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Public Interventions and Private Climate Finance Flows

EMPIRICAL EVIDENCE FROM RENEWABLE ENERGY FINANCING

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Research Collaborative
Tracking Private Climate Finance

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PUBLIC INTERVENTIONS AND PRIVATE CLIMATE FINANCE FLOWS: EMPIRICAL EVIDENCE FROM RENEWABLE ENERGY FINANCING - ENVIRONMENT WORKING PAPER No. 80

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ABSTRACT

This study uses a unique dataset of investment flows to analyse the role of two categories of public interventions (finance and policies) in mobilising flows of private climate finance worldwide and in the more specific context of flows to and in developing countries. The objectives are threefold. First, the paper presents ‘observed’ ratios of total private to public finance in selected climate-related sectors. Second, it seeks to understand the determinants of private climate finance flows by analysing the role of key public finance (bilateral, domestic and multilateral) and public policy instruments (feed-in tariffs, renewable energy quotas, the Clean Development Mechanism), while taking into account a number of market and country conditions. For reasons of data availability, the focus of this econometric analysis is on a subset of six renewable energy sectors (wind, solar, biomass, small hydro, marine and geothermal). Finally, the paper assesses the likely mobilisation impact of past public interventions in these six sectors, and draws a comparison with approaches that ignore the role of policy as well as country and market conditions.

Results suggest that both public finance and public policies have played an important role in private finance mobilisation globally. In the context of finance to and in developing countries, the results highlight the currently untapped potential of domestic public policies to increase mobilisation. The methodology proposed in this report is an initial attempt to estimate private climate finance mobilisation empirically. It should be seen as a first step towards developing more comprehensive methodologies for analysing and estimating private finance mobilisation in the global climate policy context.

Keywords: climate change, renewable energy, public interventions, private finance, investment, mobilisation, leverage, estimation

JEL classification: Q42, Q48, Q54, Q55, Q58; G3; H23; L94; O3.

RÉSUMÉ

Cette étude se base sur un ensemble unique de données concernant les flux d'investissements afin d'analyser le rôle de deux catégories d'interventions publiques dans la mobilisation de flux de finance privée à une échelle mondiale et dans le contexte plus spécifique des flux vers et dans les pays en développement. L'objectif poursuivi est triple. Dans un premier temps, le rapport présente des ratios observés entre finance privée et publique dans une sélection de secteurs relatifs au changement climatique. Dans un deuxième temps l'analyse cherche à comprendre les facteurs déterminants de la finance climat privée en analysant le rôle d'instruments clés de finance publique (bilatérale, domestique, multilatérale) et de politique publique (tarifs de rachats, quotas d'énergie renouvelable, mécanisme de développement propre), tout en prenant en compte un certain nombre de caractéristiques nationales et de marché. Pour des raisons de disponibilité de données, cette analyse économétrique se concentre sur un sous-ensemble de six secteurs liés aux énergies renouvelables (éolien, solaire, biomasse, hydro de petite taille, énergies marines, géothermie). Pour finir, le rapport évalue le probable impact des interventions publiques passées en termes de mobilisation de finance privée dans ces six secteurs, et établit une comparaison avec les approches ignorant le rôle des politiques publiques et des caractéristiques nationales et de marché.

Les résultats suggèrent qu'à la fois la finance et les politiques publiques jouent un rôle important dans la mobilisation de la finance privée à l'échèle mondiale. Dans le contexte de la finance vers et dans les pays en développement, les résultats soulignent le potentiel inexploité des politiques publiques domestiques afin de mobiliser d'avantage de finance privée. La méthodologie proposée dans ce rapport est une tentative initiale d'estimation empirique de la finance climat privée mobilisée. Elle doit être considérée comme une première étape vers le développement de méthodes plus complètes afin d'analyser et d'estimer la mobilisation de la finance climat privée dans le contexte des politiques climatiques à une échelle globale.

Mots clés: changement climatique, énergies renouvelables, interventions publiques, finance privée, investissement, mobilisation, levier, estimation

Classification JEL: Q42, Q48, Q54, Q55, Q58; G3; H23; L94; O3.

FOREWORD

This paper has been authored by Ivan Haščič, Miguel Cárdenas Rodríguez, Raphaël Jachnik, Jérôme Silva (OECD Environment Directorate) and Nick Johnstone (OECD Directorate for Science, Technology and Innovation). The opinions expressed in this paper are those of the authors and do not necessarily reflect the official views of the OECD or of the governments of its member countries.

The report is part of a broader initiative, the Research Collaborative on Tracking Private Climate Finance. The Research Collaborative, co-ordinated and hosted by the OECD Secretariat, is a network of research organisations, international finance institutions, and governments. Its overall aim is to contribute to the development of more comprehensive methodologies for estimating both private climate finance flows to, between and in developing countries, and those private flows mobilised by developed countries' public interventions.

The present study investigates the possible development and use of quantitative techniques towards estimating private climate finance mobilisation. It is complemented by other research activities investigating alternative methodological options, including case study-based qualitative approaches.

Further information available at www.oecd.org/env/researchcollaborative

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EXECUTIVE SUMMARY

The scale of investments required to finance climate change mitigation and adaptation has led to an increased focus on the role of both private finance in addressing climate change impacts and of public policies to mobilise private capital towards this end. There is, however, currently a significant degree of uncertainty about how to track private climate finance mobilised by these public finance and policy interventions. This is due to varying definitions of what constitutes "climate finance" and how it can be mobilised, as well as limited data and methodological options related to measurement. Different methodological approaches can be used to estimate mobilised private climate finance. They range from qualitative case study-based approaches to quantitative econometrics-based studies. Methods can be further distinguished between those focusing only on measuring the mobilisation from public finance versus those estimating also the impact of public policies.

This study uses a unique dataset of investment flows worldwide to assess the role of both public finance and public policy interventions in mobilising private finance for renewable energy. Public finance covers domestic, bilateral, and multilateral sources that provide support to individual projects and activities. Public policies include domestic feed-in-tariff (FIT) and renewable energy quota (REQ) schemes, which have been widely used to-date to encourage the development of such projects. This assessment is done both globally and in the specific context of financial flows to the South. The analysis controls for a number of country and market conditions that too might affect private finance flows.

Descriptive analysis of global finance flows in 14 climate-related sectors

This paper first presents a descriptive analysis of global finance flows originating from 156 countries, flowing to 158 countries, spanning the 2000-2012 time period and covering 14 climate-relevant sectors[1]. The share of private finance per sector varies from 60% to 90% of total flows, except for the water and wastewater sector (35%).

With respect to the direction of flows, the private-public finance ratios are not significantly different between domestic and cross-border sources of finance. The ratio is, however, higher for flows in (7.2) and to (13.23) the North than in (2.56) and to (2.27) the South. In terms of volumes, North domestic and North-North flows jointly account for two-thirds of total global flows. As domestic private flows (in both the North and the South) outweigh cross-border flows by far, mobilising climate finance at scale requires targeting the mobilisation of domestic private finance along with foreign sources.

Multilateral actors, which are accounted for separately as part of this analysis, play a relatively important role in financing investment in the South. Public multilateral flows from the North to the South are equivalent to only 4% of domestic flows in the South (both public and private) and to 17% of the volume of bilateral North-South flows (both public and private), but are 8 times higher than bilateral South-South flows (both public and private).

[1] Advanced transportation, biofuels, biomass and waste, carbon capture and storage, digital energy, energy efficiency, energy storage, geothermal energy, hydrogen and fuel cells, marine energy, small hydro, solar energy, water and wastewater, and wind energy.

Econometric analysis of determinants of private climate finance for six renewable energy sectors

The econometric analysis focuses on six renewable energy generation sectors (biomass, geothermal, marine, small hydro, solar, wind) for 769 country pairs (74 different source and destination countries) covering the 2000-2011 time period. In addition to several public finance and public policy interventions, the econometric model takes into consideration a number of country conditions likely to influence levels of investment flows in general. The choice of explanatory variables was, however, constrained by the lack of systematic data. For instance, while foreign direct investment (FDI) would usefully proxy investment conditions, FDI statistics are not collected and disaggregated in a way that can be used here.

Overview of explanatory variables included in the econometric model

Public finance interventions	Public policy interventions	Country and market conditions
Bilateral and/or domestic finance : · Debt and equity · ODA grants* · ODA debt* · Officially supported export credits Multilateral debt and equity	· Feed-in-tariffs (in source and destination country) · Quota systems (in source and destination country) · Clean Development Mechanism (CDM) flows*	· GDP per capita · Electricity consumption growth · Geographic distance** · Presence of a contiguous border** · Common language** · Common legal systems**

* Only relevant for 'North-South' flows ** Between pairs of source and destination countries.

The econometric analysis of flows suggests that *the provision of public finance (domestic and bilateral combined) has a positive and significant mobilisation effect on private finance flows*, with a higher effect on domestic private finance than on cross-border private finance. When further disaggregated, the results suggest that public finance to and in the South is more likely to induce private investment than public finance to and in the North. Yet, once an investment decision has been taken, the effect on volumes of private finance flows is similar in the South and in the North.

The private finance mobilisation effect of multilateral public finance is also positive and statistically significant. The magnitude of the effect is comparable to that of public finance (bilateral and domestic combined), except for overall flows to and in the South where the effect of multilateral finance is lower. This difference is explained by the important mobilisation effect of domestic public finance in the South. Moreover, the results suggest that the effect of multilateral public finance is greater on the decision whether to invest at all, than on the volume of investment once the decision to invest has been taken. A possible explanation for these results is that finance provided by multilateral financial institutions may bring important additional benefits which are not fully captured in our model. For example, there may be important spillover effects through improvements in investment conditions in the destination country due to institutional and legal reforms. To the extent that our model fails to capture such spillover effects, the results reported here will be an under-estimate of the 'true' effect of multilateral finance.

Concerning the effect of public policy interventions, results for the worldwide sample suggest that *renewable energy policies in destination countries (here represented by FIT) play an important role (positive and significant coefficient) for both the investment decision and the volume of investment*. Such evidence indicates that if countries seek to encourage and effectively mobilise private finance investments, raising the ambition of policies in destination countries will be necessary (considering the choice of policy instruments that are most suitable to domestic conditions). On the other hand there is mixed evidence for the effects of FITs in source countries on flows to destination countries. Furthermore, there is no evidence that renewable REQ policies either in source or destination countries have an impact on the decision to invest. In terms of impact on investment volumes, REQ policies in source countries appear to be negatively correlated with volumes of private finance from source to destination countries. Although it is not clear what could be the rationale for this result, it might highlight a trade-off for the source country between mobilising private finance domestically and internationally.

In terms of public interventions that are relevant only in the specific context of North-South flows, greater volumes of CDM investment are correlated with private finance flows in following years. Concerning the private finance mobilisation effect of climate-related ODA (ODA grants and ODA debt i.e. concessional loans), evidence from the data sample and model used in this analysis is not conclusive.

Simulation of the mobilisation impact of past public interventions

Results suggest that *disregarding the role played by public policies in mobilising private finance can lead to an overestimation of the mobilisation impact of public finance*. A set of simulations are undertaken with the aim to help better understand the historical mobilisation impacts of both public finance and public policy interventions over the 2000-2011 period and across the six renewable energy sectors covered. We find that 15.7% of renewable energy-related private finance flows from the North to the South can be explained by the provision of North-South bilateral public finance. The corresponding figure for multilateral public finance is 14.8%. Overall, over 30% of North-South private climate finance for renewable energy was mobilised by multilateral and North-South bilateral public finance combined. When considering all geographical origins of public and private finance, 42.2% of total renewable energy-related private finance to, between and in the South is estimated to have been mobilised over the period 2000 to 2011 by the combination of bilateral and domestic public finance, and just below 12% by multilateral public finance.

On the other hand, a descriptive analysis using some of the existing qualitative methods to estimate mobilisation might account for 100% of all observed private financing as having been mobilised by public finance. The difference in percentages arises because quantitative approaches allow the impact of public finance to be separated from those of public policies such as FITs and REQs, while controlling for relevant market and country conditions. There are, however, other reasons that could help explain the relatively low percentages estimated here. One might be that the database on which this paper draws does not include data on projects below certain threshold capacities. If public finance tends to have a particularly important mobilisation impact on projects below these thresholds, then this will not be accounted for in our estimates. Furthermore, the data used might not capture the full range of upstream (e.g. corporate-level and fund-of-fund investments) and downstream public finance provided throughout the financial value chain and playing a role in mobilising private finance.

The part of renewable energy-related private finance to, between and in the South that can be explained by domestic FIT and REQ policies is very low. This is a consequence of the low levels of renewable energy policy support in countries of the South. In contrast, estimates of the impact of domestic policies on the level of mobilisation of private finance flows to, between and in the North suggest a much greater impact. In some cases, the effect of such measures is greater than the impact of public finance. Overall, these results demonstrate *the importance of ambitious domestic policy conditions to create an enabling environment to mobilise private climate finance, both in the North and the South.*

Overall, *68% of the flows to, between and in the South and 69% of the flows to, between and in the North are estimated to have been mobilised by the combination* of *the four public interventions considered* here (i.e. domestic/bilateral and multilateral public finance, FIT and REQ policies). However, the contribution of the different types of public interventions to mobilisation varies between the North and South. There is a greater mobilisation impact of public finance in the South while the impact of public policies is more significant in the North. The remaining volumes of private finance flows not explained by public interventions are explained by country and market conditions.

The potential of domestic policies to mobilise private investment at scale, particularly in the South, is highlighted by a hypothetical scenario in which domestic FIT and REQ policies in the South are set at a level comparable to the average level observed in the North. The results suggest for instance that while observed historical levels of domestic FITs explain only 3.8% of private finance for solar energy in the South, they could have mobilised 38.9% (or USD 50bn more) if support levels had been comparable to those in the North. Similarly, while observed domestic REQ policies were estimated to have mobilised 1.8% of private finance flows to, between and in the South, they could have mobilised 42.3% (or 58bn USD more) if set at levels comparable to those in the North. These results remain illustrative.

Potential use of the research

As it stands, the results derived from this analysis may contribute to efforts to estimate private finance mobilisation in two ways:

- They may serve as a method to attribute known aggregate volumes of renewable energy-related private finance (mostly wind and solar) to the types of public finance and policy interventions (bilateral and multilateral finance, FIT and REQ policies) covered in the model developed. This makes it possible to estimate the amount of private finance mobilised collectively through these types of interventions by countries in the North into all countries of the South. Such an approach includes the possibility of attributing mobilisation to public interventions in the absence of public finance, which cannot be captured by methods based on measuring co-financing. At this stage, further disaggregation of the analysis and its results for individual public finance instruments (grants, loans, equity) and/or individual countries or group of countries (e.g. low-, lower middle-, upper middle-, high income) is not possible. This is because the sample size (number of observations) for such sub-categories would be too small to produce statistically significant results.

- They could be used to construct more qualitative adjustment factors that could be applied to mobilisation observed at the project level. This could for instance involve a public financial institution adjusting its reported mobilisation effect for a typical renewable-energy project based on the presence of a FIT or strong private investment environment. Since this process involves considerations of additional variables (e.g. country and market conditions or public policies) to explain a fixed amount of private finance, the end result would most likely be to attribute a smaller volume of finance to project-level public finance interventions. In contrast, observed unadjusted measurements of mobilisation are often based on attributing all private co-financing to public finance interventions, thereby failing to consider the mobilisation effect of public policies and the role played by country conditions.

More generally, econometric methods may provide an important value-added towards analysing and estimating private finance mobilisation. This is because they make it possible to separate the relationship between private finance and various public finance and policy interventions, while controlling for other factors that might affect private finance flows.

This analysis is a first attempt to estimate private climate finance mobilisation empirically. An important limitation regarding coverage of the database used for this analysis is the threshold for inclusion of renewable energy generation projects (e.g. >1MW capacity for solar and wind energy projects). This limitation implies for example that households' investments are not covered, which, in turn, might have implications for the coverage of financial flows to middle- and low-income countries. Hence, a selection bias could arise if flows to developing countries (in particular lowest-income) tend to disproportionately finance the deployment of smaller projects (e.g. solar cookers). In addition, the analysis could not include transactions for which the monetary value was not disclosed (just below 30% of cases). The estimated effects of public interventions are therefore exploratory and remain open to refinements, subject to better data availability. They should in particular not be extrapolated beyond the six renewable energy sectors or to other types of public finance and policy interventions than those covered. Further, the estimated effects of public finance on private finance flows should be interpreted as correlations, because there are currently not enough data to investigate these effects in terms of causality.

Pending additional data series becoming available, future work could:

- Cover climate-relevant sectors beyond renewable energy (e.g. transportation, energy efficiency).
- Expand the range of public interventions considered (e.g. public finance de-risking instruments, tax reliefs) and country conditions (e.g. investment conditions and ease of access to finance).
- Break-down the analysis and results to a more granular level for sub-sectors, individual public finance instruments, individual countries or groups of countries.
- Attempt explicitly to model the dynamic and possible reinforcement effects of past public interventions, compared to the present static model that only captures the contemporaneous impact of public interventions.
- Investigate causality between public interventions and private finance, subject to finding suitable instrumental variables to analyse possible endogeneity between private finance (dependent variable) and public finance and policy interventions (explanatory variables) i.e. the possibility that public finance and policy interventions might, to some extent, be a function of factors that also influence private finance.

1. INTRODUCTION

The scale of required investments to finance climate change mitigation and adaptation worldwide has led to an increased focus on the role of private finance. This focus is relevant not only due to limited public financial resources, but even more so given the important private benefits (financial returns) generated by such investments. In particular, it is important that public spending does not "crowd out" private investment. Rather, public finance should focus on where it is most needed to compensate for the absence of private financing altogether and to mobilise additional private sector engagement. Public interventions more broadly (finance and policies) have a key role to play in encouraging and mobilising additional private investments to low-carbon, climate resilient projects and activities.

Estimates of the current scale of climate finance suggest that private flows outweigh public flows (Buchner et al. 2014; Clapp et al. 2012). Private climate finance has therefore already become a central element spurring low-carbon climate-resilient growth, including in some developing countries. In the context of the United Nations' Framework Convention on Climate Change (UNFCCC), countries referred to as developed have committed to a goal of mobilising jointly USD 100 billion per year by 2020 for climate action in developing countries. Under the agreement, these funds may come from a wide variety of sources, public and private, bilateral and multilateral, including alternative sources.

Tracking private climate finance, together with public finance, is thus a key task in monitoring progress in the international effort to address climate change in developing countries. There is precedent for monitoring and reporting public climate finance, such as climate-related official development assistance (ODA) monitored and reported by the OECD Development Assistance Committee (DAC)[2], as well as climate finance provided and jointly reported by multilateral development banks (MDBs) on the one hand, and members of the International Development Finance Club (IDFC)[3] on the other hand. However, there is a lack of comprehensive data and no formalised methodologies both to monitor private finance and to estimate its mobilisation by public interventions. Developing measurement and reporting methods is complex but crucial to facilitate an informed evidence-based discussion about the extent to which private finance is being and can be mobilised by public finance and policy interventions. To this end, significant data, methodological and knowledge gaps as well as inconsistencies need to be tackled, including in particular a need to reconcile:

- Project- or institution-specific methodologies to account for private finance mobilisation, which are time-consuming approach with problems of transferability of findings across markets and policy contexts. Moreover, project-level estimates may overestimate the mobilisation impact of public financial instruments by not accounting for the effects of public policies and the role of country and market conditions (e.g. well-functioning financial markets);

- Private-public finance leverage ratios put forward by public finance providers to date are based on averages from multiple project-level studies, which make it difficult to account for the

[2] List of DAC members: www.oecd.org/dac/dacmembers.htm

[3] Further information at: www.idfc.org

particularities of individual projects and contexts. Using such ratios can thus result in large errors when calculating amounts mobilised at aggregate levels. Moreover, they often fail to isolate the effect of finance from the effects of wider policies and framework conditions.

The aim of this study is to contribute to addressing this research gap by using econometric methods. Applications of econometric methods may provide an important value added because they allow for the isolation of the relationship between private finance and various public interventions (public finance and public policy), while controlling for other factors that might also affect private finance flows (such as institutional framework, demand for energy services in general, etc.). The approach adopted involves combining a number of datasets to account for the respective private finance mobilisation effect of various public finance and policy interventions as well as country and market conditions. For reasons of data availability, the focus of the econometric analysis is on six renewable energy sectors (wind, solar, biomass, small hydro, marine and geothermal) that constitute only a subset of all climate mitigation and adaptation projects and activities. Pending additional data becoming available, future work could use a similar methodology and expand the analysis to cover climate finance beyond renewable energy.

The analysis presents adjusted estimates of the private finance mobilisation effect of several types of public finance and policy interventions. This is done by quantitatively estimating partial correlations, effectively decomposing (isolating) the effect of individual types of public interventions from other factors. It is intended for the empirical approach adopted and results from this paper to provide a possible methodological option for developed countries to estimate the extent to which their public interventions mobilise private climate finance. However, normative recommendations on the application of such methodology and its political acceptability (in particular for accounting purposes under the UNFCCC) are beyond the scope of the present study.

The report is structured as follows:

- Section 2 puts forward working definitions and situates the techniques used in this analysis within a proposed taxonomy of possible methodologies for analysing and estimating private finance mobilisation.

- Section 3 then introduces the dataset used for quantifying investment flows in fourteen climate-related sectors as well as the methodology applied to structure the data in a transparent way suitable for econometric analysis.

- Section 4 consists of a descriptive analysis of flows: it presents observed public-private finance ratios disaggregated by all fourteen climate-related sectors, direction (source and destination) of flows, and transaction types.

- Section 5 starts by introducing the econometric methodology for analysing the determinants of private finance (public interventions as well as market and country conditions). The results of the econometric analysis are then presented, first for total flows (all directions) and then specifically for flows to, between and in countries of the ‘South’. The section goes on to simulate the likely mobilisation impact of past public interventions in these six renewable energy sectors.

- Section 6 concludes the paper and highlights possible uses of the results of this study as well as the need for further research towards developing more comprehensive methodologies for analysing and estimating private finance mobilisation.

2. THE LEVERAGE AND MOBILISATION OF PRIVATE CLIMATE FINANCE

The terms 'co-financing', 'mobilisation' and 'leverage' are frequently used interchangeably by the climate finance community when describing the relationship between public finance (or sometimes broader public interventions) and private finance. In particular, the term 'mobilise' is used in the context of the aforementioned USD 100 billion commitment under the UNFCCC, without a clear definition being provided (Caruso and Ellis, 2013). A degree of uncertainty therefore prevails as different stakeholders use these terms inconsistently and sometimes interchangeably. Annex 1 provides definitions based, where possible, on internationally-recognised sources[4]. In the context of this study these terms are used as follows:

- *Co-financing* for the amount of private financing associated with public financing in order to finance a specific investment, project or activity.
- *Mobilisation* for the amount of private finance resulting from public interventions.
- *Leverage* for the ratio between the amount of mobilised private finance and the public "effort"[5] having led to this mobilisation.

While the measurement of private co-financing is relatively straightforward (assuming data is available), measuring mobilisation (and by extension leverage) introduces a notion of causality between the public intervention and the amount claimed to have been mobilised as a result of this intervention. The specific question of how to actually define private versus public finance is addressed in the 'Data' Section of this paper (3.3 Public versus private flows).

Decisions to invest in or provide funding to a project or activity do not happen in a vacuum. Whether a corporation or fund purchasing equity shares, or a commercial bank providing loans, private investors usually make a choice based upon a weighing of the costs and risks on the one side, against expected income and financial return on the other. Public interventions, in isolation or combination, directly or indirectly send signals, provide (dis)incentives, and/or extend financial support that can reshape both sides of the perceived risk/return equation. These interventions range at the one end from defining and implementing overarching policies to the use of specific public finance instruments at the project-level. In the context of investment in renewable energy, Table 1, although not aiming to provide an exhaustive overview, illustrates one way of summarising the spectrum of public interventions as well as the underlying country and market conditions that can play a role in mobilising private capital and finance.

[4] Adding to this spectrum, economists often speak of "crowding-in" of private efforts defined as positive spillover effects of government actions (hence, equivalent to "mobilisation") and "crowding-out" of private efforts as the negative analogue. It is important to note that both effects may be present simultaneously, underscoring the value of using econometric methods.

[5] Due to the inherent difficulties in translating public interventions into monetary terms, the donor's effort has typically been measured as the provision of public finance only (see Annex 2 for further details); concerning the ambition of public policies, corresponding quantitative measures are developed in Section 5.

Table 1. Examples of public interventions and country characteristics for investments in renewable energy

Public finance interventions	Public policy interventions	Country and market conditions
Grants	Feed-in tariffs[6]	GDP per capita
Lending (debt), both concessional and non-concessional	Quota schemes, portfolio standards, green certificates	Growth in energy markets, Energy prices (incl. taxes)
Equity investment	Tax reliefs, tax credits	Socio-cultural factors
De-risking instruments (guarantees, export credits, insurance)	Clean Development Mechanism (CDM)/ Joint Implementation (JI)	Investment conditions
Support for demonstration projects	Reducing fossil fuel subsidies	Maturity of financial sector

The private finance mobilisation impact of public finance is likely to be more easily identifiable (and possibly quantified) than the less tangible impact of policies. However, the latter must not be neglected if the objective is to meaningfully analyse how and why such mobilisation takes place. It is the combination of the various types of public interventions – finance and policies – over a period of time that ideally needs to be accounted for in estimating their impact on private decisions to invest or provision of finance. The econometric analysis presented in this paper (Section 5) estimates the effect of most of the examples of public finance and policies as well as country and market conditions listed above. The final inclusion of variables was, however, partly restricted by the unavailability of data (e.g. de-risking instruments are only partially covered due to limited coverage by currently available datasets[7]) or of suitable data series. For instance, while a Foreign Direct Investment (FDI) variable could be usefully included as a proxy for investment conditions, FDI statistics are not collected in a suitable way for the purpose of this study. Section 5.1 provides further details on the empirical and model specifications, including the choice of explanatory variables.

