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International trade and the distribution of **economy-wide benefits from the disbursement of climate finance**

Abstract

In the framework of recent international climate negotiations, industrialised countries have committed to transfer at least USD 100 billion per year to developing countries from 2020. Climate finance has become the subject of an already extensive literature. However, the economic impact of **the disbursement of climate finance** and the role of international trade in its distribution globally have not been studied yet. This paper specifically estimates the geographical distribution of economic benefits for 17 mitigation and 9 adaptation options. We use a Global Multi-Regional Input-Output framework to track both domestic as well as spill-over effects of climate finance disbursements. The relevance of spill-overs is confirmed: on average, 29% of the economic benefits of climate actions flow to countries different from the recipient country (**i.e. to the donors and third countries**). But this percentage varies widely, between 11 and 61 % depending on the type of climate action implemented as well as the recipient country. The findings are expected to be of interest for both recipient and donor countries as they provide guidance on how to maximize the economic co-benefits of climate finance.

Keywords: climate finance, international trade, GMRIO, development

1. Introduction

Financial resources are needed for both climate change mitigation and adaptation. Large-scale investments are required to significantly reduce emissions, notably in sectors that emit large quantities of greenhouse gases (GHGs). The International Energy Agency estimates that achieving a low-carbon energy sector will require an average of United States dollar (USD) 1.2 trillion in additional investments annually up to 2050 (IEA, 2014). On the other hand, according to the Adaptation Gap Report (UNEP, 2014), the global cost of adaptation is currently estimated to range between USD 70 billion and more than 100 billion per year by 2050. However, the dispersion and heterogeneity of adaptation measures make cost estimates very uncertain and probably biased downwards.

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3 Most developing countries face financial constraints (public as well as private),
4 and significant additional costs imposed on their development by the impacts of climate
5 change. Therefore, bilateral/multilateral public and private financing are all likely to be
6 important sources of funding for their mitigation and adaptation activities. Climate
7 finance is a critical topic in the United Nations' climate talks and industrialised
8 countries have committed to provide assistance to developing countries at the
9 Copenhagen Accord, and in the Cancun and Paris Agreements of the United Nations
10 Framework Convention on Climate Change (UNFCCC, 2009, 2010, 2015). In these
11 international agreements the higher-income countries have jointly pledged up to USD
12 30 billion in Fast Start Finance (FSF) for lower-income countries in the period 2010-
13 2012 and, in terms of long-term finance, USD 100 billion annually from 2020 onwards
14 (and a larger amount, still to be determined, after 2025).
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23 Some governments have started to mobilize financial resources to support
24 developing countries' mitigation and adaptation actions. The commitment for the FSF
25 period was reached, especially due to the contributions by Germany, Japan, Norway, the
26 United Kingdom (UK) and the United States of America (USA) (Gupta et al., 2014).
27 However, developed countries are far from reaching the long-term finance goal of USD
28 100 billion per year. According to OECD/CPI estimates, developed countries were able
29 to mobilize and transfer USD 57 billion on average in 2013-2014 (OECD & CPI, 2015).
30 This estimate does not include the initial capitalisation of the Green Climate Fund
31 (GCF), which accounts for USD 10.3 billion as of December 2016 (GCF, 2016). In
32 September 2016, the five main contributors to climate funds (including the GCF) were
33 UK (USD 11,228 million), Norway (USD 6,606 million), USA (USD 5,750 million),
34 Germany (USD 4,203 million), and Japan (USD 3,208 million)¹. Experts agree that
35 climate finance must be accelerated and scaled up to put the world on track to attain
36 climate-neutral and resilient development in this century (Gupta et al., 2014).
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47 So far, mitigation projects have accumulated the largest share of climate
48 finance flowing from developed to developing countries. This bias towards mitigation
49 was already detected in the FSF period, when mitigation was receiving 72% of
50 contributions (Nakhoda, Fransen, Kuramochi, & Caravani, 2013). According to the
51 OECD estimates of the 2013-2014 flows, the thematic distribution of these transfers has
52 been 77% to mitigation, 16% to adaptation and 7% to cross-cutting actions (OECD &
53 CPI, 2015). Buchner, Trabacchi, Mazza, Abramskiehn, & Wang (2015), accounting not
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3 only for internationally provided funding but also for domestically mobilized resources,
4 found a strong bias towards mitigation in 2014, particularly towards renewable energy.
5 Adaptation projects seem to have more difficulties in attracting funding than mitigation
6 projects. Exceptions are East Asia (EA) and the Pacific and Sub-Saharan Africa where
7 56% of total climate finance is for adaptation, especially for measures in the water- and
8 wastewater sector (ibid).
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13 A rapidly growing body of literature on climate finance is emerging, including
14 the study of the drivers of international transfers. Authors addressing this question from
15 a theoretical perspective have identified different causes for the current bias towards the
16 financing of mitigation over adaptation. These causes include the “global public good”
17 nature of mitigation in contrast to the local scope of adaptation, the cheap mitigation
18 opportunities in developing countries, the existence of established business models and
19 carbon markets, and the possibility to reduce future adaptation needs with investments
20 in mitigation (Abadie, Galarraga, & Rübberke, 2013; Pickering & Rübberke, 2014;
21 Pittel & Rübberke, 2013; Rübberke, 2011). Empirical analysis highlights the relevance
22 of country-specific factors, like their institutional, economic and political characteristics
23 (Halimanjaya, 2015; Pickering et al., 2015).
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32 This paper contributes to this body of literature by studying an aspect of
33 climate finance that, to the best of our knowledge, has not been considered yet: the
34 economic effects of expenditures driven by climate actions, taking into account the role
35 of international trade. *It is obvious that mitigation and adaptation actions linked to
36 climate finance have economic impacts in terms of avoided costs of climate change. In
37 addition, in some cases, these actions can have co-benefits in terms, for example, of
38 health improvements due to the reduction of air pollution. However, these are not the
39 only economic implications of climate finance.* Like any other type of expenditure,
40 projects and programmes aimed at reducing emissions and/or enhancing climate-
41 resilience require the production of goods and services, and hence, the creation of value-
42 added in various economic sectors at different locations. This paper quantifies the extent
43 to which the benefits of climate action, in terms of value-added creation, are retained by
44 recipient countries of climate finance or, by contrast, are captured by companies from
45 other countries via international trade. Moreover, by assessing the economic effects of
46 different types of climate actions in different locations, this paper provides information
47 for climate finance allocation decisions. Note that the scope of the assessment of
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3 economic effects is limited to the phase of disbursement of climate finance. Another
4 branch of the climate finance literature deals with the economic consequences of the
5 mobilization of financial resources in donor countries (Basu, Finneran, Bishop, &
6 Sundararaman, 2011; IMF, 2011; Jones, Keen, & Strand, 2013; Parker et al., 2010). We
7 also keep out of the analysis the study of the effectiveness of climate finance in terms of
8 avoided costs of future climate change.
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13 The specific objectives of this paper can be summarized in three questions.
14 First, how are the economic impacts of climate actions distributed between countries?
15 Second, distinguishing for different types of mitigation and adaptation actions, how
16 much of the impact spills over to non-recipient countries? And third, distinguishing for
17 different disbursement options (i.e. combinations of recipient country and climate
18 action), how much impact is captured by each donor country?
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24 The article is divided into five sections. After this introduction (Section 1), the
25 methods and materials are introduced in Section 2. Results are presented in Section 3,
26 and discussed in Section 4. Section 5 presents conclusions and policy implications.
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30 **2. Methods and materials**

