', 'milieuproblemen', 'klimaat slachtoffer', 'klimaat tolerant', 'bescherming tegen klimaat', 'bedreigd door klimaat', 'dam', 'bosbrand', 'cycloon', 'woestijnvorming', 'dijk', 'rampenbestrijding', 'ramprisco', 'droogte', 'erosie', 'milieuramp', 'moesson', 'overstroming', 'inondatie', 'natuurlijke catastrof', 'natuurramp', 'natuurrisico', 'veerkrachtige infrastructuur', 'zeespiegel', 'storm',

'tsunami', 'tyfoon', 'waarschuwingssysteem', 'water beheersing', 'waterbehoud', 'watervoorraden', 'veerkrachtige landbouw', 'veerkrachtig gewas', 'duurzaam gewas', 'zaadbank', 'duurzaam levensonderhoud', 'klimaatbeleid', 'nationaal actieplan klimaatverandering', 'klimaatfonds', 'fonds voor klimaat'.

List of implicit adaptation keywords : 'clean development mechanism', 'paris agreement', 'unfccc', 'united nations conference on climate change', 'conference on climate', 'climate negotiation', 'climate expert', 'climate change advocacy', 'climate change awareness', 'climate change education', 'climate education', 'food emergency', 'food security', 'food self sufficiency', 'sustainable development', 'sustainable economic development', 'zika', 'chikungunya', 'cholera', 'dengue', 'malaria', 'tuberculosis', 'yellow fever', 'sustainable agriculture', 'mecanismo de desarrollo limpio', 'acuerdo de parís', 'cmnucc', 'experto en clima', 'sensibilización contra el cambio climático', 'zika', 'chikungunya', 'cholera', 'dengue', 'emergencia alimentaria', 'seguridad alimentaria', 'malaria', 'tuberculosis', 'fiebre amarilla', 'agricultura sostenible', 'desarrollo sostenible', 'desarrollo económico sostenible', 'negociaciones climáticas', 'negociaciones de cambio climático', 'conferencia sobre el clima', 'educación sobre el cambio climático', 'mécanisme de développement propre', 'accord de paris', 'accords de paris', 'accord de paris', 'accords de paris', 'ccnucc', 'conférence sur le changement climatique', 'conférence sur le climat', 'négociations climatiques', 'expert climat', 'expert du climat', 'sécurité alimentaire', 'urgence alimentaire', 'développement durable', 'économie durable', 'agriculture durable', 'zika', 'chikungunya', 'choléra', 'dengue', 'malaria', 'tuberculose', 'fièvre jaune', 'mechanismus für umweltverträgliche entwicklung', 'paris-abkommen', 'paris-abkommen', 'klimarahmenkonvention', 'klimakonferenz', 'klimaverhandlungen', 'klimarahmenkonvention', 'klima expert', 'sensibilisierung für klima', 'aufklärung für den klima', 'klimawandels sensibilisier', 'klimawandels zu sensibilisier', 'lebensmittelnotfall', 'lebensmittelkontrolle', 'nachhaltige landwirtschaft', 'nachhaltige entwicklung', 'zika', 'chikungunya', 'cholera', 'dengue', 'malaria', 'tuberkulose', 'gelbfieber', 'schoon ontwikkelingsmechanisme', 'overeenkomst van parijs', 'raamverdrag van de verenigde naties inzake klimaatverandering', 'klimaatonderhandeling', 'onderhandeling over klimaatverandering', 'klimaatconferentie', 'conferentie over klimaatverandering', 'klimaatverdrag', 'klimaat expert', 'sensibilisering voor klimaat', 'voedselnoodsituatie', 'voedsel noodgeval', 'voedselzekerheid', 'duurzame ontwikkeling', 'zika', 'chikungunya', 'cholera', 'knokkelkoorts', 'malaria', 'tuberculose', 'gele koorts', 'duurzame landbouw'.

Chapter 3

International Climate Transfers: Have They Been Effective?

“Hang on. I think I might’ve detected a small flaw.”

Buffy the Vampire Slayer – S4E21
Primeval (2000)

Abstract. The literature has long tried to answer the question of the effectiveness of foreign aid in promoting growth among its recipients. In recent decades, foreign assistance has targeted new objectives, including climate objectives. In the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, international climate transfers to developing countries are identified as a necessary tool for addressing both the threat of climate change and the call for international climate justice. Considering the absence of consensus on climate transfers’ effectiveness, we propose a methodological review of the challenges to estimating aggregated aid impact. We then investigate three empirical strategies to estimate the effect of international public climate transfers on carbon emissions using the OECD-DAC climate finance data from 2000 to 2020 and covering 155 recipient countries. We first estimate two panel models using the instrumental variable two-stage least squares technique with a shift-share instrument and the two-step system generalised method of moments to address climate transfers endogeneity. We then propose a staggered difference-in-differences setup comparing small and large recipients and using heterogeneity-robust estimators. This strategy accounts for heterogeneity in climate transfers’ effects related to the time and length of their allocation. Our estimations converge to the absence of an effect of international public climate transfers on the recipient countries’ carbon emissions. This result holds when considering different subsamples of recipient countries and is consistent across different accounting definitions of climate transfers.

1 Introduction

Climate transfers have long been a critical element of international climate negotiations for developing countries as they partly tackle the issue of climate justice. Developed countries are historically the largest emitters of greenhouse gas (GHG) emissions. They went through industrialisation without having to consider its environmental impact while developing countries now have to face the challenge of economic development and climate change mitigation altogether. The United Nations Framework Convention on Climate Change (UNFCCC) highlights the need for international climate justice under the principle of "common but differentiated responsibilities". International climate transfers aim at helping developing countries reduce their GHG emissions and adapt to the already severe consequences of climate change. As one of the tools of international cooperation to tackle climate warming, it is necessary to assess their effectiveness. This chapter investigates their impact on developing countries' carbon emissions.

In 1992, The UNFCCC stated the need for developed countries to provide financial support to developing economies to help them meet the convention's objectives. However, no actual financial commitments were made until the 15th Conference of Parties (COP15) in 2009. Meeting in Copenhagen, developed countries then pledged to jointly mobilise 100 billion USD of "*new and additional*" (UNFCCC (2010), p.6) funding per year by 2020 to help developing countries face the challenges of climate change. This target was extended to 2025 during the Paris Agreement in 2015. According to the latest Organisation for Economic Cooperation and Development (OECD) assessment, donor countries had only mobilised USD 83.3 billion of climate funding for developing countries in 2020 (OECD, 2022a). This amount includes bilateral public climate funding (USD 31.4 billion), multilateral public climate funding (USD 36.9 billion), climate-related officially-supported export credits (USD 1.9 billion), and private climate funding mobilised by public actions (USD 13.1 billion) (OECD, 2022a). International climate finance indeed covers a large variety of funding which can be decomposed according to the donor entity and the type of funding. We first distinguish between public and private finance and between concessional and non-concessional finance. Concessional finance is below market-rate finance, mostly loans with preferential terms or grants. We thus identify private climate-related investments, private philanthropic funding, non-concessional public funding and concessional public funding. This dissertation focuses on public funding. It is either bilateral, provided directly by donor countries, or multilateral, provided by multilateral agencies (funds,

development banks etc.). We exclude private climate finance from our scope as our analysis lies within the assessment of international climate cooperation and governmental efforts. We use the term climate aid to specifically define climate-related Official Development Assistance (ODA). ODA is the OECD standard to identify development aid and implies specific concessionality requirements (OECD, 2021). We use the terms climate finance, transfers or funding to cover all climate-related public finance, including climate ODA.

Climate funding addresses two objectives: mitigation and adaptation. Mitigation corresponds to measures aiming at reducing GHG emissions, while adaptation corresponds to measures aiming at protecting societies against climate change consequences, such as sea level and temperature rise, increased frequency of natural catastrophes and extreme meteorological events. As highlighted by the 2022 OECD report (OECD, 2022a), many developing countries lack the capacity to efficiently implement such measures as well as to attract international financing. They are also particularly vulnerable to the consequences of climate change (OECD, 2022a). This vulnerability is due to limited budget capacity, institutional impediments, and geographic situations with many developing countries located in the southern hemisphere and already subject to warmer climates, frequent drought or tropical storm risks. For instance, 37 developing economies are classified as Small Islands and Developing States and are particularly impacted by climate change consequences such as sea-level rise, soil erosion and ocean acidification. Less favourable economic perspectives, fragile state capacity and legal framework, as well as higher financial risks, prevent much-needed investments in the matter. International climate transfers should fill these gaps and help mobilise other funding sources.

Yet, current climate funding does not meet the COP15 objective and the actual amounts received are contested by developing countries whose climate needs would far exceed those objectives (Yeo, 2019). According to the United Nations Environmental Programme (UNEP, 2021), the annual adaptation costs in developing countries estimated by the literature lie between USD 140 and 300 billion by 2030 and between USD 280 and 500 billion by 2050. Current international adaptation flows largely fall short of this estimation. Regarding mitigation needs, in 2021, the International Energy Agency (IEA) estimated that investments in decarbonised energy solutions in emerging and developing countries should reach over USD 1 trillion per year by 2030 (IEA, 2021).¹ This estimation indicates that developing countries' energy-related invest-

¹This figure corresponds to the estimated gross cost of mitigation. Estimating the net cost of mitigation efforts implies assessing future benefits from mitigation policies, and the alternative cost of a no-mitigation scenario (Köberle et al. (2021)). Recent papers estimate the energy-related gain would allow for a positive return on mitigation investments (see, for instance, Way et al. (2022)), and the Intergovernmental Panel on Climate Change AR6 Summary for Policymakers (IPCC, 2023) states that "even without accounting for all the benefits of avoiding potential damages the global economic and social benefit of limiting global warming to 2°C exceeds the cost of

ment needs are largely exceeding the COP15 USD 100 billion goal. The IPCC AR6 Summary for Policymakers (SPM) (IPCC, 2023) thus states that climate finance "*falls short of the levels needed to limit warming to below 2°C or to 1.5°C across all sectors and regions*" (A.4.5, p.11). This conclusion concerns all climate finance, including domestic and private finance, but scaling up international public climate funding could help leverage other sources.

The effectiveness of climate finance is closely related to the allocation of this funding by donor countries and, thus, to the environmental, economic, and geopolitical factors that motivate this allocation (see Chapter 1). As in the case of foreign aid, the literature has highlighted that the allocation of climate finance seems to be strongly driven by donor countries' economic and political motives and not only by the recipient needs (Stadelmann et al., 2014; Weiler et al., 2018; Peterson and Skovgaard, 2019; Bayramoglu et al., 2023). Bilateral relations between donor and recipient countries, such as commercial, cultural, and geopolitical ties, motivate bilateral climate finance allocation (Lewis, 2003). Weiler et al. (2018) find that if vulnerable countries receive more bilateral adaptation aid, aid allocation also serves the promotion of the donors' economic interests. Bayramoglu et al. (2023) highlight how donors' trade interests shape the distribution of bilateral climate aid. Dolšak and Crandall (2013) show that colonial ties are a strong determinant of funding decisions through the Clean Development Mechanism.

Part of the literature on international climate finance focuses on the actual content of the funded projects reported as climate-related. It reveals that climate finance projects' content might be questionable (Michaelowa and Michaelowa, 2011; Junghans and Harmeling, 2012; Weikmans et al., 2017; CARE, 2021; Bayramoglu et al., 2022; Toetzke et al., 2022). For instance, Bayramoglu et al. (2022) find that only 48.6% of climate ODA projects reported by OECD-DAC donor countries between 2002 and 2018 truly targeted climate objectives. They also find large confusion errors between mitigation and adaptation objectives. Systematic automated analyses (keyword-search algorithm, machine-learning) (Bayramoglu et al., 2022; Toetzke et al., 2022) and small-scale manual evaluations (Weikmans et al., 2017; CARE, 2021) converge to overcoding estimations close to 50% (see Chapter 2).²

Following these results, we may wonder if international climate transfers received by recipient countries are sufficiently large and well-targeted to reach their objectives (mitigation and adaptation) or, simply put if climate finance is effective. The literature has long attempted to estimate the effectiveness of foreign aid, mainly on growth, economic development, and

mitigation in most of the assessed literature" (C.2.4, p.27).

²Estimations vary depending on the type of funding and errors evaluated.

poverty reduction, with, for instance, the early contributions of [Chenery and Syrquin \(1975\)](#), [Papanek \(1972, 1973\)](#) and [Mosley \(1987\)](#). Foreign aid covers all development-related international transfers but the empirical literature mainly uses the OECD ODA standard to identify aid. Many aggregated analyses do not measure any positive impact of aid on the recipients' development, while studies at the microeconomic level has repeatedly shown that specific aid projects seemed to be effective, which [Mosley \(1987\)](#) called the micro-macro aid paradox. This chapter lies within this literature on aid effectiveness but focuses on climate-related transfers and mitigation outcomes. It discusses the methodological challenges in measuring the impact of aid at the aggregated level and proposes three different empirical approaches to estimate this effect regarding climate finance. We focus on the mitigation objective of climate finance and therefore do not try to estimate the impact of climate transfers on the recipient countries' adaptive capacity to climate change. Doing so would first imply being able to assess the country's vulnerability and resilience to climate change. The definition of adaptation actions is still debated, and their objectives (building resilience and reducing vulnerability to climate change) are difficult to measure properly. On the contrary, the mitigation objective is clear and explicit: reducing the recipient countries' GHG emissions. The expected mitigation outcome of climate finance is, therefore, easily measurable through recipient countries' GHG emissions. Furthermore, adaptation concerns have been included recently in international climate finance, and the OECD has only tracked adaptation flows since 2010. Mitigation flows still represent the majority of climate finance ([OECD, 2022a](#)) and data are available from 1998.

Part of the aid literature has assessed the impact of foreign aid on environmental issues, including GHG emissions, with mitigated results. This literature does not estimate the effect of official climate aid per se but either total foreign aid ([Arvin et al., 2006](#); [Arvin and Lew, 2009](#); [Kretschmer et al., 2013](#); [Lim et al., 2015](#)) or sectoral aid like energy or renewable energy-related aid ([Bhattacharyya et al., 2016](#); [Mahalik et al., 2021](#); [Kablan and Chouard, 2022](#); [Kretschmer et al., 2013](#)). These authors do not find any significant impact of foreign aid on the recipient's GHG emissions. For instance, [Kretschmer et al. \(2013\)](#) find total and sectoral aid efficient in reducing the energy intensity of recipient countries but do not find any significant effect of aid on emissions intensity. [Kablan and Chouard \(2022\)](#) find a small and transitory negative impact of aid for renewable energy on CO₂ emissions while [Bhattacharyya et al. \(2016\)](#) do not estimate any significant impact of environmental energy-related aid on CO₂ and SO₂ emissions.

Several recent papers have studied the effectiveness of actual climate finance, but they do not converge in their results. [Gavard and Schoch \(2021\)](#), [Lee et al. \(2022\)](#) and [Zeng et al.](#)

(2022) evaluate the impact of the climate aid projects reported to the OECD through the Creditor Reporting system while Djoundourian et al. (2022) use multilateral climate aid data from the Climate Funds Update³.

Gavard and Schoch (2021) investigate the impact of climate aid and private mitigation finance, proxied by the Clean Development Mechanism investments, on CO₂ emissions from 2005 to 2017. They use a panel fixed effect model with a generalised least squares estimator in first-difference and assume no contemporaneous reverse causality. Their results show that climate aid tends to induce a rise in emissions. They posit that this aid paradox might be due to construction activities associated with the aid projects, which are carbon-intensive, and enhance economic activities. They do not find any significant impact of private mitigation finance on emissions.

Lee et al. (2022) have estimated the impact of multilateral climate aid from 2000 to 2018 on recipients' CO₂ emissions. They first use a panel fixed effects model and account for potential endogeneity of aid in a dynamic panel data model using the system Generalised Methods of Moments (GMM) technique. They find a significant negative effect of climate aid on carbon emissions, and this effect to be greater for mitigation aid than for adaptation aid. The authors also find climate aid more efficient in reducing carbon emissions in Small Island Developing States (SIDS) and higher-income developing countries.

Zeng et al. (2022) focus on Belt and Road Initiative (BRI) recipient countries from 2000 to 2018. Using a two-step system GMM model, they find that climate aid significantly reduces the carbon emission intensity, with a stronger effect for mitigation aid. Their analysis posits a dual impact of climate aid on carbon emissions: climate aid not only directly reduces carbon emissions by increasing carbon reduction resources but also indirectly by promoting renewable energy and improving the energy structure.

Djoundourian et al. (2022) explore the effect of adaptation aid from ten multilateral funds on several GHG emissions from 2000 to 2014. They propose a staggered difference-in-differences design estimated with a two-way fixed effects regression. They empirically check the theoretical assumptions of the literature on the substitutability or complementarity of mitigation and adaptation actions (see Buob and Stephan (2013), Eyckmans et al. (2016) and Schenker and Stephan (2017) on the potential substitution effect between mitigation and adaptation actions). They posit a potential adverse effect of adaptation aid on GHG emissions as adaptation strategies could reduce the incentives for mitigating climate change. On the other hand, complementarity could result from a halo effect of adaptation aid, meaning adaptation aid would encourage a

³climatefundsupdate.org

more general pro-green policy. They find that multilateral adaptation aid significantly reduces CO₂ emissions but do not have any impact on other GHG emissions.

Contribution. Considering the absence of a consensus on the effectiveness of climate finance, we extensively discuss the potential channels through which international public climate finance could impact carbon emissions and the methodological issues faced by aid effectiveness empirical research. Building on our methodological and theoretical analyses, we propose three empirical strategies to estimate the causal impact of climate transfers. Our empirical strategies particularly target the issues of climate finance endogeneity and its heterogeneous effects. Adding to two panel models, we propose a difference-in-differences (DiD) set-up with heterogeneity-robust estimators. To our knowledge, DiD estimations robust to staggered treatment adoption and heterogeneous treatment effects have not yet been applied to our research question. Our empirical analysis also adds to the literature by covering most forms of public climate finance: concessional and non-concessional, bilateral and multilateral, and adaptation and mitigation transfers.

Our first two empirical strategies implies the estimation of two panel models, accounting for the endogeneity issue. Indeed, we believe climate transfers can be allocated to countries that made higher mitigation efforts as a reward or to countries with large emissions to benefit from a lower marginal cost of mitigation. This implies a potential simultaneous determination of climate transfers and carbon emissions. We first use an instrumental variable two-stage least squares (IV-2SLS) approach with a shift-share instrument for climate funding (Bartik, 1991). As a second instrumentation strategy, we estimate a dynamic panel model using the two-step system Generalised Methods of Moments (GMM) technique (Blundell and Bond, 1998). This dynamic model also controls for the path dependency of carbon emissions. Our third empirical strategy accounts for heterogeneous treatment effects of climate transfers through a DiD estimation in a staggered adoption design. As most developing countries have received some form of climate transfer, we binarise our treatment (climate transfers allocation) and compare high recipients of per capita funding (treated group) and low recipients (control) using Callaway and Sant'Anna (2021) estimators. This strategy enables us to consider heterogeneity in climate transfer effects related to the time countries first got treated and the length of exposure to treatment, i.e. when they first received significant funding and for how long. Additional analyses explore the effect of climate transfers on intermediary outcomes based on our theoretical discussion on public finance channels.