Annex 2 presents the results from an in depth literature review conducted as a preliminary step to developing the econometric model. It highlights that academic literature only provides generic considerations for likely determinants of levels of non-climate-specific investment and financial flows. In the specific context of climate finance, there appears to be a significant degree of uncertainty on how to best approach the measurement of private climate finance mobilised by public finance as methodologies are unsettled and required data not widely available. Moreover, with little documentation provided on the methodologies currently used to generate estimates, the various leverage ratios that have been put forward to date are difficult to interpret as well as likely to be inconsistent and imprecise. The following key methodological issues were identified based on the literature review:

- Little distinction is made between estimates based on different scales of measurement: project-level versus some higher level of aggregation;

[6] Feed-in tariff schemes are classified as public policy rather than public finance because they reward (all) renewable energy generators with a preferential tariff for the electricity/heat that they feed into the grid. They target an outcome (renewably sourced electricity) rather than a given project (in a similar way as, for instance, tax credits).

[7] In Section 5 we explore the role of guarantees for export credits, however given that this variable is broadly defined (for all sectors) the results and their interpretation are ambiguous.

- The clear focus is on public finance instruments while most often neglecting the less direct mobilisation impact of policies and country conditions;

- There is little to no consideration of spillover effects that might occur across or within sectors, countries or timescales e.g. those arising out of improvements in local absorptive capacity that in turn facilitate capital inflows.

In an attempt to provide more clarity, Table 2 outlines a proposed taxonomy of possible approaches for analysing and measuring the mobilisation of private climate finance. This study is quantitative and focuses on aggregate-level analysis (column D).

Table 2. Proposed taxonomy for analysing private climate finance mobilisation

	Qualitative Studies		**Quantitative Studies**	
Scale **Mechanism**	**A – Project level**	**B – Aggregate level**	**C – Project-level micro-data**	**D - Aggregate level (sectoral or macro-data)**
1 - *Public finance*: measure of private co-financing (no analysis of causality)*	Measured by some public finance providers e.g. EBRD (2012), Illman et al. (2014)	Measure of private co-finance at aggregate level e.g. descriptive section of the present study	Little work to date due in particular to lack of systematic data availability e.g. Cardenas et al. (2014)	Little work to date due in particular to lack of systematic data availability e.g. the present study
2 – *Public finance*: measure of the <u>direct</u> mobilisation effect (some degree of analysis of causality).*	Focus of most studies to date. Point volumes of finance (working assumption of causality) e.g. Mirabile, Benn and Sangaré (2013)	Average volumes mobilised (working assumption of causality) e.g. Stadelmann et al. (2013); Ryan et al. (2012)	Provides counterfactuals on public finance controlling for project characteristics. (decomposition of individual effects; possible to test for causality) e.g. Cardenas et al. (2014)	Provides counterfactuals on investment. (decomposition of individual effects; possible to test for causality + spillover effects) e.g. the present study
3 - *Public policies**: measure of the <u>indirect</u> mobilisation effect* (inducement effect)	Little past work; mostly qualitative (no analysis of inducement) e.g. Ockenden et al. (2012)	Little to no past work; mostly qualitative. (no analysis of inducement) e.g. Srivastava and Venugopal. (2014)	Provides counterfactuals on policy framework (inducement) e.g. Cardenas et al. (2014)	Provides counterfactuals on investment + policy framework (inducement + spillover effects) e.g. the present study

* Grants, equity, debt and de-risking instruments;

** Presence/absence and (where possible) level of ambition of policies, as well as considerations for country and market conditions.

More specifically, Section 4 provides an overview of observed aggregate level public-private finance split (i.e. respective co-financing shares) to fourteen climate-related sectors (cell D1). Section 5 presents the results of the analysis conducted to isolate and estimate the respective mobilisation impact of public finance (cell D2) as well as policies and framework conditions (D3). This is done for a subset of six renewable energy sectors (wind, solar, biomass, small hydro, marine and geothermal).

Both calculations at the individual project level and those at some level of aggregation have pros and cons involving trade-offs, in particular in terms of accuracy and transferability (scalability) of the results and underlying methodologies (Table 3). While project-level approaches have the potential to provide more accurate measurement of private co-financing, their failure to account for indirect effects will likely result in over-estimating the role played by public finance in mobilising private capital. This is an important limitation to bear in mind from the perspective of estimating and reporting both private finance mobilisation (at sectoral, country and/or international levels) as well as effectiveness (assessment of the effective use of public funds and of the impact of policies).

Econometric techniques allow for the estimation of partial correlations between the occurrence of private finance and individual factors relating to a range of public interventions (finance, policies, and measures) as well as broad market and country conditions. These techniques further make it possible to investigate spillover effects, test for causality, and, most importantly, draw generalised policy conclusions. However, they also face their own set of difficulties, such as the level of detail that can be accounted for, required variation in data, sample selection issues, as well as data availability and quality more broadly. This means that if decision-makers seek empirical guidance to estimate the mobilisation impact of broadly-defined and widely applicable public interventions (e.g. loans and feed in tariffs in generic terms), then econometric studies have the potential to provide a value added. However, for guidance and estimation of mobilisation resulting from public interventions that have been less frequently used (e.g. renewable energy tenders) or are highly context-specific, conducting a case study may remain a more practical option.

Table 3. Pros and cons of the alternative approaches to estimate private finance mobilisation

	Accuracy	**Transferability (scalability)**
A – Observed mobilisation at the individual project level	Potentially high accuracy of the calculated direct effect; yet, failure to account for indirect effects will most likely yield over-estimates of the effects of the former.	Low; difficult to find projects which are comparable across all relevant factors
B – Average observed mobilisation across project types, financial instruments, countries and contexts	Low accuracy (an average cannot accurately represent its components) for calculating direct effect and failure to account for indirect effects.	Intends to be transferable but lack of accuracy does not permit transferability in a meaningful way
C – Estimated mobilisation at the project level	Good accuracy for calculating direct and indirect effects; however, sensitive to the sample size and the modelling strategy.	Transferability increases with the size and coverage of the estimation sample.
D – Estimated mobilisation at the aggregate (sector or country) level	Increasing ability to factor in the impact of policy interventions; however, not clear what are the implications for ability to accurately represent direct effects. Moreover, can account for effects of other contextual factors which may correlate with presence of public finance or policy interventions. Level of accuracy is sensitive to the sample size, data quality and the modelling strategy.	High, if representative sample size; allows decomposition into contributions due to public finance and key public policy instruments, as well as contextual and country characteristics. However, results not transferable beyond the scope of data and variables covered by the model.

3. DATA

The Bloomberg New Energy Finance (BNEF) database is used to construct measures of financial flows directed towards selected climate-related sectors. The extraction from the database that is used in this study includes financial deals that: (i) originate from 156 different countries; (ii) flow to 158 countries; (iii) span the 2000-2012 time period; and, (iv) cover 14 climate-related sectors (see Section 3.5 Sector coverage).

While climate mitigation and adaptation activities and projects span across a wide range of sectors, Section 4 (Descriptive analysis) of this paper only covers this selection of 14 climate-related 'sectors' for which data on financial flows are available from BNEF, while Section 5 (Econometric analysis) focuses on a narrower subset of 6 renewable energy sectors (wind, solar, biomass, small hydro, marine and geothermal) for which related policy and market data are available.

3.1 Types of finance

In this paper we use BNEF's data on the following four types of financial transactions: Asset Finance deals (22657 observations, including both debt and equity), Corporate Debt (697 obs.), Venture Capital & Private Equity (4101 obs.) and Grants Awarded (2073 obs.). The analysis could not include transactions for which the monetary value was not disclosed (close to 30% of cases).

BNEF defines *asset finance* deals as "investments (debt or equity) in a specific clean energy generation project".[8] According to the BNEF metadata, these deals cover all marine, solar, wind and geothermal energy generation projects with at least 1 MW of installed electric capacity. The coverage for hydropower[9] is restricted to projects within the 1-50 MW range of installed capacity (BNEF 2012). For the purpose of this paper, we include only deals that finance new investments. We exclude refinancing transactions as such transactions are conceptually different and thus would demand a different modelling approach.

Venture capital (VC) is defined as the funding of development and initial commercialisation of technologies, products and services. These are typically high-risk, high-return initiatives. *Private equity* (PE) transactions are investments in more mature companies that typically fund the expansion of an existing business. *Corporate debt* is defined as non-government debt securities.[10] Only those transactions explicitly identifying the debt provider and debt acquirer are considered. Finally, *grants awarded* are defined as non-repayable funds disbursed by a donor to a recipient.

We distinguish two basic data objects in the BNEF database - financial transactions and organisations (firms, government agencies, etc.) - and construct a dataset that links the financial transactions with the

[8] Note that the definition used by BNEF might differ from other common uses of the term "asset finance".

[9] The inclusion of large-scale hydropower (>50MW using the BNEF definition) as a renewable energy source is controversial due to various negative impacts on ecosystems and local communities.

[10] www.businessdictionary.com/definition/corporate-debt.html#ixzz2iSUO3RIu

associated organisations. The relationships between these data objects vary according to the type of transaction, as summarised in Table 4. It is worth noting that, given the relationships between the different types of transactions along the finance value chain, some amounts might be included in more than once e.g. a corporate financing upstream might finance an asset downstream. The structure of the BNEF database does not allow netting this out.

Table 4. Types of financial transactions and organisations' roles

Types of financial Transactions	Roles of organisation
Asset Finance	· Debt Provider · Equity Provider
Venture Capital / Private Equity	· Investor · Capital acquirer
Corporate Debt	· Debt Provider · Debt Acquirer
Grants Awarded	· Donor · Recipient

Other types of financial transactions such as *mergers and acquisitions* and *public market operations* are not included in our analysis due to the lack of a clear definition of the source and destination of financial flows involved in the transactions:

- For mergers and acquisitions, it is for example not clear whether the transaction should be from the country of the buyer to the country of the seller, or from the country of the buyer to the country of the facility. More broadly speaking, this type of transaction typically does not reflect additional finance but rather changes in ownership.

- For public market, BNEF does not include information on the country of origin of funds raised. Furthermore, public market transactions are difficult to track given the high volumes and frequency of trading across multiple public global markets, and the risk of double counting or failing to identify the last owner of the asset.

3.2 Complex deal structures

There might be multiple organisations taking on a given role in each transaction. For example, there might be multiple debt providers involved in financing a project or equity investors in a venture capital transaction. However, the BNEF database does not provide information on the actual split of finance between these organisations. Such lack of breakdown of the specific portions of the finance provided by individual financiers involved is a common problem with databases monitoring and reporting financial transactions (Caruso and Jachnik, 2014). In cases where more than one organisation takes on the same role, we therefore take the pragmatic approach of calculating an unweighted fractioning of the value of the transaction for each organisation taking part in the deal. We apply such fractional counts for all types of transactions. For example, if we have three donors in a grant transaction, a third of the value of the grant is attributed to each donor. In the case of asset finance deals where we have both debt providers and equity providers for the total deal value, we use the gearing ratio (the ratio of long-term debt to equity) to compute the total share of debt (or equity) in the transaction value and then apply the unweighted fractional counts for debt and equity providers.

This approach deconstructs each transaction into multiple "fractional deals" corresponding to the combinations between the multiple financing organisations. Hence, the sum of the fractional values issued for a single transaction is equal to the total transaction value. Such fractioning procedure can be a methodological limitation given that it allocates an equal part of the transaction to each organisation when the split is not known. However, given the relatively small number of observations with multiple finance providers (6506 observations representing 14.2% of the total), we believe that the extent of this problem is reduced when flows are aggregated to the macro-level. Overall, our matched dataset contains 45818 (fractional) financial transactions[11] involving 14271 distinct organisations.

3.3 Public versus private flows

As illustrated by Table 4, we construct a dataset linking the financial transactions to the various organisations associated with these transactions. Transactions (or their fractions) are then classified as private or public according to the immediate ownership status of the organisations that provided the financing. BNEF's definitions of types of actors/organisations, from which our classification of public versus private is derived (see Table 5 below) are shown in Annex 3. It is important to note the availability and use of multiple definitional options to categorise actors as public or private. Alternatives to the immediate ownership principle used for the purpose of the present study include applying the ownership principle at the intermediate or ultimate parent level, as well the use of risk-based principles e.g. degree of commitment of government intervention in case of default (Caruso and Jachnik, 2014).

Transactions (or their fractions) are considered as public if the funds are provided via government entities, state-owned enterprises, academic and research foundations, and public charities. Flows originating from these entities, including public multilateral and bilateral development banks and agencies, are therefore by default classified as 100% public in origin, which is consistent with the DAC definition of official transactions: "*Official transactions are those undertaken by central, state or local government agencies at their own risk and responsibility, regardless of whether these agencies have raised the funds through taxation or through borrowing from the private sector. This includes transactions by public corporations i.e. corporations over which the government secures control by owning more than half of the voting equity securities or otherwise controlling more than half of the equity holders' voting power; or through special legislation empowering the government to determine corporate policy or to appoint directors*." (OECD DAC, 2013). It should, however, be noted that a number of public banks, funds and state-owned companies raise resources from capital markets, where subscribing investors are often (though not always) private. For instance, multilateral development banks increasingly issue green or climate bonds, part of which are subscribed by private investors. Disentangling public and private capital in the total resources of financers classified as "public" would, however, require detailed case studies, while it would still not allow for the identification of the true origin of finance. Depending on the viewpoint one takes in the finance value chain, any given amount might therefore be rightfully labelled as public and private, e.g. government spending (public) is raised from households (private), while private investors and finance providers can benefit from public financial participation and backing.

A further distinction, which is fundamental for our research question of analysing the mobilisation impact of different types of public interventions, is the subsequent classification of these organisations as

[11] We restrict the analysis to the 45818 completed transactions, which represent 88% of the disclosed transactions in BNEF data at the time of extraction; announced (9.4%), missing (1.9%) and abandoned (0.7%) transactions are excluded. These numbers are counts of fractional transactions, not the actual observations. Moreover, they also reflect the fact that we split AF-debt from AF-equity.

bilateral or multilateral public institutions.[12] This allows for an informed decision whether to attribute (or not attribute in the case of multilaterals) the source and destination countries of the financing, an issue which is discussed in detail below.

Transactions are classified as private if the funds are provided by family-controlled enterprises, quoted companies, joint ventures, consortia, partnerships, pre-institutional funding[13], special purpose vehicles, individuals/business angels networks, subsidiaries, private equity or venture capital firms, as well as private charities, non-for-profit and associations.[14] The amount of private finance in a transaction is then obtained as the disclosed transaction value of that transaction coming from private providers of finance.

Table 5. Classification of finance providers

<table>
<tr><th>Ownership classification</th><th>BNEF classification</th></tr>
<tr><td>Public bilateral</td><td rowspan="2">Government / public sector *
State-owned commercial entities *
Academic / research foundations *
Public charity</td></tr>
<tr><td>Public multilateral</td></tr>
<tr><td>Private</td><td>Individual / angel network,
Joint venture / consortium,
Partnership (investment, law, etc.),
Pre-institutional funding,
Private / family-controlled,
Quoted company,
Quoted-OTC,
Special Purpose Vehicle (SPV),
Subsidiary / division,
VC / PE funded
Private charity / non-profit / association</td></tr>
<tr><td>Excluded</td><td>Defunct</td></tr>
</table>

* All organisations in these classes have been reviewed on a case-by-case basis and, where applicable, classified as multilateral institution. In some cases organisations are reclassified as private organisations, notably within the “charity” category.

3.4 Sources and destinations of flows

Having identified the characteristics of the organisations that take part in the transactions, we then, for every transaction, attribute a source and a destination country of the financial flow. Similarly to categorising actors as private or public, there are different methods to characterise their country of origin. It can be broadly based on the location of the actor (e.g. corporate or tax base home), its ownership structure, its centre of economic interest, and/or origin of its revenues. These methods can lead to differing results, with the latter three requiring significant data post-processing and combining various datasets in that process (Caruso and Jachnik, 2014).

[12] This classification was done on a case-by-case basis drawing on a concordance developed by Mariana Mirabile of OECD/DCD. In some cases organisations, under the mentioned BNEF’s classifications, were reclassified as private organisations (highly relevant for academic & research foundations, and charity & non-profit associations).

[13] Defined as companies that have been set up, usually to commercialise intellectual property or technology, but are either at a very early stage or have not yet risen funding from an incubator, venture capital, private equity company or corporate venturer. They may be spin-outs from a university, company or other organisation, or they may have just been founded by an entrepreneur to exploit a market need (BNEF 2012b).

[14] Defunct organisations are excluded from the classification. They concern a very small share of organisations. Their volumes of finance cannot be attributed to a private or public classification.

For the purpose of the present study, geographical attribution is based on location. For example, an *asset finance* deal financing a wind electricity generation project has as a source country (or countries) the country of residence of debt and equity providers and as a destination country the physical location of the project. However, defining and determining the source country is not always straightforward. For example, it is not clear how the source country should be defined (e.g. location of headquarters of the parent company or of the local affiliate providing the financing), or how financial intermediaries and tax havens should be treated. Using the data at hand, we are not able to make these distinctions. We therefore assign source countries based on BNEF's tagging of headquarters' location.

The geographical attribution of finance becomes even more complex in the case of flows not linked directly to an asset, such as *corporate debt*. In this case, the debt provider (i.e. the organisation providing money in exchange for a commercial paper or bond) is considered as the source of the finance while the country of the debt acquirer becomes the destination country. Following the same line of thinking, for *venture capital and private equity* transactions the source country is attributed to the investor while the destination is the country of the organisation receiving such investment. In the case of *grants*, information on donor and recipient organisation are used to attribute source and destination country respectively.

Given the importance of the correct attribution of the source and destination of finance in this paper, flows from/to multilateral organisations are considered separately and not attributed to specific origin countries. For instance, flows originating from the Asian Development Bank (ADB) could be wrongly attributed to the Philippines as the source country if one relies on the physical location of the institution's headquarters. In reality ADB's shareholders consist of 48 developing and developed members in Asia and the Pacific region, and 19 members from outside the region[15]. More generally speaking, authors acknowledge that principles to categorise and attribute actors as well as the finance they provide prove difficult to apply in a systematic manner, especially in the case of joint ventures or complex/pooled financial and fund structures (Caruso and Jachnik, 2014).

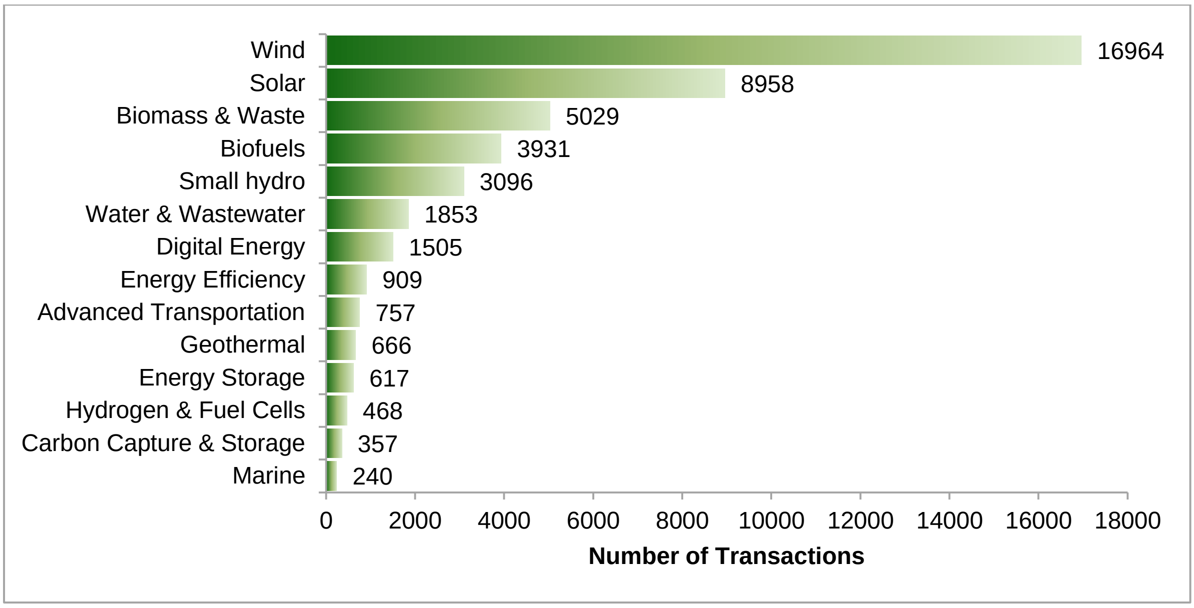
3.5 Sector coverage

Following the data processing described above, we obtain 45818 financial transactions (some of them fractional). In this paper, we re-group these transactions into 14 climate-related sectors (Figure 1 below) in order to reach a certain minimum number of transactions per sector.[16] Moreover, we exclude transactions (about 0.5%) that cannot be directly related to an investment in climate-related activities, including those classified under Government & NGOs (0.021%), Services & Support of Clean Energy (0.29%), General Financial & Legal Services (0.171%), Conventional Power (0.001%) and Nuclear Power (0.01%).

[15] See www.adb.org/site/investors/credit-fundamentals/shareholders for a full list.

[16] Financial transactions were originally classified (by BNEF) in 28 climate-related sectors. In particular, we re-group the sector labelled "Energy Efficiency" which now includes Efficiency in Built Environment (1.04%), Efficiency on the Supply Side (0.48%), Efficiency in Industry (0.46%); Hydrogen (0.19%) and Fuel cells (0.83%) are merged into a single sector; and "Water & Wastewater" now includes Water Storage (0.001%), Water Distribution (0.017%), Water Treatment (1.12%) Water Smart Technologies (0.001%), Wastewater Treatment (2.9%).

Figure 1. Number of financial transactions by climate-related sector (2000-2012)



Source: Constructed using BNEF data.

Note: According to BNEF's definition, digital energy is the convergence of the energy, telecoms and information technology industries. Examples of climate-related technologies within "digital energy" include smart grids (systems that monitor and control transmission and distribution grids).

The descriptive analysis presented in the following section (Section 4) covers these 14 climate-related sectors, while the econometric analysis (Section 5) focuses on a sub-set of six renewable energy sectors due to data availability constraints. A limitation regarding sector coverage is the threshold for inclusion of renewable energy generation projects in the BNEF database (e.g., >1MWe capacity for solar and wind energy projects). Such a threshold implies that households' green investments are not covered. This, in turn, might have implications for the coverage of financial flows to middle- and low-income countries. Hence, a selection bias could arise if flows to developing countries and in particular to lowest-income countries) tend to disproportionately finance the deployment of smaller projects (e.g. solar cookers), due to, for instance, a less developed electricity infrastructure. For example, based on the data at hand, 61% of flows (including cross-country and domestic flows) are directed to high-income countries with an average transaction value of 91m USD, on the other hand the remaining 39% of deals directed to middle- and low-income countries have an average value of 33m USD. .

3.6 Aggregation of finance flows

The final dataset used in this study provides information about total volumes of investment. It is constructed by aggregating individual financial transactions along four distinct vectors, or dimensions: source country, destination country, year and sector. In the final data set, financial transactions originate from 156 different countries, they flow to 158 countries, cover 14 sectors, and span the 2000-2012 period.

The aggregation of volumes of finance has three important implications:

- It allows for the identification of pairs of countries not investing in each other. It hence implicitly reconstructs the counter-factual. This is not feasible at the project level because only completed projects are observed.

- It makes it possible to identify the effects of both public finance and policy interventions and, possibly, test causal relationships. Such analysis at the level of case studies would require the comparison of two identical projects (unlikely in practice).

- It might allow for the measurement of spillover effects such as those arising out of improvements in local absorptive capacity that in turn facilitate capital inflows. Again, spillover effects can only be studied using data on many projects. On the contrary, the value added of studies of individual projects is the detailed information on financial characteristics such as concessional/non-concessional types of finance which can then be studied more carefully. Such details are often lost in aggregation.

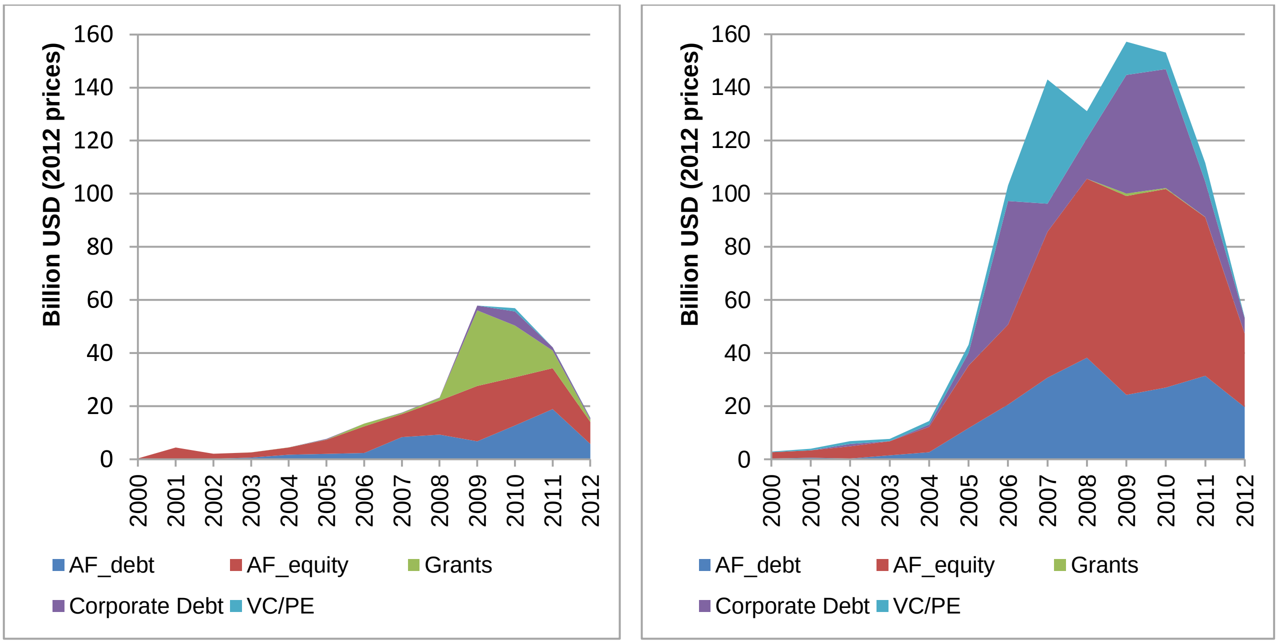
4. AGGREGATE FLOWS AND 'OBSERVED' PRIVATE-PUBLIC FINANCE RATIOS (DESCRIPTIVE ANALYSIS)

This section provides a descriptive overview of aggregate flows in the above-listed 14 climate-related sectors, originating from 156 countries, flowing to 158 countries, and spanning the 2000-2012 time period. Such aggregation was constructed from the BNEF database with distinctions based on ownership (private versus public), sector, source and destination countries (i.e. direction of flows), and type of finance. This section does not include any analysis of possible correlation between public finance (and other public interventions) and private finance, which is investigated in Section 5. Rather, Section 4 provides an order of magnitude of the public-private co-financing split at aggregate level (see cell D1 of Table 2). All finance volumes are expressed in 2012 constant USD.