31 **2.1. The Input-Output Model**

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33 The Input-Output (IO) approach has been widely applied to various areas over the last
34 50 years (Han, Yoo, & Kwak, 2004; Miller & Blair, 2009). This is the most widely
35 utilized approach for the analysis of macro-economic effects of major new expenditures,
36 as is the case for investments driven by climate policies (e.g. Allan et al., 2008; Caldés,
37 Varela, Santamaría, & Sáez, 2009; Hienuki, Kudoh, & Hondo, 2015; Markaki, Belegri-
38 Roboli, Michaelides, Mirasgedis, & Lalas, 2013; Neuwahl, Löschel, Mongelli, &
39 Delgado, 2008; Oliveira, Coelho, da Silva, & Antunes, 2013; Scott, Roop, Schultz,
40 Anderson, & Cort, 2008; Tourkolias & Mirasgedis, 2011).
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49 An IO table provides a picture of the market transactions taking place between
50 the different actors (producers, households, government, etc.) of one economic system
51 in a specific year. National IO tables, representing the national economic system, are
52 appropriate for the assessment of domestic effects of new investments, but do not
53 capture the impact in other countries (Herrerias Martínez et al., 2013; Ziegelmann,
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3 Mohr, & Unger, 2000). These effects, also called spill-over effects, refer to economic
4 impacts outside of the economy where the expenditure is made, and are driven by
5 international trade.
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9 Given the growth of vertical specialization and the increasingly global nature
10 of current supply chains (Francois, Manchin, & Tomberger, 2015; Johnson & Noguera,
11 2012; Koopman, Wang, & Wei, 2012, 2014; Los, Timmer, & de Vries, 2015;
12 Nagengast & Stehrer, 2016)², Global Multiregional Input-Output (GMRIO) tables are a
13 highly suitable tool for studies with a global scope, since they inherently reflect the
14 current interconnectivity of the world's economies. They comprise information on
15 global supply chains, reflecting the participation of the different sectors and countries in
16 the production process of each single good or service. The information about inter-
17 linkages between industries makes it possible to comprehensively track the effect of an
18 exogenous increase in demand throughout the global productive system. GMRIO tables
19 allow us to trace the value-added created by all the labour and capital directly or
20 indirectly needed for the production of final goods along their global value chains. This
21 feature makes this framework suitable for the purpose of this paper (M. P. Timmer,
22 Erumban, Los, Stehrer, & de Vries, 2014). Spill-over effects of climate policy have
23 been previously assessed using this framework at the European Union (EU) level (Arto,
24 Amores, & Rueda-Cantuche, 2015; Markandya, Arto, González-Eguino, & Román,
25 2016). [In the Appendix we show the formal structure of the multiregional IO model and
26 how we have used it to analyze the effects of climate finance.](#)
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39 The IO method is based on the assumption of a linear relationship between
40 inputs and production. It is also assumed that each sector produces one product, and that
41 each sector has a single and constant input structure. The model ignores the possibility
42 of substitution between inputs or the possibility of increasing/decreasing returns to scale
43 and technical change. A change in output is supposed to produce a proportional change
44 in inputs without affecting prices. These assumptions are only reasonable in the medium
45 term (since the change in the economic structure can be assumed to occur relatively
46 slowly), and in economies with excess capacity and involuntary unemployment, or for
47 the study of relatively small interventions that will not affect prices (Ciorba, Pauli, &
48 Menna, 2004; Tourkolia & Mirasgedis, 2011). These requisites are met in our case,
49 since the focus is on short-term effects of expenditures that, due to their limited volume,
50 cannot be expected to put pressure on wages and prices. Note that, in order to avoid
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3 arbitrary assumptions, the analysis is limited to the gross effects, ignoring the effect of
4 expenditures potentially displaced by the climate finance disbursements. The
5 assessment of net effects free of assumptions is possible using a retrospective approach
6 when historical data on the actual transformations of the economy is available (as
7 shown by Markandya et al., 2016).
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10 11 12 **2.2. The database**