We use two panel databases from the OECD: the Rio Markers Creditor Reporting System

(CRS) database (OECD, 2022b) and the OECD climate-related development finance database (OECD, 2022c). The Rio Markers CRS database covers climate ODA from 1998 to 2020 to 154 countries and from 34 donor countries and 13 multilateral institutions. It has been widely used in the climate transfers literature and corresponds to what we define as *climate aid*. The OECD climate-related development finance database is a more extensive database that tracks all concessional and non-concessional public climate finance from 2000 to 2021 to 155 recipient countries from 36 donor countries and 22 multilateral institutions. Our analyses assess the impact of the different types of climate transfers separately to account for potential heterogeneous effects depending on the objectives (mitigation and adaptation), the providing source (multilateral and bilateral) and the concessionality.

All our estimation results converge to an absence of effect of international public finance on the recipient countries' carbon emissions. Climate finance has not yet helped recipient countries reduce their carbon emissions. We call for improved international cooperation to scale up international climate finance and better identify the recipient countries' needs and the obstacles they face in implementing mitigation actions.

Our chapter is organised as follows. Section 2 analyses the potential channels of climate finance impact on carbon emissions. Section 3 is a methodological discussion on aid effectiveness estimation. Section 4 presents the data and details our empirical strategy, and Section 5 presents our main and additional results. Finally, Section 6 concludes the chapter.

2 Potential channels of climate finance impact on carbon emissions

In Subsection 2.1, we present the theoretical background against which we then analyse, in Subsection 2.2, the potential impact of climate finance on carbon emissions. We discuss the limits to climate transfer effectiveness in Subsection 2.3.

2.1 Scale, composition and technique effects

Grossman and Krueger (1993) and Grossman and Krueger (1995) first decomposed the effect of economic activity and trade on pollution into three channels: the scale effect, the composition effect and the technique effect. This decomposition was further developed and discussed by Antweiler et al. (2001) and Copeland and Taylor (2004).

The scale effect corresponds to the impact of a variation in the economic activity, everything else being equal. Keeping technology mix and sector composition constant, increasing the overall economic activity increases GHG emissions. The second effect, the composition effect, relates to the sectoral structure of the economy. Sectors have different pollution intensities. Everything else being constant, an increase in the relative importance of carbon-intensive sectors leads to higher emissions. This effect can be further decomposed between more and less carbon-intensive firms within sectors and between more and less carbon-intensive tasks within firms. Lastly, the technique effect has to do with productivity. Everything else being constant, increasing the use of polluting inputs per unit of output produces more emissions. The technique effect covers the implementation of energy-efficient technology, cleaner energy sources, new production processes and management practices that allows to reduce the output emission intensity.

Public climate finance has an evident and necessary positive impact on economic activity, which would translate into an increase in GHG emissions through the scale effect. But unlike other foreign flows, its expected outcome is reducing carbon emissions. What matters for climate finance's overall effect is, therefore, its composition and technique effect on the recipient economy. As such, climate finance includes construction work (dike, warning systems, power-plant, public transport etc.) and the development of new economic activities (agriculture, forestry) both for mitigation and adaptation purposes, with an obvious scale effect. The global effect on GHG emissions will be negative (a decrease in emissions) if these activities replace more carbon-intensive activities or improve local production processes. For instance, limited access to energy is a common issue in developing countries. The construction of a renewable energy power plant and the related electrical grid should improve energy access in the population while reducing fossil fuel use. Another example is food security, which is an important climate change adaptation challenge. Food security climate projects will aim to develop *sustainable* agricultural production, which is more resilient to climate change impacts and less water and input-consuming. More productive agricultural practices that preserve soil quality can reduce agricultural sector net emissions by preserving land Carbon Capture and Storage (CCS)

capacity. Climate finance's objective is to promote low-carbon economic development for recipient countries. Its overall effect on GHG emissions thus depends on its ability to alter the economic structure (composition effect) and the technology and skills of the recipient country (technique effect). We detail the channels through which climate transfers could reduce GHG emissions in light of the composition and technique effects analysis in the following subsection.

2.2 Climate finance channels

Cleaner technologies and practices. Many mitigation projects have a direct technique effect with the transfer of cleaner technologies, the most straightforward being renewable energy. Those projects then hopefully have spillover effects. New technologies and practices might be adopted by other firms and institutions through imitation, reverse engineering and labour turnover. Climate projects indeed imply technical cooperation, education and staff training to transfer skills specific to these new technologies. Projects can also support the development of the necessary local supply chains and markets. An example of a multilateral aid program that fits into this objective is the Scaling-Up Renewable Energy Program in Low-Income Countries (SREP) from the Strategic Climate Fund (SFC) which specifically aims to "generate over 3 million MWh per year of renewable energy, improve access to energy for over 140,000 businesses and 17.3 million people and reduce 2.5 million tons of GHG per year"⁴ ⁵. In 2015, the program approved the transfer of USD 5.5 million to "self-supply renewable energy projects" (solar and geothermal power with mini-grids) in Honduras and achieved a production of 276 MWh per year. They estimated that 174 tons of CO₂ emissions were avoided in Honduras.⁶ Projects involving cleaner technology can also relate to public transport networks development, shifting behaviours from fossil-fuels-intensive means of transport to greener options and reducing final demand for fossil fuel (sufficiency lever (Shukla et al., 2022)). Awareness-related projects play a large part in consumer behaviour change towards new and cleaner technology use. For instance, a stream of projects promotes cleaner cookstoves as an alternative to traditional kerosene, wood or coal-burning stoves which are not only highly carbon-emitting but also responsible for significant health hazards because of exposure to particulate matter and

⁴climatefundsupdate.org

⁵cif.org

⁶cif.org

other pollutants⁷.

Additionally to technology transfers, climate finance can improve production methods. On the production side, many projects target the agricultural sector and encourage agro-ecological and agro-forestry practices (intercropping, association of forestry and complementary crop culture, water management, input reduction etc.). These projects should help local producers secure a steady income in the face of climate change impacts and limit their carbon footprint through enhanced yield, soil and biodiversity protection and reduction of polluting inputs.

Private finance leverage. Another important goal of public climate finance is to mobilise and leverage private finance by decreasing investment risks. Rogner and Leun (2018) explain that investing in energy efficiency and renewable energy is perceived as risky for private investors because of the long amortisation periods, the lack of market regulation and the lower governance in developing countries. Public finance can take the form of public guarantees on private climate loans, insurance services and risk management instruments. They reduce investment risks and thus leverage private finance at a lower cost for recipient countries. For instance, the Asian Development Bank (ADB) covers up to 50% of default risk on commercial bank loans to small solar power development projects in India (World Bank/IMF, 2011). The IPCC AR6 Summary for Policymakers thus state that public finance "can leverage private finance" (IPCC, 2023). Public climate transfers may also increase trust in the recipient's economic environment and lower risk perceptions. Investment risks are indeed linked to the regulatory environment and level of governance, explaining why legislative support and capacity building are another objective of public climate finance.

Institutional support and capacity building. Many climate finance projects involve technical and legislative support to the recipient government or administration, helping them design and implement appropriate climate policies and regulatory frameworks. These include pre-feasibility study, energy and transition planning, as well as the mainstreaming of climate concerns in national development plans and government investment decisions.⁸ Kono and Mon-

⁷The World Health Organisation (WHO) estimates that 3.2 million people die prematurely from illnesses attributable to the household air pollution caused by open fires and inefficient cookstoves (who.int)

⁸We can find examples of such types of projects in the OECD Creditor Reporting System database (OECD, 2022b). In 1999, Canada disbursed USD 3.37 million to enhance India's National Ministry of Environment and Forest's capacity to address national and global environmental issues. In 2016, the Global Green Growth Institute disbursed USD 292.17 thousand to support Colombia's National Planning Department "integrate green growth into the country's broader economic planning". Finally, in 2015 Germany committed to USD 3.88 million for an advisory project toward the Chinese government's decision-makers to help them develop China's transport sector in a climate-friendly manner".

tinola (2019) suggest that climate transfers could also create a need for implementing climate legislation to carry out the financed projects. They take the example of Vietnam, where legal decisions were adopted to regulate the development and operation of wind-power activities (licensing requirements, electricity purchase prices, subsidies). The financing of wind-power projects in Vietnam through international climate finance could have accelerated the necessity for the adoption of such a regulation, which might then facilitate the development of local wind-power businesses and markets. Through national objectives, regulations and incentives, climate legislation affects GHG emissions by enabling the development of green technologies and industries and limiting polluting activities (technique and composition effect).

International climate finance also targets capacity-building. Capacity-building relates to developing the skills and resources society needs to tackle social, economic and environmental challenges efficiently. Climate capacity-building should promote the recipient's ability to implement climate policies through, among others, public agents' training, education or academic cooperation.⁹ Education and training are also necessary to transfer skills and allow for the sustainable operation of the funded climate projects. For instance, the construction of a renewable energy plant or a new public transport network needs to be accompanied by proper training of the labour force and the related public administration to allow long-term sustainable infrastructure management, i.e. ensure that the technology remains functional and economically viable over time.

Income effect. Part of the literature suggests an income effect of foreign aid on environmental outcomes: by providing additional income and relieving the recipient government's budget constraint, transfers allow it to invest in climate change mitigation and adaptation (Lim et al., 2015; Hatzipanayotou et al., 2002). Research has shown that in the midst of crises, environmental concerns are decreasing and often relegated to lower priorities (see for the COVID-19 crisis Beiser-McGrath (2022) and Drews et al. (2022)). Climate finance might thus constitute a steady earmarked support to climate policies in the face of economic shocks. However, Eyckmans et al. (2016) highlight that recipient governments could simply reallocate their current climate investments to other sectors, including carbon-intensive ones. Climate transfers could therefore be a substitute for domestic climate investments.

⁹In 2016, Norway funded a partnership between the Bjerknnes Centre for Climate Research (University of Bergen), UniResearch (Norwegian Research Centre), the Institute of Marine Research and the Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN). The partnership's objective was capacity building of IMHEN's staff to help them "acquire better understanding and advanced techniques to tackle climate change challenges" (OECD, 2022b).

Though highly debated, the Environmental Kuznet Curve (EKC) literature posits that public demand for environmental regulation will increase with income per capita. (Hübler and Keller, 2009). Through its positive income effect, climate finance could indirectly improve climate policies in the recipient country. The EKC theory has, however, not been empirically verified (Perman and Stern, 2003; Stern, 2004).

The climate finance income effect could also support the recipient country's structural transformation. The structural transformation process in developing economies is traditionally described by a compositional shift of activities towards higher productivity sectors, typically from the agricultural sector to the industrial and, in the latter stage, the service sector. The structural change accompanying economic development would translate in an increase of the share of low carbon-intensive sectors (service), and thus a reduction of carbon emissions through the composition effect (Hübler and Keller, 2009). However, it implies a sufficiently strong positive income effect of climate finance and a climate-strategic structural transformation that actually penalises carbon-intensive industries.

Incentive effect. Finally, public international climate transfers could have an incentive effect on recipient governments. By targeting the issue of climate justice, climate transfers could facilitate international cooperation. Developing countries could indeed condition their participation to fairness and equity considerations in global mitigation effort sharing. Relative to global public good provision, Barrett (2001) shows that side-payments can increase participation in international cooperation in a situation of strong asymmetry. Based on Hadjiyiannis et al. (2013)'s game analysis, we can posit another potential incentive effect from climate transfers. Recipient countries could be competing to attract international funding through higher abatement efforts. These indirect incentive effects of climate transfers may allow a decrease in recipient countries' carbon emissions.

2.3 Limits to climate transfers effectiveness

Nonetheless, an extensive literature has highlighted limits to aid effectiveness, which we detail in the present subsection.

Fungibility. As previously noted, international climate transfers could have a substitution effect on national climate investments instead of incentivising it. This effect relates to the fungibility issue. Foreign aid is nowadays mainly project-based to avoid fungibility issues which were long pinpointed as the main limitation to aid effectiveness. Allocating funds directly to projects should reduce the recipient government's discretion in their use. However, some scholars argue that fungibility issues remain with project-based aid (Feyzioglu et al., 1998; Morrison, 2012). Foreign aid may simply allow the recipient country to redirect its own expenses to other sectors it wishes to promote. The net effect is, therefore, not an increase of funding for the objectives targeted by foreign aid, in our case, climate change mitigation and adaptation. As Morrison (2012) explains, conditionality is deemed necessary because there are local political forces opposed to the policy conditions. But as a result of this opposition, it is likely that adopted policies get eventually withdrawn. Burnside and Dollar (2000), Easterly (2005), and Heckelman and Knack (2008) conclude that tied aid and aid conditionality do not systematically impact the recipient's domestic policies.

Aid fragmentation. Another limit to international climate transfers' effectiveness lies in aid fragmentation and its potential lack of scalability. Foreign aid is mainly project-based, meaning international transfers consist of a multitude of small to medium projects funded by different donors. This proliferation of projects prevents monitoring and coordination into a nationwide coherent environmental transition by recipient governments (Knack and Rahman, 2007). Fragmented small-scale climate projects may have a limited impact on policy change and the total carbon emissions of the recipient countries. According to the OECD climate-related development finance database (OECD, 2022c), from 2000 to 2021, 50% of the projects were below USD 153.508 thousand¹⁰. 75% of the projects individually amounted to less than USD 1 million.

¹⁰This figure is computed over concessional and non-concessional public commitments (current USD).

Local conditions. Furthermore, maladaptation to local conditions and lack of social acceptability can hinder these projects' effectiveness. To be efficient and economically viable, projects must be correctly integrated within the community and economic structure, and their potential for well-being improvement has to be easily perceived. For example, many mitigation projects develop small-scale renewable energy technology supply (solar home systems, renewable energy mini-grid solutions), but the existence of a domestic market is not straightforward. It is, therefore, necessary to associate these projects with developing an end-use demand base (Rogner and Leun, 2018), through complementary projects or domestic policies' support. The identification of such challenges is easier when projects are driven by domestic actors. The high fragmentation of climate finance does not facilitate an integrated planning. Besides, the literature on the determinants of aid allocation (Alesina and Dollar, 2000; Dreher et al., 2009; Martinez-Zarzoso et al., 2014; Weiler et al., 2018) has shown that it is also driven by donor strategic interests, which may limit the recipient government's engagement. It is worth mentioning that Gehring et al. (2017), studying the impact of aid fragmentation on growth, bureaucratic policy and education, estimated that sufficient recipient's administrative capacity could prevent its detrimental effect.

Institutional quality. The foreign aid literature has long theorised that aid effectiveness depended on the recipient country's institutional quality and domestic policies (Alesina and Dollar, 2000; Burnside and Dollar, 2000), though this theory is debated in empirical research (Guillaumont and Chauvet, 2001). Better institutional capacity could allow an easier implementation of climate projects and more long-lasting effect, as institutional support are needed for systemic changes. It could also reduce funding losses due to corruption. Projects supporting national climate policies imply long-term planning and cannot be efficiently carried out in a context of high political instability. The potency of climate support can thus be limited by weaker state capacity and rule of law.

Foreign aid curse. Deriving from this political-economy analysis, another stream of the literature suggests a foreign aid curse effect which could also be relevant concerning climate finance (see Morrison (2012) for a literature review on foreign aid curse theory). According to this theory, foreign aid would be similar to revenues from natural resources in leading to poor political and economic outcomes (Easterly, 2006; Deaton, 2013). Two mechanisms of the natural resource curse theory could be applied to foreign aid. First, aid volatility negatively affects domestic public policies as it prevents long-term planning (Arellano et al., 2009). This effect

is particularly relevant for climate policies which requires long-term planning. Second, [Knack \(2001\)](#) and [Brautigam and Knack \(2004\)](#) argue that, when receiving foreign aid, recipient governments no longer have to rely on their population for fiscal revenue and political support. This lower accountability hinders democracy and increases corruption. It is, however, worth noting that many developing countries, especially lower-income countries, do not have a large fiscal base on which their public policies could rely. If long-term aid dependency may need to be discussed, the foreign aid curse has not been empirically verified. This theoretical negative effect of foreign aid cannot justify reducing foreign assistance as it would drive part of the population in least-developed countries to absolute poverty. According to [Altincekic and Bearce \(2014\)](#), foreign aid is less fungible and more conditional than natural resources revenue and could less easily be used to pursue repressive and anti-democratic political strategies to stay in power. Climate finance, in particular, mainly consists of earmarked project-based transfers.

3 The methodological challenges in measuring aid effectiveness

In the present section, we discuss the methodological challenges researchers face when assessing the effectiveness of foreign transfers. We first summarise the evolution of the aid effectiveness literature in Subsection **3.1** and then review the different methodological issues associated with aid impact evaluation in Subsection **3.2**.

3.1 Overview of the aid effectiveness literature

The literature has long tried to estimate the effectiveness of foreign aid, with the early contributions of [Chenery and Eckstein \(2009\)](#), [Papanek \(1972\)](#), [Papanek \(1973\)](#) and [Chenery and Syrquin \(1975\)](#). This first generation of literature focused on the impact of foreign aid on growth through capital accumulation. They used simple growth models that assumed a stable and linear relationship between growth and capital investment.

In 1987, [Mosley \(1987\)](#) disputes earlier results and their underlying models. He contests the plausibility of the two assumptions that all foreign aid constitutes investment and that all capital

investment translates into growth. He also raises concern about potential reverse causation: the poorer recipient countries might receive more assistance because of their lower growth. He thus concludes with the existence of a "micro-macro paradox", stating that if we might estimate an effect of foreign aid at the microeconomic level, effects at the aggregated levels are difficult to identify.

The next generation of empirical studies uses improved panel data methods. Notably, it takes into account potential endogeneity issues, recipients' heterogeneity and non-linearity in the impact of aid (Boone, 1996; Burnside and Dollar, 2000, 2004; Collier and Dollar, 2002; Hansen and Tarp, 2001; Chauvet and Guillaumont, 2003; Dalgaard et al., 2004). For instance, Boone (1996) uses three instruments to control for aid endogeneity: the logarithm of population, a composite variable of aid-allocation political motives and twice-lagged aid. Burnside and Dollar (2000) posits a conditional effect of aid depending on the quality of the recipient economic policies while Easterly (2003) assumes this effect is conditional on political regimes. Both include interaction variables with, respectively, policy quality indexes and indexes of political liberties. As a last example, Hansen and Tarp (2001) investigate potential diminishing returns to aid by including a squared aid term in the aid-growth regression.

Despite improvements in the empirical strategies employed, the results are still mitigated, and in 2008 Rajan and Subramanian (2008) revive the micro-macro paradox. They review earlier empirical literature, discuss the possible reverse causation bias and investigate different approaches. They yet cannot find any effect of aid on growth regardless of the estimation strategy, the time period or the subcategory of aid. Meanwhile, the microeconomic literature, with the substantial contributions of Abhijit V. Banerjee and Esther Duflo (Banerjee and Duflo, 2009), finds positive effects for specific projects. The need to explain this absence of effect at the aggregated level led to a large political economy and political sciences literature, which we discussed in the previous section on limits to aid effectiveness (Subsection 3). Roodman (2009) also adopts a critical view on the causal interpretation of earlier results because of their high sensitivity to methodological choices. The scepticism regarding the possibility of valid causal inferences for the aid-growth nexus is based on aid heterogeneity and data quality but mostly on the capacity of econometrics techniques to capture effects as small as those of aid on complex phenomena such as the growth process. The aid literature then turns to a more disaggregated framework, analysing specific types of aid and outcomes to account for aid heterogeneity (Kretschmer et al. (2013) on energy intensity, Dreher et al. (2008) on school enrolment ratio, Mishra and Newhouse (2009) on infant mortality or Gopalan and Rajan (2016) on water supply). The more recent literature on foreign aid has mainly studied its architecture and

allocation (Clist, 2011; Barthel et al., 2014; Martinez-Zarzoso et al., 2014; Fuchs et al., 2015; Gehring et al., 2017), includes political economy concerns (Dreher et al., 2015; Dietrich, 2015) and focuses on new donor countries such as China (Dreher et al., 2021; Wellner et al., 2022) or on specific recipient countries Barrett (2001).