4.1 Types of private and public transactions

Figures 2 and 3 highlight significant growth of both private and public finance in the 14 climate-related sectors up to 2007, the negative impact of the 2008 financial crisis on private flows with a rebound thereafter, and a noticeable decrease of both public and private finance in 2011 (2012 data does not cover the full year). Overall, yearly private flows outweigh public flows by a factor of approximately three. This further highlights the importance of examining how public interventions mobilise private finance.

Figure 2. Public (left) and private (right) flows per transaction type (2000-2012)



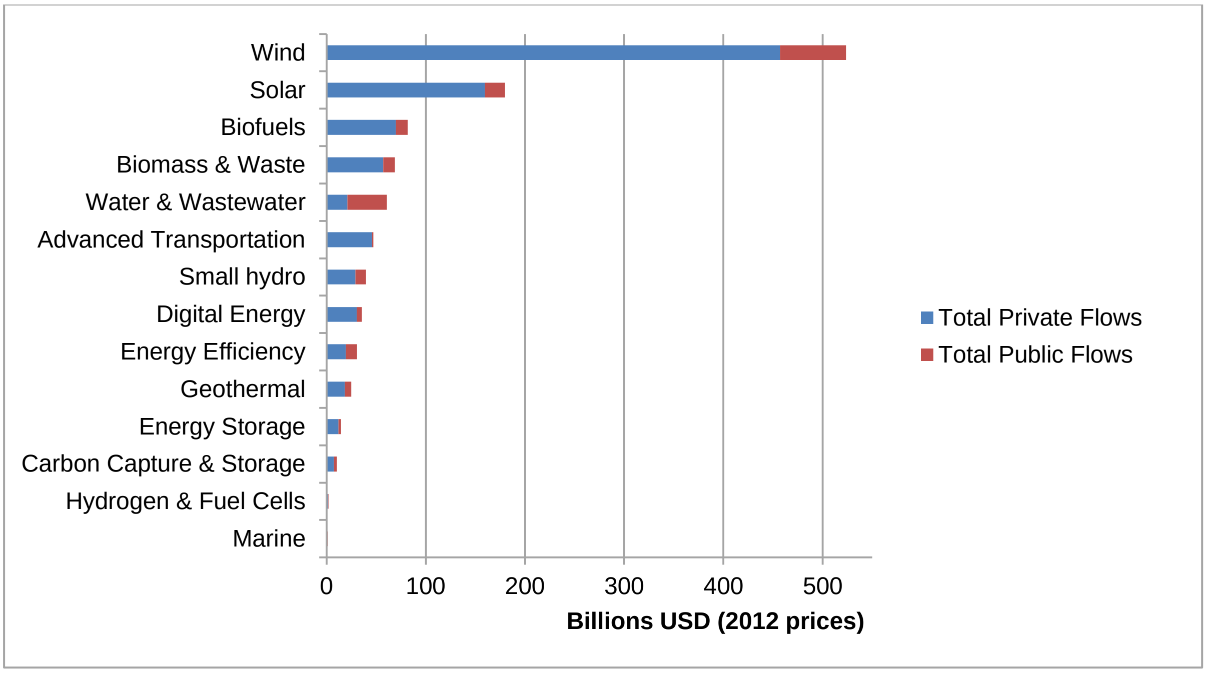
Source: Constructed using BNEF data
Note: 2012 data does not cover the full year

Recall that in terms of types of financial transactions, the working definition used in this analysis includes (based on BNEF nomenclature): asset finance (AF) debt, AF equity, corporate debt, and venture capital (VC) / private equity (PE). Grants are included a single time in Figure 2 but are then excluded from the rest of Section 4 due to the absence of coverage by BNEF prior to 2008 and its limited coverage of private grants altogether. Public finance instruments (including grants) are, however, fully accounted for as an explanatory variable in Section 5 (using the OECD Development Assistance Committee (DAC) data on climate-related Official Development Assistance (ODA)).

4.2 Characterisation of sectors

As per Figure 3, renewable energy, and in particular wind, represent the vast majority of the finance (both private and public) provided in the 14 climate-related sectors over the 2000-2012 period. This is likely due to a combination of fairly widespread and targeted public support (policies and finance) and the fact that these are relatively mature technologies. Marine energy is on the contrary characterised by less systematic government support[17] and is still at early stages of technological development; hence a significantly lower percentage (60%) of private finance co-financing than wind (87%) and solar (89%).

Figure 3. Volumes of public and private flows per sector (2000-2012)



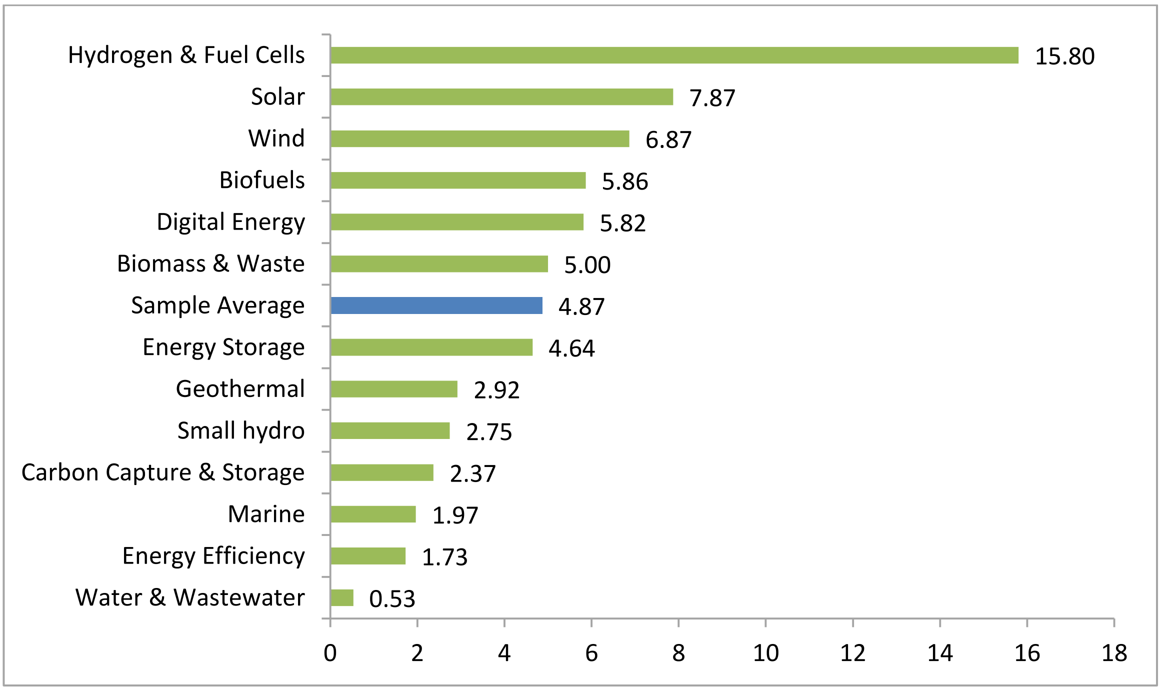
Source: Constructed using BNEF data.

As shown in Figure 4, private finance represents between about 60 to 90% of total flows in the climate-related sectors considered, except for water and wastewater (only 35%). It is possible that this sector is characterised by relatively lower expected private benefits (less attractive financial returns), since it is generally not as liberalised as the energy sector, and in many countries remains in the hands of state- or publicly-owned enterprises.

[17] The numbers presented here however do not include government-funded research and development programs, which are a type of public support that government often use for immature technologies.

A possible rationale to explain the pattern across sectors is that the shares are related to the ratio of private-to-public benefits of investment. For example, while solar and wind energy are relatively cost-competitive, CCS and marine energy are much less mature and competitive. The public sector may provide financing to such sectors in an effort to induce learning and reduce risk, bringing costs down in due course. Therefore, despite the overall magnitude of public and private investment into these sub-sectors being low, one would expect to see a high share of public co-financing.

Figure 4. Observed ratio of private to public finance per sector (2000-2012)

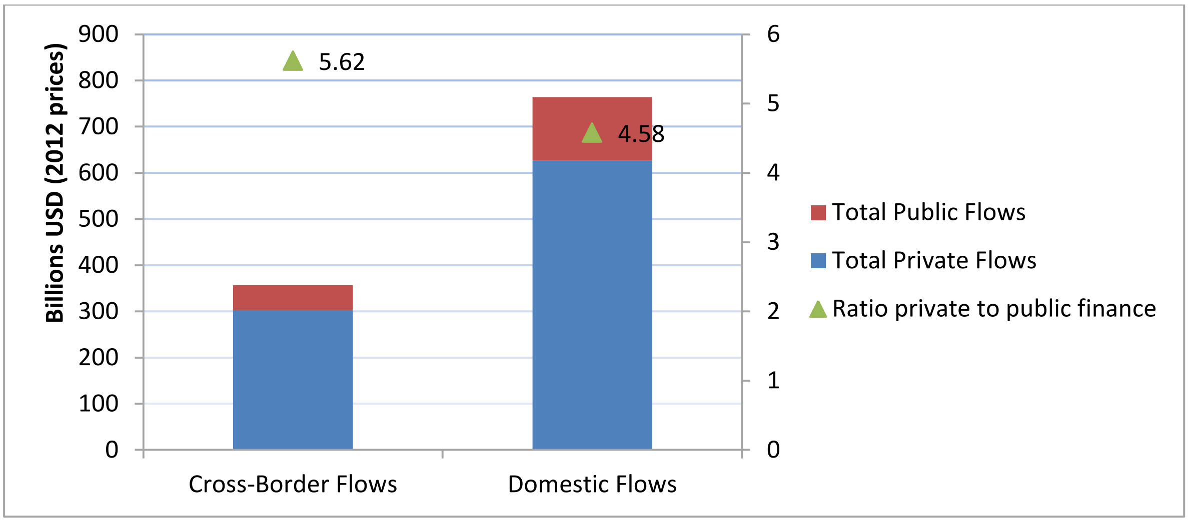


Source: Constructed using BNEF data.

4.3 Domestic versus cross-border flows

As illustrated in Figure 5, domestic flows (both public and private) outweigh cross-borders flows by more than double. This does not come as a surprise given that investors typically invest in what they know and understand best, which is generally in domestic markets. This highlights the need not only to look into the mobilisation of international private finance, but even more so to include domestic private finance in the analysis. In terms of ratio of private to public finance, the data highlights that cross-border flows have a higher private-public finance ratio than domestic flows, however, this difference is rather small.

Figure 5. Public-private split and observed ratios for cross-border and domestic flows (2000-2012)



Source: Constructed using BNEF data.

4.4 Direction of flows

To be able to present directional flows, countries are classified as North (developed) or South (developing). Various options of possible classification criteria were considered including the UNFCCC Annex I[18] versus non-Annex I[19] groupings. However, due to the lack of a systematic and regular updating process of the Annex I country list[20] this option was left aside in favour of the World Bank's classification based on gross national income (GNI) per capita. Based on the World Bank's classification, every country is classified as low-income, middle-income (subdivided into lower middle and upper middle), or high-income[21]. For the purpose of this study, low- and middle-income countries are grouped as South while high-income countries make up the North. This makes it possible to conduct the analysis based on country characteristics rather than using an ad hoc classification such as the current UNFCCC grouping, which lacks precise economic meaning in current times. The World Bank classification is revised and updated on a regular basis. A dynamic classification is therefore applied in this paper to reflect the changing classification of countries arising from changes in GNI over time. Focusing on country characteristics makes sense for the purpose of this analysis, which investigates the mobilisation effect of public interventions under various country and market conditions, rather than to track flows of finance between specific countries.

An alternative classification is the OECD-DAC list of ODA donors and recipients. However, only marginal differences were observed based on the examination of various trial runs based on DAC lists compared to numbers presented below using the World Bank classification. This is because the DAC recipient list is derived from (but not updated as frequently as) the World Bank's classification. Most importantly, the relevant differences, if any, are identified econometrically in Section 5.

[18] Full list: http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php

[19] Full list: http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php

[20] Only few new countries have acceded to Annex I over time (Croatia, the Czech Republic, Cyprus, Liechtenstein, Malta, Monaco, Slovakia and Slovenia).

[21] For more complete information: http://data.worldbank.org/about/country-classifications

An important methodological point is that public flows from/to multilateral institutions are isolated as part of this analysis. Conceptually, this is because these institutions constitute a separate source/channel of public finance compared to bilateral or domestic public finance, and we investigate their specific role in mobilising private finance. However, unlike bilateral flows, we are not able to assign a source country to multilateral flows due to a lack of adequate systematic methodology for accurately allocating multilateral institutions (e.g. banks or funds) and the finance they provide to upstream individual countries. Most of them have combined shareholding as well as receive funds from both multiple North and South countries, while the country where they are headquartered is typically not an accurate criterion for determining whether a given multilateral actor should be accounted for as originating from the North or the South.

An alternative could be to investigate in great detail the origin of the funding of multilaterals. In this context, authors acknowledge the OECD DAC methodology for calculating imputed multilateral ODA in the context of measuring donor efforts[22]. The method apportions and attributes to individual donor countries the disbursements of about 20 multilateral actors based on the percentage represented by an individual donor country's contributions in the same year to the core resources of the multilateral actor under consideration. As highlighted by the OECD DAC, any methodology for imputing multilateral flows to upstream individual countries can, however, only ever be an approximation. Reasons for this include the fact that core resources received by multilateral agencies are not earmarked for a specific purpose but rather pooled, as well as the existence of multiple funds and disbursement channels typically managed by multilaterals. Using imputed data as an input variable for the econometric model (Section 5) could compromise the integrity of the empirical analysis. In particular, imputed multilateral flows would result in an assumption of the existence of flows between pairs of countries, which in reality did not take place. This further motivated the methodological choice of not attributing multilateral finance to individual countries within the scope of the present study. In addition, as highlighted in section 3.3, multilaterals increasingly raise additional funds on capital markets, thereby making allocation to specific countries even more technically complex and inexact, as well as raising the question of the partially private origin of the resources managed by public finance institutions.

Figure 6 clearly illustrates that North domestic and North-North cross-country flows (although only half of the size of North domestic) jointly account for the vast majority of flows[23]. In the context of flows to, between and in countries of the South, incoming international flows are low in absolute and relative terms compared to domestic. Any analysis aiming at measuring mobilisation in the South therefore needs to account for how domestic flows are being mobilised. One important aspect to bear in mind is that two countries represent a very large proportion of domestic volumes due to the size of their renewable energy markets, including the USA for the North and China for the South. Although this greatly impacts the volumes presented here, such “over-representation” is investigated and accounted for as part of the econometric analysis (Section 5) and our results are robust to the exclusion of China from the sample (see Annex 4 for further details).[24]

[22] See: www.oecd.org/dac/stats/oecdmethodologyforcalculatingimputedmultilateraloda.htm

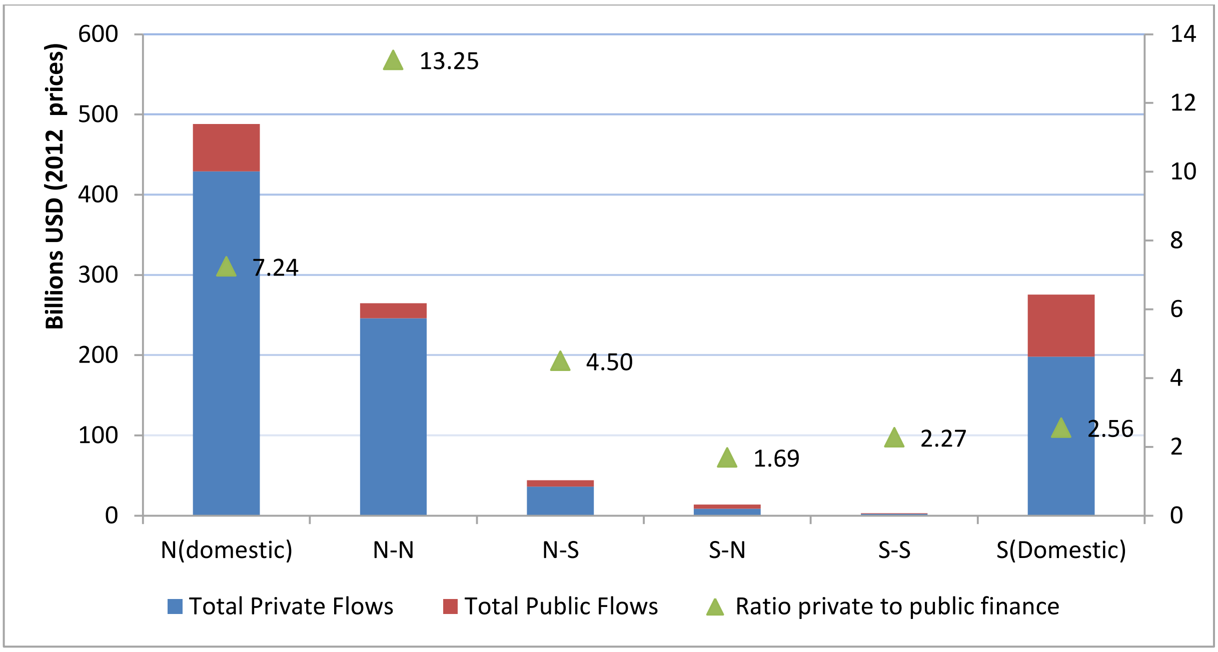
[23] The coverage threshold of the BNEF database (e.g. >1MW capacity for solar and wind energy projects) implies that small-scale transactions are not included. This could have a potential impact on the relative scaling of flows to/in the South versus flows to/in the North if the proportion of small projects financed in the South is significantly higher than that in the North.

[24] Within the group of ‘South’ it would be interesting to distinguish between middle-income and low-income countries. However, the sample is not large enough to provide reliable estimates for narrower definitions of the ‘South’. The number of observations for low-income countries is very low. The econometric analysis includes a variable for GDP-per-capita that controls precisely for this aspect.

Private flows represent the majority of finance flows in the 14 climate-related sectors in all directions. However, the ratio of private to public finance in (7.2) and to (13.25) the North is higher than in (2.56) and to (2.27) the South. Likely reasons for such variation include:

- Existence of well-developed private financial services industries (i.e. commercial banks, investment banks, funds, private equity and venture capital funds), established financial mechanisms as well as underlying policy support in the North;
- Less mature (sometimes possibly close to inexistent) private financial services industries in the South, combined with limited public support as well as partly inadequate country and market conditions to absorb both financing and industrial-scale energy technologies.

Figure 6. Public-private split and observed ratios for different direction of flows (2000-2012)

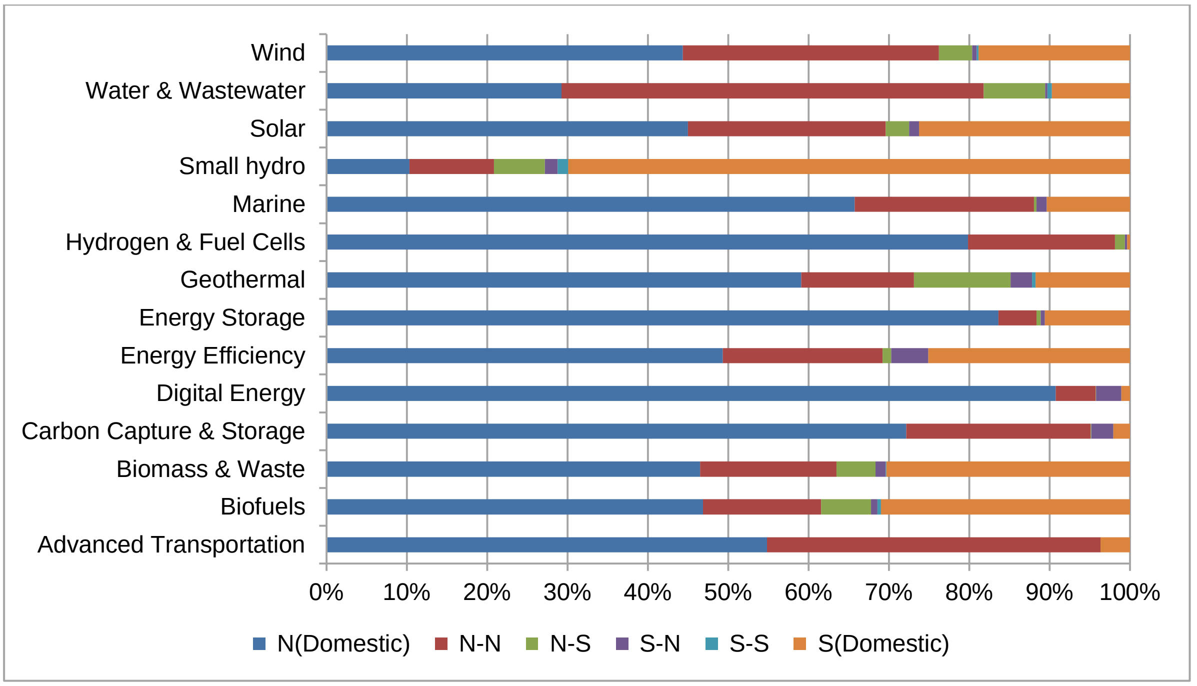


Source: Constructed using BNEF data. Country classification based on Gross National Income per capita.

In terms of direction of flows by sector, key observations from below Figures 7 and 8 include:

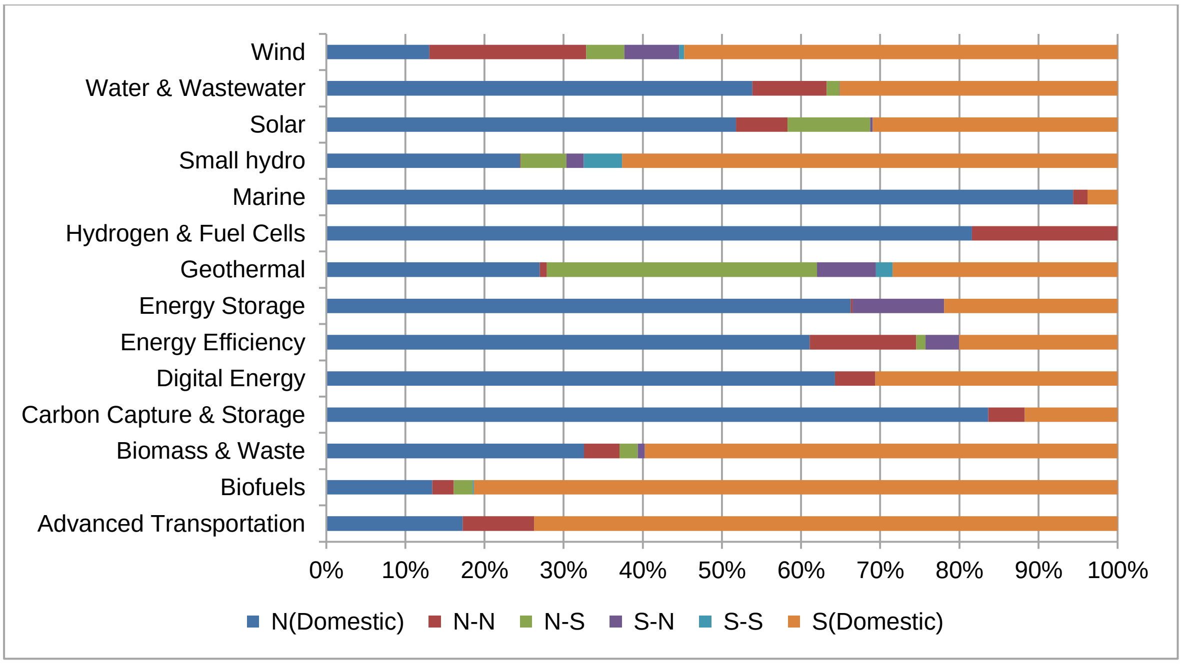
- A high share of South domestic private flows for small hydro (Figure 7); this could be explained by the relatively low-tech and decentralised characteristics of this sector, making it well suited for countries with less developed infrastructure.
- Low shares of South domestic and South-South public flows in hydrogen and fuel cells, marine energy, as well as carbon capture and storage sectors (Figure 8). The reason could be that the underlying technologies are still at very early stages of development, hence costly in the absence of public policy demand. Another likely explanation is that governments in the North are more likely than governments in the South.to be able to afford financing early stage deployment.

Figure 7. Private flows directional split per sector in percentages (2000-2012)



Source: Constructed using BNEF data.

Figure 8. Public flows directional split per sector in percentages (2000-2012)



Source: Constructed using BNEF data.