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14 In order to apply this model two sets of data are required: 1) the GMRIO database, that
15 provides information at industry level on production, technical coefficients, final
16 demand and value-added for different countries; and 2) the data required to define the
17 demand shock (f^{st} in the model, see the Appendix) per climate action and recipient
18 country.
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24 From the various GMRIO databases (see Tukker & Dietzenbacher, 2013), the
25 World Input-Output Database (WIOD) is chosen. Two important advantages of WIOD
26 are the following: first, it is public and freely available; and, second, it is based on
27 national Supply and Use Tables (SUT), which contain information in terms of
28 commodities that is required for the definition of the demand shocks. World Input-
29 Output Tables (WIOT) from the WIOD combine information on national production
30 activities for 59 products and 35 industries with international trade data for 40 countries
31 (27 EU countries³ and 13 other major countries) for the period 1995-2011 (see Timmer
32 et al. (2012) for further information on the database). The WIOD has certain
33 weaknesses related to measurement issues⁴ and an important limitation for our analysis:
34 the absence of least developed countries, where climate finance disbursements are most
35 needed.
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44 The analysis focuses on the most recent data (i.e. year 2011) and on all the
45 countries included in the WIOD. Brazil, China, Indonesia, India and Mexico are
46 considered climate finance recipient countries, and the rest of countries are considered
47 donor countries. Donors are divided into four groups: USA, EU, EA (Japan, Korea and
48 Taiwan) and other developed countries (ODC: Australia, Canada, Russia and Turkey).
49 While this set does not include all countries, it represented approximately 84% of global
50 GDP and 72% of global GHG emissions in 2011. The set of recipient countries
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3 represents around 60% of the emissions as well as GDP from developing countries in
4 2011 (World Bank Indicators).
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7 Demand shocks are calculated for different types of climate actions using
8 different sources of information. Following previous categorizations of climate action
9 measures (Blazejczak, Braun, Edler, & Schill, 2014; Buchner et al., 2013; OECD/IEA,
10 2014; Prowse & Snilstveit, 2010; REN21, 2014, p. 21; UNFCCC, 2014b), 26 climate
11 actions are considered, divided into three groups:
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16 - Mitigation: This group consist of those actions with benefits in terms of GHG
17 emissions reductions, including 14 renewable energy technologies (biogas
18 power; biomass energy at large scale; biomass energy at small scale;
19 concentrated solar power (CSP); deep geothermal energy; surface geothermal
20 energy; hydropower; ocean power; offshore wind power; onshore wind power;
21 photovoltaics; renewable energy in buildings; renewable energy in transport;
22 solar thermal energy) and three energy efficiency measures (building insulation;
23 energy efficiency in industry; transport infrastructures);
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- 26 - Adaptation: This group consist of those actions that improve the resilience of
27 societies, including measures in six sectors (coastal protection; disaster risk
28 reduction; human settlements, infrastructure and spatial planning; social
29 protection; waste and wastewater; water supply and management).
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- 32 - Mitigation and adaptation (M&A): This group contains three actions with
33 benefits in both aspects (agriculture, fishing and livestock; capacity building;
34 forestry and land use, terrestrial ecosystems).
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43 For each climate action, a particular cost structure has to be determined. Cost
44 structures consist of the distribution of the total costs of implementation of one action
45 amongst the IO industries or commodities. Cost structures have to be defined in terms
46 of the commodities classification of the SUT of WIOD (i.e. the Statistical Classification
47 of Economic Activities in the European Community or NACE⁵). The cost structures of
48 mitigation actions are taken from the literature: most renewable energy technologies
49 from Lehr, Nitsch, Kratzat, Lutz, & Edler (2008) and Lehr, Lutz, & Edler (2012); ocean
50 energy from Allan et al. (2008); renewable energy in transport and buildings and energy
51 efficiency measures from Markaki et al. (2013). Detailed information at project level of
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3 National Adaptation Programmes of Action (NAPA) (UNFCCC, 2014b) is used for the
4 definition of the cost structures of the rest of the climate actions. Since each climate
5 action in adaptation comprises very different types of interventions, one particular
6 NAPA project has been selected for each type, as shown in Table 1. The cost structure
7 of each climate action is calculated as the average of the cost structures of the different
8 types of interventions it comprises. The allocation of expenditures contained in NAPA
9 projects to the commodity categories of the SUT is done following the correspondence
10 in Table 2.
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17 Figure 1 shows the obtained cost structures in terms of commodities, showing
18 clearly the differences between the types of climate action envisaged. It shows, for
19 example, that almost any type of project requires some construction work (commodity
20 code 45), machinery (commodity code 29) and other business services (commodity
21 code 74). On the contrary, only few actions, such as introducing biofuels in transport,
22 require agricultural products (commodity code 1).
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28 There is uncertainty regarding the cost structures defined for each climate
29 action. The cost structure of renewable energy technologies depends on where and when
30 the data on costs was gathered, due to differences in the costs of raw materials and
31 labour, the different levels of commercial maturity of technologies, the evolution of
32 global markets, etc. Adaptation projects or programs are very heterogeneous, and the
33 site-specific circumstances influence costs. The approach proposed here can be used to
34 undertake concrete case studies departing from data of particular projects, something
35 that would enhance the accuracy of results. However, the ambition of this paper is to
36 extract general conclusions about the sharing of economic benefits of climate finance
37 that are not evident at first glance.
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45 Obtained cost structures are based on cost data that include taxes and trade
46 margins. Since the WIOT are expressed at basic prices (i.e. the amount actually received
47 by producers), trade and transport margins and taxes need to be reallocated. WIOD
48 International Supply Tables contain the information required to calculate tax and
49 margins rates for each recipient country⁶ and commodity. The part of the expenditure
50 corresponding to taxes is reallocated according to the government expenditure structure
51 in each recipient country, which is calculated with information from the WIOD
52 International Use Tables. The amount corresponding to trade margins (calculated with
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3 margins rates and the expenditure net of taxes) is reallocated according to the share of
4 the total margins corresponding to each trade and transport service in each recipient
5 country, which is calculated with information from the WIOD International Supply
6 Tables.
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10 Once the cost structures are expressed in basic prices, the next step is to
11 differentiate where commodities are produced. Using the WIOD International Use
12 Tables, the portion of the total demand that is produced domestically, along with the
13 portion that is imported from all the other countries, are calculated for each recipient
14 country and each commodity. Finally, the demands of each commodity and country are
15 allocated to the WIOT industries according to market shares calculated with the
16 information of the International Supply Tables. The resulting demand shocks (f^{st})
17 contain additional final demands, at basic prices, to different sectors (in different
18 countries) that each climate action entails in each recipient country.
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27 **3. Results**