The question of aid effectiveness is, therefore, a long-standing concern in economic research with no consensual empirical conclusions, despite refinements in the methodologies. Our analysis focuses on the specific effect of international climate transfers on carbon emissions, but we define our empirical strategy based on the challenges highlighted by the foreign aid effectiveness literature. We detail and discuss these methodological issues in the following subsection.

3.2 Methodological challenges

This subsection focuses on four major methodological issues when investigating the impact of foreign aid, which also apply to the specific category of climate transfers. The first difficulty relates to the heterogeneous and potentially non-linear effects of aid (Subsection 3.2.1). Aid endogeneity and reverse causation are another significant challenge faced by the empirical researcher (Subsection 3.2.2). The last difficulties we discuss are the time dynamics of aid effectiveness (Subsection 3.2.3), non-stationarity (Subsection 3.2.4) and data measurement issues (Subsection 3.2.5).

3.2.1 Heterogeneity and non linearity

The main sources of heterogeneity that can condition aid effectiveness relate to aid composition, recipient countries' features and time effects.

As stated above, foreign aid can be decomposed into different subcategories targeting different outcomes. Aid is also mainly project-based, and even at the sectoral aid level, projects may differ significantly, with different scopes and implementation capacities and specific targets. Aid effectiveness may as well vary depending on the providing sources. Bilateral aid is partly driven by strategic commercial and political motives (Lewis, 2003; Weiler et al., 2018; Bayramoglu et al., 2023), but one could expect multilateral aid to be less distorted. It is, therefore, common to investigate the impact of bilateral and multilateral aid separately (Rajan and

Subramanian, 2008), as we do in Annex B. Furthermore, specific donors, whether donor countries or multilateral agencies, do not have the same allocation criteria, foreign aid policies, or monitoring capacity. Foreign aid is, therefore, an aggregate of highly heterogeneous transfers.

Recipient countries' specific characteristics also affect their treatment response. Recipient countries of foreign aid are all developing countries¹¹ but they vary greatly in size, income level, industrialisation and economic structure, state capacity, political regimes, environmental vulnerability, exposure to risks and conflicts, participation in global trade and international political power. Several of these features could affect the capacity of aid projects to reach their objectives, as we have detailed in Subsection 2.3. These country-specific characteristics also affect the type of aid received. Projects carried out in a middle-income industrialised country are not similar to those carried out in a Small Island Developing State (SIDS). This adaptation to local contexts and needs is necessary, but for the empirical researcher, it implies aggregating very different activities in a single variable.

Aid effects are also heterogeneous over time. First, the content of aid evolves. Gender equality concerns have been mainstreamed in development and environmental aid over the past years. Female inclusion, as well as being a crucial objective of its own, can foster aid effectiveness.¹² For instance, in cases where women are responsible for household fuel collection, development of female-led businesses for the last-mile supply chain of renewable energy appliances can be more efficient.¹³ One can also expect aid projects to benefit from previous experiences and to identify and correct past flaws. It implies that aid effects will not be the same at different points in time and that countries receiving aid at different periods will have different treatment responses. Besides, there might be underlying reasons explaining the different timing of aid reception. Specific countries' features might explain why they received assistance earlier. Time heterogeneity might then also be linked to country heterogeneity. In our DiD strategy (see Section 4.3), we investigate this possibility by controlling for group-time heterogeneity.

If treatment effects are heterogeneous, then standard fixed effects (FE) regression coefficients do not recover an average treatment effect. As Gibbons et al. (2018) explains, the fixed effects regression computes a weighted average of group-specific treatment effects based on their sample frequency and the conditional variance of the treatment. To address heterogeneity

¹¹The International Monetary Fund proposes an annual classification of developing and emerging countries (IMF, 2022). Every three years, the OECD-DAC publishes a list of potential ODA recipient countries based on their income level.

¹²cif.org

¹³See the mini-grid project in Tanzania from the Climate Investment fund: cif.org. See also Lighting Africa projects in Kenya: lightingglobal.org.

issues, the literature on aid effectiveness has largely used interaction variables and subsample analysis.

Burnside and Dollar (2000) and Collier and Dollar (2002) suggest that aid effectiveness is conditional on the quality of the recipient country's economic policies and include aid and policy indexes interaction terms in their regressions. Guillaumont and Chauvet (2001) also uses several interaction variables, adding that the impact of aid is also conditional on the country's vulnerability to external and climatic events. Dalgaard et al. (2004) interact aid with the fraction of land in tropical areas as a proxy for the recipient country's structural characteristics. Following this literature, we include an interaction variable between climate transfers and an institutional quality index in our panel model estimations. However, the use of interaction variables assumes that we have identified the main sources of heterogeneity and that there are no other conditional effects. It also assumes the absence of heterogeneity in the other predictors' coefficient (Gibbons et al., 2018). The results are furthermore sensitive to the presence of outliers in both aid and the conditional variables (Guillaumont and Wagner, 2014).

Subsample analyses are commonly carried out in the aid literature. Rajan and Subramanian (2008) estimate the effect of foreign aid on growth across different periods, considering multi-lateral and bilateral aid and different categories of aid. They, however, note that analysing aid impact at the category-level supposes aid is not fungible. Regarding climate aid, Bhattacharyya et al. (2016) investigates its impact on carbon emissions for different world regions separately. This strategy implies again identifying the main source of heterogeneity correctly and defining the sample accordingly with the risk of losing statistical power. Keeping these limits in mind, we carry out a panel model analysis over several subsamples, considering the objectives of climate aid, the type of provider and several recipient countries' characteristics (Subsection 5.2).

Less common is the use of quantile regressions. Groß and Nowak-Lehmann Danzinger (2022) use this technique to estimate the impact of aid on total factor productivity and Martínez-Zarzoso et al. (2017) for the effect of aid for trade on the recipient exports. Quantile regressions allow for distinct effects of aid along the outcome distributions. Depending on their initial outcome level, aid could indeed affect the recipient countries differently.

Another concern of the literature has been the potential non-linear effect of aid. First, a minimal amount of aid might be needed for aid to be effective. A potential higher threshold has also been argued, where the marginal contribution of aid would become null because of limited absorptive capacity. This assumption has been investigated through the addition of a squared aid term (Burnside and Dollar, 2000; Collier and Dollar, 2002; Hansen and Tarp, 2001; Rajan

and Subramanian, 2008). Non-parametric and semi-parametric estimations have also been used. Wagner (2014) posits that these thresholds may differ according to the recipient countries' characteristics. To account for these two types of non-linearities, they estimate a semi-parametric additive model (generalised additive partial linear model). The non-linear components of the dependent variables are entered additively, and their marginal effects are explicitly estimated. Their results support the hypothesis of a lower and a higher threshold with diminishing marginal returns. Nowak-Lehmann et al. (2014) estimate a smooth transition model using the dynamic feasible generalised least squares approach. In a smooth transition model, coefficients are a continuous function of another variable, allowing for heterogeneity in the coefficients across countries and time. They use institutional and macroeconomic variables to capture this heterogeneity.

To deal with heterogeneity, we chose to apply the recent developments in the policy impact evaluation literature to our research question. There has been a recent flourishing literature on average treatment effects estimation when the treatment is staggered and the treatment effects are heterogeneous (Goodman-Bacon, 2021; de Chaisemartin and D'Haultfoeuille, 2020; Sun and Abraham, 2021; Callaway et al., 2021). More specifically, we propose a DiD setup using Callaway et al. (2021)'s estimators (Section 4.3). This estimation technique avoids the bias of standard panel models and addresses heterogeneity regarding the time of treatment and the length of exposure to treatment. To our knowledge, only Djoundourian et al. (2022) have used a DiD setting to estimate aid impact on GHG emissions. They, however, focus on adaptation aid and use a standard two-way fixed effects (TWFE) estimator, which is biased when treatment effects are heterogeneous (Goodman-Bacon, 2021).

3.2.2 Endogeneity

The foreign aid literature has promptly theorised that the aid-growth relationship could be simultaneous. Foreign aid allocation could be higher for countries with higher needs, i.e. lower economic performance, or, on the contrary, it could target successful recipient countries. Regarding climate transfers, they could either prioritise countries with higher mitigation needs, thus higher GHG emissions, or countries who made greater mitigation efforts as a reward. Donor countries might also want to benefit from the lower marginal cost of mitigation in countries with large emissions. This way, they could advertise better results from their climate aid

policy at a lower cost. Not only does this implies a potentially reverse causation, but the sign of this effect is unknown. The second difficulty the empirical researcher faces is, therefore, determining the direction of causality between aid allocation and the outcome of interest.

To correctly estimate the causal effect of aid on the outcome of interest, the literature has used different instrumentation strategies. Among these, [Hansen and Tarp \(2001\)](#)'s instruments have been widely used. They include lagged and transformation of aid variables, interactions of aid variables with policy variables, and transformation of policy, GDP or population variables. They also use lagged imports of arms as a proxy of strategic motives for aid allocation, i.e. motives unrelated to the economic situation of the recipient country as their outcome of interest is growth. [Rajan and Subramanian \(2008\)](#)'s instrument is a predicted aid/ratio generated from a regression at the donor-recipient level. They predict non-economically motivated aid based on bilateral determinants such as past colonial relations and relative population size. [d'Aiglepierre and Wagner \(2013\)](#) studying the link between aid for education and both school enrolment and gender equality also use bilateral variables to construct their instruments. They compute weighted sums of aid for primary education with cultural proximity variables (distance, common border, common religion and common language) as weights. [Wagner \(2014\)](#) includes a similar instrumentation strategy in their generalised additive partial linear model.

The validity of the exclusion restriction of instruments used in the early aid effectiveness literature has been disputed. [Rajan and Subramanian \(2008\)](#) and [Deaton \(2010\)](#) argue that lagged policy variables, and all the more lagged aid, cannot be considered exogenous. For instance, the use of a policy as a control variable and its lagged value as an instrument implies contemporaneous policies directly affect the outcome, but past policies do not. Considering the long-term effect of most public policies, this assumption is highly doubtful.

Many instrumentation strategies in the aid effectiveness literature involve the use of the Generalised Method of Moments (GMM) ([Rajan and Subramanian, 2008](#); [Dreher et al., 2008](#); [Kretschmer et al., 2013](#); [Hübler and Keller, 2009](#); [Gopalan and Rajan, 2016](#)). System GMM estimations ([Blundell and Bond, 1998](#)) use a system of a level and first-differenced equations. Lagged values of the level endogenous variables are used as instruments of the first-differenced equation, while lagged values of the first-differenced endogenous variables are instruments of the level equation. System GMM estimations of macro-panel data may face issues related to weak instruments and instrument proliferation because instruments increase quadratically with the time dimension. As a solution for the latter issue, [Roodman \(2009\)](#) proposes to limit the lag

depth of the instrument or to collapse the instrument matrix.

Arndt et al. (2009) also argue that the system GMM estimator is only valid if the country fixed effects and omitted variables are orthogonal to the lagged first-differenced instruments, which cannot be tested. It means country-specific characteristics must be orthogonal to past absolute variations in aid. Arndt et al. (2009) propose an extension of the inverse probability weighted squares (IPWLS) estimator to instrumental variables setting. They build a binary assignment-to-treatment variable as the instrument, which they then use as the treatment variable in the propensity score. Their estimator assigns greater weight to countries with the characteristics of large aid recipients that, yet, do not receive large amounts of aid (and vice versa), considering these countries more informative.

To tackle the endogeneity issue, we employ two alternative strategies. We first use an instrumental variable two-stage least squares (IV2SLS) strategy with a shift-share instrument (Bartik, 1991). We describe this strategy and the construction of the shift-share variable in Section 4.2. We investigate the exogeneity of our instrument in Appendix A. Following the literature on aid and GHG emissions, we also estimate a dynamic panel model using the two-step system GMM method as a benchmark (Kretschmer et al., 2013; Bhattacharyya et al., 2016; Kablan and Chouard, 2022; Lim et al., 2015; Lee et al., 2022; Zeng et al., 2022) (see Section 4.2).

3.2.3 Dynamic effects

Another concern for the estimation of aid effects is the dynamic dimension. Aid effects are not only contemporaneous. Aid transfers target complex and long-term processes, whether growth or, in our case, GHG emissions mitigation. Only considering contemporaneous relationships may prevent us from estimating the actual effects of aid. The effects of aid may not only be deferred but also long-lasting. Aid received in the past may have enabled changes that still affect the outcome today. The temporal dimension also involves aid volatility. We may expect different outcomes between recipient countries that have received aid consistently or sporadically. As we discussed in Section 2.3, aid volatility prevents long-term planning, while consistent support allows for more systemic changes.

Clemens et al. (2012) recommend distinguishing between short-impact and long-impact aid, though this categorisation is not possible. For instance, they suggest that budget support and infrastructure investment might produce growth within a few years, and their impact is there-

fore assessable with the right time lag. As [Nowak-Lehmann et al. \(2012\)](#), they use a five-year average. Earlier literature ([Burnside and Dollar, 2000](#); [Collier and Dollar, 2002](#); [Clemens et al., 2004](#)) uses four-year periods in their estimations. [Rajan and Subramanian \(2008\)](#) use long-run averages (1960-2000; 1970-2000; 1980-2000; and 1990-2000), arguing that long-time horizons can better capture spillover effects.

It is, therefore, standard practice to use lags or moving averages when estimating aid impact. Still, the appropriate choice of lags is not clear, and the researcher is often constrained by the time dimension of his data. In our panel model, we use three-year and five-year moving sums of aid, while our DiD analysis uses a seven-year time unit.

3.2.4 Stationarity

Non-stationarity of the aid and outcome variable is yet another issue to consider in aid effect estimation. [Nowak-Lehmann et al. \(2012\)](#) stress that regressions run between stationary and non-stationary variables can result in spurious relationship ([Granger and Newbold, 1974](#)). Non-stationarity also causes the residuals to be auto-correlated, which biases the estimated coefficient variances. Auto-correlation also renders lagged instruments endogenous, which is a particular concern for GMM estimations. First-difference estimators are commonly used to address first-order auto-correlation ([Kretschmer et al., 2013](#); [Bhattacharyya et al., 2016](#); [Hübler and Keller, 2009](#)). We test our dependent (CO2 emissions per GDP) and independent (three-year moving sum of climate transfers per capita) variables for unit roots using the Levin-Lin-Chu and the Harris-Tzavalis tests. The results of our tests allow us to reject the null hypothesis of a unit-root process and support the stationarity property of our variables. The Arellano-Bond test for serial correlation of the error terms is also performed on our system GMM estimations and confirms the absence of auto-correlation.

3.2.5 Data quality

Finally, empirical assessments of aid effectiveness are plagued by low data quality and mis-measurement issues. The definition of foreign aid is not evident, and most papers use the ODA

standard from the OECD-DAC, which does not cover all types of development finance. In this chapter, we use climate ODA, following the aid literature, and international public climate finance, which includes non-concessional transfers using two OECD-DAC databases. We describe these data in Section **4.1**.

Climate transfers have been tracked since the adoption of the Rio Markers in 1998. These markers were created to monitor the mainstreaming of environmental concerns in development assistance, but they only became mandatory for DAC member countries in 2006 (with effect on 2007 flows) (OECD, 2020). Multilateral donors, non-DAC donors, and non-ODA transfers are not subject to this obligation. The voluntary use of the Rio markers is widespread, but we cannot exclude under-reporting of climate finance. It is a particular concern for earlier years. Since the COP15 in 2009 and the 100 USD million commitment, donors have been incentivised to report on their climate finance. Concern and scrutiny have increased in the matter. At COP16 in 2010, the Green Climate Fund (GCF) was established. The GCF is a major multilateral climate fund, with initial mobilisation of 9.3 USD billion in 2014 and 10 USD billion pledges for 2020-2023, which is accountable to the COP. The Standing Committee on Finance (SCF) was also established at COP16, whose objectives include "the measurement, reporting and verification of support provided to developing countries Parties"¹⁴. Annual workshops have also been organised during which developed country parties detail their climate finance strategies. Finally, the UNFCCC has launched a climate finance data portal to track the mobilisation of resources towards developing countries. Several multilateral donors¹⁵, including the Green Climate Fund, DAC member countries and most non-DAC donor countries use the Rio markers methodology from the OECD to identify their climate finance. Multilateral development banks¹⁶ use the climate components methodology (OECD, 2018). The OECD-DAC have been collecting climate components data since 2013, multilateral flows in our database were therefore incomplete before this year.¹⁷ For this reason, and heterogeneity concerns described earlier, we conduct our analysis on multilateral and bilateral transfers separately in Appendix **B**. We argue that climate finance data have become more reliable, but multilateral data are incomplete, and we cannot exclude that earlier bilateral data may suffer from under-reporting.

A second issue relates to the discretion providers have in what they consider climate-related

¹⁴unfccc.int

¹⁵The Adaptation Fund, the Climate Investment Fund, the Global Environmental Facility, the Global Green Growth Institute, the International Fund for Agricultural Development and the Nordic Development Fund

¹⁶The Asian Infrastructure Investment Bank, the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the European Investment Bank, the Inter-American Development Bank, the International Finance Corporation and the World Bank

¹⁷oecd-ilibrary.org

finance. We explore this problem in-depth in Chapter 2, where we show that all donor countries misreport development projects without climate components as being climate-related. We estimate that this over-reporting is severe, with an average of 48.6% of over-reported ODA projects between 2002 and 2018. In Appendix B, we replicate our empirical strategy on climate ODA data from which we have excluded those over-reported projects.

4 Data and empirical strategy

To investigate the effect of climate finance on recipient countries' carbon emissions, we propose three alternative empirical strategies. The first two imply panel models and are described in Subsection 4.2. Our third empirical strategy is a difference-in-differences setup, which we detail in Subsection 4.3. First, we present our data in the following Subsection 4.1.

4.1 Data

GHG. Regarding GHG emissions data, we use the "Our World in Data (OWID) CO2 and Greenhouse Gas Emissions Dataset" (Ritchie et al., 2020) which gathers emissions and energy-related variables from different sources. We focus on CO2 emissions instead of total GHG emissions because of greater data availability for CO2 emissions. The primary source of carbon emissions data in the OWID database is the Global Carbon Project¹⁸. We use CO2 emissions per GDP (excluding land use, land-use change, and forestry, expressed in kg per dollar of GDP) to reflect developing countries' dual objective to achieve sustainable growth. It also allows us to set aside the scale effect of climate transfers and focus on the composition and technique effects (see Subsection 2.1). In our additional specifications, we use CO2 emissions per capita (in tonnes) and energy intensity (primary energy consumption in kWh per dollar of GDP). Primary energy consumption data are also from the OWID database, and GDP data are extracted from the World Bank Open Data catalog (World Bank, 2021a) and corrected for inflation using the 2010 United States (US) Consumer Price Index (CPI). Carbon emissions data are available for 154 out of the 155 recipients of climate transfers. Emissions and energy data are missing for

¹⁸globalcarbonproject.org

Tokelau, which is, therefore, excluded from the analysis.

Climate Finance. We consider two types of climate transfers: climate ODA (climate aid) and total public climate finance.