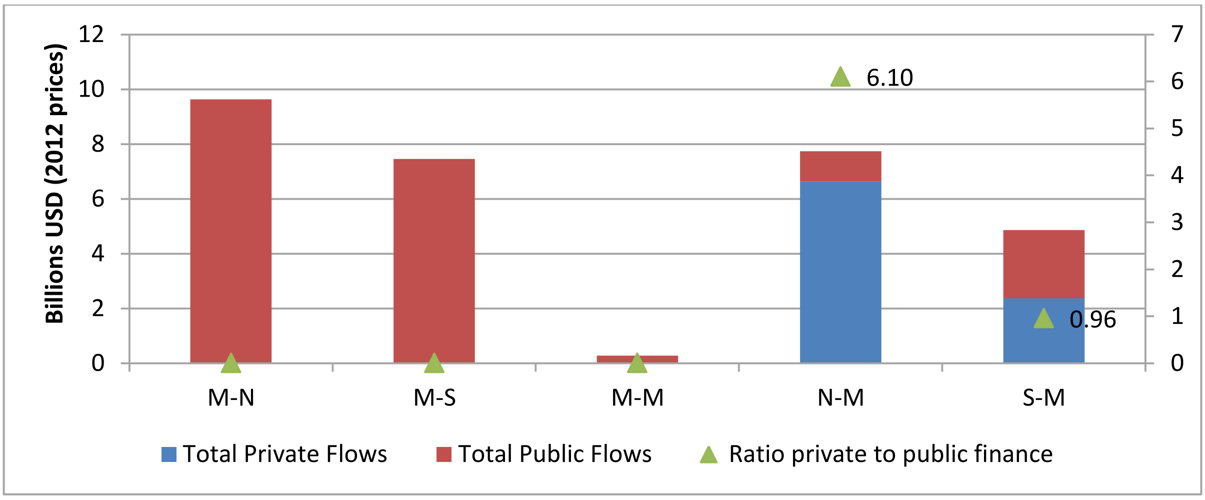
4.5 Role of multilateral flows

As previously mentioned, multilateral flows are accounted for separately from North and South bilateral flows. Figure 9 underlines the relative importance of flows from multilaterals finance compared to volumes of bilateral flows and domestic finance presented in Figure 6:

- Multilateral-to-North flows (below 10bn USD) captured by the data used for the purpose of this analysis originate 100% from public entities and only equivalent to about 2% to domestic North finance (488bn USD both public and private), and less than 4% to North-North flows (265bn USD both public and private).
- Similarly, multilateral-to-South flows (about 7bn USD) originate 100% from public entities and are equivalent to only approximately 17% of North-South flows (both public and private). They, however, outweigh bilateral South-South flows (both public and private) by a factor of close to 8.

Multilateral to South corresponds mostly to traditional development aid flows from multilateral banks and dedicated climate/green funds. In absolute terms, multilateral-to-North flows are higher than Multilateral-to-South; this might come as a surprise but can be explained by the fact that the 'multilateral' category includes not only funds and institutions dedicated to financing activities and projects in the South but also institutions active in the North (e.g. European Investment Bank).

Figure 9. Direction of multilateral flows and public-private split (2000-2012)



Source: Constructed using BNEF data. Country classification based on Gross National Income per capita.

Considering flows to multilaterals, public flows originate both from the North and the South; such mixed sources support the methodological choice of not allocating flows from multilaterals either to the North or the South.[25] Private flows from the North to Multilaterals are close to three times higher than those from the South to Multilaterals. The relative share of private finance to multilateral institutions[26] is much higher for flows originating from the North than those originating from the South. This could be explained by the greater maturity of capital markets and the private financial services industry in the North.

[25] Future work could consider examining the shareholding structure of multilateral institutions and sources of replenishments of their funds.

[26] In recent years, an increasing number of multilateral funds set up by public donors clearly aim for a significant private participation.

5. THE MOBILISATION IMPACT OF PUBLIC INTERVENTIONS (ECONOMETRIC ANALYSIS)

This section presents the econometric methodology for analysing the determinants of private finance (public interventions as well as country and market conditions). The results of the econometric analysis are then presented, first for total flows and then for flows to, between and in the North as well as to, between and in countries of the South. For reasons of data availability, the focus is on a subset of six renewable energy sectors (wind, solar, biomass, small hydro, marine and geothermal). Finally, the study assesses and simulates the likely mobilisation impact of past public interventions in these six renewable energy sectors.

5.1 Empirical specification

The construction of the model and its empirical specification are motivated by the literature on gravity models. Gravity models have been developed to study international trade (e.g., Feenstra et al. 2001) and applied to study the impacts of trade on the environment (e.g., Frankel and Rose 2005), to study international investment (Rose and Spiegel 2002; Keller and Levinson 2002) as well as international technology transfer (e.g., Keller 2002, 2004, 2009; Haščič and Johnstone 2011; Dechezleprêtre et al. 2013). Building on the approach adopted by these past studies, this paper models private financial flows as a function of bilateral (between pairs of countries) economic relations, proxied by geographic distance, proximity in investment conditions, public policy conditions, etc. Formally,

$$PrivateFinance_{ijkt} = \beta_0 + \boldsymbol{\beta_1'}\boldsymbol{PUBLIC}_{ijkt} + \boldsymbol{\beta_2'}\boldsymbol{MARKET}_{ijkt} + \boldsymbol{\beta_3'}\boldsymbol{CONTROL}_{ijkt} + \alpha_i + \gamma_j + \delta_k + \theta_t + \epsilon_{ijkt} \quad 1]$$

where $i = (1, \dots, I)$ and $j = (1, \dots, J)$ index respectively the source and destination country[27], $k = (1, \dots, 6)$ includes six renewable energy generation sectors (wind, solar, biomass, small hydro, marine and geothermal) and $t = (2000, \dots, 2011)$ indexes the year of the financial flow. As explanatory variables we include vectors (in bold) that describe the policy and the market conditions alongside a vector of control variables.

$\boldsymbol{PUBLIC}_{ijkt}$ is a vector of variables that capture public interventions that are hypothesised to have an effect on private finance through public finance and policy (see Table 1). Among the public finance interventions, we first include bilateral flows of $PublicFinance_{ijkt}$ to renewable energy in the form of debt or equity (for both asset corporate transactions) using BNEF data. Public grants are excluded due to limited coverage by the BNEF database, as previously highlighted. They are, however, included in the Official Development Assistance (ODA) variable (see below).

Second, we include public finance flows from multilateral organisations $Multilateral_{jkt}$ towards renewable energy sector k (using BNEF data) such as the World Bank, the Asian Development Bank, or

[27] Flows to multilateral organisations are excluded from all estimations.

Inter-American Development Bank. As discussed in Section 4, this variable is aggregated across all multilateral organisations due to the lack of adequate methodology for allocating finance from multilateral actors to specific source (donor) countries. Consequently, the variable does not vary across source countries.

Third, we include variables representing ODA monitored and reported by the OECD-DAC. ODA measures public concessional finance outflows from DAC member countries. It is the core component of developed countries' (North) financial support to developing countries (South). Our model includes the two main forms that ODA currently takes, ODA_loan_{ijt} and ODA_grant_{ijt}, narrowing the data to ODA related to climate-change mitigation activities (broader than renewable energy). These are monitored and reported using the Rio Markers. These variables are constructed using project-level information; Annex 5 provides a detailed description of the construction of these variables.

Fourth, we include two variables representing officially supported export credits: $Export\ Credits_{ijt}$ to represent the volume of public lending directly supporting a country's exports, and $Export\ Credit\ Guarantees_{ijt}$ representing the volume of private export credits guaranteed by public institutions. These two variables cover all sectors and activities because it is not possible to disentangle their energy, climate or environment components. Officially supported export credits can play a key role in the transfer and use of development-beneficial technologies in developing countries, including in terms of low-emission climate-resilient solutions. Their use in the context of financing developing countries is controversial because they require the recipient developing country to purchase goods and/or services from the developed country issuing the export credit (what is referred to as tied aid). Both variables are constructed using OECD-DAC data. Annex 5 includes a more detailed description of the construction of these variables.[28]

Fifth, policy interventions supporting renewable energy are represented by two variables: feed-in tariffs (in USD per kWh using 2011 prices) for both source and destination country (FIT_{ikt} and FIT_{jkt} respectively) and renewable energy quotas (in percentage points) in source and destination country (REQ_{it} and REQ_{jt}). Both policy measures are taken from the OECD-EPAU (2013) Renewable Energy Policy Database (for a detailed discussion see Cardenas et al. 2014).

Finally, we include $CDM/JI\_investment_{jkt-1}$ from UNEP Risoe CDM/JI Pipeline Analysis and Database. This variable measures the volume of investment in millions of 2011 USD deflated by an investment deflator. We use the lagged value of investment in order to avoid a potential endogeneity problem, as (a portion of) this investment volume might be included in the BNEF data (our left-hand side variable). The Clean Development Mechanism (CDM) within the Kyoto Protocol was designed to encourage financial flows and technology transfers from developed to developing countries in order to accelerate efforts to mitigate climate change. Its success in doing so, however, remains open to question. Annex 5 provides a detailed description of the construction of this variable.

By definition, three of the variables (CDM, export credits/guarantees and ODA) have as a destination one of the countries classified as South. Moreover, in cases where bilateral information was available, source countries are, by definition, North countries[29]. Hence, we are only able to investigate the mobilisation effect of these variables on private flows to countries of the 'South'.

[28] We are thankful to OECD-DCD staff members for having helped us extract, structure and interpret DAC data, including in particular on officially supported export credits.

[29] Note that there is not a perfect match between classifications done on the CDM data (Annex I vs non-Annex I), and ODA/export credit data (DAC members vs DAC list of recipients). Consequently, a small portion of the programmes are excluded.

$\boldsymbol{MARKET}_{ijkt}$ is a vector of geographic and socio-economic (framework) conditions that might influence financial flows between a pair of source and destination countries. We use the CEPII dataset[30] and include variables such as $Distance_{ij}$ measuring the geographic distance in kilometres between the most important cities of both countries, weighted by population. We also include dummy variables for $Common\_language\_d_{ij}$ (equal to one if both countries share the same official language and zero otherwise) and $Common\_legal\_system_{ij}$. Differences in official languages and legal systems might translate into higher costs for private investors. Finally, a dummy variable is constructed that takes on the value of 1 when the source and destination countries are members of a common regional trade agreement, and another variable when they are both members of the World Trade Organization.

Next, from the World Bank database we include GDP per capita for both source and destination country (GDP_{it} and GDP_{jt}) and their squared terms because we expect to find non-linearities (e.g., wealthier countries tend to be a source of larger financial flows but probably at a decreasing rate). From the OECD/IEA World Energy Balances database, we include $Electricity\_consumption\_growth_{it\ (or\ jt)}$ of the source or destination country to reflect changes in market opportunities.

The volume of financial flows between countries is also a function of certain financial conditions in the respective countries e.g. presence of a structured financial services industry, information asymmetries, exchange rate differences, trade protectionism or membership in regional trade agreements and the resulting patterns of trade and investment. To capture the influence of such bilateral investment conditions, a variable accounting for levels of Foreign Direct Investment (FDI_{ijt}) could be a suitable proxy. This would in particular help disentangle the financial motivation from the environmental motivation to invest in a given country. OECD and IMF were considered as potential data sources. However, FDI data is measured and aggregated as a change in value of asset holdings, or net flows, with disinvestments accounted for as negative flows. This is not suitable for the purpose of this study which requires a measure of the volumes of new additional investment, or gross flows (only positive flows) in each direction, to be consistent with the construction of our dependent variable.

$\boldsymbol{CONTROL}_{ijkt}$ is a vector of variables that are intended to capture the idiosyncratic characteristics of the BNEF database. $BNEF\_Private\ Finance_{it}$ is constructed as the sum of all private flows going out of country i while $BNEF\_Private\ Finance_{jt}$ are all the inward private flows received by country j, including domestically. In constructing these two variables the flows are aggregated across all countries and all sectors (all 28 sub-sectors mentioned in Section 4 above). To avoid endogeneity problems, we subtract the amount of the dependent variable from these two control variables. These variables play an important role in the regression; they allow to (i) account for any possible biases due to idiosyncratic differences in BNEF database with respect to its coverage of countries, years, sectors and financial instruments; and to some extent (ii) control for the size of the clean energy component of the financial market in both the source and the destination countries.

Finally, we include dummy variables for source country[31] α_i , destination country γ_j, sector δ_k and year θ_t to capture any heterogeneity that is invariant in the respective dimension. The remaining variation of the dependent variable is captured by the error term ϵ_{ijkt}.

[30] Harmonised data for gravity equations from the Centre of Prospective Studies and International Information (CEPII in French). www.cepii.fr/CEPII/fr/bdd_modele/bdd.asp

[31] This set of dummies is sometimes excluded in order to achieve convergence of the estimation (specified at the end of each regression table).

5.2 Estimation method

Models with dependent variables censured at zero are typically implemented using a Tobit estimation procedure. A Tobit model is a mixed model associating (1) a Probit that models the binary decision of investment, i.e. estimates the probability of observing a strictly positive flow of private finance, and (2) a classic linear model (ordinary least squares regression on the uncensored observations) that analyses the amount invested once a positive investment decision has been taken. While Tobit analyses both (1) the investment decision as well as (2) the volume invested, it does so by assuming that this decision to invest and the volume invested are determined by the same process. However, if the process which generates the decision to invest in a given project is different from the process which determines the volumes invested, the implementation of a Tobit model is inappropriate. For example in the case under study, the two explanatory variables of primary interest (multilateral finance and bilateral public finance) may have very different implications on the two decisions (whether to invest and how much to invest). For instance, the provision of financing from a multilateral source may have significant implications on the decision of private investors to commit financing to a given project, irrespective of the level of financing provided i.e. it serves as a "signal" even if the amounts provided are limited.

In order to address this possibility, in this paper we implement a type-II Tobit (also called the "Heckman selection model") that allows the two processes (participation and volume) to vary as well as allows the errors of the two decisions to be correlated. Hence, the Heckman selection model allows us to disentangle and interpret both the signalling (decision whether to invest) and the volume (decision how much to invest) effects of each explanatory variable. To test the statistical significance of estimated coefficients, we use cluster-robust standard errors to account for possible heterogeneity across country-pair clusters.[32] Estimation results using the Heckman procedure are discussed in Section 5.3 (and reported in detail in Annex 7) and these results are then used to generate estimated mobilisation impacts discussed in Section 5.4.[33]

This estimation strategy gives a high importance to the procedure in which zeros for private finance flows were imputed.[34] Indeed, a zero in our dataset, reflects the assumption that no private flow for that combination of dimensions (i,j,k,t) existed. This imputation is straightforward when a public finance investment was made for that combination of dimensions, since it implies that a country is covered by the dataset. However, when there is no public finance recorded for that combination of dimensions, the absence of value could alternatively reflect incomplete coverage of our dataset. As a consequence, we opt to impute zeros on the basis of dimensions i,j,t (not k). This means that "if a sector is covered for a given country-year combination, then all sectors are covered". Consequently, we impute a zero investment volume for the remaining sectors (of the country-year combination). In our judgement, this is the most conservative approach. The idea is to compare the policy framework in countries in which investment (private or public) occurs for a given year and sector against countries with no investment. This is important because it has implications for how a counterfactual case is constructed and considered, and hence estimates of the mobilisation effect. Running the regression analysis without making any assumptions on zero investment would not let us test the 'crowding-in' effect. The alternative would be to

[32] Identification of the Heckman procedure is achieved with the proper selection of the exclusion variable. We identified WTO membership for the country pair as a suitable exclusion variable: it is correlated with the decision of investment and uncorrelated with the volume. Annex 6 explores this subject more in depth.

[33] We also conduct background robustness checks using alternative modelling strategies as discussed in Annex 6 and find that the key qualitative results are robust to such modifications.

[34] To some extent, Heckman selection models are more suitable to account for excess of zeros than Tobit methods.

impute (more) zeros under a less conservative approach[35]. In that case, one would intuitively expect to find a greater impact of bilateral public finance[36]. Exactly how much this would make a difference compared with our current approach remains an empirical question.

We obtain a maximum sample size of 13937 observations. This includes 769 country pairs (74 different source and destination countries), covers the 6 renewables sectors and spans the 2000-2011 period. Tables A7.8 and A7.9 provide the descriptive statistics, and Table A7.10 lists the countries. The current lack of corresponding data on the relevant policy framework conditions prevents us from covering more countries, extending the time period to 2012, and including other sectors from among the 14 climate-related sectors covered in the descriptive section of this paper. Pending data availability, future analyses could apply a similar methodology on an expanded set of both sectors and types of public interventions.

Finally, concerning the estimated effects of public finance, they should be interpreted in terms of correlations. At this point, we do not have enough elements to interpret these effects in terms of causality. Investigating the question of causality would imply addressing the possible endogeneity between private finance (dependent variable) and public interventions (independent variables). This would require identifying and being able to include in the model a suitable “instrument” variable i.e. correlated with renewable energy-related public interventions but not with renewable energy-related private finance. One option could be non-climate-related ODA flows but those are only relevant in the North-South context, while our analysis of flows to the South includes domestic South and South-South flows.

5.3 Empirical results

Here we briefly summarise the econometric results, which consist of both estimated coefficients indicating the average effect of the variables considered, as well as computed elasticities to estimate the marginal effect of these variables (see Annex 7 for further details). First, we estimate a ‘base’ model specification on a full sample of flows worldwide, distinguishing between cross-border and domestic flows (models H1 to H3 in Table A7.1). Second, we test the same hypotheses in the context of flows to countries of the ‘North’ and countries of the ‘South’ (models H4 and H5 in Table A7.2).[37] Third, we test the inclusion of several additional policy variables that are relevant only in the context of flows to the ‘South’ (models H6 to H8 in Table A7.5).

[35] For instance: (i) if a country is covered for one sector, it is covered for all sectors; (ii) if a destination is covered in one year, it is covered for all subsequent years; (iii) if a source is covered for one year, it is covered for all subsequent years.

[36] It is not clear how this affects the estimated impact of other public interventions.

[37] We split the worldwide sample in two – flows to ‘North’ (North-North, South-North, and North domestic) and flows to ‘South’ (North-South, South-South, and South domestic) – using dynamic assignment of countries to the different groups based on the World Bank’s GNI classification (small sample sizes prevent use from estimating regressions of domestic flows separately). This distinction in two samples makes sense because the ‘North’ is an economic space with relatively well-functioning institutions and low capital market imperfections (and hence fewer financing constraints), while many countries of the ‘South’ suffer institutional problems and face capital market failures. Ideally, we would control for these aspects econometrically; however, in the absence of corresponding data (as highlighted in Section 5.1, FDI was considered as a proxy but suitable data was unavailable), these aspects will remain unexplained and their time-invariant components will be captured in country effects. Dividing the sample in two more homogenous sub-samples allows us to better understand the rationales for the empirical results. A subsequent split by direction of flow (N-N, N-S, S-N, S-S), would not yield the desired estimates, as it would only estimate the effect by the type of source irrespective of policy interventions from other sources. On the other hand, splitting the sample only by type of destination captures the relative importance of the source of investment, and allows us to compare the average impact of investment from the North on overall investment in the South.

The results suggest that the **provision of public finance** (bilateral and/or domestic depending on the models) **has a positive and significant effect on private finance flows in all the models estimated** (see coefficients in Table A7.1). At the global level, the effect is higher on domestic than on cross-border private finance, as evidenced by the higher coefficients (both for investment decision and investment volume). This is independent of the fact that, other things being equal, domestic flows tend to be significantly larger. The effect of public finance provided by multilateral institutions is also positive (though relatively lower) and statistically significant.

When we consider these effects separately for flows to and in the South and flows to and in the North (Table A7.2), we find that the effect of public finance (bilateral and domestic combined) on the **decision** to invest private finance is greater for flows to and in the South than for flows to and in the North. This suggests that public finance to/in the South is more likely to induce private investment decisions than public finance to/in the North. Yet, once an investment decision has been taken, the effect on **volumes** of private finance is similar in the South and in the North. Results are robust across estimation samples (full, cross-border, domestic) and direction of flows (flows to North, flows to South).

The estimated marginal effects (Table A7.3) are greater for public finance (bilateral and domestic combined) than multilateral public finance for both the decision to invest and the volumes of flows invested. This might be a function of more direct lines of responsibility. With one less layer of responsibility bilateral and domestic public financiers might be better able to direct their finance towards projects which induce complementary private finance flows. Alternatively, their objectives might be different, focusing on projects which are "closer to market".

However, it is also interesting to note that the magnitude of the elasticity on the decision to invest (compared to volume of finance) is much greater for multilateral public finance. This may be a reflection of the relatively greater importance of the "signalling" effect for multilateral finance than for bilateral finance. A possible explanation is that finance provided by multilateral financial institution may bring important additional benefits which are not fully captured in our model. For example, there may be important spillover effects through improvements in investment conditions in the destination country, for example, due to accompanying institutional and legal reforms. To the extent that our model fails to capture such spillover effects, the coefficients and marginal effects reported here will be an under-estimate of the 'true' effect of multilateral finance.

Concerning the effect of public policy interventions, results for the worldwide sample suggest that *FIT policies* in destination countries play an important role (positive and significant coefficient) for both the investment decision and the volume of investment. Such evidence indicates that if countries seek to encourage and effectively mobilise private finance investments, raising the ambition of policies in destination countries will be vital (considering the choice of policy instruments that are most suitable to domestic conditions).

On the other hand there is mixed evidence for FITs in source countries. They are correlated with higher investment volume, but there is no significant effect on the decision to invest. There is no evidence that *REQ policies* in source or destination countries have an impact on the decision to invest. Concerning the impact on investment volumes, it seems that REQ policies in source countries are negatively correlated with the volume of private finance outflows. Although it is not clear what could be the rationale for this result, this might highlight a possible trade-off for the source country between mobilising private finance domestically and internationally.

Results for the other explanatory variables vary to a certain extent. In most cases we find evidence that private investors tend to invest in nearby destinations rather than in countries geographically far away, and in countries with which they share a common legal system (though not for flows to South), but not necessarily a common official language (which has an effect on investment decisions but not volumes). We also find evidence that regional trade agreements, as well as opportunities arising from the growth of electricity markets, tend to both motivate and attract greater volumes of private finance flows.

Finally, both BNEF control variables are often positive and significant. This suggests that we successfully control for database coverage and hence partly mitigate idiosyncratic biases, such as the fact that we would be more likely to observe positive and larger private finance flows if the underlying database has a good coverage of this particular country-pair and year combination.

We also investigate the persistence of the effects of public interventions over time. We find that lagged values of *public bilateral finance* and *multilateral finance* (alone or in combinations with their contemporaneous counterparts) have a significant and positive effect, although of lower magnitude than the contemporaneous effect.[38] This indicates that future work should also examine how to account for the mobilisation effect of past public interventions when analysing the effect of contemporaneous interventions.

Finally, we test the inclusion of several additional public policy and finance variables that are relevant only in the context of flows to countries of the ‘South’. We test them separately because these variables are not relevant for all countries and/or direction of flows: (i) Only a subset of countries qualifies for CDM/JI investment, necessitating the use of yet another country classification (see Annex 7); (ii) bilateral flows of Official Export Credits[39] and ODA (as captured by the DAC) occur, by definition, only in the N-S context.[40]

As presented in Table A7.5, we find that greater volumes of CDM/JI investment are correlated with private finance flows in the following year (we also test longer lags and find that this effect is persistent over time). We find no evidence of an effect of export credits or guarantees. However, caution should be taken when interpreting this result because this variable is broadly defined (not energy, climate or environment specific), and may thus not be capturing the specific mobilisation of private finance for renewable energy/climate-related exports. Finally, we also test the effect of official development assistance (ODA) directed at supporting mitigation efforts in the form of grants and concessional loans. Evidence is not conclusive as the models identify no significant effects of either of ODA variables. It must be noted that there is potentially a partial overlap between the ODA variables and the (bilateral) public finance because BNEF’s public finance data might include flows of concessional public finance. For this reason analysis using this variable is exploratory and is not included in the ‘base’ model specification.

[38] This holds for lags for up to 5 years that we have tested. We also test the cumulative effect of public finance by including a variable representing the sum of public finance flows in the previous two (or three, or more) years. To avoid collinearity with the contemporaneous value, this stock variable excludes the current year’s public finance flows. The results suggest a significant and positive effect, although again one that falls over time. In what follows we stick to the base model specification due to potential collinearity problems. Excluding lags and stocks also makes the estimation of marginal effects and mobilisation impacts possible. These results are available on request.

[39] To date, most export credits are actually provided for transactions among countries of the ‘North’; corresponding data is, however, not captured by the DAC.

[40] In order to estimate the effect of these variables in the flows to South context, we set Official Export Credits and ODA to zero in the case of domestic flows, and exclude ‘South’ to ‘South’ cross-border flows. This imputation procedure allows us to test the relative contribution of ODA and export credits both on N-S flows and `South’ domestic flows.

5.4 Simulated mobilisation impact of public interventions

In this section we use the estimated coefficients from our 'preferred' model of flows to, between, and in the South (model H5 in Table A7.2; also see Section 5.3 above) to conduct simulations that can inform the discussion on estimations of private climate finance mobilisation. Overall, the model achieves a very good fit as shown in Figure A7.1. However, it should be emphasised that the figures presented in this section are exploratory and pertain only to the six renewable energy generation sectors included in the analysis. Moreover, the estimates presented are likely to be the lower bounds of these effects. This is because they are based on a static model that only capture the contemporaneous impact of public interventions, while there might be dynamic reinforcements of the impact of these interventions over time. Such dynamic reinforcements could include for instance a progressive reduction of investment-related risk levels, decreasing unit costs over time due to learning effects, economies of scale in investments, and institutional improvements that often accompany policy amendments.

We undertake a set of simulations to help understand the historical mobilisation impacts of public interventions. In contrast to the evaluations of marginal effects of additional contributionsreported in Annex 7, here the aim is to evaluate the impact of public interventions in their totality. The question we want to answer is how much private finance has been mobilised historically due to the overall envelope of public finance and policy over the estimation period and across all six renewable sectors. In other words, we ask what share of private finance can be explained to have been mobilised by public interventions.

Figure 10 shows the simulated mobilisation impacts for the whole sample of flows to, between, and in the South[(41)]. We find that 15.7% of renewable energy-related private finance flows from the North to the South can be explained by the provision of North-South bilateral public finance. The corresponding figure for multilateral public finance is 14.8%. Overall, over 30% of North-South private climate finance for renewable energy was mobilised by multilateral and North-South public bilateral finance and public finance combined. When considering all geographical origins of public and private finance, 42.2% of total renewable energy-related private finance to, between and in the South is estimated to have been mobilised over the period 2000 to 2011 by the combination of bilateral and domestic public finance, and just below 12% by multilateral public finance.