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29 Using this multiregional framework the amount of value-added generated by each
30 country contributing (directly or indirectly) to the production of the goods and services
31 needed for the climate actions is obtained. In this section, the research questions listed
32 in the introduction are answered. Since impacts at the sector level are not the focus of
33 this research, results are aggregated at country level.
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38 **3.1. Geographic distribution of the value-added impact**

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40 The first question is how the economic impacts caused by the implementation of climate
41 actions are distributed between countries. Figure 2 displays the geographic distribution
42 of the value-added impact of the 26 climate actions considered, depending on where
43 climate finance is disbursed. For example, [looking at the results for India, it can be seen](#)
44 [that](#) out of every USD 100 spent in climate actions in India, USD 80 remain in the
45 Indian economy, China and the EU capture four USD each, the USA and ODC capture
46 two USD each, EA countries capture one USD and the remaining seven USD go to the
47 rest of the world (ROW).
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54 On the one hand, the figure shows the differences in the ability of the
55 economies of recipient countries to hold on to the value-added: in India and Brazil
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3 around 80% of the benefit remains within the domestic economy, but Mexico and
4 Indonesia retain no more than two thirds. China is in an intermediate position among
5 recipient countries, retaining 72% of the impact of its climate actions. On average, spill-
6 overs account for 28.6% of the total impact.
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10 On the other hand, the ability of countries to attract spill-over effects also
11 varies. The EU is the region that benefits most from international spill-overs in most
12 cases. It captures 9% of the impacts generated when climate actions are implemented in
13 China and 7% in the cases of Brazil, Indonesia and Mexico. It is also the donor that
14 captures the highest share of spill-overs from India, where these are in any case very
15 low for all donors. Note that the USA captures 15% of the impacts when climate actions
16 are implemented in Mexico, but less than 3% from other recipient countries. EA
17 captures 6% of the impacts generated by climate actions in China and 5% in the case of
18 Indonesia. In fact, EA captures more spill-overs than the USA in these two countries.
19 China also substantially benefits from spill-overs independently of the destination of
20 climate finance. Spill-overs attracted by China are among the largest when climate
21 finance goes to India, Brazil and Indonesia. For example, China attracts more spill-
22 overs from India and Indonesia than the USA does, and a similar level of spill-overs
23 from Brazil.
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34 In order to clarify how impacts generated by climate finance are distributed
35 among countries, consider the following example, illustrated in Figure 3: if each of the
36 four donor countries (or group of countries) transferred one USD to a hypothetical GCF
37 and this four USD fund was equally distributed among the five recipient countries, each
38 of the donors would recover the following amounts in the form of spill-overs: USD 0.27
39 for the EU, USD 0.21 for the USA, USD 0.15 for EA and USD 0.08 for ODC. The
40 amounts obtained by recipient countries would be USD 0.72 for China, USD 0.65 for
41 India, USD 0.64 for Brazil, USD 0.53 for Indonesia and USD 0.49 for Mexico.
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48 Figure 4 summarises the distribution of the value-added impacts of this
49 hypothetical climate finance architecture. This example clearly shows that international
50 trade redirects the value-added impacts from recipient countries to the countries that
51 produce the inputs required for the deployment of climate actions.
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3.2. Spill-overs by type of climate action

So far, average impacts across a wide range of climate actions have been presented. But the geographical distribution of value-added is different for each type of climate action: some produce mainly domestic impacts whereas others generate a large proportion of spill-overs. Figure 5 shows the spill-overs associated with each type of investment on average for the considered recipient countries.