Climate aid data are from the OECD-DAC Creditor Reporting System Rio Markers database (OECD, 2022b). OECD-DAC member countries report their foreign aid at the project level through the Creditor Reporting System (CRS). For each development project they are reporting, they indicate if it targets mitigation and adaptation objectives using the Rio Markers Methodology. Note that these projects can also participate in other environmental or development objectives. You can refer to Neumann Noel and Bayramoglu (2022) and the second chapter of this dissertation for more information on the CRS and the Rio Marker Methodology and detailed descriptive statistics on climate aid allocation. The OECD CRS database also gathers development projects funded by multilateral institutions. We consider projects that target principally or significantly mitigation and adaptation objectives and are funded by donor countries and multilateral organisations. Mitigation aid represents the larger share of climate ODA. However, adaptation projects are only reported as such in the OECD CRS since 2010 (Neumann Noel and Bayramoglu, 2022) while data for mitigation aid are available from 1998. Furthermore, the use of the Rio Markers has been made mandatory for bilateral donors in 2006 only, with application on 2007 flows. Reporting of mitigation objectives of bilateral ODA flows before 2007 was only voluntary. The use of the Rio Markers by multilateral organisations is also voluntary. Because of these limitations, we might not be able to track all climate-related ODA, especially in earlier periods. Our climate ODA flows correspond to ODA grants and ODA loans. ODA flows have to be concessional and provided by official agencies (OECD, 2021). Equity investments, export credits, and private grants are therefore not included in these variables. We favour using aid disbursements instead of aid commitments as the latter does not translate into immediate transfers and implies further delay before their impact can be measured. Our climate ODA data range from 1998 to 2020 and covers 155 recipient countries, 34 donor countries, 12 multilateral organisations, and the EU Institutions, which we include in multilateral providers. In our specifications, we use alternatively total, bilateral, and multilateral climate ODA. We also differentiate between mitigation ODA and adaptation ODA.

Total international public climate finance data are from the OECD Climate-related development finance database (OECD, 2022c) that tracks concessional and non-concessional public climate finance from 2000 to 2021 to 155 recipient countries from 36 donor countries and 22 multilateral institutions (we define EU institutions as multilateral providers). This database also

covers climate-related ODA flows. However, only commitments are available, and data from 1998 to 1999 are not included. We, therefore, prefer using climate-related ODA disbursements from the OECD CRS database when specifically analysing the impact of climate aid, in accordance with the first and second chapters of this dissertation on the trade determinants and the reporting of climate aid. Climate finance flows in this database are reported using the Rio Markers methodology on a voluntary basis, except for bilateral ODA flows from 2007, as previously explained. Multilateral development banks use the climate components methodology to report climate finance flows. According to the OECD (OECD, 2023), the two methodologies have closely related definitions of climate change mitigation and adaptation. From the OECD climate-related development finance database, we build several total public climate finance variables, distinguishing between mitigation and adaptation flows and between bilateral and multilateral providers.

Climate transfers are aggregated at the recipient-year level and computed per capita. They are corrected for inflation using the 2010 US CPI. Table 3.1 presents descriptive statistics for our carbon emissions and climate transfers variables from 2000 to 2020.

Controls. Control variables include the main determinants of GHG emissions as defined by the literature (see the previously presented literature on the environmental impact of aid as well as Le Quéré et al. (2019)): GDP per capita, demographic growth, share of urban population, the openness of the economy (export and imports in percent of GDP), energy use per capita (in kWh), industry value-added (in percent of GDP), renewable energy consumption (in percent of total energy consumption). We also include Foreign Direct Investment (FDI) (net inflows, in percent of GDP). According to Hübler and Keller (2009), foreign investments could have a higher impact on the energy intensity of a developing country than domestic investments, as they could include more energy-saving technology transfers. Data for these variables are extracted from the World Bank Open Data Catalog (World Bank, 2021a). We prefer the share of renewable energy over that of fossil fuel because the latter contains too many missing observations. Following the literature on the effectiveness of foreign aid (see Subsection 3.1), we include institutional quality variables from the World Governance Indicators (WGI) (World Bank, 2021b). We use the Governance Effectiveness index and the Corruption Control index. The WGI indexes score between -2.5 and 2.5, with the lower values corresponding to countries with the lowest outcomes. Table 3.2 presents descriptive statistics of our control variables. Several countries are missing important control data, especially for the early years.¹⁹

¹⁹GDP data are missing for Anguilla, the Cook Islands, Montserrat, Niu, the Democratic People's Republic

Table 3.1: Descriptive statistics: main variables

	Sum	Mean	SD	Min	Max	N
Outcome						
CO2	345,558.1	107.9	681.2	0.0	10,667.9	3,202
CO2 per GDP	2,282.7	0.8	1.1	0.0	16.3	2,999
CO2 per capita	8,676.6	2.7	3.9	0.0	35.4	3,202
Energy per GDP	11046.8	3.9	6.1	0.1	86.5	2,816
Mitigation ODA						
Bilateral	43,375.1	13.5	93.4	0.0	2,170.3	3,213
Multilateral	914.0	0.3	4.5	0.0	170.6	3,213
Total	44,289.1	13.8	93.7	0.0	2,170.3	3,213
Adaptation ODA						
Bilateral	54,680.2	17.0	192.0	0.0	6,362.8	3,213
Multilateral	3,182.9	1.0	15.4	0.0	668.9	3,213
Total	57,863.1	18.0	193.2	0.0	6,362.8	3,213
Climate ODA						
Bilateral	84,163.1	26.2	215.2	0.0	6,367.2	3,213
Multilateral	3,792.3	1.2	16.1	0.0	668.9	3,213
Total	87,955.4	27.4	216.7	0.0	6,367.2	3,213
Mitigation finance						
Bilateral	5.2e+07	16,077.7	134,339.0	0.0	5095638.0	3,213
Multilateral	1.8e+07	5,596.6	52,736.3	0.0	2396295.2	3,213
Total	8.5e+07	26,365.3	191,353.9	0.0	5202584.5	3,213
Adaptation finance						
Bilateral	5.8e+07	17,915.4	182,868.4	0.0	5879714.5	3,213
Multilateral	2.1e+07	6,499.7	61,396.7	0.0	2022298.1	3,213
Total	9.8e+07	30,530.3	226,897.7	0.0	5879714.5	3,213
Climate finance						
Bilateral	9.6e+07	29,942.2	232,152.6	0.0	6163937.5	3,213
Multilateral	3.8e+07	11,823.2	88,820.6	0.0	2396295.2	3,213
Total	1.6e+08	50,987.6	309,690.5	0.0	6163937.5	3,213

Total CO2 emissions in million tons, CO2 per GDP in kg per unit of GDP. CO2 per capita in tonnes. Aid per capita in USD corrected for inflation (US CPI 2010)

4.2 Empirical strategy: panel models

To estimate the impact of climate transfers on the recipient countries' carbon emissions, we first use two alternative panel models: a simple panel model (equation 3.1) and a dynamic panel

of Korea, Saint Helena and Wallis and Futuna. Few GDP data are available for South Sudan, Somalia, Nauru and Eritrea. No energy-related data are available for Tuvalu, Wallis and Futuna, Palau, the Marshall Islands and Anguilla.

Table 3.2: Descriptive statistics: control variables

Variable	Mean	SD	Min	Max	N
GDP per capita	4,261.6	4,822.5	91.1	30,502.3	3,001
Industry (% V.A.)	26.5	12.7	3.2	86.7	2,905
Trade (% GDP)	78.7	37.2	0.8	348.0	2,634
FDI (% GDP)	4.4	6.3	-37.2	103.3	2,920
Energy per cap.	12,673.2	17,699.7	103.1	176,087.5	2,950
Renewable energy (%)	38.0	30.9	0.0	98.3	2,923
Urban population (%)	48.9	20.7	8.2	100.0	3,066
Population growth	1.6	1.4	-6.9	11.8	3,087
Governance	-0.5	0.7	-2.5	1.6	2,941
Corruption	-0.4	0.7	-1.9	1.7	2,951

Energy per capita and energy per GDP in kWh.

model (equation 3.2). Our simple panel model is estimated using an instrumental variable two-stage least squares (IV2SLS) approach to account for the potential endogeneity issue of climate transfers. The dynamic panel model is estimated with the two-step system general method of moments (GMM). GMM estimations of dynamic panel models are widely used in the aid effectiveness literature and have been used in most papers on the effect of aid on GHG emissions (Kretschmer et al., 2013; Bhattacharyya et al., 2016; Kablan and Chouard, 2022; Zeng et al., 2022; Lee et al., 2022). We, therefore, include them in our analysis as reference estimations.

$$E_{jt} = \alpha \sum_t^{t-3} Aid_{jt} + \beta Z_{jt} + \gamma_j + \delta_t + \epsilon_{jt} \quad (3.1)$$

$$E_{jt} = \zeta E_{jt-1} + \alpha \sum_t^{t-3} Aid_{jt} + \beta Z_{jt} + \gamma_j + \delta_t + \epsilon_{jt} \quad (3.2)$$

Where j and t represent respectively the recipient country and year, E are carbon emissions per GDP, Aid is climate transfers per capita, Z are control variables and γ_j and δ_t are country and year fixed effects.

Model 3.1 and model 3.2 explain carbon emissions per GDP by climate transfers per capita, the previously described time-variant control variables (Subsection 4.1) and country and year time-invariant unobserved effects. The dynamic panel model (equation 3.2) includes lagged carbon emissions per GDP as an independent variable to control for path dependency.

As climate projects and policies cannot have an immediate effect and projects are often carried out over several years, we use in both models a three-year moving sum of climate transfers to better capture their potential effect on carbon emissions. We use a five-year moving sum in supplementary analyses (see Appendix C). Our baseline estimations in Section 5.1 use total climate ODA per capita and total climate finance per capita. In Appendix B, we investigate the effect of disaggregated climate finance (mitigation and adaptation objectives, multilateral and bilateral providers). In Appendix B, we also compare the effect of climate ODA to total ODA (i.e. all foreign aid) and to *clean* climate ODA data from Chapter 2. This last variable corresponds to climate ODA data from which we have excluded over-reported projects, i.e. climate-reported projects that are not actually climate-related as per our evaluation (Chapter 2).

Both models account for country and year time-invariant unobserved effects. We believe that specific time-invariant countries' characteristics may affect countries' mitigation efforts decisions or capacity. For instance, geographical location partly determines a country's environmental vulnerability and so its incentive to mitigate climate change. The potential of access to renewable energy solutions such as hydroelectric power is also dependent on geographical factors. We, therefore, include country fixed effects in our IV2SLS estimations, and country-specific effects are accounted for by the first-difference transformation of the system GMM estimation process. We also control for year unobserved effects, which could affect recipient countries' carbon emissions. For instance, global or regional events such as international climate negotiations or climate and economic shocks might constrain or incentivise mitigation efforts. We, therefore, include year fixed effects²⁰ in our IVSLS estimations and a year dummy in our GMM estimations.

Endogeneity. Standard ordinary least squares (OLS) estimations might be biased due to endogeneity issues. Indeed, we believe climate finance might be allocated in priority to countries that made higher mitigation efforts as a reward or, on the contrary, to countries with larger emissions to benefit from a lower marginal cost of mitigation. This implies a simultaneous relation between climate transfers and emissions. To estimate the causal impact of climate transfers on

²⁰We choose fixed effects because we expect these country-specific characteristics and annual shocks to be correlated with our independent variables. We use the Stata command `xtoverid` to compute a test of overidentifying restrictions without homoscedasticity assumption, which confirms our choice of fixed effects over random effects.

carbon emissions, we then need to correct for this potential simultaneity.

We do so in our first model by using the instrumental variable approach in a two-stage least squares (IV2SLS) estimation with a shift-share instrument based on the work of [Bartik \(1991\)](#). This method has been widely used, mainly in the trade literature ([Autor et al., 2013](#); [Mayer et al., 2014](#); [Aghion et al., 2018](#); [Bombardini and Li, 2020](#); [Bayramoglu et al., 2023](#)). It allows us to compute exogenous *expected* allocation of climate funding by excluding sources of variation in climate funding related to the recipients' carbon emissions. In the first stage of the estimation, we instrument the levels of our climate transfer variables using their expected level, i.e. the shift-share instrument. We then use the predictions as the regressors in the second stage of the estimation. To construct our shift-share instrument, we use the project-level climate finance and climate ODA databases described in Subsection [4.1](#) and aggregate transfers at the donor, recipient and year level. We balance our panel database by including null transfers. As a first step, we compute donor i quasi total annual climate transfers by aggregating all its transfers for the year t excluding the ones to recipient j :

$$DonorTransfer_{ijt} = \sum_{\substack{j' \\ j' \neq j}} Transfer_{ij't} \quad (3.3)$$

We then compute the share of climate finance from donor i to recipient j over the three previous years:

$$S_{ijt}^{Transfer} = \frac{\sum_{t'=t-1}^{t-3} Transfer_{ij't'}}{\sum_{t'=t-1}^{t-3} Transfer_{it'}} \quad (3.4)$$

Finally, we build expected climate transfers by allocating the donor i quasi-total climate transfer to the recipient j depending on its relative importance in the total donor climate finance flows over the three past years:

$$PredictedTransfer_{jt} = \sum_i S_{ijt}^{Transfer} \times DonorTransfer_{ijt} \quad (3.5)$$

We obtain a shift-share variable where shifts in donor climate transfers are allocated to recipient countries depending on their past relative importance in the donor climate transfers. For instance, if donor i chooses to increase its total climate finance allocation, not based on a variation in country j emissions since we excluded it in the first step, the expected climate transfer

received by country j will increase proportionally to its initial share in the donor i climate finance allocation. This method allows us to identify variations in climate transfers that are not due to variations in recipient j carbon emissions. Indeed, policy choices and economic conditions that determine donor i total allocation are unlikely to be directly correlated to a specific recipient country's carbon emissions, ensuring the exogeneity of our instrument. Since we use a three-year moving sum of climate transfers in our specifications, we compute our instrument as a three-year moving sum of the predicted climate transfers.

Our second model is estimated using the two-step system generalised method of moments (GMM) (Blundell and Bond, 1998). In this model, the lagged dependent variable creates a second endogeneity issue. The system GMM approach allows us to correct for the endogeneity of both climate transfers and the lagged dependent variable. GMM identification relies on first-differencing the data and using the lagged endogenous variables as instruments. The system GMM estimates a system of two equations, a level equation and a difference equation. Lagged levels are used as instruments for the first-differenced equation, while lagged first-differences instrument the level equation. To avoid instrument proliferation due to our relatively large time-dimension (Roodman, 2009), we limit the lag depth to $t - 3$.

In Subsection 3.2.1, we discussed the potential heterogeneous effect of climate funding, meaning that the α coefficient in equations 3.1 and 3.2 could differ among groups of countries or allocation time. We, therefore, first include a standard interaction variable between climate transfers and the governance effectiveness index to account for a potential conditional effect of funding on the recipient's institutional quality.²¹ We then replicate our IV2SLS estimation on different subsamples of recipient countries in Subsection 5.2, distinguishing recipient countries by income, carbon emissions and climate funding allocation. Allocation time heterogeneity is discussed in our third empirical strategy in the following Subsection 4.3.

Carbon emissions variables and control variables defined in \mathbb{R}_+^* are log-transformed.²² Climate transfer variables and control variables defined in \mathbb{R} are transformed using the *asinh*

²¹We have replicated this estimation with other interaction variables, including corruption control index, GDP per capita and income group dummy, with similar results.

²²GDP per capita, industry value-added (in percent of GDP), energy per capita, urban population (in percent of the total population) and trade (in percent of GDP).

function.²³²⁴ Standard errors are clustered at the recipient country level to account for heteroscedasticity and correlation of the residuals.

4.3 Empirical strategy: difference-in-differences

Recent literature has highlighted the bias in the two-way fixed effects (TWFE) estimators when the effects of the explanatory variable (hereafter, treatment effects) are heterogeneous over time (Gibbons et al., 2018; de Chaisemartin and D’Haultfoeuille, 2020; Goodman-Bacon, 2021). We discuss the potentially heterogeneous effect of climate finance over time in Section 3.2.1. This bias implies that TWFE estimates of coefficient α from equations 3.1 and 3.2 would not be the average effect of climate finance but a weighted sum of treatment effects across groups. The researcher cannot purposefully control these weights, which are not necessarily the most economically relevant and, more puzzling, can be negative. We, therefore, propose an alternative strategy to estimate the impact of climate finance on recipient countries’ carbon emissions using these recent developments in the policy evaluation literature. Specifically, a very prolific literature on difference-in-differences (DiD) estimation in the case of staggered treatment adoption design and heterogeneous treatment effect has emerged (de Chaisemartin and D’Haultfoeuille, 2020; Goodman-Bacon, 2021; Callaway and Sant’Anna, 2021; Sun and Abraham, 2021; Borusyak and Spiess, 2021; Callaway et al., 2021; de Chaisemartin and D’Haultfoeuille, 2022). You can refer to Roth and Poe (2022) for an extensive literature review of these estimators. DiD setups estimate the effect of a treatment by comparing a treated group and a non-treated group (control group) using the before-and-after treatment dimension. To assess the average effect of the treatment on the treated (ATT), we need to know what the outcome of interest would be, had the treated group not received the treatment (counterfactual). We, however, cannot observe this outcome. What we can observe is the outcome without treatment of the non-treated group. Assuming both groups’ outcomes would have evolved similarly in the absence of treatment allows us to estimate the effect of the treatment on the treated group.

When applying this counterfactual framework to our research question, the outcome is carbon emissions per GDP, and treatment is climate finance allocation. However, we do not have

²³Total population growth, renewable energy consumption (in percent of total energy consumption) governance effectiveness and corruption control indexes.

²⁴ $\forall x \in \mathbb{R}, \operatorname{asinh}(x) = \ln(x + \sqrt{x^2 + 1}) = \operatorname{sinh}^{-1}(x)$

a self-evident control group, as the vast majority of developing countries has received, at least at some point, climate finance. Our databases include 154 recipients, and the International Monetary Fund currently classifies 156 countries and territories as emerging or developing economies (IMF, 2022). Hence, our solution is to compare high and low climate finance recipients. We propose a DiD design where we estimate the effect on carbon emissions of having received a relatively large amount of climate finance per capita compared to other recipients by binarizing our climate finance variable. Furthermore, to account for the long-term effect of climate funding, we redefine our time unit as 7-year periods. This time aggregation also enables us to observe enough countries starting treatment at each period. Too-small treated groups would render the DiD analysis unreliable. We observe carbon emissions over three treatment periods, i.e. 2000-2006, 2007-2013 and 2014-2020, and over three pre-treatment periods, i.e. 1979-1985, 1986-1992 and 1993-1999. We compute the sum of climate transfers per capita over each treatment period and define treatment as having received strictly more than the 70th percentile over the period. We define a relative threshold because climate finance has vastly increased for all recipient countries between 2000 and 2020. The 70th percentile was chosen based on climate finance distribution, which is mostly concentrated on small amounts (see Figure J.4 in the appendix). The 70th percentile allows us to avoid the issue of having treated and untreated countries with very close climate finance allocation. We explore alternative thresholds for treatment definition in Appendix G. We define outcome as the relative variation in CO2 emissions per GDP between the first and last year of the 7-year period. We, therefore, have a multi-period staggered DiD setup as treated countries do not all enter treatment during the first period.