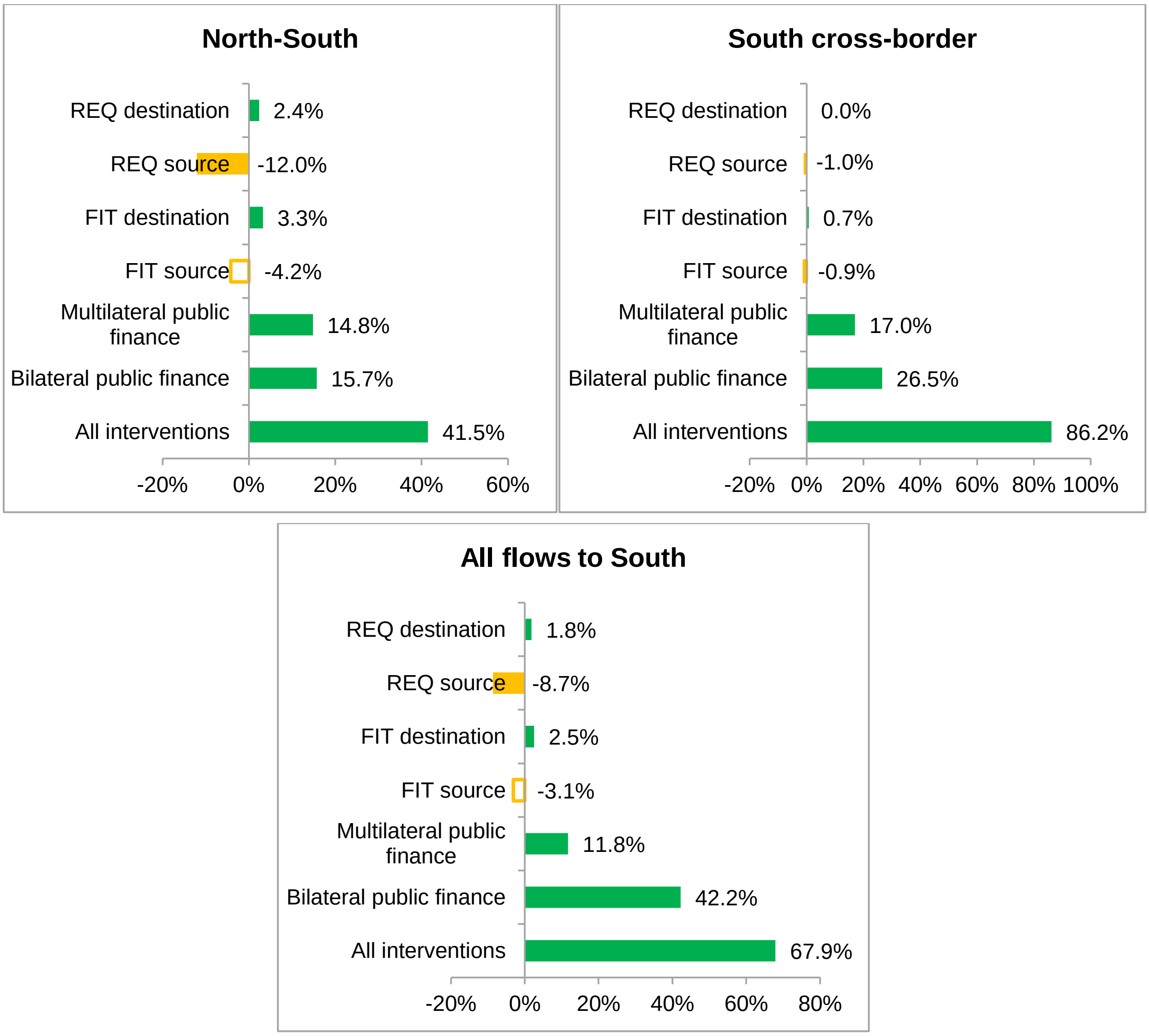
On the other hand, a descriptive analysis using some of the existing qualitative methods to estimate mobilisation might account for 100% of all observed private financing as having been mobilised by public finance. The difference in percentages arises because quantitative approaches allow the impact of public finance to be separated from those of public policies such as FITs and REQs), while controlling for relevant market and country conditions. There are, however, other reasons that could help explain the relatively low percentages estimated here. One might be that the database on which this paper draws does not include data on projects below certain threshold capacities. If public finance tends to have a particularly important mobilisation impact on projects below these thresholds, then this will be only partially accounted for in our estimates. Furthermore, the data used might not capture the full range of upstream (e.g. corporate-level and fund-of-fund investments) and downstream public finance provided throughout the financial value chain and playing a role in mobilising private finance. As highlighted in by recent OECD analysis, this is an issue that is common to most databases monitoring and reporting financial transactions (Caruso and Jachnik, 2014).

The part of renewable energy-related private finance to, between and in the South that can be explained by the level of domestic public policy support instruments (FIT, REQ) is very low in relative

[41] $Simulted\ mobilisation\ (\%) = \frac{Predicted\ Private\ Finance\ \ at\ observed\ values - \text{Predicted}\ Private\ Finance\ \text{without the intervention}}{Predicted\ Private\ Finance\ without\ the\ intervention}$

terms. This is a likely consequence of the fact that countries of the South tend to feature, on average, low levels of FIT and REQ ambition. One would however expect a greater absolute impact of public policy instruments in countries with higher support levels. Therefore, we also generate estimates of mobilisation impacts for private finance flows to, between and in the North (Figure 11). Indeed, estimations of the impact of FITs and REQs on the level of mobilisation of private finance flows to, between and in the North suggest a relatively greater impact than in the case of flows to, between and in the South. In some cases the effect of such measures is even greater than the impact of public finance. Overall, these results demonstrate the importance of domestic policy conditions, both in the North and the South.

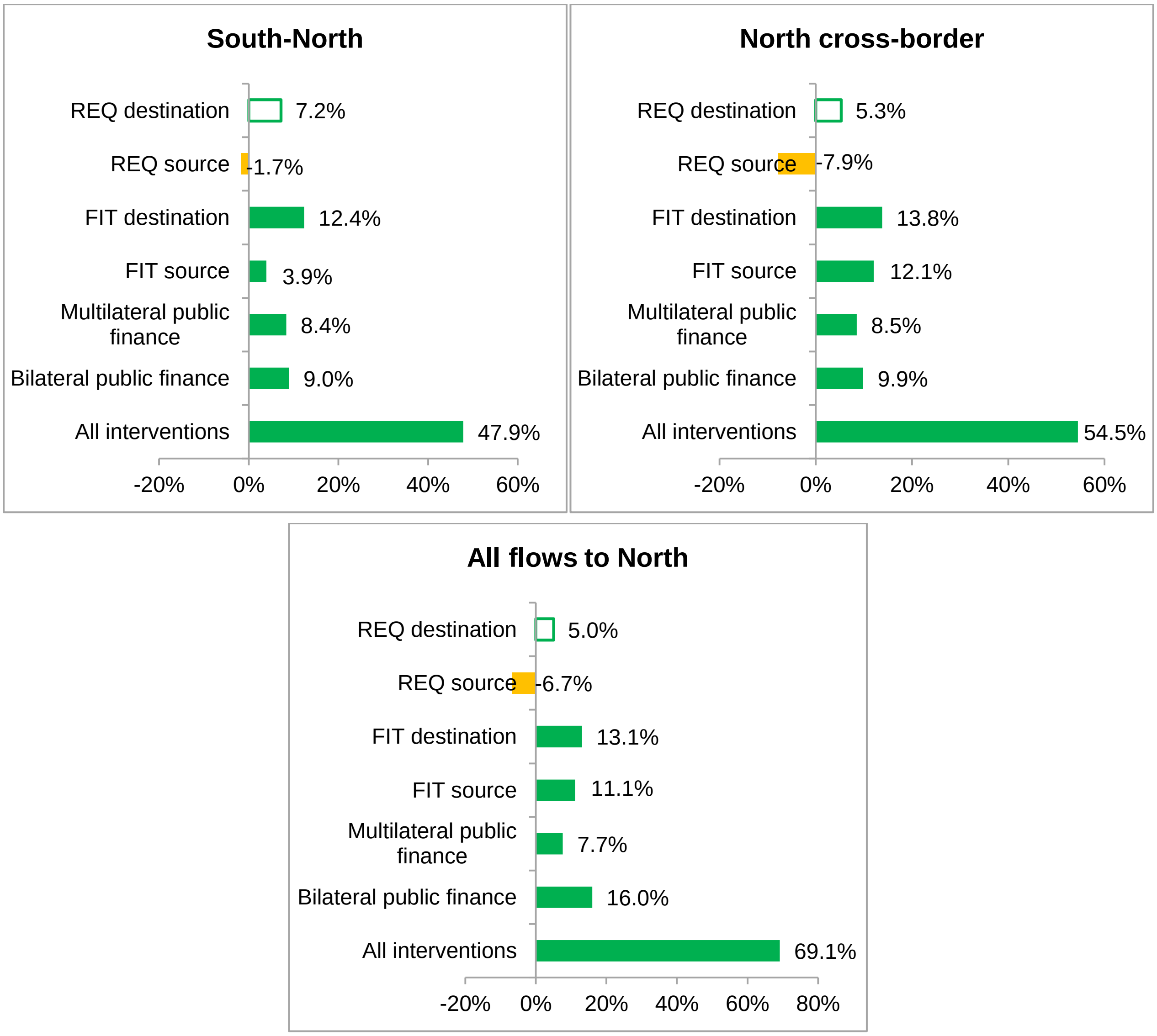
Figure 10. Simulated mobilisation of public interventions on private flows to, between and in South



Note: The geographical direction indicated by the title of each of the three charts applies to the origin of both private and public finance variables i.e. Under "North-South", 15.7% is the simulated effect of North-South bilateral public finance on North-South private finance. Under "All flows to South", 42.2% is the simulated effect of combined North-North, South-South and domestic South public finance on all private finance to, between and in the South. The effect of "All interventions" does not correspond to the sum of individual interventions because the model is non-linear. Bars without fill indicate statistical insignificance at the 10% level of estimated coefficients for investment and volume decisions.

Concerning the impact of public interventions overall, these results suggest that the share of private finance flows that can be explained by the four types of public interventions considered (bilateral and multilateral finance, FIT and REQ) is similar in the two cases: 68% for flows to, between and in the South, and 69% for flows to, between and in the North. However the contribution of the different types of public interventions is very different with a greater mobilisation impact of public finance in the South compared with a more significant impact of public policies in the North. In the case of North cross-border flows public policies have a greater mobilisation impact than public finance. The remaining volumes of private finance flows not explained by public interventions could be explained by country and market conditions.

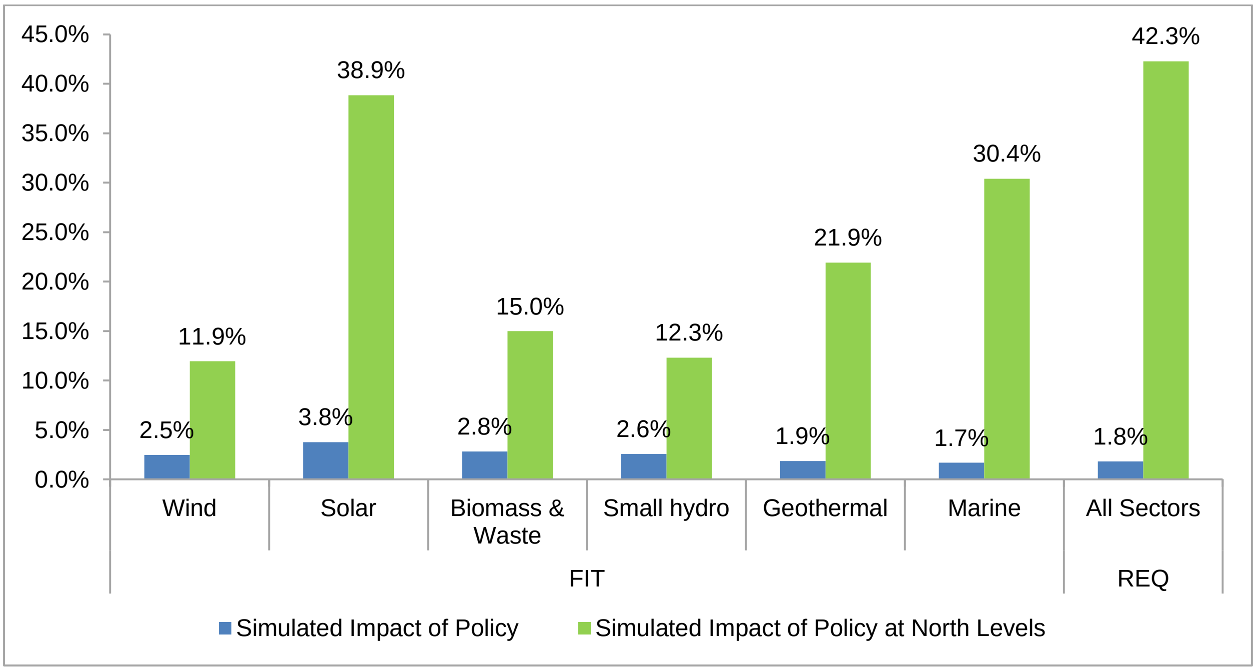
Figure 11. Simulated mobilisation of public interventions on private flows to, between and in North



Note: The geographical direction indicated by the title of each of the three charts applies to the origin of both private and public finance variables i.e. Under “North cross-border”, 9.9% is the simulated effect of North-North bilateral public finance on North-North private finance. Under “All flows to North”, 16.0% is the simulated effect of combined North-North, South-North and domestic North public finance on all private finance to, between and in the North. The effect of “All interventions” does not correspond to the sum of individual interventions because the model is non-linear. Bars without fill indicate statistical insignificance at the 10% level of estimated coefficients for investment and volume decisions.

Next, given that policy ambition plays an important role in mobilising private finance, we examine the following policy scenario: How much private finance could have been mobilised in the South during the 2000-2011 period if the mean level of domestic FITs and REQs support in the South were set at the mean level of support observed in the North? (Mean values vary by year and sector as detailed in Annex 8, Tables 8.1 and 8.2). Figure 12 shows the results under such scenario and compares them against the mobilisation actually achieved (at observed historical levels of FIT support in the South).

Figure 12. Simulated mobilisation of South domestic policies on flows to, between and in the South



For example, while observed historical levels of domestic FITs explain only 3.8% of private finance for solar energy in the South, they could have mobilised 38.9% (or 50bn USD more) if support levels were comparable to those in the North. Similarly, we find that while observed levels of REQs explain 1.8% of private finance in the South, they could have mobilised 42.3% (or 58bn USD more) at levels similar to those in the North. These results are illustrative because further qualification would be needed taking into account the parallel evolution of other policy variables as well as country and market conditions that play a key role in private finance mobilisation. The simulation however highlights the untapped potential of public policy, in particular the important role of domestic policies to attract and mobilise private investment.

6. CONCLUSIONS

This study uses a unique dataset of investment flows to analyse the role of various public interventions in mobilising flows of private climate finance worldwide using econometric techniques. In doing so, the aim is to inform international discussions on how to estimate and better understand the mobilisation of private climate finance mobilised by public policy and public finance interventions, which have to date mainly focused on qualitative and case-study based analyses.

An initial descriptive analysis of global finance flows in 14 climate-related sectors highlights that domestic private flows outweigh cross-border flows by more than double – both globally, as well as when considering specifically flows to, between and in the North and flows to, between and in the South. Targeting the mobilisation of domestic private finance along with foreign sources of private finance therefore appears to be of high importance. The mobilisation of domestic private finance is especially relevant in the context of flows to, between and in the South, where international inflows are significantly lower than domestic flows.

Based on an econometric analysis of the determinants of worldwide flows for a subset of six renewable energy sectors, we find that the provision of public finance (bilateral and domestic combined) has a positive and significant mobilisation effect on private finance flows. This result is robust across the different models estimated, estimation samples (full, cross-border, domestic) and direction of flows (globally, to the North, to the South). Moreover, the results suggest that the effect of multilateral public finance is greater on the decision whether to invest at all than on decisions related to the volume of investment (once the decision to invest is taken).

Concerning the effect of public policy interventions, results for the worldwide sample highlight that feed-in tariff (FIT) policies in destination countries play an important role (positive and significant coefficient) for both the investment decision and the volume of investment. Results suggest that in the North, public policies play a more important role than public finance. In contrast, in the South the effect of policies is relatively low compared to the effect of public finance (domestic in particular). This is in part because countries in the South tend to feature low levels of policy support. Such evidence indicates that if countries seek to encourage and effectively mobilise private finance investments to the South, encouraging domestic investment along with an increase in the ambition of policies in destination countries will be vital (considering the choice of policy instruments that are most suitable to domestic conditions).

As it stands, the results derived from this analysis may contribute to efforts to estimate private finance mobilisation in two ways:

- They may serve as a method to attribute known aggregate volumes of renewable energy-related private finance (mostly wind and solar) to the types of public finance and policy interventions (bilateral and multilateral finance, FIT and renewable energy quota policies) covered in the model developed. This makes it possible to estimate the amount of private finance mobilised collectively through these types of interventions by countries in the North into all countries of the South. Such an approach includes the possibility of attributing mobilisation to public interventions in the absence of public finance, which cannot be captured by methods based on measuring co-financing.

At this stage, further disaggregation of the analysis and its results for individual public finance instruments (grants, loans, equity) and/or individual countries or group of countries (e.g. low-, lower middle-, upper middle-, high income) is not possible. This is because the sample size (number of observations) for such sub-categories would be too small to produce statistically significant results.

- They could be used to construct more qualitative adjustment factors that could be applied to mobilisation observed at the project level. This could for instance involve a public financial institution adjusting its reported mobilisation effect for a typical renewable-energy project based on the presence of a FIT or strong private investment environment. Since this process involves considerations of additional variables (e.g. country and market conditions or public policies) to explain a fixed amount of private finance, the end result would most likely be to attribute a smaller volume of finance to project-level public finance interventions. In contrast, observed unadjusted measurements of mobilisation are often based on attributing all private co-financing to public finance interventions, thereby failing to consider the mobilisation effect of public policies and the role played by country conditions.

More generally, econometric methods may provide an important value-added towards analysing and estimating private finance mobilisation. This is because they make it possible to separate the relationship between private finance and various public finance and policy interventions, while controlling for other factors that might affect private finance flows.

This analysis is a first-of-its-kind attempt to estimate private climate finance mobilisation empirically. The results presented are exploratory and open to refinement subject to better data availability. Results should not be extrapolated to other climate-related activities beyond the six renewable energy sectors included in the analysis, nor to other types of public finance and policy interventions. The lack of data coverage on small-scale private finance transactions and investments is also an important caveat when using and interpreting the results. For example, empirical estimates of the private finance mobilisation effect of public interventions for less commercially-mature climate-related technologies and/or smaller scale investments may be expected to differ from the estimates presented here for fairly large renewable energy transactions.

Pending additional data series becoming available, future work could use a similar methodology to:

- Cover climate-relevant sectors beyond renewable energy (e.g. transportation, energy efficiency).

- Expand the range of public interventions considered (e.g. public finance de-risking instruments, tax reliefs) and country conditions (e.g. investment conditions and ease of access to finance).

- Break down the analysis and results to a more granular level for individual sub-sectors, public finance instruments and/or individual countries or group of countries.

- Attempt explicitly to model dynamic effects of past public interventions, include analysing the (likely negative) impact of recent FIT schemes moratoriums, interruptions or cancelations.

- Investigate actual causality between public policy or finance interventions and private finance.

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ANNEX 1. DEFINITIONAL CONSIDERATIONS

Co-financing is defined by the International Monetary Fund (IMF) as "The joint or parallel financing of programs or projects through loans or grants to developing countries provided by commercial banks, export credit agencies, other official institutions in association with other agencies or banks, or (…) multilateral financial institutions" (IMF, 2003). This definition focuses on development finance (flows to developing countries) and includes equally public and private co-financiers; both considerations suit the scope of the present study well. It is however worth referencing a complementary, more operational definition from Campbell 2013, which refers to "A type of financing in which the different lenders agree to fund under the same documentation and security packages but may have different interest rates, repayment profiles, and terms". An important and relevant distinction is made here between the common project/activity being funded by co-financiers, and the likely different terms and conditions under which each is providing part of the total funding needed (or guaranteeing/insuring the whole or part of it). Significantly, differences in terms and conditions are typically observed between public and private co-financiers. However, referring to 'co-financing' as such does not imply any causality between the provision of funds by one or more of the co-financiers and the participation of the others towards reaching financial close.

Mobilisation is not a financial term per se. It is typically used in military contexts (a country or government organising troops for active service) or, more broadly, referring to bringing (any type of) resources into use for a particular purpose (Oxford Dictionaries, 2013). The word has been applied by climate finance practitioners in the specific context of describing the role played by countries (public finance in particular) in increasing the amounts of private finance flowing to a targeted type of climate-beneficial activities. Compared to the mechanical measurement of co-financing, mobilisation therefore introduces a notion of causality between the public intervention and the amount claimed to have been mobilised as a result of this intervention. How to define 'causality' remains an open question subject to multiple interpretations.

Leverage has – in contrast to 'mobilisation'– a clear meaning in finance, as "*the use of borrowed funds to increase profitability* [typically the return of an investment] *and buying power"*. Leverage ratio is then defined as *"the amount of long term debt relative to equity*" (IMF, 2003) and measures the relative amount of debt used to finance a firm's assets. A firm with significantly more debt than equity is considered to be highly leveraged. In the climate finance context, leverage is used in relation to its broader definition referring to the influence used to achieve a desired result i.e. the use of public interventions to increase revenue/return and decrease risks in order to encourage more private investment (as for mobilisation, causality therefore has to be demonstrated). As a consequence of this rather loose use of the term, it has proven difficult to agree internationally on how climate finance leveraging and leverage ratios should be understood; both the nominators and denominators of the ratio lacking clear definitions.

In addition, the chemical term **catalysing** is being increasingly used to refer to the ability of public interventions to act as a catalyst of (i.e. increase the rate of, accelerate) private investments.

ANNEX 2. LITERATURE REVIEW

This section provides an overview of how 'mobilisation' and 'leverage' have, to date, been applied and studied in practice. This is based on a review of (i) the 'grey' literature (including OECD work) that, for the most part, has focussed on reviewing and comparing current practices by individual countries, development finance institutions and funds in terms of calculating mobilisation and/or defining leverage ratios; (ii) academic literature that mostly falls outside of the domain of climate finance and focuses on empirical evidence of drivers of international financial flows in general (i.e. not only climate-related finance).

A2.1 Methodological approaches at project or institution level

Only few information sources were found on definitions and methodologies for measuring the mobilisation of private climate finance by public finance/interventions. The below therefore includes references where resources mobilised could be public as well. Although not directly applicable in the context of this study, these do provide relevant information on existing methodological options.

In 2011, Brown et al. investigated varying leverage ratios definitions used by different funds and institutions. A key point illustrated in the paper was that for many institutions, mobilisation is simply defined as equalling co-financing (Brown et al., 2011). This can imply accounting by default for total project costs without necessarily demonstrating causality i.e. that the public finance provided specifically by the institution claiming mobilisation attracted funding that would otherwise not have happened.

As part of its work on climate finance tracking, the OECD-hosted Climate Change Expert Group (CCXG) released in September 2012 a background document, which looked into how leverage had been defined to date. Based on projects and financial institutions reviewed, key conclusions were that very large variations exist between and within definitions, as well as within specific project types/geographical regions: "*some entities highlight private finance mobilised, whereas others include both public and private. Some calculate the leverage of concessional loans only whereas others include concessional and non-concessional loans. Some exclude co-financing from the recipients whereas others include it.*" The analysis therefore concluded that reporting comparability and consistency could not be ensured, while double counting would surely occur if adding amounts of reported leveraged climate finance from different organisations (Ellis and Regan, 2012).

The CCXG recently completed a more comprehensive study comparing definitions and methods in use to estimate the amount of mobilised climate finance (Caruso and Ellis, 2013). In addition to confirming wide variations in methodologies and a significant risk of double counting when aggregating individual reporting, the study put forward four components of a proposed framework for measuring mobilised climate finance at the project level (Table A2.1). These were then applied to different types of public finance instruments (debt, equity, grant, and de-risking), with the findings underlining the need to differentiate calculations methodologies per instrument type.

Table A2.1. Variation between methodologies to assess and estimate mobilisation

Criteria	Examples of more conservative approaches	Examples of less conservative approaches
Causality between a public intervention and mobilised finance	Assessing whether an activity is additional; Only counting climate relevant sub-component; Providing justification for direct value-added.	Assessing mobilisation based on total project costs
Attribution of mobilised finance to individual actors	Estimating a pro rata share of mobilised finance; Only counting private finance that originates from the public institution's home country.	Assuming an intervention has mobilised all external financing; Counting mobilised private finance from all geographic sources.
Determining public or private shares of mobilised finance	Systematic and disaggregate tracking of whether other actors are public or private (facilitates efforts to minimise double counting).	Not tracking whether other actors are public or private (makes double counting more likely)
Assumed lifespan of mobilisation effect	Excluding financing that predates intervention; 'Tapering' financing mobilised in subsequent investment/funding rounds.	Including all financing that was raised before and after an intervention

Source: Adapted from Caruso and Ellis, 2013.

One of the calculation methods considered as being on the 'more conservative' side by Caruso and Ellis was the United Kingdom's project level approach to forecast and monitor mobilised private climate finance for the purpose of UNFCCC reporting (Ockenden et al., 2012). The approach has the benefit of focusing on the mobilisation of private flows only. It consists of a number of steps: identify donor support (actions, investments, measures); identify private climate finance contribution from various sources; consider what level of private climate finance is additional; and isolate the level of private climate finance attributable to the donor spend. The actual leverage ratio calculation of public to private finance attributed to the donor spend is calculated as shown in Figure A2.1. The UK approach makes further consideration of context- and country-specific differences. It highlights the need to move beyond forecasting towards establishing a monitoring framework to report mobilisation.