For example, out of every USD 100 spent in ocean power plants, USD 45 (on average for our set of recipient countries) go to countries different from the host country. Spill-overs range from 17% to 45%. Several actions related to renewable energy sources (ocean power, solar thermal power, onshore wind, geothermal surface, hydropower and the introduction of renewable energy in buildings) produce spill-overs in excess of 35%. The spill-overs from other renewable energy technologies (photovoltaics, small biomass, biogas and offshore wind), energy efficiency measures in industry, construction of infrastructures for transport and adaptation, disaster risk reduction actions and adaptation measures in the water sector range from 30% to 35%. The spill-overs from some renewable energy technologies (CSP, large biomass, deep geothermal and biofuels), adaptation measures (waste management and social protection) and M&A actions (agriculture and capacity building) range from 20% to 30%. Finally, spill-overs of less than 20% are generated in the forestry sector, insulation of buildings and protection of coasts.

Table 3 presents for each type of action the portion of the impact that occurs in each country⁷. Figures for recipient countries reflect the percentage of impact that each one holds on to from domestic climate actions. For example, out of every USD 100 spent in capacity building projects in China, USD 78 remain in the Chinese economy. Figures for donor countries reflect the percentage of impact that each donor country attracts on average from the recipient countries considered. For example, the USA captures on average four USD out of every USD 100 spent in adaptation of the agriculture sector of the considered recipient countries. The figures do not add up to 100%, since spill-overs captured by countries other than donors are not included. Recall that a significant share of the impact of climate actions in different recipient countries ends up in China, a fact that is not reflected in Table 3.

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3 This table clearly illustrates that measures with larger impacts on the
4 economies of recipients offer limited benefits for donor countries in terms of spill-over
5 effects. Depending on the type of action, the average domestic share of the impact
6 ranges from 57% to 84% (see column 6 in Table 3). Differences exist depending on the
7 regions where actions are implemented. Brazil and India retain between 68% and 89%
8 of the relevant impacts, while Mexico holds on to between 39% and 83%, depending on
9 the type of action.
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15 Average figures are included for broader categories of climate action (last four
16 rows in Table 3). Depending on the recipient country, the domestic share of the impact
17 of M&A actions is between 76% and 86%. Other adaptation measures and energy
18 efficiency actions enable countries to hold on to between 64% and 82% of the impacts.
19 Deployment of renewable energy sources of energy retains only between 53% and 77%
20 of the impacts.
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26 According to our results, the climate actions with the highest impact for
27 recipient countries are the following: forestry sector and capacity building actions in the
28 case of M&A; coastal protection, social protection and waste management actions in the
29 case of adaptation; building insulation in the case of energy efficiency; and the use of
30 biofuels, deep geothermal, large biomass and CSP generation in the case of renewable
31 energy.
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36 Depending on the type of action, the average spill-overs that accrue to donor
37 countries range from 2% to 7%, with substantial differences between donors (last
38 column in Table 3). Hence, depending on the donor country, renewable energy
39 investments may provide spill-overs of between 2% and 8%, energy efficiency
40 measures and adaptation between 2% and 7% and M&A actions between 1% and 5%
41 (last four rows in Table 3). From the point of view of donor countries, the types of
42 climate actions that result in a significant portion of impacts taking place in their
43 economies are the following ones: ocean, wind, solar and hydropower for renewable
44 energy sources; those in the industry sector and transport infrastructures for energy
45 efficiency projects; actions in the water sector, infrastructures and disaster risk reduction
46 measures for adaptation; and actions in the agriculture sector for M&A.
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3 Although there is a common pattern for all countries included on the same side
4 of the climate finance transfer (i.e. recipients or donors) regarding the effects of each
5 type of action, there are slight variations. For example, India experiences a larger impact
6 than the average recipient country due to the introduction of biofuels and water supply
7 and management investments. China also stands out because of the size of the local
8 impact of biofuels and photovoltaics. The same occurs with donors. For instance the EU
9 stands out because of the size of the spill-overs received from ocean power investments.
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15 **3.3. Spill-overs by donor country and disbursement option**

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17 In the previous section, spill-overs by donor country, given as average, did not enable to
18 distinguish differences caused by the location where actions are implemented. The size
19 of spill-overs captured by a donor country depends not only on the type of climate
20 action, but also on the recipient country where it is undertaken. Table 4 gathers the
21 results relative to the portion of spill-overs that each donor country can expect from
22 climate-related expenditures in the different recipient countries⁸. To rank climate
23 finance disbursement alternatives according to potential of value-added spill-overs, this
24 table could help to identify the best options for each donor country.
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31 The USA benefits especially from climate projects in Mexico, regardless of
32 their type, as it captures between 7% (coastal protection) and 24% (ocean energy) of the
33 total impact in the form of spill-overs. Other investment options that offer good returns
34 to the USA are ocean energy projects in Brazil and Indonesia and onshore wind projects
35 in Brazil (5% each). China is the country that generates the largest spill-overs for the
36 EU and ODC. The action that offers the largest spill-overs for the EU is ocean power in
37 China and in Mexico (13%). Indonesia, Mexico and Brazil offer spill-overs of 7% on
38 average for the EU. ODC's best options are small biomass projects in China (5%),
39 ocean power and onshore wind in Mexico (4%) and ocean power in Indonesia (4%). EA
40 benefits especially from ocean energy and surface geothermal investments in Indonesia
41 (11%), but also from several types of projects in China and Mexico (7%).
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50 Several combinations of location/type of action have a very limited potential to
51 generate spill-overs for donors. Cases with average spill-overs below 2% include most
52 climate actions in India, several in Brazil (social protection, renewable energy in
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3 transport, capacity building and forest adaptation, building insulation and coastal
4 protection), and building insulation and coastal protection in Indonesia.
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7 8 **4. Discussion**