We use Callaway and Sant’Anna (2021)’s doubly-robust estimator as it allows us to estimate average treatment effects at different levels. Callaway and Sant’Anna (2021) approach first estimates average treatment effect at the group-time level (equation 3.6), the group being defined by the period units first enter the treatment. It then allows to compute different aggregate of this group-time ATT, most notably a group-average ATT, a time-average ATT and an overall ATT. However, Callaway and Sant’Anna (2021)’s estimator does not account for individuals exiting the treatment. Once an individual (here, a recipient country) enters treatment, it stays in the treated group for the following periods. This means our treatment can be defined as having received strictly more than the 70th percentile *at least once*. The control group comprises countries that never cross the 70th percentile threshold (never treated).

$$ATT(g, t) = \mathbb{E}[E_t(g) - E_t(0)|G_g = 1] \quad (3.6)$$

With $ATT(g, t)$ the average treatment effect at time t on group g , group g being composed of all countries that first received treatment at time g . G_g is a binary variable that takes value 1 if the country is first treated in period g . $E_t(g)$ is the relative variation in carbon emissions per GDP of group g at time t and $E_t(0)$ the potential outcome without treatment at time t , i.e the relative variation in carbon emissions per GDP had the group g not received climate finance.

The identification of a causal effect in a DiD setup relies on the parallel trends (PT) assumption, that is, the parallel evolution of the outcome variable between the treated and control groups in the absence of treatment. The parallel trends assumption can also be conditional on covariates (conditional parallel trend (CPT)). This assumption cannot be verified since the treated group's outcome in the absence of treatment cannot be observed. Its credibility is usually assessed based on pre-treatment periods. In our case, our empirical strategy is based on the assumption of a parallel evolution of CO2 emissions per GDP between the treated and non-treated countries, conditional on the pre-treatment values of the GDP per capita and energy use per capita. The validity of this assumption is investigated in Appendix A.2.

The second assumption on which relies a DiD estimation is the absence of anticipation effects, meaning individuals' outcomes before treatment are not affected by their anticipation of the treatment. We discussed a potential endogeneity issue of climate finance allocation in the case of our panel models. DiD estimations do not directly allow for endogeneity correction, but by binarizing our treatment and regrouping our analysis on longer periods, we mitigate potential anticipation effects. Indeed, it seems unlikely that seven years before the first climate finance allocation, recipient countries had anticipated the possibility of receiving relatively more funds than other countries by increasing their mitigation effort or had lowered their mitigation effort knowing external funding would come.

Finally, data quality may constitute a potential limitation to our analysis. DiD estimation uses the before-and-after treatment dimension, but, in our case, the start of the treatment may not be as straightforward. Climate finance data are donor-reported data starting in 2000, but there might have been non-reported transfers before. However, as climate concerns in international transfers were still scarce, we believe potential climate funding before 2000 was not significant. Early transfer data also suffer from under-reporting issues since the reporting of climate objectives became mandatory for DAC countries in 2006, and the public tracking of climate finance flows gained importance with the USD 100 billion commitment. If this under-

reporting does not correspond to any strategic motivations, it should be randomly distributed across recipient countries and binarizing our treatment with a relative threshold should mitigate this issue.

5 Results

In Subsection **5.1**, we present the main results of our IV2SLS and GMM estimations. In Subsection **5.2**, we replicate our panel analyses on different subsamples to assess potential sources of heterogeneity in climate finance’s impacts. In Subsection **5.3**, we detail the results of our DiD analysis considering group and time heterogeneity. Finally, in Section **5.4**, we investigate alternative outcomes.

5.1 Panel models: baseline results

Table **3.3** presents the main results of our panel analyses. Estimations are carried over the 2000-2020 period to match the scope of our climate finance database. The dependent variable is CO2 emissions per GDP. Columns (1) and (4) correspond respectively to our IV2SLS and GMM estimations for total climate ODA per capita, while columns (2) and (5) present IVSLS and GMM results for total climate finance per capita. Column (3) includes an interaction variable between climate finance per capita and the governance effectiveness index. Neither climate ODA nor climate finance has a significant effect on CO2 emissions per GDP in any specifications. Point estimates are also very close to 0. Regarding our control variables, we find a consistent negative correlation between CO2 emissions intensity and renewable energy use (in percent of total energy use) and a positive correlation with total energy use per capita. In our GMM estimations, we find, as expected, a positive correlation with lagged emissions intensity. The estimate for the governance effectiveness index is positive and significant in our GMM estimations only.

We replicate column (2) specification decomposing climate finance in its adaptation and mitigation components and considering multilateral and bilateral providers separately and present the results in Figure **B.2** in the appendix. Total climate finance, whether bilateral or multilateral, does not impact CO2 emissions per GDP. We do not find any effect of mitigation finance either. However, we do find a significant and positive effect of total and bilateral adaptation

finance. Adaptation finance, therefore, increases the recipients' CO₂ emissions intensity. Note that adaptation estimations are carried over the period 2010-2020 as the tracking of adaptation finance only started in 2010. This type of funding does not explicitly aim to reduce the recipient country's emissions, so an absence of effect is expected, but this positive impact is more puzzling. Indeed, as the definition of our dependent variable already controls for the scale effect, this result means adaptation finance increases the carbon intensity of the recipient country's economic activities or increases its share of carbon-intensive activities. We also replicate column (2) specification with different aid variables in Figure B.3 in the appendix. We alternatively investigate the effect of total ODA and *clean* climate ODA from Chapter 2. Clean climate ODA should identify climate ODA that truly targets climate objectives. Nevertheless, we do not find any significant impact of either variables.

In all our IV2SLS estimations, the Cragg-Donald Wald F-Stat and the Kleibergen-Paap Wald rk F-stat (which does not assume i.i.d errors) are well above the Stock and Yogo critical values, indicating we do not have weak instrument issue. The Kleibergen-Paap rk LM statistics, which tests for under-identification issues, is significant at the 1% level, further indicating that our instruments perform correctly.

Regarding our GMM estimations, the Sargan-Hansen J test of overidentifying restrictions posits the null hypothesis that the instruments are uncorrelated with the error term. As our test statistic is never significant, we cannot reject the null hypothesis of valid instruments. We investigate the exogeneity of our instrument in Appendix A.1. The Arellano-Bond test for serial correlation of the error term is performed on the first-differenced errors. The negative 1st order correlation and the absence of 2nd order correlation of the first-differenced errors indicate the error terms in level are serially uncorrelated. We can therefore exclude serial correlation bias.

These test results support the validity of our specifications and, thus, the credibility of our estimates.

Robustness. Table C.4 in the appendix replicates our panel models specifications from Table 3.3 using a five-year moving sum instead of a three-year moving sum for the definition of climate transfer variables (and the corresponding instruments) with similar results.

Instrumentation strategies might add some noise to the estimations. We therefore present Ordinary Least Square (OLS) estimations results in Table D.5 in the appendix. OLS results are similar to the IV results: neither climate ODA nor climate finance has an effect on the recipient countries' carbon emissions.

We replicate our IV2SLS estimations with alternative clustering levels of standard errors and present the results in Tables E.6 and E.7 in the appendix. Alternative clusterings of standard errors do not affect our estimation results.

Finally, we explore potential non-linear effects of climate transfers by adding squared terms for climate finance and climate ODA in specifications 1, 2, 4 and 5 from Table 3.3. We present the results in Table F in the appendix. We do not find any significant effect of climate ODA, but we find a positive decreasing effect of climate finance in the GMM estimation. Though this effect is not confirmed by the IV2SLS estimation results, it implies that climate finance could actually increase carbon emissions per GDP in the recipient country, with a decreasing marginal effect.

5.2 Panel models: subsample analyses

In the present subsection, we replicate the specification in column (2) from Table 3.3 on different subsamples from 2000 to 2020. The dependent variable is still CO2 emissions per GDP. Variables are transformed and corrected for inflation as described in Section 4.1, and we use the control variables, the same fixed effects (recipient and year) and clustering level (recipient) as in our main IV2SLS analyses.

Figure 3.1 assesses the impact of total climate finance, mitigation finance and adaptation finance on recipient countries by income group. There is a high heterogeneity among recipient countries regarding their economic development, which can affect the type of climate projects carried out, and the efficiency with which the funding is used. We can, for example, expect very different needs and different implementation capacities between China, a fast-growing industrialised economy, and Burkina Faso, which the OECD defines as one of the countries most in need (Least Developed Country (LDC) and landlocked country with fragile context).²⁵

The income group variable in the OECD-DAC CRS database (OECD, 2022b) and the OECD climate-related development finance database (OECD, 2022c) establishes the following classification: Least Developed Countries (LDCs, 47 countries in the database), other Low-Income Countries (LICs, 2 countries), Lower-Middle Income Countries (LMICs, 36 countries), More Advanced Developing Countries and Territories (MADCTs, 12 countries) and Upper-Middle

²⁵oecd.org

Table 3.3: Panel models

	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IVSLS	IV2SLS	GMM	GMM
Climate ODA	0.01 (0.01)			0.00 (0.01)	
Climate finance		0.00 (0.01)	0.00 (0.01)		0.01 (0.00)
Climate finance x Governance			0.00 (0.01)		
CO ₂ _{t-1}				0.78*** (0.05)	0.73*** (0.06)
GDP	-0.85*** (0.07)	-0.85*** (0.07)	-0.85*** (0.07)	-0.23*** (0.05)	-0.27*** (0.06)
Industry	0.04 (0.05)	0.04 (0.05)	0.04 (0.05)	0.01 (0.02)	0.02 (0.02)
Trade	0.01 (0.06)	0.01 (0.06)	0.01 (0.06)	-0.01 (0.01)	-0.01 (0.02)
FDI	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.00)	-0.01 (0.01)
Energy	0.56*** (0.12)	0.56*** (0.12)	0.56*** (0.12)	0.19*** (0.04)	0.22*** (0.06)
Renewable	-0.19*** (0.05)	-0.19*** (0.05)	-0.19*** (0.05)	-0.04** (0.01)	-0.04*** (0.01)
Pop. growth	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)	0.00 (0.01)	-0.00 (0.01)
Urban pop.	0.51* (0.27)	0.52* (0.27)	0.53* (0.28)	0.03 (0.02)	0.03 (0.02)
Governance	-0.04 (0.05)	-0.04 (0.05)	-0.06 (0.08)	0.05** (0.02)	0.05** (0.02)
Corruption	0.04 (0.05)	0.04 (0.05)	0.03 (0.05)	-0.03 (0.02)	-0.03 (0.03)
N	2026	2026	2026	2137	2137
R-sq	0.62	0.62	0.62		
K.P. LM stat	39.51***	20.48***	12.05***		
K.P. F stat	153.40	220.32	67.14		
C.D. Wald F-stat	1561.08	1633.73	663.98		
(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))					
AR(1) z-score				-6.14***	-5.84***
AR(2) z-score				-1.60	-1.47
Hansen J stat				109.41	101.77

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Income Countries (UMICs, 56 countries). We follow this classification but aggregate LDCs and other LICs in the lower-income group to have a subsample large enough for this analysis. Table H.11 in the appendix details the composition of our income groups. *Lower income*

corresponds to LDCs and other LICs, *middle income* corresponds to LMICS, *upper-middle income* corresponds to UMICs and *upper income* corresponds to MADCTs. As for the whole sample, climate and mitigation finance do not affect the recipient country’s carbon emissions per GDP, regardless of income level. As described in the previous section, adaptation finance has a significant positive effect on the whole sample, but this effect is no longer significant when considering subsamples of countries based on income level. Estimation results regarding the upper-income group must be interpreted cautiously as the sample contains few observations.

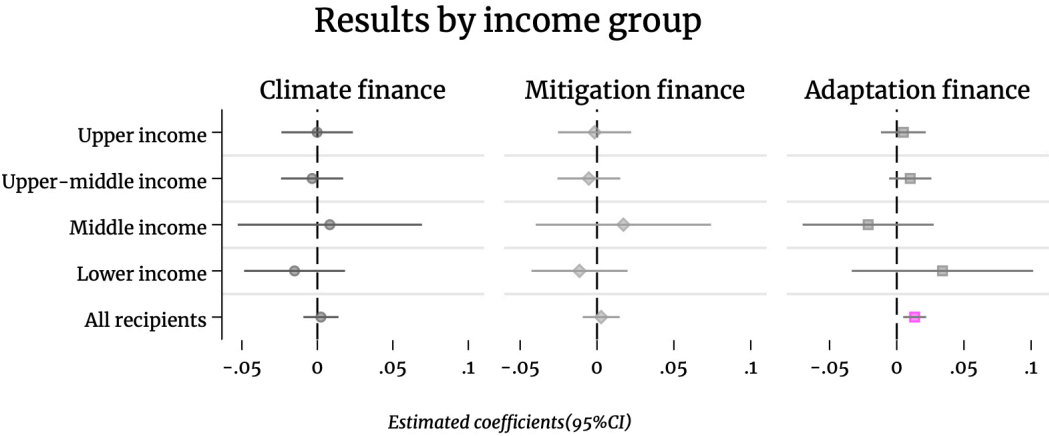


Figure 3.1: IV2SLS: results by income group

Figure 3.2 presents our IV2SLS results when considering the 20 recipient countries with alternatively the highest CO2 emissions per GDP, the highest CO2 emissions per capita and the highest absolute CO2 emissions. The corresponding countries and emissions variables are detailed in Tables H.12, H.13 and H.14. Those countries are the ones for which the mitigation needs are the most pressing among developing countries. We could therefore expect greater concern for mitigation projects’ implementation and efficiency from both the donor and recipient’s part. However, we yet again do not find any effect of climate finance nor its components on the highest emitters of carbon emissions.

Finally, Figure 3.3 presents the effect of climate, mitigation and adaptation finance when considering only the top 30 recipients of climate finance in absolute value and climate finance per capita.²⁶ Tables H.15 and H.16 summarise the countries in these subsamples and their cli-

²⁶We extend the size of our subsample to 30 countries compared to the carbon emissions subsample analysis

Results by CO2 emissions level

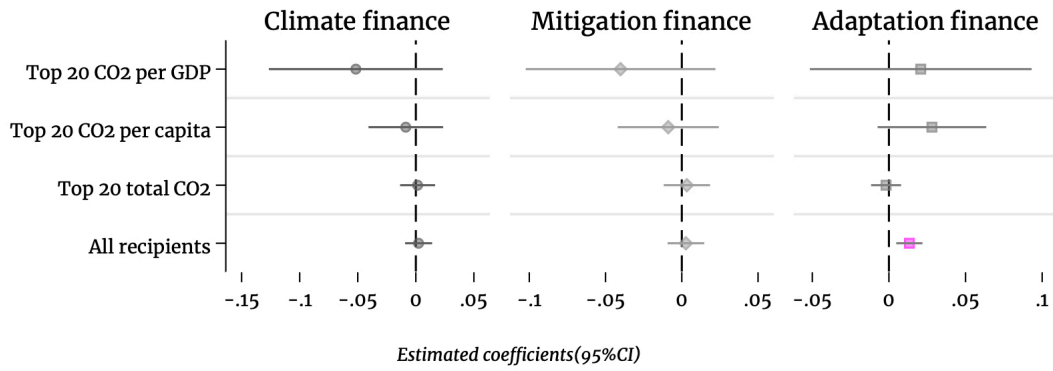


Figure 3.2: IV2SLS: results by emissions level

Results by allocation level

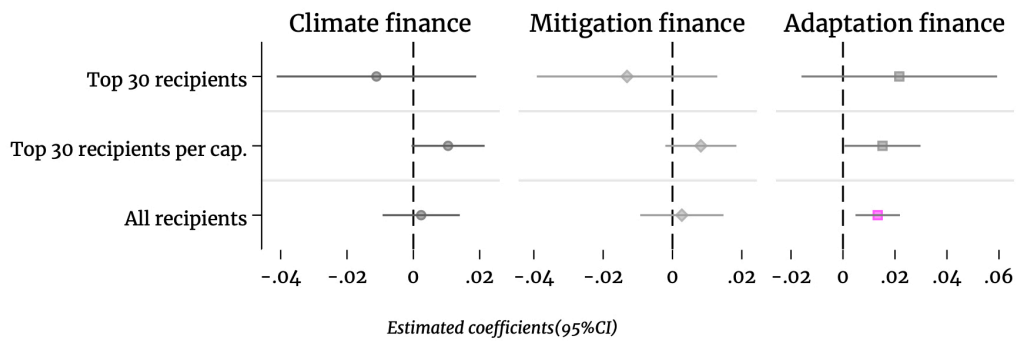


Figure 3.3: IV2SLS: results by allocation level

mate finance allocation. There might be a threshold effect for climate finance to be efficient. Indeed, if climate transfers are not large enough, the funded climate projects are not ambitious enough, and they cannot have an impact on reducing the country's total emissions per GDP. Thus, even if we do not find an effect on the whole sample of recipient countries, we might expect climate finance to be efficient when only considering countries that received large amounts of climate finance. We, nonetheless, find no effect of either total climate finance per capita, mitigation finance per capita or adaptation finance per capita on the top recipient countries' carbon emissions per GDP. There might still exist a threshold for climate finance to be efficient, but it has, then, not yet been reached over the period 2000-2020.

As in our main IV2SLS estimations, the Cragg-Donald Wald F-stat and the Kleibergen-Paap Wald rk F-stat are above Stock and Yogo critical values, and the Kleibergen-Paap rk LM statistics are significant at the 1% level. It indicates that we do not have an under-identification nor a weak identification problem in any of the previous estimations.

5.3 Difference-in-differences analysis

In the present subsection, we detail the results of our DiD analysis, as described in Subsection 4.3. The dependent variable is the relative change in CO2 emissions per GDP, and the treatment is a binary variable indicating that the country has received more climate finance per capita than the 70th percentile. The time unit is a 7-year period.

Table 3.4 presents our different ATT estimates using Callaway and Sant'Anna (2021) estimation method. Callaway and Sant'Anna (2021) propose an $ATT_{g,t}$ estimator (equation 3.6) corresponding to the average treatment effect on the group g at time t . Group g is defined by the period observations enter the treatment. For instance, $g_{2000-2006}$ comprises all countries that first receive more climate finance per capita than the 70th percentile during the first period, i.e. 2000-2006. Similarly, $g_{2007-2013}$ regroups countries that pass this relative threshold during the second period, i.e. 2007-2013. Group ATTs are the average ATTs for each group over the three treatment periods, while time ATTs are the average ATTs for each period over the three groups. The overall ATT is the average ATT over all groups and periods (see Callaway and Sant'Anna

because many large recipients of climate finance have missing observations for important control variables.

(2021) for the weighting functions of the different aggregation schemes).

In our setup, group $g_{2000-2006}$ is composed of 45 countries, group $g_{2007-2013}$ of 13 countries and group $g_{2014-2020}$ of 9 countries. The control group, i.e. countries that never pass the 70th percentile threshold, contains 86 countries. The groups' composition can be found in Table **I.17** in the appendix. Our setup allows us to investigate heterogeneity in treatment effects depending on the time of the treatment and the length of exposure to the treatment. Indeed, the effect of climate finance can differ over time. First, climate transfers in the early 2000s were drastically smaller than in the 2010s. Climate concerns and international pressure have also increased over the period; we could therefore imagine an improvement in the climate projects funded by foreign donors and multilateral agencies. Projects could have become more ambitious, better suited to local contexts and better monitored because of a more result-oriented turn in international aid. This would imply higher time ATTs for the latter periods. Treatment effects can also differ depending on the length of treatment exposure, i.e. for how long countries have received a large amount of climate finance. We can expect that countries that have started to receive larger amounts of climate finance early on will experience a higher effect (larger group ATTS). However, Callaway and Sant'Anna (2021) estimation method does not account for the possibility of exiting and re-entering the treatment. This means our group ATTs do not fully account for the length of treatment exposure, as a few countries were treated during the first period but not the second and third. There may also be another source of group heterogeneity. Specific countries' characteristics may explain that they were prioritised earlier in climate finance allocation, and these country-specific characteristics could result in different treatment effects.