Figure A2.1 UK approach to calculating leverage ratio at the project level

$$\text{Leverage ratio} = \frac{Total\ Additional\ Private\ Finance\ Mobilised}{Total\ Donor\ Finance}$$

$$= \frac{Attributable\ Additional\ Private\ Finance\ Mobilised}{Individual\ Donor\ Finance}$$

Source: Ockenden et al., 2012.

The OECD Development Assistance Committee recently carried out a survey on 'Guarantees for Development' in the context of its work to modernise statistics on external development finance (Mirabile, Benn and Sangaré, 2013). The aim was to estimate the volume of private finance to developing countries mobilised by guarantee schemes. In addition, the survey intended to contribute to the on-going discussions on how to measure the leverage impact of different development finance instruments. For the purposes of the survey, the term "amount mobilised" was defined as *"the full nominal value of the instrument (e.g.*

loan, equity) to which the guarantee relates, regardless of the share of this value covered by the guarantee." This rather conservative approach (in contrast to accounting for total project costs), was motivated in particular by the aim to reduce the risk of double counting in the context of future potential statistical data collection by the DAC. In addition, the study discusses methodological difficulties with calculating leverage ratios, such as measuring both the donor effort to mobilise (denominator) and the amount mobilised (numerator). One of the conclusions from this initial study[42] is that project-specific leverage ratios are not appropriate for quantifying the leverage from guarantees at aggregate level. Instead, they may be used at the institutional level to measure the strategic use of resources. This however raises the issue of encouraging public resources to be spent in relatively higher-income countries rather than lowest-income countries where the need for (public) external development finance is greatest (Mirabile, Benn and Sangaré, 2013).

A2.2 Observed leverage ratios at project or institution level

A number of public institutions providing development/climate finance have reported information on observed leverage ratios based on individual projects to which they contributed funding. Two examples are referenced below – the European Bank for Reconstruction and Development (EBRD) and the German Agency for International Cooperation (GIZ) – because they illustrate well the possible variation in calculation methods and differences in actual ratios across sectors and financial instruments. There is however rather limited information available on the underlying details of how these leverage ratios are derived.

The EBRD launched a Sustainable Energy Initiative[43] (SEI) in 2006 that consists of three components:

- Project-level financing: concessional or market-based loans; equity, grants;
- Technical assistance: market analysis, energy audits, training, awareness raising;
- Policy dialogues with governments: Support development of strong institutional and regulatory frameworks that incentivise sustainable energy (EBRD, 2012).

For project-level financing where EBRD provides finance along private financiers[44], the bank calculated leverage as the ratio of total project value divided by EBRD financing (Tanaka, 2012). This has resulted in a reported average private sector leverage ratio for SEI projects of **3.3** for the period 2006-2011 (Table A2.2). However, key differences across sectors exist. For example, sustainable energy financing facilities (credit lines through banks) have the lowest leverage ratio reflecting the financing structure of these projects; transport energy efficiency projects have the highest leverage reflecting large average total investments requiring significant co-financing; and finally, renewable energy projects (mostly wind) have an above average leverage ratio of 3.9.

[42] Follow-up work by the DAC is foreseen.

[43] See www.ebrd.com/pages/sector/energyefficiency/sei.shtml

[44] Such as commercial banks, institutional investors, private project developers and operators, private corporations

Table A2.2 EBRD' SEI leverage ratios (2006-2011 private sector projects)

SEI area	Project type	EBRD contribution (€ million)	Total project value (€ million)	Financial leverage (Total project value / EBRD contribution)
1	Industrial energy efficiency	1,956	5,575	2.8
	Agribusiness energy efficiency	794	2,403	3
	Transport energy efficiency	425	3,177	7.5
	Building energy efficiency	447	1,662	3.7
2	Sustainable energy financing facilities *	1,595	2,496	1.6
3	Electric power distribution	290	1,351	4.7
	Electric power generation	520	1,264	2.4
	Natural resources	1,007	4,960	4.9
	Electric power transmission	-	-	-
4	Renewable energy (excl. large hydro)	948	3,742	3.9
	Large hydro	44	108	2.5
5	Municipal services: waste, water/sewage	339	869	2.6
	Public transport energy efficiency	94	695	7.4
	Steam / district heating	252	458	1.8
	Total	8,713	28,761	3.3

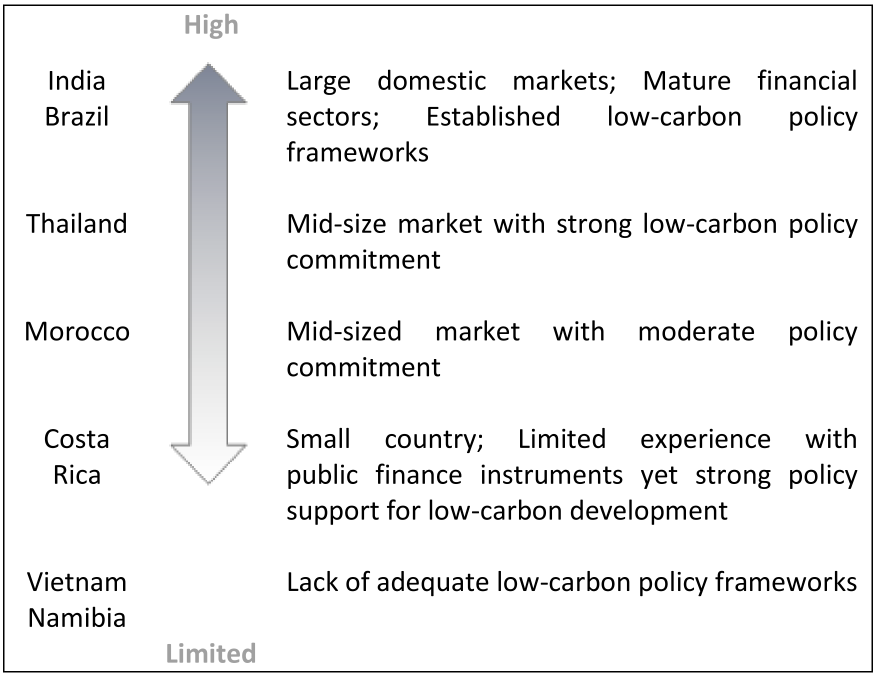
* credit lines through commercial banks.

Source: Tanaka, 2012.

For the same period, EBRD also calculated leverage in relation to the technical assistance it provided as underlying support to scaling up investments. Three different calculation methods were used: (i) considering EBRD SEI finance only (most conservative), (ii) SEI project finance, and (iii) total project value (least conservative). Depending on the definition used and the business area considered, the potential leverage "claims" differ from **30** (most conservative for municipal energy efficiency infrastructure) to over **2000** (least conservative for industrial energy efficiency or renewable energy) (Tanaka, 2012). This illustrates the considerable impact of the choice of a definition, as well as large variations across sectors (types of technologies) and instrument types (e.g. compared with the much lower leverage reported by EBRD from loans and equity).

No attempt was made by the EBRD to quantify the mobilisation impact of "policy dialogues with governments", or of policy and market conditions. Indeed, current approaches to measure mobilisation and define leverage ratios typically consider market and policy conditions in a qualitative manner. For instance, a 2011 report of the German Agency for International Cooperation (GIZ) acknowledged that "*any single financing mechanism by itself will be insufficiently nuanced to meet the needs of low-carbon development in a meaningful way*" (GIZ 2011). The report provides an indicative qualitative evaluation of relative mobilisation potential in a few countries based on the absence or presence (back at the time of the report) of a range of policy and market conditions.

Figure A2.2 The relative leverage potential of public finance instruments



Source: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), 2011.

A2.3 Observed average leverage ratios at the aggregate level

In addition to self-reporting of project-level leverage ratios by individual international development finance institutions, some publications have intended to put forward average leverage ratios for specific instruments and/or types of public finance providers. This was most often done based on information provided by individual institutions such as the two mentioned above.

The 2010 report of the United Nations High-Level Advisory Group on Climate Change Financing (UN AGF) is often referred to as the starting point for discussions about the use of public instruments to facilitate climate change-related private investment. The AGF derived observed private-public leverage ratios based mainly on types of interventions and instrument used by multilateral development banks e.g. International Finance Corporation (IFC), EBRD, etc. (Table A2.3). One of the assumptions put forward in the AGF report is lower leverage ratios for concessional finance in relatively more developed countries, where private capital already flows at significant levels independently from public finance. This suggests that mobilisation needs to be considered on a per-instrument basis, while also differentiating based on country conditions. The AGF however further suggests that a 1 to 3 ratio could be considered as a conservative average across the above listed types of multilateral public instruments mobilising private climate finance.

Table A2.3 Indicative observed private-public climate finance leverage ratios

Public instruments Instrument	Observation base	Potential leverage
Non concessional or partly concessional debt	Includes EBRD	2 to 5
Debt financed via grant (concessional) funds	MDBs	~ 8 to 10
Equity and guarantees financed via grants	IFC	Up to 20
Equity investments in projects with private sponsors	MDBs	~ 8 to 10
Donor financed climate funds (part concessional)	Climate Investment Funds (multi-donor)	~3
Carbon offset mechanism	Clean Development Mechanism	~4.6 (average); up to 9

Source: United Nations High-Level Advisory Group on Climate Change Financing, 2010.

End 2012, the Inter-American Development Bank (IDB) published a report on *The Role of National Development Banks* [NDBs] *in Intermediating International Climate Finance to Scale-up Private Sector Investments* (Smallridge et al., 2012). This included a framework for measuring NDB per-instrument leverage ratios and a comparative overview with those of MDBs, as per the AGF report (Table A2.4). This comparison highlights the likely need to differentiate leverage ratios calculations per instrument type, but also potentially based on the type of actor behind the public instrument, where multilateral, bilateral and national institutions would for instance not necessarily achieve equivalent mobilisation.

Table A2.4 Estimated leverage factors of NDB instruments

Category of instrument	MDB estimated leverage factor	NDB estimated leverage factor
Non-concessional debt	2-5	2-5
Debt financed via grants	8-10	8-10
Non-concessional debt	N/A *	1
Debt financed via grants	N/A *	4-8
Direct equity	8-10	12-15
Equity financed via grants	20	20
Direct equity	N/A *	12-15
Equity financed via grants	N/A *	N/A *
Guarantee at non-concessional rates	N/A *	4-8
Guarantees financed via grants	20	25

* N/A is listed for instruments frequently used by NDBs but for which no analysis is available for MDBs (or vice-versa).

Source: Smallridge et al., 2012.

The same year than the AGF report was released, a note was published by the public policy research and advocacy organisation Center for American Progress (Caperton 2010). It provides indicative characteristics for five mechanisms that international climate funds backed by developed country finance could use to mobilise private finance for clean energy in developing countries (Table A2.5).

Table A2.5 Characteristics of selected private finance leveraging mechanisms

Mechanism	Type of finance leveraged	Risk level	Mitigates many risks or few	Leverage ratios (private to public)
Loan guarantee	Debt	High	Many	6 - 10
Policy insurance	Debt	Medium	One (but adaptable)	10 and above
Foreign exchange liquidity facility	Debt	Low	One	?
Pledge fund	Equity	Low	Many	10
Subordinated equity fund	Equity	High	Many	2 - 5

Source: Caperton, 2010.

In all three studies (AGF, IDB, Caperton), the limited/absence of information on assumptions and data prevents from using the ratios for the purpose of measuring mobilisation at aggregate level. Furthermore, the notion of average leverage embedded in ratios presented is not compatible with the wide range of observed methodological variations highlighted in the first part of the literature review (see Table A2.1).

A2.4 Using average leverage ratios to estimate aggregate mobilised private finance

In some instances the average observed leverage ratios based on project-level measurement have been used to calculate mobilised climate finance at the aggregate levels (country, globally). For example, in 2012 the International Energy Agency (IEA) published a piece of work to estimate total investments in energy efficiency[45] in developing countries (Ryan et al., 2012). Due to the absence of systematic monitoring and reporting of investments in energy efficiency, the IEA could not rely on existing aggregates. A proxy method was therefore developed and used based on:

- Available data from MDBs and BFIs on the public finance they provided for energy efficiency in developing countries;
- Average private-public leverage ratios based on both individual discussions with MDBs/BFIs and the AGF study as indicative starting points, which were differentiated based on countries' levels of development and public finance mechanisms likely to be used within this context (grants, concessional and non-concessional loans, etc.).

Given the uncertainty and approximations inherent to the use of leverage ratios, the final aggregate estimations derived using this methodology were presented using a lower and upper bound based respectively on public private leverage ratios of 2 and 8 (Table A2.6 below).

[45] Energy efficiency is typically considered as a sub-set of 'climate change mitigation' activities although definitions of which specific activity and project types are to be tagged as falling under energy efficiency vary significantly across financial institutions.

Table A2.6 IEA's aggregate estimates of mobilised private finance for energy efficiency

	Annual energy efficiency spend (USD billions)	Private finance mobilised annually (USD billions)	
		Lower bound	Upper bound
MDBs	4.9 *	9.8	39.21
IDFC members	18.88 **	37.76	151.21
TOTAL	23.78	47.56	190.25

** 2008-2011 average for the following MDBs: Asian Development Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank, World Bank Group*

*** Estimated from the 2012 IDFC report (includes 16 bilateral and national development finance institutions)*

Source: Ryan et al., 2012.

This remains to date the only methodological attempt to generate aggregate estimations of mobilised private climate finance (for projects aimed at improving energy efficiency), while accounting (at least partly) for local context and conditions in the recipient country. This was however done "manually". The present study (focused on renewable energy) aims at taking this research area a step forward by providing elements based on econometric analysis that might allow doing similar exercises in the future.

Another publication (Stadelmann et al. 2013) is more directly related to the context of the UNFCCC and possible ways to measure and report climate finance mobilised towards the fulfilment of the USD 100 billion commitment. It provides an overview of private flows from developed to developing countries. Calculations relating to mobilisation of private flows are here again based on average leverage ratios derived from past studies (e.g. Brown et al., 2011) as well as from project-level data from the Global Environment Facility[46] (GEF). A number of lower and upper bounds were calculated for different instruments and concessionality levels based on various GEF projects sample populations. These ratios were then applied to generate estimates of aggregate levels of private finance to and in developing countries mobilised by bilateral and multilateral banks, agencies and funds. The lower to upper bound variations range from USD 2 billion to 25 billion for bilaterals, and USD 2 billion to 50 billion for multilaterals. This further underlines the inherent impreciseness of the use of average leverage ratios for calculating mobilisation at aggregate level. In addition, no mention was made of how policy and country/market conditions may have been accounted for as part of this study.

A2.5 Determinants of international financial flows

There is a scarcity of academic publications on the mobilisation impact of public interventions on flows of private climate finance. Consequently, the literature review is expanded beyond the domain of climate-related investments. In doing so, the focus remains on the effect of policy and framework conditions because this has been identified above as a key research gap. Still, there does not appear to have been any study directly attempting to quantify the mobilisation impact of public policy interventions. However, several published studies provide empirical evidence of the determinants of international financial flows. For instance, Portes and Rey (2005) broadly investigate national preference in asset holdings, highlighting a clear link with information asymmetries or 'informational frictions'.

[46] See www.thegef.org

Of more direct relevance to the focus of the present paper, a series of publications investigate the determinants of cross-border financial flows to developing countries. In this context, most studies include a key distinction between country-specific (domestic) determinants such as domestic institutions, policies, country risk, macroeconomic fundamentals, etc. and global (foreign) determinants such as economic conditions in capital exporting countries, international liquidity, etc. The latter are typically considered as important in explaining capital flows to emerging market economies, and their effects therefore need to be controlled for in considering the role of domestic country-specific policies and conditions.

A starting point is Robert E. Lucas's 1990 study 'Why doesn't capital flow from rich to poor countries?'. The author puts forward the paradox of low volumes of investment in poorer economies despite the Law of Diminishing Returns suggesting the opposite should be happening. Differences in human capital and capital market imperfections are mentioned as possible explanatory factors (Lucas, 1990).

The 'Lucas paradox' has been further investigated in follow-up work by Alfaro et al. (2008) who identified low institutional quality as the leading explanation (e.g. protection of property rights, corruption, government stability, bureaucratic quality, law and order). Using the example of Peru, they found that improvements of countries' institutional quality has the potential to increase capital inflows to poor countries.

Similarly, Papaioannou (2009) concluded that institutional quality is empirically the most significant variable correlating with international financial flows, suggesting that "*poorly performing institutions, such as weak protection of property rights, legal inefficiency, and a high risk of expropriation are major impediments to foreign bank capital*".

Another study by Taylor and Samo (1997) examined both long- and short-term determinants of capital flows to developing countries[47] such as economic fundamentals (available investment opportunities, expected returns, attitudes toward risk), government policies and capital market imperfections. Authors however underlined the difficulty "*to assess the impact of these policies and distortions because they generally overlap, creating both impediments and stimuli to capital flows*". This statement more generally highlights the fact that empirical analyses to date have focused on identifying the most important barriers to investments and financial flows to developing countries, rather than quantifying the positive mobilisation impact of specific policies and country/market conditions.

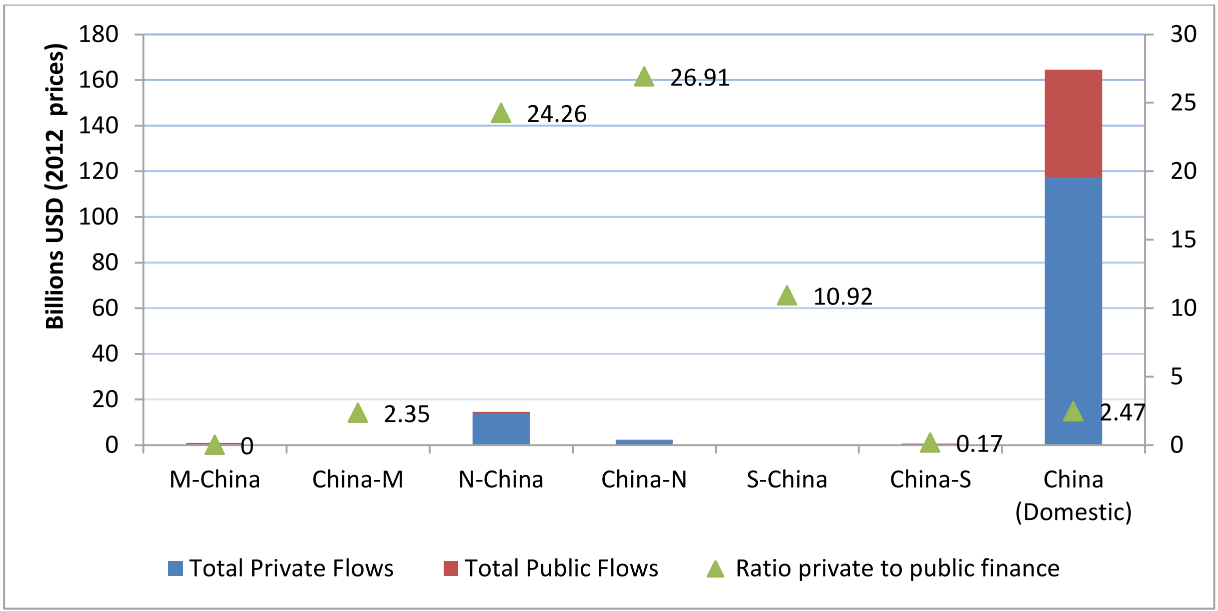
[47] Based on analysing flows from the United States to Latin American and Asian countries.

ANNEX 3. BNEF DEFINITIONS

Organisation's Ownership	BNEF Definition
Academic / Research foundation	Universities, national labs and certain research foundations have complex ownership structures, somewhere on the spectrum from public to semi-private. It's not worth trying to figure it out, as it is generally not possible to invest directly in them, so we log them separately.
Charity / Non-profit / Association	Organisations that are set up as non-profit-making, and are regulated and overseen as such by the authorities. Examples - Greenpeace, most industry associations, lobbying groups.
Defunct	Companies or organisations that are no longer operating. Companies may have sold their assets or been closed down, governmental programmes may have been wound up.
Government / Public sector	Central and local government agencies, ministries, programmes run by the public sector.
Individual / Angel network	Wealthy individuals, known as "angels" who invest in young companies either alone or in groups. If a group of angels creates a formal fund, then it would not be classified here but under either Partnership or Private / Family Controlled, depending on its legal structure.
Joint Venture / Consortium	Joint Venture: A company set up by two or more others, with the shares owned purely by them. If they bring in a VC or Private Equity (leveraged buy in/out) investor, then the company should be classified as VC / PE funded as it must be managed for rapid value creation and an exit by the investor, which will be interesting to track. Consortium: Formal or informal grouping of companies, combining their efforts towards a specific purpose (frequently used for large project developments.
Partnership (investment, law etc)	Lawyers and professional service firms form limited or other partnerships, as do many money managers. It's ownership structure that suits businesses that do not require direct investment and where the executives are also generally long-term owners and want a high degree of control.
Pre-institutional funding	Companies that have been set up, usually to commercialise intellectual property or technology, but are either at a very early stage or have not yet raised funding from an incubator, venture capital, private equity company or corporate venturer. They may be spin-outs from a university, company or other organisation, or they may have just been founded by an entrepreneur to exploit a market need.
Private / family-controlled	Not all private companies are suitable for venture or private equity funding. Those that are closely controlled by a family or family trust, or which have a diffuse ownership structure are classified as Private / family controlled, as are smaller companies that are not start-ups, but are not expected to scale in a way that would be attractive to outside investors. When we come across companies that are not quoted or subsidiaries of other companies, they are classified as private / family-controlled until we find out more about their sources of funding and whether they are looking for venture money.
Quoted company	Companies whose shares are publicly traded on any major stock market. Companies on the over-the-counter market (OTCBB, Pink Sheets) are classified as VC- / PE-funded if they have investors of the following sort: incubators, venture capital, PE leveraged buy-out buy-in, corporate venturers.
Quoted-OTC	Quoted-OTC companies are those which are listed on junior or venture markets, or in the over-the-counter market. They form an intermediate category, between Private/family-controlled or VC/PE-funded companies and companies quoted on the world's major markets.
Special Purpose Vehicle (SPV)	Organisations set up with the specific purpose of building or buying a particular asset or set of assets, and which raise project finance in order to do so. Many power generation projects are structured in this way, with the SPV entering into contracts for building and maintaining the asset, selling the resulting electricity, raising debt finance etc.
State-owned commercial entity	Around the world, much of the energy industry is state-owned. Often, however, even state-owned assets are owned through entities that try to behave commercially, competing with the private sector. Indeed they may accept private investment, or at some stage even be privatised – hence it's interesting to separate them out from other governmental bodies.
Subsidiary / Division	Companies majority-owned or controlled by a private or publicly-quoted company. We track them because they might at some point be spun out and/or given their own listing, or sold.
VC / PE funded	Companies that have raised at least one round of finance from an incubator, VC, private equity buy-in / buy-out company or corporate venturer. These are companies that are being aggressively managed for value creation, and already have sufficient track record to have attracted investment.

ANNEX 4. IMPORTANCE OF FLOWS TO, FROM AND IN CHINA

Figure A4.1. Volume of flows to, from and in China and observed public-private finance ratios



***Source*: Constructed using BNEF data. Country classification based on Gross National Income per capita.**

Table A4.1 Importance of flows to, from and in China as a percentage of overall flows

	Total private flows	Total public flows
Multilateral-China / Multilateral-South		13.15%
China-Multilateral / South-Multilateral	6.82%	2.78%
North-China / North-South	38.56%	7.15%
China-North / South-North	25.38%	1.60%
South-China / South-South	6.24%	1.30%
China-South / South-South	4.99%	65.34%
China domestic / South domestic	59.15%	61.23%

ANNEX 5. CONSTRUCTION OF EXPLANATORY VARIABLES

A5.1 Data from the Centre d'Études Prospectives et d'Informations Internationales (CEPII)

CEPII makes available a "square" gravity dataset for all world pairs of countries, for the period 1948 to 2006.[48] This dataset was generated by Keith Head, Thierry Mayer and John Ries to be used in the Head et al 2010.[49] From this dataset we include the following variables:

- Common Official Language: is a dummy variable equal to 1 if both the source and the destination countries have the same official language. Official or national languages and languages spoken by at least 20% of the population of the country (and spoken in another country of the world) following the same logic than the "open-circuit languages" in Mélitz (2002)[50].

- Distance: is a continuous variable measuring the distance using city-level data to assess the geographic distribution of population (in 2004) inside each nation. The basic idea is to calculate distance between two countries based on bilateral distances between the biggest cities of those two countries, those inter-city distances being weighted by the share of the city in the overall country's population.[51]

- World trade organization membership: is a dummy variable equal to 1 if the source or destination countries are members, this information comes from the WTO web site.

- Common legal origin: is a dummy variable equal to 1 if both source and destination countries have the same legal origins. Data on common legal origins of the two countries are available from Andrei Shleifer at http://post.economics.harvard.edu/faculty/shleifer/Data/qgov_web.xls.

CEPII gravity variables were matched to our dataset on a country-pair basis, taking into account the last available year (2006).

A5.2 Clean Development Mechanism and Joint Implementation (CDM/JI) projects dataset

The CDM/JI Pipeline Analysis and Database contains all CDM/JI projects that have been sent for validation/determination. This database is used for the construction of the CDM/JI variable.

[48] http://www.cepii.fr/CEPII/en/bdd_modele/bdd.asp extracted the 25th of November.

[49] HEAD, K., T. MAYER AND J. RIES, 2010, "The erosion of colonial trade linkages after independence" Journal of International Economics, 81(1):1-14. (formerly CEPII discussion paper # 2008-27).

[50] Mélitz, J. (2002), "Language and Foreign Trade", CEPR Discussion Paper# 3590.

[51] The general formula developed used for calculating distances between countries can be found in Head and Mayer (2002).

The host of the project is used as the destination. We only include registered projects, which span from 2004 to 2011 in the CDM database and from 2008-2011 in the JI database. Out of the 27 different sectors, we only keep the 6 sectors studied in this paper: Wind, Solar, Hydro, Geothermal, Marine (as Tidal) and Biomass& Waste (as Biomass Energy, Methane avoidance and Landfill gas).