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10 Results show that the stimulus generated by climate-related expenditures is shared out
11 between the recipient country and other economies, including donor countries, due to
12 international trade. This fact may have implications for both donors and recipients when
13 making decisions about climate finance allocation.
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17 From the point of view of a potential donor, as long as its ability to capture
18 spill-overs is substantial, contributing to climate finance might be a way to stimulate
19 exports and growth. Since the size of potential benefits differs from one donor to
20 another, as results on spill-overs show, the influence of this factor on climate finance
21 decisions might also vary.
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27 Despite that spill-overs might currently be only receiving marginal attention
28 from the donors, it is remarkable that those donors benefitting from significant spill-
29 overs are also major contributors to climate funds (i.e. UK, USA, Germany and Japan).
30 The great ability of China to capture spill-overs may also be somehow related to the
31 prominence of China as donor in South-South cooperation. In fact, China does not hide
32 the fact that foreign aid is seen as a way to expand exports (Minas, 2014; The Climate
33 Group, 2013).
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39 Our results indicate the potential of each type of action and alternative location
40 for generating spill-over effects via demand for donors' industries products. The group
41 of measures that produce the largest spill-overs includes several mitigation and
42 adaptation options requiring goods with high technology content that are not usually
43 produced domestically in many recipient countries, such as machinery (commodity code
44 29), electrical, communication and precision equipment (commodities code 31-33) and
45 motor vehicles (commodity code 34).
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51 So far, investments in the energy sector have been a priority in the use of
52 climate finance (UNFCCC, 2014a). According to our results, this may have produced
53 substantial spill-overs for donors. Agriculture and water, the main sectors receiving
54 finance for adaptation, are also associated with the generation of substantial spill-overs
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3 due to the requirements of machinery (commodity code 29) and research and
4 development services (commodity code 73) (see Figure 1). Asia and the Pacific region
5 (including two recipients that generate large spill-overs, such as China and Indonesia)
6 are the main recipients of past climate finance. This would suggest that the search for
7 spill-overs has been one of the factors determining the international allocation of
8 climate finance. However, a significant proportion of funds has been used for mitigation
9 in the forestry sector in Latin America, a fact that would not be consistent with the
10 prospects of spill-over effects.
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17 On the other hand, projects that are most able to stimulate recipient countries'
18 economies are those intensive in locally produced services like construction work
19 (commodity code 45) and other business services (commodity code 74), as is the case
20 for many adaptation options. Allocating the same priority to support for adaptation as to
21 mitigation has recently become a core element rather than a peripheral issue in the
22 United Nations' climate talks, especially due to developing countries' demands (Fridahl
23 & Linnér, 2015; Galarraga & Román, 2013, 2015; GCF, 2014). This position in favour
24 of increased support for adaptation by developing countries would make sense from the
25 perspective of trying to increase the local impact of climate finance disbursements.
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32 To sum up, the donor's bias towards funding renewable energy projects and the
33 developing countries' demand for more funding for adaptation would be consistent with
34 the economic interests of each group of countries', in the light of our results. Results
35 also provide insights about an additional aspect that should be borne in mind when
36 assessing alternative investment options from the point of view of both donors and
37 recipients.
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43 Our results reinforce the idea that the impacts of climate finance are best
44 assessed on a global scale, and demonstrate the potential of GMRIO databases as tools
45 for analysing economy-wide impacts of climate finance. However, the already
46 mentioned shortcomings of the IO method apply here too. Recall also that our
47 assessment only considers the positive short-term effects associated with new
48 expenditures, but does not account for other impacts on the medium/long term
49 associated with potential displaced expenditures, changes in prices or income.
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51 Furthermore, we only explore the "ancillary" economic impacts of climate finance, in
52 the sense that we do not account for the direct economic benefits of mitigation and
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3 adaptations in terms of avoided impacts (which is the ultimate objective of climate
4 finance).
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7 There are several ways to extend the present research: first, by broadening the
8 scope of analysis to include additional countries. Our analysis only considers five major
9 recipient countries. This might lead to an underestimation of the size of spill-over
10 effects, since it has already been argued that small countries generate more spill-overs
11 (see, for example, Dietzenbacher, Guilhoto, et al., 2013).
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16 This connects with a second possible extension of our research: identifying
17 factors that can explain the results. Despite the fact that all recipient countries
18 considered are big economies, Table 3 shows differences in the abilities of these
19 countries to retain the impacts of similar types of investment. Apart from size,
20 Dietzenbacher et al. (2013) point to the openness of economies to explain the size of
21 spill-overs. The small spill-overs generated by Brazil could thus be a consequence of
22 the big size of its economy and the low dependency on imports (a result that the said
23 authors corroborate in the paper cited). Beutel (2003) points to two additional factors:
24 development level and competitiveness. In fact, competitiveness might provide an
25 explanation of results for Mexico: despite the big size of the Mexican economy, its
26 weaker competitive position in relation to the USA economy could explain the size of
27 the spill-overs between the two countries. Competitiveness might also help us
28 understand why EU countries and the USA, among the donors, and China, among the
29 recipients, are where most relevant spill-overs occur⁹. Other factors that could be
30 included in the study of the determinants of the magnitude of spill-overs are the
31 productive specialization and geographical location.
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43 As previously explained, value-added includes labour remuneration and capital
44 compensation. Thus, one part of the impact accrues to workers and the rest to owners of
45 capital. According to Timmer et al. (2014) from 1995 to 2008 the capital share of value-
46 added has increased globally, but especially in emerging countries such as China, India,
47 Brazil and Mexico. Given the sizeable foreign investment flows, it can be imagined that
48 a significant part of the domestic impact of climate actions in emerging regions is in the
49 form of revenues of multinational companies, whose headquarters are in the most
50 economically advanced regions. Our results do not enable to observe these kind of spill-
51 overs. So, a third possible extension of this paper would consist of separating labour and
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3 capital impacts, and within the latter differentiate the part corresponding to foreign
4 capital.
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6 7 **5. Conclusions** 8