Despite considering time and group heterogeneity, we do not find any effect of international public climate finance on CO₂ emissions per GDP, as none of our ATTs is significant. More specifically, we find that receiving a larger amount of climate finance per capita does not affect the recipient country's relative change in carbon emission intensity. This result, though not reassuring, is coherent with those of our panel analyses. We investigate the credibility of the conditional parallel trend assumption on which our design relies in Appendix **A.2**. We present pre-treatment ATTs (placebo) and the result of a pre-trend test. We also replicate our strategy but defining our treatment with a different threshold (60th and 80th percentiles) and present the results in Appendix **G**.

Table 3.4: DiD setup: 70th percentile threshold

Dep. var:	CO2 per GDP relative change
Overall ATT	-1.25 (8.76)

Group ATT	-2.20 (7.87)
$\xi_{2000-2006}$	1.21 (10.65)
$\xi_{2007-2013}$	-12.87 (15.40)
$\xi_{2014-2020}$	-3.20 (14.35)

Time ATT	-0.88 (7.82)
2000-2006	2.04 (6.59)
2007-2013	-2.00 (8.54)
2014-2020	-2.66 (16.38)
N	662
Control group	Never treated
Clustering	Country
Method	Doubly-robust

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.4 Alternative outcomes

We now investigate the effect of climate finance on alternative outcomes, specifically carbon emissions per capita (Table 3.5) and energy intensity (Table 3.6). We replicate our IV2SLS and GMM strategies from Table 3.3 with the same variable transformation, fixed effects and clustering level over the period 2000-2020.

First, when using carbon emissions per capita as the dependent variable instead of carbon emissions per GDP, we include the effect of climate finance on the scale of the economy. Second, energy intensity represents a potential channel through which climate finance could affect the recipient country's emissions, as the energy sector is the largest source of GHG emissions. The World Resource Institute estimates 76% the share of global emissions due to the energy sector in 2019 (Climate Watch, 2022). Songwe et al. (2022) defend that transformation of the energy systems must be a priority of climate finance. Through technology transfer and composition effects (see Subsection 2.2), climate finance could improve the recipient country's energy efficiency or decrease its share of energy-intensive activities and, by doing so, its GHG emissions. It would be useful to assess the effect of climate finance on fossil fuel use specifically. However, those data contain many missing observations, and a selection bias is very likely to occur as these missing observations are not randomly distributed.

As in our previous analyses, we do not find any effect of climate finance or climate ODA. Most estimates are not significant and close to 0. We do find a small significant (at the 10% level) and positive effect of climate finance on carbon emissions per capita in our GMM estimations with a coefficient of 0.01. A 10% increase in climate transfers per capita would therefore lead to a 0.1% increase in the recipient country's carbon emissions per capita. We must, therefore, conclude that international climate finance does not reduce recipient countries' carbon emissions per capita, nor does it improve their energy intensity. These results are consistent with our main estimations.

Note that our GMM estimations regarding energy intensity might be biased by serial correlation of the errors as the Arellano-Bond test statistic for the second-order correlation is significant.

Table 3.5: Alternative outcome: CO2 per capita

	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IVSLS	IV2SLS	GMM	GMM
Climate ODA p	0.00 (0.01)			0.00 (0.00)	
Climate finance		0.00 (0.01)	0.00 (0.01)		0.01* (0.00)
Climate finance x Governance			0.00 (0.01)		
CO2 _{t-1}				0.90*** (0.05)	0.88*** (0.05)
GDP	0.15** (0.06)	0.15** (0.07)	0.15** (0.07)	-0.00 (0.01)	0.01 (0.02)
Industry	0.04 (0.05)	0.04 (0.05)	0.04 (0.05)	0.02 (0.01)	0.02 (0.01)
Trade	0.04 (0.05)	0.04 (0.05)	0.04 (0.05)	0.00 (0.01)	-0.00 (0.01)
FDI	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.00 (0.00)	-0.00 (0.00)
Energy	0.56*** (0.12)	0.56*** (0.12)	0.56*** (0.12)	0.09** (0.04)	0.10*** (0.04)
Renewable	-0.18*** (0.05)	-0.19*** (0.05)	-0.19*** (0.05)	-0.01 (0.01)	-0.02 (0.01)
Pop. growth	0.03* (0.02)	0.03* (0.02)	0.03* (0.02)	0.00 (0.01)	0.00 (0.01)
Urban pop.	0.53* (0.27)	0.53* (0.27)	0.55* (0.28)	-0.01 (0.01)	-0.01 (0.01)
Governance	-0.03 (0.05)	-0.03 (0.05)	-0.07 (0.08)	0.02 (0.01)	0.03* (0.01)
Corruption	0.03 (0.05)	0.03 (0.05)	0.03 (0.05)	-0.02 (0.01)	-0.02 (0.02)
N	2026	2026	2026	2137	2137
R-sq	0.47	0.47	0.47		
K.P. LM stat	39.51***	20.48***	12.05***		
K.P. F stat	153.40	220.32	67.14		
C.D. Wald F-stat	1561.08	1633.73	663.98		
(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))					
AR(1) z-score				-5.92***	-5.89***
AR(2) z-score				0.45	0.48
Hansen J stat				105.44	107.45

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3.6: Alternative outcome: energy intensity

	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IVSLS	IV2SLS	GMM	GMM
Climate ODA	-0.01 (0.01)			0.00 (0.00)	
Climate finance		0.00 (0.01)	0.00 (0.01)		-0.00 (0.00)
Climate finance x Governance			-0.00 (0.01)		
Energy _{t-1}				0.90*** (0.03)	0.90*** (0.03)
GDP	-0.81*** (0.06)	-0.81*** (0.06)	-0.81*** (0.06)	-0.07*** (0.02)	-0.07*** (0.01)
Industry	0.07 (0.06)	0.06 (0.06)	0.06 (0.06)	0.03* (0.02)	0.03 (0.02)
Trade	0.04 (0.07)	0.04 (0.07)	0.04 (0.07)	0.02 (0.02)	0.02 (0.02)
FDI	0.02*** (0.01)	0.02** (0.01)	0.02*** (0.01)	0.00 (0.01)	0.00 (0.01)
Renewable	-0.22*** (0.05)	-0.22*** (0.05)	-0.22*** (0.05)	-0.03*** (0.01)	-0.03*** (0.01)
Pop. growth	-0.02 (0.02)	-0.02 (0.02)	-0.02 (0.02)	-0.03** (0.01)	-0.03** (0.01)
Urban pop.	0.77*** (0.26)	0.80*** (0.26)	0.78*** (0.26)	0.06*** (0.02)	0.05*** (0.02)
Governance	0.06 (0.05)	0.06 (0.05)	0.10 (0.09)	0.06*** (0.02)	0.05** (0.02)
Corruption	-0.02 (0.05)	-0.02 (0.05)	-0.02 (0.05)	-0.01 (0.02)	-0.01 (0.02)
N	2026	2026	2026	2135	2135
R-sq	0.55	0.55	0.55		
K.P. LM stat	39.55***	20.46***	12.05***		
K.P. F stat	153.20	220.57	67.08		
C.D. Wald F-stat	1559.10	1634.72	664.16		
(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))					
AR(1) z-score				-6.14***	-6.22***
AR(2) z-score				-2.20**	-2.21**
Hansen J stat				107.01	108.05

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

In this chapter, we investigate the effect of international public climate finance on recipient countries' carbon emissions in the context of the USD 100 billion commitment. Following the aid impact literature, we identify the main methodological challenges to estimating this effect and propose three empirical strategies. First, we estimate two panel models using the IV2SLS technique with a shift-share instrument and the two-step system GMM to account for climate finance endogeneity. We then propose a DiD setup using (Callaway and Sant'Anna, 2021)'s estimator and comparing high and low recipients of climate finance. This strategy allows us to explore treatment effects heterogeneity related to the time and length of treatment exposure. Recipient countries and types of finance heterogeneity are also explored through subsample analyses.

All our estimations converge to an absence of effects of international public finance on the recipient countries' carbon emissions. This result holds when considering carbon emissions per GDP or per capita and is consistent across all measures of climate transfers. We conclude that climate finance has not yet helped recipient countries reduce their carbon emissions. Contrary to a part of the aid-growth literature, we do not come to the conclusion that international transfers are fruitless (Easterly, 2006; Moyo, 2009). We firmly defend the necessity of international climate transfers and argue that the solution plausibly lies within the content and amount of those investments. A potential explanation for the absence of effects of climate finance is that mitigation policies do not have immediate results. The scaling up of climate finance is recent, and disbursements have not yet reached the intended targets. The current mitigation projects funded through climate transfers may be too small and fragmented to enable systemic changes. Climate finance effectiveness may also be limited by a lack of local actors' involvement or domestic institutional support. Furthermore, as investigated in Chapter 2, many projects reported by donors as climate-related have actually no climate component. This over-reporting reduces the scale of actual climate finance and consequently its capacity to induce long-term systemic changes in the recipient countries' economic structure. We, therefore, call for a scale-up of international climate finance and an improvement of climate investments' content through better monitoring of the donors' reporting and better identification of the recipients' needs and contexts.

In further developments and to better understand the absence of effects of climate finance on aggregated carbon emissions, we will investigate the impact of sectoral climate transfers on

the recipient countries' sectoral emissions and energy use. This strategy will allow us to capture part of the composition effect. Indeed, the lack of an overall effect of climate finance on carbon emissions could be explained by the opposition of a positive composition effect and a negative technique effect. Climate finance could improve the carbon intensity of the recipients' overall economy through the technique effect while increasing the share of carbon-intensive activities, such as energy supply. Decomposing climate finance and emissions at the sectoral level could help us investigate this hypothesis. We will also assess intermediary outcomes of climate finance toward carbon emissions reduction. First, we will consider the recipient countries' energy mix. Because of low data availability, this analysis will be conducted on a small sample of recipient countries. We will then estimate the leverage effect of public climate finance on private climate investments. Public climate finance could indirectly improve developing countries' mitigation through the mobilisation of climate-related private finance. Finally, We will complete our current empirical strategies with additional robustness checks. We will first add a sensitivity analysis of our main DiD results to violations of the conditional parallel trends assumption using (Rambachan and Roth, 2022) methodology. We will then replicate our DiD strategy using alternative heterogeneity-robust estimators such as de Chaisemartin and D'Haultfoeuille (2022)'s estimator. Then, we will further investigate the robustness of our instrumentation strategy by controlling for non-random exposure of recipient countries to shifts in donor allocation following Borusyak and Hull (2020).

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Appendix

A Robustness check

A.1 Instrument exogeneity

Table A.1: Instrument exogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	GDP	Industry	Trade	FDI	Energy	Renewable	Pop.	Urban	Gov.	Corr.
Pr. ODA	0.02 (0.02)	0.03** (0.01)	0.03*** (0.01)	0.02 (0.02)	0.01 (0.01)	0.02 (0.02)	0.01 (0.02)	-0.00 (0.00)	-0.00 (0.01)	0.02** (0.01)
N	2578.00	2512.00	2270.00	2515.00	2521.00	2488.00	2646.00	2628.00	2656.00	2662.00
R-sq	0.96	0.89	0.82	0.53	0.98	0.98	0.79	0.99	0.92	0.93
F-stat	1.38	4.40	9.31	0.46	1.20	0.71	0.19	0.00	0.09	4.26
Cluster	j	j	j	j	j	j	j	j	j	j
FE	j t	j t	j t	j t	j t	j t	j t	j t	j t	j t
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	GDP	Industry	Trade	FDI	Energy	Renewable	Pop.	Urban	Gov.	Corr.
Pr. finance	0.00 (0.01)	0.00 (0.00)	-0.01 (0.01)	0.00 (0.01)	-0.01 (0.00)	0.01 (0.01)	0.00 (0.01)	-0.00*** (0.00)	-0.00 (0.00)	0.01* (0.00)
N	2,578	2,512	2,270	2,515	2,521	2,488	2,646	2,628	2,656	2,662
R-sq	0.96	0.89	0.82	0.53	0.98	0.98	0.79	0.99	0.92	0.93
F-stat	0.05	0.75	1.24	0.04	1.84	1.42	0.00	8.82	0.13	3.30
Cluster	j	j	j	j	j	j	j	j	j	j
FE	j t	j t	j t	j t	j t	j t	j t	j t	j t	j t

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

For our instruments to be valid, they must be uncorrelated with the recipient countries' observables. We first regress the variables used in our IV2SLS strategy on our instruments, using recipient country (i) and year (t) fixed effects and clustering standard errors at the recipient country level. Variables are transformed as described in Section 4.2. Table A.1 shows correlation estimates between our instruments (predicted climate ODA and predicted total climate finance) and our main IV2SLS specification's covariates. We find that our instruments

are mostly uncorrelated with the country's observables, supporting the plausibility of their exogeneity. Indeed, most estimates are not significant. We note that predicted climate ODA has a small positive correlation with the share of industry value-added, the relative importance of trade in the GDP and the corruption index and that predicted climate finance has a small negative correlation with the share of urban population and a small positive correlation with the corruption index. However, these correlations are close to 0, and the associated F-stats are very small. We can therefore argue that our instruments are quasi-randomly distributed across our sample's observations, and so plausibly exogenous.

In a second step, we verify that the donor quasi-total climate transfers ($DonorTransfer_{ijt}$ in Section 4.2) used in the construction of our shift-share instruments are also uncorrelated with the recipient country's observables. Our identification strategy is based on variations in the donor climate transfer allocation uncorrelated to the recipient's characteristics. Constructing the donors' quasi-total transfers by removing flows to specific recipient j should guarantee this absence of correlation and, so, the exogeneity of our instruments. We check the validity of our strategy by regressing quasi-total donor transfers (in terms of climate ODA and total climate finance) on our IVSLS-estimations covariates using donor country (i), recipient country (i) and year (t) fixed effects and clustering standard errors at the country-pair (ij) level. Table A.2 presents our estimates. Donor quasi-total climate finance flows are uncorrelated with the recipient country's characteristics, as none of the estimates is significant. Donor quasi-total climate ODA flows are significantly correlated with the recipient's GDP, industry share, energy use, urban population and corruption index, but correlation estimates are close to 0, and the associated F-stat are small. We, therefore, do not find any strong correlation between quasi-total donor climate ODA flows and the recipient country's observables. Our estimates show that quasi-total donor flows are quasi-randomly distributed across our sample observations, enabling us to use exogenous climate transfer variations in our IV2SLS strategy.

In a further analysis, we will investigate the possibility that recipient countries are not randomly exposed to these quasi-random shifts in donor allocation, following the methodology developed by [Borusyak and Hull \(2020\)](#).

Table A.2: Quasi-total donor transfers exogeneity

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	GDP	Industry	Trade	FDI	Energy	Renewable	Pop.	Urban	Gov.	Corr.
ODA	-0.00** (0.00)	-0.00** (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00** (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00** (0.00)	-0.00 (0.00)	-0.00* (0.00)
N	25,629	25,184	23,729	25,193	24,224	23,956	25,975	25,846	25,637	25,637
R-sq	0.96	0.86	0.83	0.56	0.98	0.98	0.83	0.99	0.92	0.92
F-stat	4.38	3.94	2.11	0.05	6.57	0.24	0.11	4.05	0.02	3.05
Cluster	ij	ij	ij	ij	ij	ij	ij	ij	ij	ij
FE	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	GDP	Industry	Trade	FDI	Energy	Renewable	Pop.	Urban	Gov.	Corr.
Finance	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)	-0.00 (0.00)
N	171,057	165,585	150,138	166,440	168,150	166,611	175,959	174,762	167,637	168,207
R-sq	0.96	0.88	0.81	0.49	0.98	0.97	0.78	0.99	0.91	0.92
F-stat	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
Cluster	ij	ij	ij	ij	ij	ij	ij	ij	ij	ij
FE	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year	i j year

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

A.2 Conditional parallel trends assumption

Table A.3 presents our pre-treatment $ATT_{g,t}$, that is, the ATT of group g at period t , considering treatment actually started at period t . Pre-treatment periods are defined as described in Section 4.3: T_1 covers 1979 to 1985, T_2 covers 1986 to 1992 and T_3 covers 1993-1999. For instance, the $ATT_{T_1-T_2}$ of the group $g_{2000-2006}$ estimates the treatment effect on the group starting treatment the fourth period (2000-2006), as if the treatment had actually started in period T_2 . T_1 corresponds to the last before-treatment period, i.e. the base period, in this placebo estimation. Similarly, $ATT_{T_2-T_3}$ estimates the ATT as if the treatment had first occurred in T_3 , with T_2 the base period. The group $g_{2007-2013}$ $ATT_{T_1-T_2}$ could not be estimated due to insufficient data ²⁷

The pre-trend test estimates the chi2 statistics of the null hypothesis that all pre-treatment $ATT_{g,t}$ are statistically equal to zero. Our test statistics is not significant, so we accept the null hypothesis, which supports our conditional parallel trend hypothesis. Indeed, conditional on pre-treatment GDP per capita and energy use per capita and in the absence of actual treatment, we should not be able to estimate any effect. Significant pre-treatment $ATT_{g,t}$ would indicate different trends of CO2 emissions per GDP relative change between the treated group g and the never-treated group.

²⁷Too many countries of the group $g_{2007-2013}$ are missing CO2 emissions data for the period 1979-1985.

Table A.3: Pre-treatment ATTs

Dep. var:	CO2 per GDP relative change
$\mathfrak{S}_{2000-2006}$	
ATT_{T1-T2}	-109.10 (111.56)
ATT_{T2-T3}	131.64 (297.16)

$\mathfrak{S}_{2007-2013}$	
ATT_{T1-T2}	omitted (.)
ATT_{T1-T2}	924.99 (840.71)

$\mathfrak{S}_{2000-2006}$	
ATT_{T1-T2}	56.42 (863.93)
ATT_{T1-T2}	688.83 (702.19)

Pretrend chi2	11.80
N	662
Control group	Never treated
Clustering	Country
Method	Doubly-robust

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure A.1 plots the average fitted values of CO2 emissions per GDP relative change of the treated groups and the control group over time. From period T_2 , we graphically observe a growing conditional pre-trend for the three treated groups and the control group. Short pre-trends (from T_{-1} to T) are very similar between the control group and the group $g_{2000-2006}$, the largest treated group. We, therefore, argue that the conditional parallel trend assumption is plausible for the group $g_{2000-2006}$ and that group $g_{2000-2006}$ ATTs are reliable. We confidently confirm that receiving more climate transfer per capita did not help $g_{2000-2006}$ countries reduce their CO2 emissions per GDP. During the last pre-treatment period, from T_3 to T_4 , CO2 trends were also close between the never-treated group and group $g_{2014-2020}$. However, CO2 emissions relative change increased faster in the group $g_{2007-2013}$ than in the never-treated group from T_2 to T_4 . Further analysis to assess the sensitivity of our results to conditional parallel trend violations regarding $g_{2007-2013}$ and $g_{2014-2020}$ are needed, following the work from [Rambachan and Roth \(2022\)](#).