We construct variables accounting for the number of projects, number of certificates, number of MW of electric capacity installed and total investment. These variables are constructed by aggregating individual CDM **and** JI projects by destination and year. For these variables we construct the contemporaneous variable as well as the lagged and stock variables. The CDM/JI database is exhaustive; hence, zeros are imputed for the remaining countries, years and sectors.

Investment values are in millions of 2011 USD dollars using the investment deflator (below) and transformed using an Inverse Hyperbolic Sine Transformation.

"UNEP Risoe CDM/JI Pipeline Analysis and Database, accessed in October 2013" http://www.cdmpipeline.org/index.htm.

A5.3 Official Export Credits

Officially supported export credits can play a key role in the transfer and use of development-beneficial technologies in developing countries, including in terms of low-emission climate-resilient solutions. Their use in the context of financing developing countries is controversial because they require the recipient developing country to purchase goods and/or services from the developed country issuing the export credit. Two variables are constructed, public export credits, and private exports credits publicly guaranteed. The latter variable is the aggregation of private non-bank flows and bank flows. Both variables cover all sectors and activities, as it was not possible to isolate their energy, climate or environment component. This information is used to attribute a source and a destination of the export credit. The dataset extends from 2000 to 2011. For domestic flows we impute a zero, however for cross-border South flows we are not able to impute a value. Both variables are in millions of 2011 USD using the GDP deflator provided by the World Bank, they are transformed using the IHS transformation.

A5.4 Official Development Assistance (ODA)

ODA donors report their aid flows (in millions of USD) in the Creditor Reporting System (CRS). The CRS dataset contains the information detailed the project level which is used to construct aggregated information at the source, destination and year level.

Since 1998 the Development Assistance Committee (DAC) has monitored aid targeting objectives of the Rio Conventions through its CRS using the "Rio Markers". Every aid activity reported to the CRS should be screened and marked as either (i) targeting the conventions as 'principal objective' or a 'significant objective', or (ii) not targeting the objective. There are four Rio markers, covering: biodiversity, desertification, climate change mitigation, and climate change adaptation. The adaptation marker was introduced in 2010. The same activity can be marked for several objectives, e.g. climate change mitigation and biodiversity. Hence, the aggregation across different Rio markers can lead to double counting. Rio markers are defined as follows:

- Biodiversity-related aid is defined as activities that promote at least one of the three objectives of the Convention: the conservation of biodiversity, sustainable use of its components (ecosystems, species or genetic resources), or fair and equitable sharing of the benefits of the utilisation of genetic resources.

- Desertification-related aid is defined as activities that combat desertification or mitigate the effects of drought in arid, semi-arid and dry sub-humid areas through prevention and/or reduction of land degradation, rehabilitation of partly degraded land, or reclamation of desertified land.

- Climate change mitigation-related aid is defined as activities that contribute to the objective of stabilisation of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system by promoting efforts to reduce or limit GHG emissions or to enhance GHG sequestration.

- Climate change adaptation-related aid. In December 2009 the DAC members approved a new marker to also track aid in support of climate change adaptation. This new marker will complement the existing climate change mitigation marker, and thus allow presentation of a more complete picture of aid in support of developing countries' efforts to address climate change.

We only include climate change mitigation-marked ODA projects since it is the category that accounts for projects that generate greenhouse gases reductions, out of which renewable energy projects are a significant share along with transport and water.

We use project-level information to in order to construct the variables for our analysis. First, we include all projects that have been marked as having a ‘principal’ or ‘significant’ climate change mitigation objective. Second, we distinguish between projects financed by ODA (concessional) loans or ODA grants, as this split will provide information on the underlying differences of both types of aid. Finally, we aggregate these variables across source (donor), recipient (destination), and year. ODA variables are in millions of 2011 USD using the GDP deflator provided by the World Bank, they are transformed using the IHS transformation.

A5.5 Investment Deflator

Extracted the 6 Jan 2014 from the FRED Economic Data, St. Louis FED (http://research.stlouisfed.org/fred2/series/INVDEF)

“The deflator for investment goods is constructed following Gordon (1990), Cummins and Violante (2002), and Fisher (2006). I first extrapolated forward the time series models fitted by Cummins and Violante (2002) to construct updated annual quality-adjusted deflators for equipment and software and the durables component of personal consumption expenditures. The fixed investment deflator is obtained by chain-weighting the equipment and software deflator I constructed with the deflator for non-residential structures from NIPA. Chain-weighting the fixed investment and the residential investment deflator from NIPA gives the gross private domestic investment (GPDI) deflator. Finally, the investment deflator is constructed by chain-weighting the GPDI deflator and the deflator for personal consumption expenditures on durables. The result of this procedure is an annual time series for the investment deflator. As in Fisher (2006), I construct a quarterly time series by interpolating the annual deflator with the quarterly deflator for the same aggregate constructed exclusively from NIPA data. The relative price of investment, pI, is the investment deflator divided by the GDP deflator (JGDP).”

R. DiCecio (2009). "Sticky wages and sectoral labor comovement," *Journal of Economic Dynamics and Control*, 33(3): 538-53. (http://dx.doi.org/10.1016/j.jedc.2008.08.003).

ANNEX 6. MODELLING STRATEGY

A6.1 Gravity Models

The gravity model is inspired by Newton's gravity equation, it is based on the idea that the attraction between two countries is directly proportional to their size (GDP as a proxy) and inversely proportional to their distance (transaction costs, institutional similarities, policy framework, etc. as proxies). The flexibility in terms of country grouping and sample split offered by gravity models makes it possible to address our research question on the policy determinants of private flows to 'South'.

Gravity models form one of the oldest and largest literatures in empirical economics (Leamer and Levinsohn 1995). They have been developed to study trade (Tinbergen 1962; Linnemann 1966; Leamer and Stern 1971; Baldwin 1994; Eichengreen and Irwin 1996; Feenstra 1998; Anderson and van Wincoop 2003), international agreements (Orefice and Rocha 2014), international investment (Rose and Spiegel 2002; Keller and Levinson 2002), the impacts of trade on the environment (e.g., Frankel and Rose 2005) and international technology transfer (e.g., Keller 2002, 2004, 2009; Haščič and Johnstone 2011; Dechezleprêtre et al. 2013). Their theoretical framework is justified by Bergstrand (1989) for the factorial model, Deardorff (1979) develops the Hecksher-Ohlin model, Anderson and van Wincoop (2003) accounted for relative trade costs in endowment-economy models, Helpman, Melitz and Rubinstein (2008) develop a theoretical framework in the context of firm heterogeneity and Okawa and van Wincoop 2012 develop a theory for financial holdings.[52]

The debate has turned now to the performance of different estimation methods, providing a workhorse of econometric modelling techniques aiming to address the issues that arise when estimating gravity models. These issues are namely the transformation of the dependent variable, presence of heteroskedasticity, overdispersion, zeros and missing data, clustering of errors, trade resistance terms, endogeneity, fixed-effects and double, triple or higher indexation. This annex discusses these topics in the context of our data and model specification.

A6.2 Empirical topics

Heteroskedasticity and transformation of variables

Estimation of gravity models in levels rather than in logs can lead to heteroskedasticity, typically arising due to large variation in country size. Hence, gravity models are traditionally log-transformed. This practice simplifies estimation as it log-linearizes the multiplicative form of the gravity equation, it reduces the skewness in data (e.g. a thin and long tail for high values) and aims to correct the non-constant variance of the errors. However, log transformation only partially corrects the heteroskedasticity and the functional

[52] This list is non-exhaustive. The volume of papers produced with gravity models has been increasing at higher rates in the past years.

form problem. Since the log of zero is undefined, the conditional expectation of the log of the dependent variable is approximately equal to negative infinity[53].

It is a common practice to add an arbitrary small constant to the dependent variable. However, this might only complicate the problems at it may bias coefficients, making them sensitive to the choice of the constant (Flowerdew and Atkin 1982; King 1988). MacKinnon and Magee (1990) discuss additional transformations to the dependent variables such as the Box-Cox transformation and the Inverted Hyperbolic Sine Transformation. As the log-transformation, the box-cox transformation is not defined for zero values, hence it will not be useful in our setting. On the other hand, the *inverted hyperbolic sine* (ihs) transformation[54] is defined for any positive values, zero included. IHS transformation is equivalent to a log function for reasonable values[55], thus allowing for the same interpretations as when using a log transformation (e.g. in terms of elasticity)[56]. While IHS transformation is defined for zero values, it does not address the possible bias of coefficients arising in the presence of heteroskedasticity[57].

Other estimation techniques can address the biases generated by the transformation of the dependent variable. In particular, Silva and Tenreyro (2006) point out that neglecting the Jensen's inequality[58] in Ordinary Least Squares estimations can lead to misleading interpretations of the results in the presence of heteroskedasticity. They suggest the use of the Poisson Pseudo-Maximum Likelihood Estimator that deals with both the bias of coefficients in the presence of heteroskedasticity and the presence of zeros[59].

Helpman, Melitz and Rubinstein (2008) develop a theoretical model à la Melitz (2003) to account for heterogeneity of firms. They adapt a Heckman selection model[60], which is a two-step estimation, that estimates the decision of trade (extensive margin) and the volume of trade (intensive margin). In particular, the difficulty of estimating such models lies in finding the appropriate exclusion restriction variable, this variable has to be correlated with the decision of trade but not with the volume of trade. The estimation of a selection model without the exclusion restriction might generate inconsistent estimates, therefore rejecting the null hypothesis of a significant cross-equation error correlation of the two-step procedure. The non-rejection of the null hypothesis indicates that a model with independent estimations of the decision of trade and the volume of trade is more appropriate, in practice this a amounts to estimate a hurdle log-normal model (or craggit), which estimates a Probit in the first step and a truncated log-normal regression in the second step with independent cross-equation correlation.

[53] Heteroskedasticity does not play a big role in the transformation of regressors.

[54] The Inverse Hyperbolic Sine transformation is defined for positive values by:

$$\mathrm{ihs}(y) = \ln\left(y + \sqrt{1 + y^2}\right) \approx \ln(2y) = \ln(2) + \ln(y)$$

[55] Equivalence is already quite accurate for y≥2 and can be considered as very accurate for y≥3 since values differ by less than 1% after this threshold.

[56] See Burbidge et al. 1988 for a discussion of econometric properties. See Pence 2006 for an application to wealth data.

[57] Also, it poses additional complications in the calculation of the fitted values under the modified conditional expectation.

[58] The expected value from the logarithm of a random variable is different from the logarithm of its expected value i.e. $E(\ln y) \neq \ln E(y)$

[59] The model proposed is a non-linear, exponential gravity model with an additive error term. Their estimator is in theory a weighted least squares estimation whose first order conditions coincide with Poisson estimation. Silva and Tenreyro 2006 shows that the PPML estimator avoids the transformation of the dependent variable making possible the estimation for zero-flows. Moreover, PPML does not require the data to follow a Poisson distribution.

[60] Also called type-2 tobit

Additional non-linear models might provide information on the conditional distribution of the errors, for instance, a more restrictive assumption on the conditional distribution of the errors is imposed by the estimation of a Tobit, where the underlying assumption is that the conditional probability distribution of the error determines both the volume and the decision of investment. In addition, Tobit estimation might not provide consistent estimates if the assumption of normality and homoskedasticiy of the errors is violated.

Overdispersion

Count-data models may be preferred under some of the assumptions mentioned above. However, additional modelling issues arise in the estimation of count-data modes. First, note that the traditional Poisson model assumes equidispersion of the dependent variable. In practice overdispersion[61] is common (Cammeron and Trivedi 2010), and it leads to the presence of unobserved heterogeneity. The Negative Binomial model is a more general model than the Poisson model because it accommodates overdispersion and reduces to the Poisson model as this overdispersion tends to zero. However, the Negative Binomial model presents its own problems as it is highly sensitive to the scale of the dependent variable, undermining the validity of the estimates (Bosquet and Boulhol 2010).[62]

Zero flows

Initial studies of trade estimated gravity models only on positive values. Nevertheless, disregarding countries that do not trade excludes important information on the determinants of trade, and it likely produces biased estimates (Helpman Melitz and Rubinstein 2008). In the context of aggregated micro-data, the imputation of zeros is directly related to the coverage of the database. Indeed, a zero in our dataset, assumes that no flow for that combination of dimensions (i,j,k,t) existed. The imputation is straightforward when a public finance investment was made for that combination of dimensions, however when there is no public finance either we opt to impute zeros on the basis of dimensions i,j,t (not k). This means that "if a sector is covered for a given country-year combination, then all sectors are covered". Consequently, we impute a zero investment volume for the remaining sectors (of the country-year combination). In our judgement, this is the most conservative approach. The idea is to compare the policy framework in countries in which investment (private or public) occurs for a given year and sector against countries with no investment, and running the regression analysis without making any assumptions on zero investment would not let us test this 'crowding-in' effect. The alternative would be to impute (more) zeros under a less conservative approach[63], and intuitively, one would expect to find a greater impact of bilateral public finance[64]. Exactly how much this would make a difference compared with our current approach remains an empirical question.[65]

Another concern generated by the imputation of no flows is the excess of zeros[66]. The PPML put forward by Silva and Tenreyro 2006 might present a problem of limited dependent variable in the case of

[61] The conditional variance exceeds the conditional mean

[62] Silva and Tenreyro (2006) construct an estimator which does not make any assumption on dispersion, therefore providing consistent estimations even under overdispersion.

[63] For instance: (i) if a country is covered for one sector, it is covered for all sectors; (ii) if a destination is covered in one year, it is covered for all subsequent years; (iii) if a source is covered for one year, it is covered for all subsequent years.

[64] It is not clear how this affects the estimated impact of other public interventions.

[65] One could imagine an econometric exercise in which we test the model according the database coverage assumption; this exercise is, however, out of the scope of this paper.

[66] A less conservative assumption would further exacerbate the number of zeros imputed.

excess of zeros (Burger et al. 2009). Hence, Burger et al. 2009 considers modified versions of the count models, namely the Zero-Inflated Poisson Pseudo-Maximum Likelihood and Zero-Inflated Negative Binomial Pseudo-Maximum Likelihood estimation. In practice, these zero-inflated models (Lambert 1992; Green1994; Long 1997) are two-step estimations of their count model counterparts[67]. In turn, Silva and Tenreyro (2009) argues that even in the presence of a high percentage of zeros[68] PPML estimation provides consistent beta coefficients.

In addition to the estimation methods mentioned before, other estimation methods can deal with the existence of zeros, we consider Non-linear Least Squares (NLS), Feasible Generalised Least Squares (FGLS), Gamma Pseudo-Maximum Likelihood (GPML) (Gómez-Herrera, 2013). However, each of them present their own set of problems when applied to our setting. First, NLS in this setting is inefficient as it assigns more weight to observations with a larger variance. Furthermore, this procedure is not robust to heteroskedasticity and sample selection bias (Silva and Tenreyro 2006). Second, Martínez Zarzoso et al. 2007 argue that FGLS is the appropriate model if we ignore the exact form of Heteroskedasticity in data, since it weights the observations according to the square root of their variances and is robust to heteroskedasticity, in practice, the difficulty to implement such estimator is that the variance-covariance matrix has to be estimated in the first step[69].Third, GPML is analogous to the PPML aforementioned, however, in the GPML case the conditional variance of the dependent variable is assumed to be proportional to its conditional mean. This assumption leads to assigning less weight to observations with a larger conditional mean (PPML assigns same weight to all observations). Hence, the implementation of GPML, NLS and FGLS estimation in the presence of large proportion of zeros will lead to inefficient estimates.

Endogenous regressors

Endogeneity in gravity models has been studied using standard instrumental variables and control function approaches. These approaches have been mainly applied to test the endogeneity of preferential or regional trade agreements in the context of bilateral trade (Eeger et al 2011). However, in the context of our study regional agreements are included only for trade, and hence they are likely exogenous with respect to private investment in RE.

In the other hand, given the dimensions explored in our study, there is a concern that public finance might be endogenous.[70] However, it is not clear how could this be addressed because it is not clear what variable could serve as a suitable instrument for public finance. One option could be non-climate ODA flows but those are only relevant in the North-South context, while our more holistic analysis of flows to the South includes domestic South and South-South flows.

Errors

The traditional interpretation of disturbances in the literature of gravity models relates to unmeasured part of true trade costs (Eaton and Kortum 2002), a measurement error of the trade costs, or a measurement error for the rest of the explanatory variables (Baltagi et al. 2013).

[67] They consider two latent groups within the population: those having strictly zero counts and a group having a zero probability of having counts other than zero.

[68] Percentages of zeros in the dependent variable varying from 61% to 83%

[69] The construction of the variance covariance matrix is further complex in the presence of zeros in the dependent variable.

[70] FITs and REQs are likely exogenous given that do not vary by country pairs.

The use of data at different levels of aggregation can create some problems, in particular, if errors tend to be correlated according to cross-sectional units (source, destination, etc) then an important assumption in OLS is violated[71]. A natural generalization is the assumption that errors are clustered; this means that observations within one dimension (e.g. source) are correlated in some unknown way, inducing correlation in ϵ_{ijkt} within this dimension (e.g. source) but that this and other dimensions (e.g. source and destination) do not have correlated errors. In practice, OLS estimation of the log-linear model using robust/clustered errors corrects the estimated errors to account for heteroskedasticity, however it does not have an effect on the estimates of the parameters[72]. In order to account for heterogeneity of country-pairs, gravity model literature has traditionally clustered in these dimensions. In our setting we conduct a set of robustness checks by clustering by Source, Destination and Country-Pair, we find that significance and sign of coefficients does not vary greatly (results not reported here), thus, country-pair clustering in preferred because such cluster is more likely to capture the unobserved heterogeneity in bilateral investment relations. In addition to clustered errors, the inclusion of fixed effects is motivated in order to deal with potential unobserved heterogeneity.

Quadruple indexation and fixed effects

The use of fixed effects by way of indicator variables is well established in gravity modelling[73]. In general, with the inclusion of these fixed effects, the parameters that are not fully collinear with the fixed effects can be estimated with less danger of endogeneity bias (Baltagi et al. 2013). The number and type of fixed effects to include depends on the indexation (dimensions of the model) and the type of estimation to be performed (cross-sectional versus panel data). Indeed, gravity model with triple and higher indexation inevitably leads to panel data estimation. However, some additional issues may arise in the estimation of such models in the gravity framework.

First, panel-data fixed-effects estimation leads to the exclusion of all time-invariant variables. In our setting this will amount to exclude all the market variables capturing the common socio-economic characteristics (common currency, common legal system, etc.). This exclusion of variables can be avoided by the estimation of random country-pair effects. Random-effects estimation relies on the assumption that the pattern of unobserved heterogeneity is distributed randomly with given mean and variance, this strong assumption is rarely met in reality. In fact, the estimation of gravity models with random effects is usually done only for comparison with fixed effects models[74]. Indeed, the random-effects model is rejected in most of the cases, including our case[75]. Alternatively, Hausman and Taylor (1981) develop a linear method that allows the estimation of time-invariant variables. This estimation makes the strong assumption that some regressors are uncorrelated with the fixed effects, thus, they can serve as instruments for their identification (Cameron and Trivedi 2010). In practice, the estimation of a Hausman-Taylor will not take into account the potential heteroskedasticity presented by the dependent variable transformation, more importantly,

[71] Errors are independently and identically distributed, i.e. ϵ_{ijkt} is iid

[72] Hence, in presence of clustered errors, OLS estimates are unbiased but standard errors may be incorrect, leading to inappropriate inference in high proportion of finite samples. In this sense, the PPML estimator (using robust/cluster errors) is preferred as it provides consistent estimates under more general conditions. (Silva and Tenreyro 2006).

[73] Anderson and van Wincoop 2003 develops a theoretical framework for the inclusion of these fixed effects (calling them ‘multilateral resistant terms’) which models the relative trade costs in endowment-economy models. See Baltagi et al. 2013 for a list of seminal papers including fixed effects.

[74] See Egger 2000, 2002, 2004a,b, and Egger and Pfaffermayr 2003 (as mentioned by Baltagi et al. 2013).

[75] We estimate both FE and RE panel-data linear models (ignoring the potential bias introduced by the large number of zeros), the Hausman test indicates that the fixed-effects estimation is preferred. Additionally, Hausman test for Poisson FE versus RE failed to converge even with the exclusion of all fixed effects.

being a linear method it does not deal consistently with a large percentage of zeros on the dependent variable.

Second, a large number of fixed effects might introduce the incidental parameter problem in panel-data models. Moreover, this problem becomes more important in non-linear (short) panel-data models and leads to inconsistent estimates[76]. In our setting non-linear panel-data models have the potential to take into account the number of zeros in our dependent variable. However, the quadruple indexation of our setting poses several problems in the estimation of non-linear models. With quadruple indexation gravity equations there are many options for modelling fixed effects. The common practice[77] is to only include main effects, in our setting this translates in the inclusion source, destination, sector and time effects. A more general version is to include interactions of these fixed effects (e.g. source-time, destination-time, and source-destination), this version can also be extended to include sector effects as well[78]. Empirically, country-pair effects explain more variation in bilateral flows than country-time effects, supporting the inclusion of our time-invariant bilateral variables[79]. We approach empirically the question on the number of additional fixed effects, for our preferred estimation method we depart from the main effects benchmark and subsequently test the inclusion of additional fixed-effects modelling options.

Therefore, given the large percentage of zeros and the quadruple indexation we are constrained to the use of non-linear methods and ensure the inclusion of fixed effects. We thus conclude that a cross-sectional non-linear approach will be both more flexible in the treatment of zeros and allow the inclusion of the appropriate fixed effects. The next section presents the results for the estimation methods discussed in this annex, and provides empirical evidence for our preferred modelling strategy.

A6.3 Comparing estimation methods

This summary underlines two results from the gravity estimation literature: 1) the preferred estimation method has to be chosen on the basis of data, and 2) the method has to be compared with alternatives. Table A6.1 presents a summary of the potential issues in our dataset and the capabilities of different estimation methods to address them.

As a preliminary examination, we test the importance of the inclusion of fixed effects and the presence of heteroskedasticity. The Likelihood Ratio test rejects strongly the null hypothesis of non-significance of fixed-effects; hence, the inclusion of fixed effects is supported both theoretically and empirically. Second, the Lagrange multiplier test finds that the null hypothesis of homoskedasticity is strongly rejected, thus errors are heteroskedastic. Therefore an estimator that allows for the estimation of clustered-robust standard errors and the inclusion of fixed-effects is preferred. Using the benchmark model equation [1] in section 5, our preferred option is estimation using the Heckman method and we perform robustness checks using alternative methods for comparison.

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[76] For this reason, the probit version for fixed effects estimator in panel data is not available. Hence, since tobit combines a probit and a regression, tobit for panel data only exists random effects. Moreover, some of the models discussed in previous sections (Craggit, Tobit or Heckman), do not have their counterpart in panel-data fixed-effects models.

[77] This model has been proposed by Mátyás (1997, 1998), see list of references in Baltagi et al. 2013.

[78] Source-sector-time, destination-sector-time, source-destination-sector and sector-year effects

[79] Baltagi et al. 2013 points out that this implies a big chance for omitted country-pair specific effects to induce endogeneity.

Table A6.1 Summary of estimation methods

Method	Excess of zeros	Heterosk edasticity	Clustered errors	Time-invariant variables	Additional fixed effects	Additional issues[80]
OLS log(y)	✗	✗	✓	✓	✓	Information lost due to exclusion of zeros
Truncated OLS log(y)	✗	✗	✓	✓	✓	Information lost due to exclusion of zeros
OLS log(y+constant)	✗	✗	✓	✓	✓	Results subject to choice of constant
Tobit	✗	✗	✓	✓	✓	Decision of investment and volume are assumed to be determined by the same process.
Craggit	✓	✗	✓	✓	✓	Decision of investment and volume are assumed to be independent
Heckman	✓	✗	✓	✓	✓	Identification subject to finding the exclusion variable
Poisson (P and PPML)	✗	✓	✓	✓	✓	Investigate carefully in excess of zeros
Negative Binomial (NB and NBPML)	✗	✓	✓	✓	✓	Sensitive to scale of dependent variable
Zero-Inflated Poisson (ZIP and ZIPPML)	✓	✓	✓	✓	✓	Find a variable that distinguishes excess zeros from true zeros
Zero-Inflated Negative Binomial (ZINB and ZINBPPML)	✓	✓	✓	✓	✓	Find a variable that distinguishes excess zeros from true zeros
Linear Panel FE	✗	✗	✓	✗	✗	Problems of convergence with additional fixed-effects
Linear Panel RE	✗	✗	✓	✓	✗	Problems of convergence with additional fixed-effects. RE strong assumption.
Hausman-Taylor Panel FE	✗	✗	✓	✓	✗	Problems of convergence with additional fixed-effects
Tobit Panel RE	✗	✗	✓	✓	✗	Problems of convergence with additional fixed-effects. RE strong assumption.
Poisson Panel FE	✗	✓	✗	✗	✗	Problems of convergence with additional fixed-effects
Poisson Panel RE	✗	✓	✗	✓	✗	Problems of convergence with additional fixed-effects. RE strong assumption.

[80] The list is not exhaustive; the topics covered here are those most relevant for our data and model.