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10 Studies assessing the economic impacts of climate-related expenditures at the national
11 level have noted the relevant role of international trade. For instance, Lehr et al. (2008)
12 conclude that if low-carbon technologies create employment in Germany, this is due to
13 exports. Other studies also show that the ability to retain economic gains depends on the
14 share of components that can be manufactured domestically (Ciorba et al., 2004;
15 Markaki et al., 2013; Oliveira et al., 2013). These previous findings point to the relative
16 position of economies in international markets as a factor in determining the economic
17 gains from climate investments.
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24 Our results confirm that international trade has an important role in the
25 distribution of the economic benefits of climate finance. While the largest portion of the
26 value-added generated by climate actions is domestic (71% on average), a significant
27 share (29% on average) spills over to other economies. Spill-overs accruing to the
28 considered donor countries range from 10% to 28%, depending on the climate actions
29 implemented and the location.
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35 The magnitude of the spill-overs varies with the nature of the project.
36 Deployment of renewable energy technologies generates large spill-over effects, while
37 M&A actions produce substantial domestic impact and limited spill-overs. The type of
38 actions that offer recipient countries the best opportunities to grow do not coincide with
39 those that benefit donor countries in the form of spill-overs. Nevertheless, there are
40 some mitigation and adaptation options that involve substantial benefits in terms of
41 value-added in both donor and recipient countries (i.e. renewable energy sources like
42 CSP and offshore wind, infrastructures for transport and adaptation, and water supply
43 and management projects).
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51 While renewable energy deployment is the type of intervention with better
52 return in terms of spill-overs for all donors, some differences have been identified. The
53 USA benefits from substantial spill-overs from any type of climate project that is
54 implemented in Mexico. Largest spill-overs to the EU come from renewable energy
55 projects implemented in China and Mexico. ODC benefit similarly from renewable
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3 energy investments in China, Mexico and Indonesia, while EA benefits especially from
4 renewable energy in Indonesia.
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7 Several climate actions have been identified that might be unlikely to find
8 funding opportunities if donors made their decisions exclusively based on the prospects
9 of capturing value-added impacts. This is the case of coastal protection in Indonesia,
10 where two million people are exposed to rising sea level rise (IPCC, 2001). In these
11 specific situations the international community should implement mechanisms to ensure
12 that sufficient climate financial flows reach the most vulnerable regions.
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17 Even though the main purpose of climate finance is enabling climate action in
18 recipient countries, the study of the economic impact of climate finance disbursements
19 provides useful insights on how country-driven climate strategies may make a major
20 contribution not only to low carbon development and climate change adaptation, but
21 also to overall economic development. The current analysis has therefore focused on the
22 opportunities of the transition towards decarbonised and resilient societies although, in
23 future developments, it could be used to complement this assessment of economic
24 benefits with the estimation of mitigation potential of financed climate actions.
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31 Taking into account that the long-term finance commitments of higher-income
32 countries under the United Nations' Climate talks entail reaching USD 100 billion per
33 year by 2020¹⁰, spill-over effects may add up to several billion USD per year. Thus, our
34 results constitute valuable information for governments to help them understand the
35 economic consequences of decisions about climate finance allocation. For example, our
36 results suggest that correcting the current bias towards mitigation in climate finance
37 flows would not only enhance developing countries' climate resilience, but also
38 contribute to their economic growth.
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45 Finally, our findings may help aligning mitigation and adaptation to climate
46 change with industrial policy. Thus, our results suggest that some recipient countries
47 have significant room for manoeuvre for improving their ability to retain the value-
48 added generated by capital-intensive projects, such as those involving renewable energy
49 technologies. Such projects require machinery, transportation and communication
50 equipment, and mineral and metal inputs that must typically be brought from abroad.
51 Thus, in order to maximise the domestic impact of climate finance, recipient countries
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3 could pursue strategies aimed at improving the competitiveness of their industrial
4 sectors. Technology transfer programmes may also enhance the ability of these
5 countries to decrease their dependency on imports of capital goods that generate
6 relevant spill-overs. As long as such programmes help to build up competitive industries
7 that can provide substitutes for the imported goods, the domestic impact of climate
8 finance may multiply.
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12 **Notes**