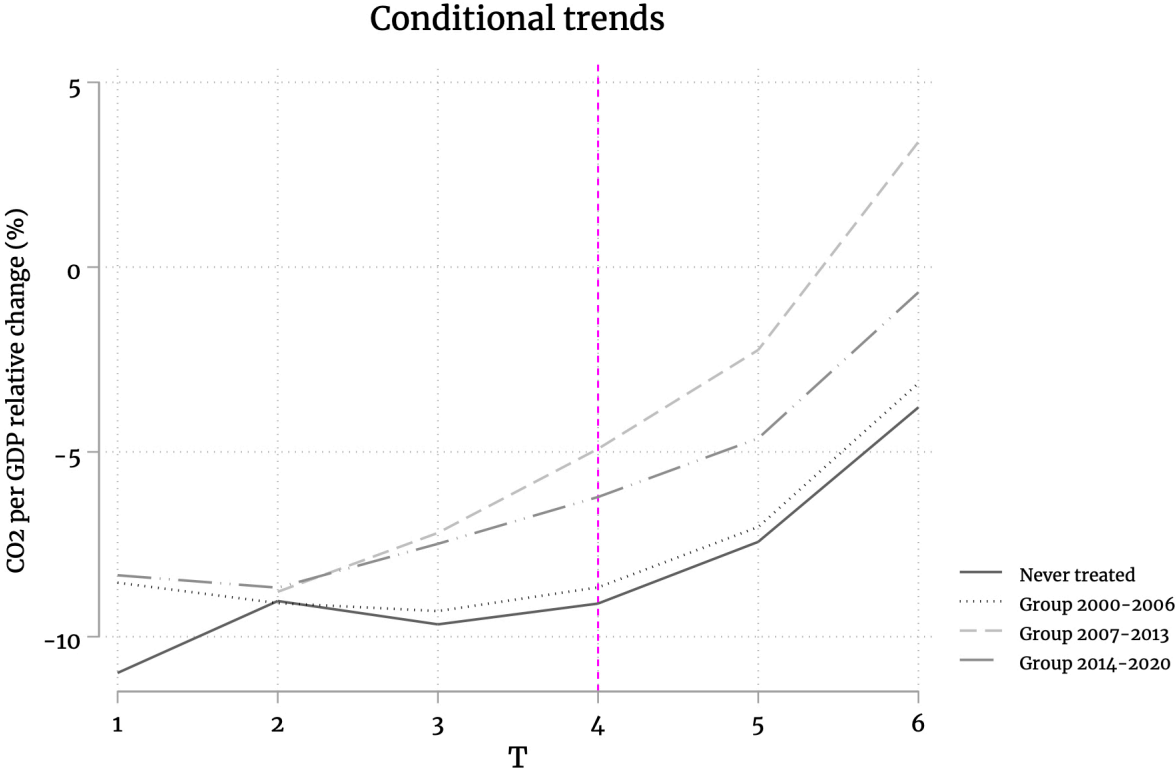


Figure A.1: Conditional parallel trends

B Panel models: additional results

Figure **B.2** replicates column (2) specification from Table **3.3** decomposing climate finance according to its objectives and sources. Mitigation and total climate finance estimations are carried over the period 2000-2020. Adaptation estimations cover from 2010 to 2020 as the adaptation Rio Marker was only introduced in 2010. As commented in Section **5.1**, we find a significant positive effect of total and bilateral adaptation finance and no effect of mitigation finance.

Figure **B.3** provides our results when replicating our IV2SLS strategy from Table **3.3** with different aid variables. We first investigate the effect of total ODA and, alternatively, use a corrected measure of climate ODA based on chapter **2** analysis. This variable corresponds to climate ODA excluding over-reported projects. This measure should identify climate ODA that truly targets climate objectives. Nevertheless, we do not find any significant impact of climate ODA, even when using this corrected measure. Total ODA does not affect CO2 emissions per GDP either. Estimations are carried over the period 2002-2018 to match the sample of corrected climate ODA.

Estimations from Figures **B.2** and **B.3** use transfers per capita corrected for inflation using the US 2010 CPI, as all other monetary variables in this paper. Instruments are computed as described in Section **4.2** using the appropriate climate transfer variable. The Cragg-Donald Wald F-Stats and the Kleibergen-Paap Wald rk F-stats are above Stock and Yogo critical value, and the Kleibergen-Paap rk LM statistics are significant at 1%.

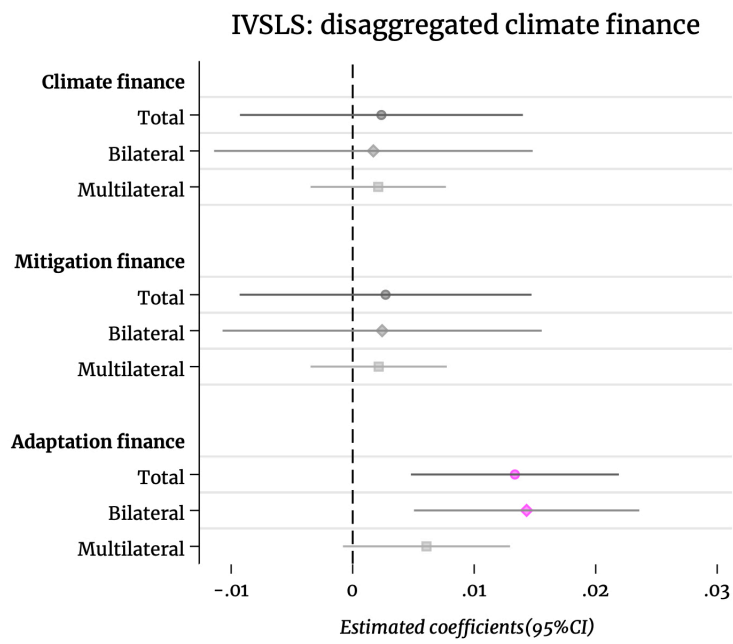


Figure B.2: Disaggregated climate finance

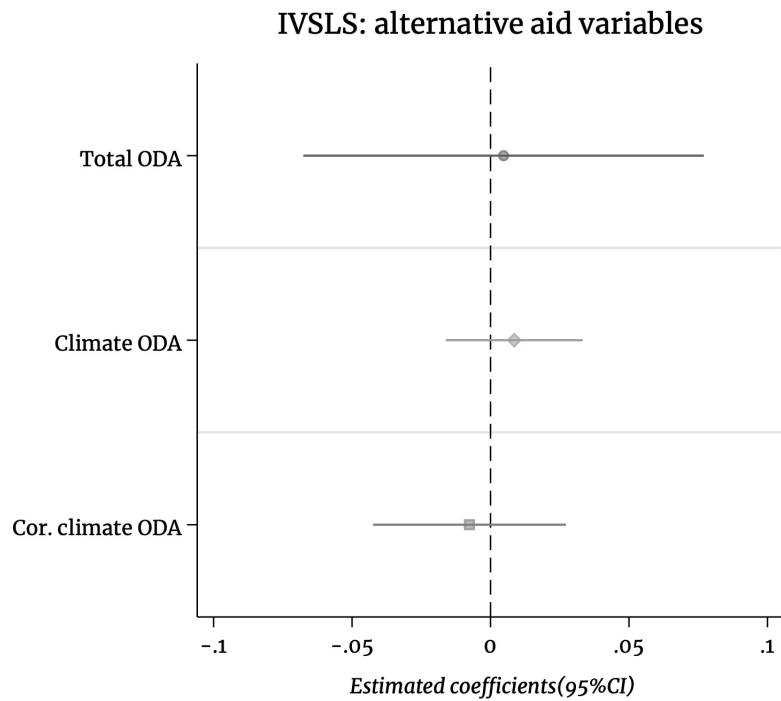


Figure B.3: Alternative aid variables

C Panel models: alternative lags

Table C.4: Five-year moving sum

	IV2SLS	IVSLS	IV2SLS	GMM	GMM
Climate ODA	0.00 (0.02)			0.01 (0.01)	
Climate finance		0.00 (0.01)	0.00 (0.01)		0.01 (0.00)
Climate finance x Governance			-0.00 (0.01)		
CO2 _{t-1}				0.76*** (0.05)	0.70*** (0.07)
GDP	-0.86*** (0.08)	-0.86*** (0.08)	-0.86*** (0.08)	-0.24*** (0.05)	-0.29*** (0.06)
Industry	0.01 (0.06)	0.01 (0.06)	0.01 (0.06)	0.01 (0.02)	0.01 (0.03)
Trade	0.01 (0.06)	0.01 (0.06)	0.01 (0.06)	-0.01 (0.02)	-0.02 (0.02)
FDI	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)	-0.01 (0.00)	-0.01 (0.01)
Energy	0.56*** (0.13)	0.56*** (0.13)	0.56*** (0.13)	0.20*** (0.04)	0.24*** (0.06)
Renewable	-0.19*** (0.05)	-0.19*** (0.05)	-0.19*** (0.05)	-0.04*** (0.01)	-0.05*** (0.02)
Pop. growth	0.02 (0.02)	0.01 (0.02)	0.01 (0.02)	-0.00 (0.02)	-0.01 (0.02)
Urban pop.	0.54* (0.32)	0.54* (0.32)	0.53 (0.33)	0.03 (0.03)	0.05 (0.03)
Governance	-0.02 (0.05)	-0.02 (0.05)	0.00 (0.09)	0.05** (0.02)	0.05** (0.03)
Corruption	0.03 (0.05)	0.03 (0.05)	0.03 (0.05)	-0.04 (0.02)	-0.04 (0.03)
N	1799	1799	1799	2137	2137
R-sq	0.58	0.58	0.58		
K.P. LM stat	38.55***	19.66***	10.91***		
K.P. F stat	150.43	199.22	52.56		
C.D. Wald F-stat	1466.32	1676.61	679.12		
(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))					
AR(1) z-score				-6.11***	-5.61***
AR(2) z-score				-1.58	-1.47
Hansen J stat				108.45	101.36

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

D OLS estimations

Table D.5: Climate transfers: OLS estimations

	(1)	(2)	(3)
Climate ODA	0.01 (0.01)		
Climate finance		0.00 (0.00)	0.00 (0.00)
Climate finance x Governance			0.00 (0.00)
GDP	-0.85*** (0.06)	-0.85*** (0.06)	-0.85*** (0.06)
Industry	0.03 (0.04)	0.03 (0.04)	0.04 (0.04)
Trade	0.02 (0.06)	0.02 (0.06)	0.02 (0.06)
FDI	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
Energy	0.57*** (0.11)	0.57*** (0.11)	0.57*** (0.11)
Renewable	-0.19*** (0.05)	-0.19*** (0.05)	-0.19*** (0.05)
Pop. growth	0.01 (0.02)	0.01 (0.02)	0.01 (0.02)
Urban pop.	0.40* (0.21)	0.42* (0.22)	0.43* (0.22)
Governance	-0.05 (0.05)	-0.05 (0.05)	-0.08 (0.06)
Corruption	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)
N	2245	2245	2245
R-sq	0.97	0.97	0.97
F stat	36.92***	36.36***	38.23***

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

E Panel models: alternative clustering of standard errors

Table E.6: Alternative clustering: recipient and year

	(1)	(2)	(3)
Climate ODA	0.01 (0.01)		
Climate finance		0.00 (0.01)	0.00 (0.01)
Climate finance x Governance			0.00 (0.01)
GDP	-0.85*** (0.06)	-0.85*** (0.07)	-0.85*** (0.07)
Industry	0.04 (0.05)	0.04 (0.05)	0.04 (0.05)
Trade	0.01 (0.06)	0.01 (0.06)	0.01 (0.05)
FDI	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Energy	0.56*** (0.12)	0.56*** (0.12)	0.56*** (0.12)
Renewable	-0.19*** (0.05)	-0.19*** (0.05)	-0.19*** (0.05)
Pop. growth	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
Urban pop.	0.51* (0.26)	0.52* (0.27)	0.53* (0.27)
Governance	-0.04 (0.05)	-0.04 (0.05)	-0.06 (0.08)
Corruption	0.04 (0.04)	0.04 (0.05)	0.03 (0.04)
N	2026	2026	2026
Cluster	Recipient Year	Recipient Year	Recipient Year
R-sq	0.62	0.62	0.62
K.P. LM stat	11.22***	8.50***	6.82***
K.P. F stat	78.49	193.50	80.46
C.D. Wald F-stat	1573.59	1646.81	669.30

(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table E.7: Alternative clustering: year

	(1)	(2)	(3)
Climate ODA	0.01 (0.01)		
Climate finance		0.00 (0.00)	0.00 (0.00)
Climate finance x Governance			0.00 (0.00)
GDP	-0.85*** (0.01)	-0.85*** (0.02)	-0.85*** (0.01)
Industry	0.04 (0.03)	0.04 (0.01)	0.04 (0.03)
Trade	0.01 (0.01)	0.01 (0.01)	0.01 (0.01)
FDI	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Energy	0.56*** (0.03)	0.56*** (0.03)	0.56*** (0.03)
Renewable	-0.19*** (0.02)	-0.19*** (0.01)	-0.19*** (0.02)
Pop. growth	0.02* (0.01)	-0.02* (0.01)	0.02* (0.01)
Urban pop.	0.51*** (0.05)	0.52*** (0.06)	0.53*** (0.06)
Governance	-0.04 (0.02)	-0.04*** (0.02)	-0.06* (0.04)
Corruption	0.04** (0.01)	0.04** (0.02)	0.03** (0.01)
N	2026.00	2026.00	2026.00
Cluster	year	year	year
R-sq	0.62	0.72	0.62
K.P. LM stat	14.94***	12.81***	11.96***
K.P. F stat	120.72	254.21	53.87
C.D. Wald F-stat	1472.79	1541.33	626.41

(Stock-Yogo critical value 10%: 16.38 for eq. (1) & (2) and 7.03 for eq.(3))
Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

F Panel models: non-linear effects

Table F.8: Non-linear effects

	(1)	(2)	(3)	(4)
	IV2SLS	IV2SLS	GMM	GMM
Climate ODA	-0.03 (0.03)		-0.00 (0.01)	
Sq. Climate ODA	0.01 (0.00)		-0.00 (0.00)	
Climate finance		0.00 (0.01)		0.02** (0.01)
Sq. Climate finance		0.00 (0.00)		-0.00** (0.00)
CO2 _{t-1}			0.80*** (0.05)	0.70*** (0.07)
GDP	-0.85*** (0.06)	-0.85*** (0.07)	-0.22*** (0.05)	-0.29*** (0.06)
Industry	0.04 (0.05)	0.04 (0.05)	0.00 (0.02)	-0.00 (0.03)
Trade	0.01 (0.06)	0.01 (0.06)	-0.00 (0.02)	0.01 (0.02)
FDI	0.00 (0.01)	0.00 (0.01)	-0.00 (0.00)	-0.01 (0.00)
Energy	0.56*** (0.12)	0.56*** (0.12)	0.17*** (0.04)	0.24*** (0.06)
Renewable	-0.18*** (0.05)	-0.19*** (0.05)	-0.03*** (0.01)	-0.05*** (0.01)
Pop. growth	0.02 (0.02)	0.02 (0.02)	-0.00 (0.01)	-0.02 (0.02)
Urban	0.49* (0.26)	0.52* (0.27)	0.04 (0.02)	0.03 (0.03)
Governance	-0.04 (0.05)	-0.04 (0.05)	0.05** (0.02)	0.05** (0.03)
Corruption	0.03 (0.05)	0.03 (0.05)	-0.02 (0.02)	-0.04 (0.03)
N	2026	2026	2137	2137
R-sq	0.62	0.62		
K.P. LM stat	52.79***	20.91***		
K.P. F stat	62.87	127.28		
C.D. Wald F-stat	585.17	828.58		
(Stock-Yogo critical value 10%: 7.03 for eq. (1) & (2))				
AR(1) z-score			-6.26***	-5.76***
AR(2) z-score			-1.61	-1.55
Hansen J stat			97.16	102.60

Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

G DiD analysis: alternative treatment threshold

Table **G.9** presents our DiD results when using the 60th percentile as a threshold to determine treatment. This estimation is based on the assumption of parallel trends between countries receiving more finance per capita than the 60th percentile and countries that never pass this threshold, conditional on the pre-treatment values of the GDP per capita and energy use per capita. Table **G.10** presents our DiD results when using the 80th percentile as a threshold. The treated and never-treated groups further differ when using this treatment definition so we add another condition for the parallel trend to hold. We estimate our ATT based on the hypothesis of a parallel trend conditional on the pre-treatment values of the GDP per capita, energy use per capita and the share of urban population. The pre-trends tests indicates that all pre-treatment $ATT_{g,t}$ are statistically equal to zero, supporting the validity of our CPT assumptions. Considering these alternative treatment definitions, we still do not find an effect of receiving higher climate transfer per capita on the countries' emissions relative change.

Table G.9: DiD setup: 60th percentile threshold

Dep. var:	CO2 per GDP relative change
Overall ATT	-4.55 (8.97)

Group ATT	-4.46 (8.24)
$\xi_{2000-2006}$	-3.63 (10.57)
$\xi_{2007-2013}$	-10.04 (14.39)
$\xi_{2014-2020}$	2.77 (15.80)

Time ATT	-4.50 (8.25)
2000-2006	-2.81 (7.64)
2007-2013	-8.74 (9.98)
2014-2020	-1.96 (14.99)
N	662
Control group	Never treated
Clustering	Country
Method	Doubly-robust

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table G.10: DiD setup: 80th percentile threshold

Dep. var:	CO2 per GDP relative change
Overall ATT	-1.19 (7.69)

Group ATT	0.29 (7.55)
$\xi_{2000-2006}$	-1.08 (9.59)
$\xi_{2007-2013}$	-7.08 (12.69)
$\xi_{2014-2020}$	15.48 (19.75)

Time ATT	0.17 (6.65)
2000-2006	5.01 (6.07)
2007-2013	4.10 (8.76)
2014-2020	-8.61 (12.42)
N	662
Control group	Never treated
Clustering	Country
Method	Doubly-robust

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

H Panel models: subsamples description

Table **H.11** details the income-level groups used in the subsample analysis in Section **5.2**. Table **H.12** regroups the 20 highest CO2 emitters per GDP among our sample of 153 recipient countries over the 2000-2020 period. Table **H.13** and Table **H.14** respectively present the 20 highest CO2 emitters per capita and highest absolute CO2 emitters among our sample of 153 recipient countries over the 2000-2020 period. Table **H.15** presents the 30 largest recipients of total climate finance and Table **H.16** the 30 largest recipients of climate finance per capita.