ANNEX 7. ESTIMATION RESULTS

Table A7.1 Base model specification – Heckman model

	Full Sample (H1)	Cross-Border (H2)	Domestic (H3)
Volume of private finance (ln) (linear equation)			
Public finance (ln)	0.3908***	0.2298***	0.2875***
	[0.0307]	[0.0816]	[0.0331]
Domestic flow	1.1102*	.	.
	[0.6240]	.	.
Multilateral finance (ln)	0.1326***	0.0974**	0.1633**
	[0.0332]	[0.0384]	[0.0696]
FIT source	0.6178**	0.3244	
	[0.2674]	[0.2940]	
FIT destination	0.5432**	0.2385	1.4251**
	[0.2668]	[0.2868]	[0.5739]
REQ source	-4.2120**	-4.8411***	-2.5754
	[1.7067]	[1.8742]	[3.5940]
REQ destination	1.9993	1.7464	.
	[1.4893]	[1.5842]	.
GDP-per-capita source	0.1112*	-0.0574	
	[0.0618]	[0.0731]	
GDP-per-capita destination	0.0293	-0.0734	0.3071***
	[0.0522]	[0.0581]	[0.1064]
Weighted geographic distance	-0.0375	-0.0426	.
	[0.0835]	[0.0811]	.
Common official language	-0.3448**	-0.3294**	.
	[0.1690]	[0.1664]	.
Regional Trade Agreement	0.2607	1.13E-01	.
	[0.2074]	[0.2053]	.
Common legal system	0.1255	0.0514	.
	[0.1429]	[0.1453]	.
Growth in electricity cons. source	0.6818	-4.8446***	
	[1.6427]	[1.7330]	
Growth in elect. cons. destination	0.6471	-3.1599***	6.0714***
	[1.2775]	[1.1850]	[1.9311]
BNEF control source	0.1537***	0.2428***	0.0126
	[0.0495]	[0.0543]	[0.0803]
BNEF control destination	0.2824***	0.3265***	0.3074***
	[0.0406]	[0.0456]	[0.0661]
Year dummies	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes
Source country dummies	No	No	No
Destination country dummies	No	No	-

Decision of investment (probit equation)			
Public finance (ln)	0.2727***	0.1685***	0.3549***
	[0.0327]	[0.0392]	[0.0575]
Domestic flow	0.3052	.	.
	[0.1933]	.	.
Multilateral finance (ln)	0.1641***	0.1609***	0.2539***
	[0.0156]	[0.0160]	[0.0830]
FIT source	0.1645	0.2028	
	[0.1337]	[0.1365]	
FIT destination	0.4268***	0.4594***	0.3798
	[0.1112]	[0.1076]	[0.3228]
REQ source	0.0222	-0.308	2.222
	[0.5819]	[0.6127]	[1.9418]
REQ destination	0.8918	0.6499	.
	[0.5660]	[0.5963]	.
GDP-per-capita source	0.0809***	0.0815***	
	[0.0222]	[0.0229]	
GDP-per-capita destination	0.1006***	0.0972***	0.1805***
	[0.0186]	[0.0193]	[0.0596]
Weighted geographic distance	-0.0480*	-0.0374	.
	[0.0248]	[0.0245]	.
Common official language	0.1186**	0.1365***	.
	[0.0521]	[0.0526]	.
Regional Trade Agreement	0.0964	8.77E-02	.
	[0.0612]	[0.0628]	.
Common legal system	0.0556	0.0445	.
	[0.0422]	[0.0417]	.
Growth in electricity cons. source	0.3727	-0.1048	
	[0.4283]	[0.4921]	
Growth in elect. cons. destination	0.2921	-0.0469	1.7805*
	[0.3973]	[0.4252]	[0.9814]
BNEF control source	0.0580***	0.0440***	0.0985**
	[0.0157]	[0.0160]	[0.0397]
BNEF control destination	0.0597***	0.0523***	0.0412
	[0.0130]	[0.0130]	[0.0349]
Country-pair in WTO (dummy)	0.3975*	0.0722	
	[0.2222]	[0.1633]	
Destination country in WTO (dummy)			1.2789***
			[0.1712]
Year dummies	Yes	Yes	Yes
Sector dummies	No	No	No
Source country dummies	No	No	No
Destination country dummies	No	No	-
Observations (of which uncensored)	13937 (1992)	11446 (1341)	2491 (651)
Test of independence of equations (Null hypothesis that Rho=0)	rejected at 1%	rejected at 5%	not rejected

Note: * 10%, ** 5%, *** 1% significance levels. Cluster-robust standard errors in brackets.

Table A7.2 Flows by destination (World Bank classification) – Heckman model

	Flows to North (H4)	Flows to South (H5)
Volume of private finance (ln) (linear equation)		
Public Finance (ln)	0.3883***	0.3898***
	[0.0394]	[0.0470]
North domestic (dummy)	base level	
North cross-border (dummy)	-0.6744	
	[0.7289]	
South-North (dummy)	-0.8422	
	[0.8052]	
North-South (dummy)		base level
South cross-border (dummy)		-0.3347
		[0.3012]
South domestic (dummy)		0.3607
		[1.2098]
Multilateral finance (ln)	0.1451***	0.1032**
	[0.0399]	[0.0448]
FIT source	0.7746***	-0.0366
	[0.2949]	[0.4485]
FIT destination	0.6523**	0.0135
	[0.3157]	[0.4916]
REQ source	-3.2382*	-7.3334***
	[1.8235]	[2.6074]
REQ destination	1.3139	1.0894
	[1.5273]	[4.7273]
GDP-per-capita source	0.052	0.1606*
	[0.0707]	[0.0972]
GDP-per-capita destination	0.0994	0.0867
	[0.0703]	[0.0771]
Weighted geographic distance	-0.0925	-0.1279
	[0.1008]	[0.1463]
Common official language	-0.3061	-3.07E-01
	[0.1921]	[0.2435]
Regional Trade Agreement	0.0059	0.2615
	[0.2608]	[0.2202]
Common legal system	0.161	-0.2452
	[0.1660]	[0.2164]
Growth in electricity cons. source	-1.6027	4.2371**
	[1.9373]	[1.9893]
Growth in elect. cons. destination	5.1004***	-0.4146
	[1.8351]	[2.3319]
BNEF control source	0.2106***	0.1191
	[0.0557]	[0.0757]
BNEF control destination	0.3185***	0.0649
	[0.0472]	[0.0625]

Year dummies	Yes	Yes
Sector dummies	Yes	Yes
Source dummies	Yes	Yes
Destination dummies	Yes	Yes
Decision of investment (probit equation)		
Public finance (ln)	0.2577***	0.3094***
	[0.0322]	[0.0700]
North domestic (dummy)	base level	
North cross-border (dummy)	-0.3476	
	[0.2358]	
South-North (dummy)	-0.4062	
	[0.2543]	
North-South (dummy)		base level
South cross-border (dummy)		-0.2438
		[0.2019]
South domestic (dummy)		0.1614
		[0.5036]
Multilateral finance (ln)	0.1582***	0.1911***
	[0.0188]	[0.0296]
FIT source	0.2794*	-0.2782
	[0.1563]	[0.3073]
FIT destination	0.3916***	0.5329**
	[0.1255]	[0.2505]
REQ source	-0.2413	1.3095
	[0.6387]	[1.2436]
REQ destination	0.5445	3.3596**
	[0.6254]	[1.5429]
GDP-per-capita source	0.1020***	0.0175
	[0.0255]	[0.0441]
GDP-per-capita destination	0.1322***	0.0613
	[0.0245]	[0.0397]
Weighted geographic distance	-0.0444	-0.0383
	[0.0315]	[0.0601]
Common official language	0.0968	0.1824*
	[0.0591]	[0.1061]
Regional Trade Agreement	0.076	0.2232**
	[0.0777]	[0.1070]
Common legal system	0.0835*	-0.0025
	[0.0471]	[0.1012]
Growth in electricity cons. source	0.1431	1.2909
	[0.5446]	[0.9602]
Growth in elect. cons. destination	1.1046	0.5026
	[0.7003]	[0.8418]
BNEF control source	0.0559***	0.0548*
	[0.0178]	[0.0318]
BNEF control destination	0.0521***	0.0569*

	[0.0158]	[0.0293]
Country-pair in WTO (dummy)[81]	0.0154	0.5315*
	[0.1954]	[0.2874]
Year dummies	Yes	Yes
Sector dummies	No	No
Source country dummies	No	No
Destination country dummies	No	No
Observations (of which uncensored)	10330 (1564)	3607 (428)
Test of independence of equations (Null hypothesis that Rho=0)	rejected at 1%	rejected at 1%

Note: * 10%, ** 5%, *** 1% significance levels. Cluster-robust standard errors in brackets.

Table A7.3 Estimated marginal effects and elasticities for North-South flows (model H5)

		Heckman (volume)	Heckman (decision)
Bilateral Public Finance	p1	0.3567***	0.0454***
Bilateral Public Finance	mean	0.3597***	0.0487***
Bilateral Public Finance	p99	0.3893***	0.1213***
Multilateral Public Finance	p1	0.0950**	0.0285***
Multilateral Public Finance	mean	0.0952**	0.0301***
Multilateral Public Finance	p99	0.0994**	0.0665***
FIT source	p1	n.e.	n.e.
FIT source	mean	-0.0026	-0.0034
FIT source	p99	-0.0322	-0.0292
FIT destination	p1	n.e.	n.e.
FIT destination	mean	0.0003	0.0021**
FIT destination	p99	0.0106	0.119 (p-value=0.11)
REQ source	p1	n.e.	n.e.
REQ source	mean	-0.1305***	0.0039
REQ source	p99	-0.6146***	0.024
REQ destination	p1	n.e.	n.e.
REQ destination	mean	0.0031	0.0016**
REQ destination	p99	0.0709	0.049* (p-value=0.054)

Note: * 10%, ** 5%, *** 1% significance levels. "n.e." = not estimable, cannot be estimated at zero.

[81] We tried several exclusion variables and found that WTO membership is a suitable candidate because it is correlated with decision of investment but not with the volume. The problem is that in this regression inclusion of all four sets of fixed effects causes convergence problems.

Table A7.4 Estimated elasticities for North-South flows, by sector (model H5)

Heckman (volume)	Wind	Solar	Biomass	Small Hydro	Geothermal	Marine
Bilateral Public Finance	0.3845***	0.3546***	0.3667***	0.3770***	0.3719***	0.1916
Multilateral Public Finance	0.1018**	0.0939**	0.0971**	0.0998**	0.0985**	0.0507*
FIT source	-0.0029	-0.0027	-0.0028	-0.0028	-0.0028	-0.0014
FIT destination	0.0003	0.0003	0.0003	0.0003	0.0003	0.0002
REQ source	-0.1396***	-0.1287***	-0.1331***	-0.1368***	-0.1350***	-0.0695
REQ destination	0.0033	0.0031	0.0032	0.0033	0.0032	0.0017

Note: The Heckman selection equation does not include sector dummies, hence the elasticities do not vary across sectors.

Table A7.5 Extensions to models of flows to the South (World Bank classification)

Flows to south			
	(H6)	**(H7)**	**(H8)**
	Volume of private finance (ln) (linear equation)		
CDM/JI Investment[t-1] in destination	-0.0013		
	[0.0325]		
Export credits		-0.0429	
		[0.0518]	
Public guarantees to private export credits		-0.027	
		[0.0291]	
ODA grants towards mitigation			-0.1953
			[0.1862]
ODA loans towards mitigation			-0.0611
			[0.0609]
…and other covariates as in model H5 (not reported)			
Year dummies	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes
Source dummies	Yes	Yes	Yes
Destination dummies	Yes	Yes	Yes
	Decision of investment (probit equation)		
CDM/JI Investment[t-1] in destination	0.1275***		
	[0.0193]		
Export credits		-0.0315	
		[0.0253]	
Public guarantees to private export credits		-0.0106	
		[0.0133]	
ODA grants towards mitigation			0.0317
			[0.1303]
ODA loans towards mitigation			-0.1097
			[0.0745]
…and other covariates as in model H5 (not reported)			
Year dummies	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes
Source dummies	Yes	Yes	Yes
Destination dummies	Yes	Yes	Yes
Pseudo R-squared	0.209	0.216	0.216
N observations	4345 (499)	3894 (470)	3894 (470)

Note: * 10%, ** 5%, *** 1% significance levels. Cluster-robust standard errors in brackets.

Table A7.6 Estimated elasticities for North-South flows: Additional policy interventions

Public intervention	Heckman (volume)	Heckman (decision)
CDM/JI investment [t-1]	-0.00122	0.01965***
Export credits	-0.04238	-0.00594
Public guarantees to private export credits	-0.03433	-0.00187
ODA grants towards mitigation	-0.20176	0.00405
ODA loans towards mitigation	-0.09082	-0.01642

Table A7.7 provides results obtained using the alternative DAC classification of countries as ‘North’ (DAC members) and ‘South’ (DAC recipients). The consequence is that, compared with the World Bank classification, some countries previously classified as ‘North’ move to the group of ‘South’ (e.g. Poland is listed as a recipient – ‘South’ in DAC classification- for late years[82], but `North’ according to the WB classification, the same goes for Croatia, Czech Republic, Estonia, Korea (until 2010), Saudi Arabia and Singapore among others). The outcome of such re-grouping is that the ‘South’ is now more heterogeneous (with respect to income and financial conditions) and this will affect the empirical results. Overall, the major findings are robust to the choice of country classification (WB or DAC).

Table A7.7 Flows by destination (DAC classification) – Heckman model

Heckman - Linear	**Flows to North (H9)**	**Flows to South (H10)**
Volume of Private Finance (ln)		
Public Finance (ihs)	0.3901***	0.3834***
	[0.0393]	[0.0567]
North domestic (dummy)	base level	
North cross-border (dummy)	-1.4808**	
	[0.7198]	
South-North (dummy)	-2.2079***	
	[0.6924]	
North-South (dummy)		base level
South cross-border (dummy)		-0.2156
		[0.3814]
South domestic (dummy)		0.6849
		[1.4179]
Multilateral finance (ihs)	0.1422***	0.0985**
	[0.0439]	[0.0502]
FIT source	0.8883**	0.5538
	[0.3677]	[0.6376]
FIT destination	0.8376**	0.0412
	[0.3794]	[0.5693]
REQ source	-2.6648	-7.6474***
	[2.0340]	[2.8761]
REQ destination	2.2661	3.8879

[82] Poland became a DAC member in October 2013, (i.e. became a ‘North’ country under DAC classification)

	[1.7217]	[4.2078]
GDP-per-capita source	0.0167	0.1669
	[0.0769]	[0.1138]
GDP-per-capita destination	0.1193	0.0536
	[0.0754]	[0.0845]
Weighted geographic distance	0.026	-0.0885
	[0.0970]	[0.1554]
Common official language	-0.2924	-0.5403
	[0.2003]	[0.3319]
Regional Trade Agreement	0.2471	0.1741
	[0.2735]	[0.2515]
Common legal system	0.1666	-0.1276
	[0.1780]	[0.2557]
Growth in electricity cons. source	0.3294	5.9195**
	[2.0342]	[2.3949]
Growth in elect. cons. destination	5.2745***	0.9218
	[1.9998]	[2.3050]
BNEF control source	0.2008***	0.1175
	[0.0610]	[0.0871]
BNEF control destination	0.3033***	0.0877
	[0.0493]	[0.0750]
Year dummies	Yes	Yes
Sector dummies	Yes	Yes
Source dummies	Yes	Yes
Destination dummies	Yes	Yes
Heckman - Probit		
Public finance (ihs)	0.2607***	0.2940***
	[0.0333]	[0.0705]
North domestic (dummy)	base level	
North cross-border (dummy)	-0.6080**	
	[0.2508]	
South-North (dummy)	-0.8227***	
	[0.2775]	
North-South (dummy)		base level
South cross-border (dummy)		-0.0829
		[0.2123]
South domestic (dummy)		0.5447
		[0.6191]
Multilateral finance (ihs)	0.1337***	0.1982***
	[0.0202]	[0.0332]
FIT source	0.1558	-0.4286
	[0.1847]	[0.2634]
FIT destination	0.4151***	0.7539***
	[0.1455]	[0.2798]
REQ source	-0.0524	0.0549
	[0.6986]	[1.2963]
REQ destination	0.7832	-0.1471
	[0.7166]	[1.6883]

GDP-per-capita source	0.0970***	-0.0169
	[0.0283]	[0.0498]
GDP-per-capita destination	0.1338***	0.1075**
	[0.0286]	[0.0470]
Weighted geographic distance	-0.0059	-0.0126
	[0.0335]	[0.0704]
Common official language	0.1012*	0.1875
	[0.0603]	[0.1320]
Regional Trade Agreement	0.1435*	0.1738
	[0.0810]	[0.1203]
Common legal system	0.1207**	-0.0531
	[0.0519]	[0.1077]
Growth in electricity cons. source	1.0105	0.4859
	[0.6553]	[1.0596]
Growth in elect. cons. destination	0.9598	1.2074
	[0.7963]	[0.9833]
BNEF control source	0.0619***	0.1011***
	[0.0198]	[0.0349]
BNEF control destination	0.0523***	0.028
	[0.0176]	[0.0287]
Country-pair in WTO (dummy)		0.6653**
		[0.3131]
Year dummies	Yes	Yes
Sector dummies	No	No
Source country dummies	No	No
Destination country dummies	No	No
Observations (of which uncensored)	8916 (1438)	3556 (430)
Test of independence of equations	rejected at 0.01	rejected at 0.05

Figure A7.1 Goodness of fit of model H5

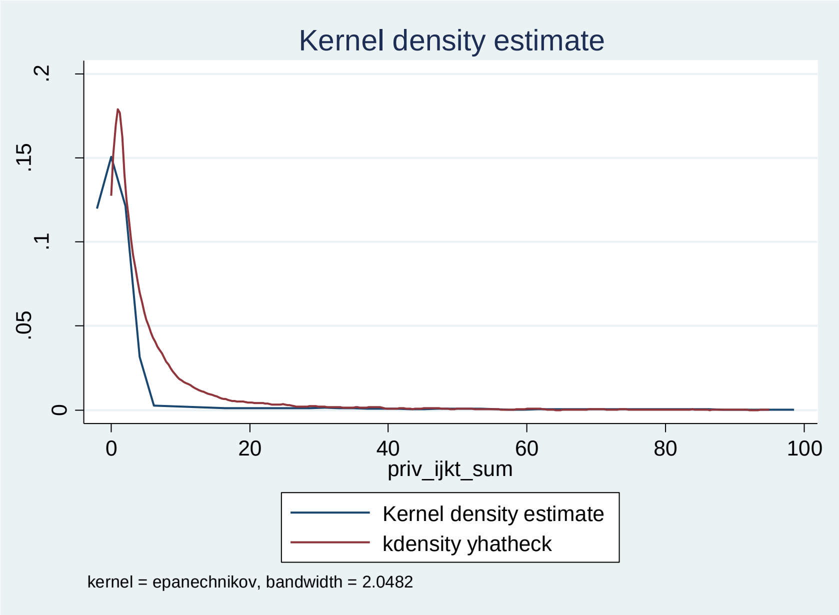

Table A7.8. Descriptive statistics – full sample (model H1)

Variable	Obs	Mean	Std. Dev.	Min	Max
Domestic Flow (dummy)	13937	0.1787	0.3831	0	1
Private Finance (mln USD)	13937	40.099	536.4	0	39027.7
Private Finance (ln)	13937	0.5425	1.4979	0	10.572
Public Finance (mln USD)	13937	5.3328	111.1	0	7212.8
Public Finance (ln)	13937	0.1064	0.6775	0	8.8837
Multilateral Finance (mln USD)	13937	5.9635	71.3	0	1952.1
Multilateral Finance (ln)	13937	0.1586	0.8334	0	7.5772
FIT source	13937	0.0802	0.1827	0	1.5987
FIT destination	13937	0.0768	0.1784	0	1.5987
REQ source	13937	0.0216	0.0368	0	0.1820
REQ destination	13937	0.0198	0.0362	0	0.1820
GDP per capita source (USD)	13937	213692.0	320050.5	208.58	1113572.0
GDP per capita source (ln)	13937	11.2803	1.5180	5.3403	13.9231
GDP per capita destination (USD)	13937	168428.9	280670.9	554.44	1113572.0
GDP per capita destination (ln)	13937	10.9478	1.5980	6.3180	13.9231
Weighted distance	13937	4460.6	4797.8	0	19516.6
Weighted distance (ln)	13937	6.6124	3.2627	0	9.8791
Common Official Language (dummy)	13937	0.3504	0.4771	0	1
Regional Trade Agreement (dummy)	13937	0.6142	0.4868	0	1
Common legal system (dummy)	13937	0.4425	0.4967	0	1
Electricity consumption growth in Source	13937	0.0130	0.0416	-0.1237	0.3365
Electricity consumption growth in Destination	13937	0.0184	0.0437	-0.1241	0.2534
BNEF control, source country (mln USD)	13937	6562.7	13027.4	0.1201	70441.4
BNEF control, source country (ln)	13937	7.1626	2.1855	0.1134	11.163
BNEF control, destination country (mln USD)	13937	4764.7	10218.4	0.1153	63848.2
BNEF control, destination country (ln)	13937	6.5790	2.2792	0.1091	11.064
Country-pair in WTO (dummy)	13937	0.9840	0.1255	0	1

Table A7.9 Descriptive statistics – flows to the South sample (model H5)

Variable	Obs	Mean	Std. Dev.	Min	Max
Private Finance (mln USD)	3607	39.812	562.079	0	24310.5
Private Finance (ln)	3607	0.4628	1.3910	0	10.0987
Public Finance (mln USD)	3607	11.224	164.0	0	5337.8
Public Finance (ln)	3607	0.1629	0.8591	0	8.5828
Multilateral Finance (mln USD)	3607	4.2505	28.0515	0	534.1
Multilateral Finance (ln)	3607	0.1983	0.8953	0	6.2825
FIT source	3607	0.0797	0.1952	0	1.5987
FIT destination	3607	0.0256	0.1057	0	0.9921
REQ source	3607	0.0193	0.0339	0	0.1690
REQ destination	3607	0.0031	0.0128	0	0.0700
GDP per capita source (USD)	3607	226219.1	340692.9	208.6	1113572.0
GDP per capita source (ln)	3607	11.1640	1.7273	5.3403	13.9231
GDP per capita destination (USD)	3607	64267.7	87775.5	554.4	353198.2
GDP per capita destination (ln)	3607	10.0148	1.6572	6.318	12.7748
Weighted distance	3607	5077.7	4629.3	0	18745.6
Weighted distance (ln)	3607	6.3919	3.7668	0	9.8388
Regional Trade Agreement (dummy)	3607	0.5268	0.4994	0	1
Common Official Language (dummy)	3607	0.3679	0.4823	0	1
Common legal system (dummy)	3607	0.4769	0.4995	0	1
Electricity consumption growth in Source	3607	0.0195	0.0446	-0.1237	0.2528
Electricity consumption growth in Destination	3607	0.0509	0.0500	-0.1241	0.2534
BNEF control, source country (mln USD)	3607	7412.2	14173.6	0.9512	70441.4
BNEF control, source country (ln)	3607	7.0326	2.4403	0.6685	11.1626
BNEF control, destination country (mln USD)	3607	3048.2	7907.9	0.5916	45624.8
BNEF control, destination country (ln)	3607	5.8557	2.2453	0.4647	10.7282
Country-pair in WTO (dummy)	3607	0.9548	0.2077	0	1

Table A7.10 Countries included in the econometric analysis

Sample for flows worlwide (74 countries)		Sample for flows to and in the South (67 countries)	
Albania	Kenya	Albania	Latvia
Algeria	Latvia	Algeria	Lithuania
Argentina	Lithuania	Argentina	Luxembourg
Australia	Luxembourg	Australia	Malaysia
Austria	Malaysia	Austria	Mexico
Azerbaijan	Malta	Belgium	Morocco
Belgium	Mexico	Bolivia	Nepal
Bolivia	Morocco	Bosnia and Herzegovina	Netherlands
Bosnia and Herzegovina	Nepal	Brazil	New Zealand
Brazil	Netherlands	Bulgaria	Nicaragua
Bulgaria	New Zealand	Canada	Nigeria
Canada	Nicaragua	Chile	Norway
Chile	Nigeria	China	Peru
China	Norway	Colombia	Philippines
Colombia	Pakistan	Costa Rica	Poland
Costa Rica	Peru	Croatia	Portugal
Croatia	Philippines	Czech Republic	Romania
Cyprus	Poland	Denmark	Russia
Czech Republic	Portugal	Dominican Republic	Saudi Arabia
Denmark	Romania	Estonia	Singapore
Dominican Republic	Russia	Finland	South Africa
Estonia	Saudi Arabia	France	Spain
Finland	Singapore	Germany	Sweden
France	Slovenia	Greece	Switzerland
Germany	South Africa	Guatemala	Thailand
Ghana	Spain	Hungary	Togo
Greece	Sweden	Iceland	Turkey
Guatemala	Switzerland	India	Ukraine
Honduras	Thailand	Indonesia	United Arab Emirates
Hungary	Togo	Ireland	United Kingdom
Iceland	Turkey	Israel	United States
India	Ukraine	Italy	Uruguay
Indonesia	United Arab Emirates	Japan	Venezuela
Ireland	United Kingdom	Kenya	
Israel	United States		
Italy	Uruguay		
Japan	Venezuela		

ANNEX 8. LEVELS OF POLICY AMBITION IN THE 'NORTH'

Table A8.1 Mean level of FITs in countries of the North (in 2011 USD per kilowatt-hour)

Year	Wind	Solar	Biomass	Small hydro	Geothermal	Marine
2000	0.0667	0.0970	0.0585	0.0653	0.0747	0.0567
2001	0.0686	0.1084	0.0572	0.0640	0.0739	0.1042
2002	0.0587	0.1133	0.0585	0.0646	0.0590	0.1038
2003	0.0789	0.2448	0.0856	0.0724	0.0835	0.1225
2004	0.0856	0.3211	0.0983	0.0795	0.0982	0.1348
2005	0.0919	0.3765	0.1029	0.0863	0.1038	0.2431
2006	0.1438	0.5098	0.1789	0.1609	0.2280	0.4534
2007	0.1623	0.5422	0.1978	0.1685	0.3127	0.4942
2008	0.1995	0.5448	0.2456	0.2130	0.3645	0.4866
2009	0.1847	0.4762	0.2146	0.1679	0.3165	0.3480
2010	0.1904	0.4555	0.2192	0.1755	0.3211	0.3293
2011	0.2014	0.4244	0.2290	0.1787	0.3282	0.3467

Table A8.2. Mean level of REQs in countries of the North

Year	All renewables
2000	0.02442639
2001	0.01598287
2002	0.01771621
2003	0.02819511
2004	0.03494479
2005	0.04120638
2006	0.04656271
2007	0.05451433
2008	0.06224334
2009	0.07212502
2010	0.08217184
2011	0.09673036