Table H.11: Income groups

Lower income	Middle income	Upper-middle income	Upper income
Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic People's Republic of Korea, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan, Tanzania, Timor-Leste, Togo, Tuvalu, Uganda, Vanuatu, Yemen, Zambia, Zimbabwe	Armenia, Bolivia, Cabo Verde, Cameroon, Congo, Côte d'Ivoire, Egypt, El Salvador, Eswatini, Georgia, Ghana, Guatemala, Honduras, India, Indonesia, Jordan, Kenya, Kosovo, Kyrgyzstan, Micronesia, Moldova, Mongolia, Morocco, Nicaragua, Nigeria, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Syrian Arab Republic, Tajikistan, Tunisia, Ukraine, Uzbekistan, Vietnam, West Bank and Gaza Strip	Albania, Algeria, Antigua and Barbuda, Argentina, Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, China (People's Republic of), Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Equatorial Guinea, Fiji, Gabon, Grenada, Guyana, Iran, Iraq, Jamaica, Kazakhstan, Lebanon, Libya, Malaysia, Maldives, Marshall Islands, Mauritius, Mexico, Montenegro, Montserrat, Namibia, Nauru, Niue, North Macedonia, Palau, Panama, Paraguay, Peru, Saint Helena, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Serbia, South Africa, Suriname, Thailand, Tonga, Turkey, Turkmenistan, Venezuela, Wallis and Futuna	Anguilla, Barbados, Chile, Cook Islands, Croatia, Oman, Saint Kitts and Nevis, Saudi Arabia, Seychelles, Slovenia, Trinidad and Tobago, Uruguay

Table H.12: Top-20 CO2 intensive countries

Recipient	CO2 per GDP	CO2 per capita	Total CO2
Azerbaijan	42.533581	78.890999	716.71198
Belarus	40.083775	132.964	1265.171
Bosnia and Herzegovina	30.67095	112.26	400.86801
China (People's Republic of)	36.842064	118.875	164119.14
India	28.29833	29.111	36455.684
Iran	42.326107	156.91701	11756.31
Iraq	31.989101	89.25	2857.5239
Kazakhstan	66.55851	298.71301	4980.4312
Kyrgyzstan	40.494194	28.909	163.427
Lesotho	28.766184	23.205	47.243
Moldova	26.120619	24.353001	99.948997
Mongolia	81.609299	184.52901	546.27502
North Macedonia	30.191521	92.830002	191.73
Serbia	39.349632	112.566	1018.693
South Africa	34.245903	182.26801	9393.7549
Trinidad and Tobago	46.139946	622.07898	830.34399
Ukraine	73.632996	128.00999	5897.1279
Uzbekistan	113.62127	84.908997	2410.304
Vietnam	26.160833	2.629002	2944.9431
Zimbabwe	25.237919	16.819	217.483

CO2 per GDP in kg per unit of GDP, CO2 per capita in tonnes, total CO2 in million tons.

Table H.13: Top-20 CO2 per capita emitting countries

Recipient	CO2 per GDP	CO2 per capita	Total CO2
Anguilla	.	207.315	2.7680001
Belarus	40.083775	132.964	1265.171
China (People's Republic of)	36.842064	118.875	164119.14
Equatorial Guinea	24.999706	180.95599	175.998
Iran	42.326107	156.91701	11756.31
Kazakhstan	66.55851	298.71301	4980.4312
Libya	23.669579	181.61099	1110.677
Malaysia	21.583567	153.884	4360.126
Mongolia	81.609299	184.52901	546.27502
Montserrat	.	173.399	.84200001
Nauru	.	114.111	1.165
Oman	19.380453	285.71799	974.66797
Palau	23.294058	245.998	4.5510001
Saudi Arabia	23.698582	367.01001	10303.337
Slovenia	8.9997969	161.104	327.457
South Africa	34.245903	182.26801	9393.7549
Trinidad and Tobago	46.139946	622.07898	830.34399
Turkmenistan	.	232.987	1217.621
Ukraine	73.632996	128.00999	5897.1279
Venezuela	.	123.788	3422.9719

CO2 per GDP in kg per unit of GDP, CO2 per capita in tonnes, total CO2 in million tons.

Table H.14: Top-20 total CO2 emitting countries

Recipient	CO2 per GDP	CO2 per capita	Total CO2
Algeria	21.045771	69.051003	2555.9719
Argentina	12.17804	87.591003	3594.116
Brazil	7.6163344	46.518002	9117.6191
China (People's Republic of)	36.842064	118.875	164119.14
Egypt	25.092905	47.646	4033.094
India	28.29833	29.111	36455.684
Indonesia	20.285467	38.493	9451.6641
Iran	42.326107	156.91701	11756.31
Iraq	31.989101	89.25	2857.5239
Kazakhstan	66.55851	298.71301	4980.4312
Malaysia	21.583567	153.884	4360.126
Mexico	9.9236851	84.431999	9572.4922
Pakistan	20.307371	18.632999	3404.781
Saudi Arabia	23.698582	367.01001	10303.337
South Africa	34.245903	182.26801	9393.7549
Thailand	19.791208	76.182999	5117.542
Turkey	12.084427	91.473999	6762.3721
Ukraine	73.632996	128.00999	5897.1279
Venezuela	.	123.788	3422.9719
Vietnam	26.160833	32.629002	2944.9431

CO2 per GDP in kg per unit of GDP, CO2 per capita in tonnes, total CO2 in million tons.

Table H.15: Top-30 recipient countries of total climate finance

Recipient	Climate finance	Climate finance per capita
Argentina	6356613.5	51783.293
Bangladesh	27074408	36574.184
Bolivia	5313727.5	146190.98
Brazil	19329998	14993.924
China (People's Republic of)	24283088	2549.9797
Colombia	9546083	37468.43
Ecuador	6596635.5	72990.336
Egypt	15668489	28070.031
Ethiopia	10892585	18888.367
India	73546240	8919.5928
Indonesia	22904772	12704.659
Jordan	6227403	102391.64
Kenya	12144326	40342.949
Mexico	10973406	17549.859
Morocco	14711952	65049.246
Myanmar	7331654	56912.086
Nepal	5503755	44252.965
Nigeria	5901860.5	10629.312
Pakistan	12918130	11637.06
Peru	7383443	40918.563
Philippines	17280636	40490.098
Serbia	5889286	102080.45
South Africa	5403598	20217.297
Sri Lanka	5375758.5	57473.746
Tanzania	5937861.5	16757.102
Tunisia	6345818.5	111910.89
Turkey	23462146	44430.43
Ukraine	11155860	36674.746
Uzbekistan	8745919	77847.078
Vietnam	15860724	31892.352

Climate finance in USD millions. Climate finance per capita in USD.

Table H.16: Top-30 recipient countries of per capita climate finance

Recipient	Climate finance	Climate finance per capita
Antigua and Barbuda	110580.93	426888.38
Barbados	83045.164	293922.72
Cabo Verde	638812.56	383758.34
Cook Islands	125900.72	1673863
Costa Rica	3371405.3	346843.41
Dominica	247605.34	1352142.9
Georgia	4322331	274108.41
Grenada	214555.09	992965.06
Guyana	931449.44	335778.81
Kiribati	408023.53	715422.25
Maldives	464995.78	342547.56
Marshall Islands	303208.34	1431045.5
Mauritius	1199313.1	352721.28
Micronesia	202268.64	558631.81
Montenegro	895853.25	276447.28
Montserrat	39289.402	5198755.5
Nauru	130789.64	3562851.8
Niue	63908.344	6163937.5
Palau	108128.4	1406453.5
Saint Helena	17097.027	1044811.5
Saint Kitts and Nevis	19123.578	360674.53
Saint Lucia	183060.72	455366.59
Saint Vincent and the Grenadines	271513.56	1234019.8
Samoa	555831.56	435338.5
Sao Tome and Principe	215812.19	225840.03
Seychelles	76243.375	235301.97
Solomon Islands	736921.38	342650.38
Tonga	445501.06	1557608
Tuvalu	211247.69	3968829.5
Vanuatu	790563.38	540463.63

Climate finance in USD millions. Climate finance per capita in USD.

I DiD setup: groups description

Table I.17: Treatment status

Never treated	Group _{2000–2006}	Group _{2007–2013}	Group _{2014–2020}
Afghanistan, Algeria, Angola, Argentina, Bangladesh, Belarus, Botswana, Brazil, Burkina Faso, Cambodia, Cameroon, Central African Republic, Chad, Chile, China (People's Republic of), Colombia, Congo, Croatia, Cuba, Côte d'Ivoire, Democratic People's Republic of Korea, Democratic Republic of the Congo, Dominican Republic, Egypt, El Salvador, Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gambia, Ghana, Guatemala, Guinea, Guinea-Bissau, Haiti, India, Iran, Iraq, Jamaica, Kazakhstan, Kenya, Kyrgyzstan, Lebanon, Lesotho, Liberia, Libya, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mexico, Moldova, Mozambique, Myanmar, Nepal, Niger, Nigeria, Oman, Pakistan, Papua New Guinea, Peru, Philippines, Rwanda, Saudi Arabia, Sierra Leone, Slovenia, Somalia, South Africa, South Sudan, Sudan, Syrian Arab Republic, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Turkmenistan, Uganda, Ukraine, Uzbekistan, Venezuela, Yemen, Zambia, Zimbabwe	Albania, Armenia, Azerbaijan, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Burundi, Cabo Verde, Cook Islands, Costa Rica, Gabon, Georgia, Guyana, Honduras, Indonesia, Jordan, Lao People's Democratic Republic, Marshall Islands, Mauritius, Micronesia, Mongolia, Morocco, Namibia, Nauru, Nicaragua, Niue, North Macedonia, Palau, Paraguay, Saint Helena, Samoa, Senegal, Serbia, Seychelles, Solomon Islands, Sri Lanka, Suriname, Timor-Leste, Tonga, Tunisia, Turkey, Tuvalu, Vietnam, West Bank and Gaza Strip	Antigua and Barbuda, Barbados, Djibouti, Dominica, Kiribati, Maldives, Montenegro, Montserrat, Saint Kitts and Nevis, Vincent and the Grenadines, Uruguay, Vanuatu, Wallis and Futuna	Belize, Comoros, Ecuador, Fiji, Grenada, Kosovo, Panama, Saint Lucia, Sao Tome and Principe

J DiD analysis: climate finance distribution

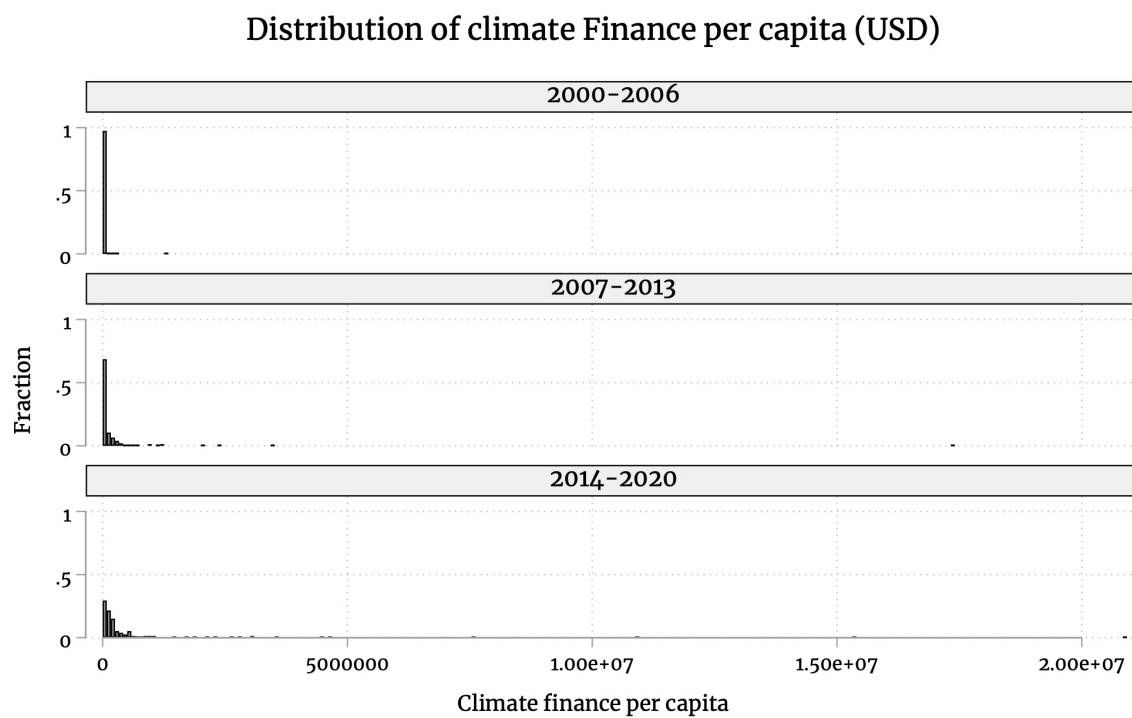


Figure J.4: Climate finance distribution

Conclusion

“I may be dead, but I’m still pretty.”

Buffy the Vampire Slayer – S1E12
Prophecy Girl (1997)

This dissertation proposes an extensive assessment of international public climate finance, from allocation issues to effectiveness. International public climate finance is a redistribution tool from developed to developing countries based on both capacities and responsibilities. On the capacity side, reaching global net-zero emissions implies large investments that developing countries are not able to make. They are also the most severely impacted by climate change consequences which further reduce their capacity to finance the transition to net-zero. Both considerations justify international financial transfers from higher-income countries toward mitigation and adaptation activities in developing countries. On the responsibility side, developed countries bear the highest responsibility for historical GHG emissions. The fast increase in anthropogenic emissions over the last century is the consequence of their carbon-intensive industrialisation process. They are still the highest GHG emitters per capita and, yet, the less threatened by climate change impacts. International public climate finance is therefore justified by both the need to finance the global net-zero transition and the equity issue of differentiated responsibility and vulnerability, which we refer to as international climate justice.

After decades of international agreements stating that developed countries should provide assistance to developing countries in addressing climate change challenges, COP15 in 2009 in Copenhagen finally defined a quantified commitment. Developed countries pledged to jointly mobilise USD 100 billion per year by 2020 toward developing countries’ climate needs. Fourteen years later, and as we approach the definition of a new target by COP Parties in 2025, this

dissertation reviews international climate finance architecture, its allocation and its impacts. It highlights three different issues in three complementary chapters.

In the first chapter, we investigate the donor countries' bilateral trade motivations in the allocation of bilateral climate aid using a combination of theoretical modelling and econometric analysis. We posit that climate aid allocation by donor countries is motivated by the preservation of trade flows with recipient countries, that are based on historical and geopolitical relationships and are threatened by climate change consequences. Climate aid, through its impact on the recipient country's productivity and adaptive capacity, allows for positive income and terms-of-trade effects. These two mechanisms increase trade flows between the donor and recipient countries. Our empirical analysis confirms the bilateral trade motivation in the allocation of bilateral climate aid by donor countries. We estimate an elasticity of climate aid around 0.3 for the donors' exports, but we do not find any effect of the donor's imports on climate aid allocation.

The second chapter of this dissertation explores the content of the activities reported as international climate aid. More specifically, we develop a methodology based on a Python-coded keyword search to assess the climate content of 63,195 projects reported as climate aid by donor countries between 2002 and 2018. We estimate that almost half of the climate-reported projects do not target any climate-related issue. This chapter highlights a large and time-persistent miscoding of climate aid by donor countries. It also shows large heterogeneity in miscoding behaviours among donor countries. Following the political-economy literature, we propose an empirical analysis of the drivers of this miscoding. We estimate that donor countries with stricter budget constraints and environmentally-concerned populations might miscode development projects as climate-related for electoral motives. Miscoding could be a strategy to display high climate aid contributions without actually increasing their aid allocation.

Following the results of the first two chapters, the third chapter sets out to evaluate the effectiveness of international public climate finance. Using recently published and more exhaustive data, it estimates the impact of international public climate finance on the recipient countries' carbon emissions. This chapter lies within the literature on aid effectiveness and builds upon the methodological tools that have been investigated so far to estimate the aggregated impacts of aid transfers. It also proposes the application of a difference-in-differences design to the research question of climate finance effectiveness. To do so, it takes advantage of the recent advances in the literature that offers heterogeneity-robust average treatment effect estimators. Our empirical analysis does not find any effect of international public climate finance on the

recipient countries' carbon emissions. This absence of effects is consistent across all estimation strategies and subsamples.

The lessons we can draw so far from international public climate finance are not highly optimistic. Our first conclusion can be summarised as "too late, too few". The USD 100 billion by 2020 commitment was already far below recipient countries' estimated needs, and according to the latest OECD report (OECD, 2022), it was not reached in time. In 2020, estimated international climate finance toward developing countries amounted to USD 83.3 billion (OECD, 2022). Accounting for all activities wrongly reported as climate-related, the actual amount of international climate finance is even lower. The scale-up of climate finance is urgent, and the new target that should be adopted by Parties in 2025 will have to be ambitious.

The second conclusion from this dissertation is that the set of an ambitious target will only be credible if it is accompanied by third-party monitoring of climate finance reporting. Higher transparency and accountability are expected, and they imply an internationally recognised definition and accounting method of international climate finance. For instance, some donor countries report development projects with climate co-benefits at face value, while others apply weights to only report the climate components of the projects. Neither is in the wrong as no international rule defines what accounting method should be applied in this very common situation.

Our third conclusion is that higher transparency is also needed regarding the distribution of public climate finance. It may imply an agreement of Parties on more precise guidelines and the evaluation of recipients' needs. The recent tendency has been an increase in adaptation finance to low-income and vulnerable countries and a stronger concentration of mitigation finance toward more industrialised and emerging economies. The gap yet remains with higher investments in mitigation than adaptation activities. Strategic donor interests should not prevent a fair and efficient allocation of international climate finance. The definition of what a *fair* allocation should be can only result from international negotiations, but it should most likely rest on needs and capacities.

Finally, discussions must also address ways to make climate finance more effective. It could, for instance, imply better cooperation with the recipient countries to integrate international public climate investments in national climate plans. It also necessitates the design and implementation of sustainable financial solutions considering developing countries' heavy indebtedness. While results from the Paris Summit for a New Global Financing Pact are yet to be seen, we can expect it to help keep the momentum going on the debt burden issue over the

next climate negotiations. Improve climate finance effectiveness might also rely on increasing private sources. Current private climate investments toward developing countries are indeed largely insufficient (Climate Policy Initiative, 2022). Discussions must therefore address how public climate finance can help mobilise private investments.

This dissertation has several limitations. First, it focuses on international public climate transfers and does not discuss alternative global policies to address climate change issues. Part of the literature has shown the advantages of climate policy-mix at the national or sectoral level (Ravigné et al., 2022). Global policy-mix, which could cover, for instance, international carbon pricing, emission permits and redistribution tools such as climate transfers, are very likely necessary (see for instance Hamdi-Cherif et al. (2011)). The efficient combination of international climate policies is beyond the scope of this dissertation.

This dissertation neither discusses the *fair* contribution of developed countries to international climate finance targets nor does it examine the social acceptability of climate transfers by donor countries' populations. A recent study by Colenbrander et al. (2021) has proposed an estimation of fair contributions to climate finance based on countries' size, income and historical responsibilities. We also refer to a survey by Douenne et al. (2023) on the social acceptability of global redistributive policies that indicates a majority support for transfers from high to low-income countries in Europe and the United States.

Most importantly, this dissertation proposes an aggregated analysis, first on all recipient countries and second on overall mitigation and adaptation objectives. Yet, the project-level study in the second chapter highlights the diversity of climate-related activities and how many development and environmental objectives intertwine with mitigation and adaptation outcomes. For instance, the protection of marine biodiversity increases the ocean's carbon capture and storage capacity and the resilience and sustainability of fish-based activities. We see here how connected sustainable natural resources management, biodiversity protection, climate change mitigation and food security are. The complementarity of developmental, environmental and climate activities is not studied in this dissertation. Our aggregated analysis would greatly benefit from being completed by case studies and microeconomic-level analyses. Chapter three opens the way to many research possibilities. Among them, we think of a microeconomic analysis focusing on a particular recipient country at the firm and sectoral levels to further investigate the different mechanisms of climate finance and its effect on the economic structure, energy mix, and policy choices. Extensions to adaptation outcomes will also be necessary. It may imply analyses on aggregated measures of climate vulnerabilities (see, for instance the ND-GAIN

(2022) country index) or, considering the diversity of adaptation needs, specific outcomes such as natural hazards management, access to water, food security etc. Once again, microeconomic and macroeconomic-level analyses should complete each other to inform policymakers on the best way to reform international climate finance. We have until 2025.

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