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16 [1] Accounting for the current pledges according to the web site Climate Funds Update
17 (2016).
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20 [2] For example, Timmer et al. (2014) using the GMRIO framework show that the
21 process of international production fragmentation is pervasive: between 1995 and 2008
22 the content of foreign value-added in manufactures increased in 85% of the examined
23 goods.
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27 [3] In the WIOD and in this paper UK is still considered a Member State of the
28 European Union.
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31 [4] For a detailed description of the WIOD project, the WIOT and main weaknesses see
32 Dietzenbacher, Los, Stehrer, Timmer, & de Vries (2013), Timmer et al. (2012) and
33 Timmer, Dietzenbacher, Los, Stehrer, & de Vries (2015).
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37 [5] Table A.1. in the Appendix displays the NACE classification of commodities.
38 NACE stands for Nomenclature statistique des activités économiques dans la
39 Communauté européenne
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43 [6] Since this information is not available for two recipient countries (China and
44 Indonesia), average values of the other recipient countries (Brazil, India and Mexico)
45 are used instead.
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49 [7] Figures for recipient countries (columns 1-5) reflect the percentage of impact that is
50 retained by each country when it receives climate finance. Figures for donor countries
51 (columns 7-10) reflect the percentage of impact that each donor country attracts on
52 average when climate finance is disbursed to the recipient countries considered. The
53 colour scale reflects the attractiveness of each climate action for each country (from the
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3 point of view of its potential for creating domestic impacts in the case of recipient
4 countries, and spill-overs in the case of donors). So, the colour scale ranks values
5 column-wise. The most attractive options are in darker tones and the least attractive
6 ones in lighter tones. The table is sorted by the value of column 6 (Average Recipient)
7 in descending order.
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11 [8] The colour scale reflects the attractiveness of each climate action for each donor
12 country (from the point of view of its potential for creating spill-overs). So, the colour
13 scale ranks the values referred to one donor (including different climate actions in
14 different locations). The most attractive options are in darker tones and the least
15 attractive ones in lighter tones.
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20 [9] Six European countries, the USA and Japan were in the top-ten global
21 competitiveness ranking 2011-2012. China occupies the highest position amongst the
22 BRICS, and Mexico is in 58st place out of 144 in the global ranking (Schwab, 2011).
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26 [10] This amount is similar to the level of total net official development assistance and
27 official aid received in 2005: 108.45 USD billions (The World Bank, 2016).
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Appendix

Table A.1. NACE classification of commodities

Code	Description
1	Products of agriculture, hunting and related services
2	Products of forestry, logging and related services
5	Fish and other fishing products; services incidental of fishing
10	Coal and lignite; peat
11	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying
12	Uranium and thorium ores
13	Metal ores
14	Other mining and quarrying products
15	Food products and beverages
16	Tobacco products
17	Textiles
18	Wearing apparel; furs
19	Leather and leather products
20	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
21	Pulp, paper and paper products
22	Printed matter and recorded media
23	Coke, refined petroleum products and nuclear fuels
24	Chemicals, chemical products and man-made fibres
25	Rubber and plastic products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment not elsewhere classified (n.e.c.)
30	Office machinery and computers
31	Electrical machinery and apparatus n.e.c.
32	Radio, television and communication equipment and apparatus
33	Medical, precision and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; other manufactured goods n.e.c.
37	Secondary raw materials
40	Electrical energy, gas, steam and hot water
41	Collected and purified water, distribution services of water
45	Construction work
50	Trade, maintenance and repair services of motor vehicles and motorcycles; retail sale of automotive fuel
51	Wholesale trade and commission trade services, except of motor vehicles and motorcycles
52	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods
55	Hotel and restaurant services
60	Land transport; transport via pipeline services
61	Water transport services
62	Air transport services
63	Supporting and auxiliary transport services; travel agency services
64	Post and telecommunication services
65	Financial intermediation services, except insurance and pension funding services
66	Insurance and pension funding services, except compulsory social security services
67	Services auxiliary to financial intermediation
70	Real estate services
71	Renting services of machinery and equipment without operator and of personal and household goods
72	Computer and related services
73	Research and development services
74	Other business services
75	Public administration and defence services; compulsory social security services
80	Education services

85	Health and social work services
90	Sewage and refuse disposal services, sanitation and similar services
91	Membership organisation services n.e.c.
92	Recreational, cultural and sporting services
93	Other services
95	Private households with employed persons

Structure of the multiregional IO model

The structure of a multiregional IO model is illustrated with the example of a three-country model. It consists of a system of linear equations that describe the relation between inputs and final products in each sector. In this case, the standard demand-driven model can be written as $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{F} = \mathbf{L}\mathbf{F}$

$$\text{With } \mathbf{x} = \begin{pmatrix} \mathbf{x}^1 \\ \mathbf{x}^2 \\ \mathbf{x}^3 \end{pmatrix}, \quad \mathbf{I} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \quad \mathbf{A} = \begin{pmatrix} \mathbf{A}^{11} & \mathbf{A}^{12} & \mathbf{A}^{13} \\ \mathbf{A}^{21} & \mathbf{A}^{22} & \mathbf{A}^{23} \\ \mathbf{A}^{31} & \mathbf{A}^{32} & \mathbf{A}^{33} \end{pmatrix}, \quad \mathbf{F} = \begin{pmatrix} \mathbf{f}^{11} & \mathbf{f}^{12} & \mathbf{f}^{13} \\ \mathbf{f}^{21} & \mathbf{f}^{22} & \mathbf{f}^{23} \\ \mathbf{f}^{31} & \mathbf{f}^{32} & \mathbf{f}^{33} \end{pmatrix} \quad \text{and}$$

$$\mathbf{L} = \begin{pmatrix} \mathbf{L}^{11} & \mathbf{L}^{12} & \mathbf{L}^{13} \\ \mathbf{L}^{21} & \mathbf{L}^{22} & \mathbf{L}^{23} \\ \mathbf{L}^{31} & \mathbf{L}^{32} & \mathbf{L}^{33} \end{pmatrix}$$

Where \mathbf{x}^r is the column vector of gross outputs in country r with elements x_i^r indicating the production in country r of products of sector i . \mathbf{I} is an identity matrix of the appropriate dimension (in this case, three). \mathbf{A}^{rs} is the matrix of input coefficients calculated as $\mathbf{A}^{rs} = \mathbf{Z}^{rs} (\hat{\mathbf{x}}^s)^{-1}$, where \mathbf{Z}^{rs} is the matrix of intermediate inputs from country r to country s , with elements z_{ij}^{rs} indicating the sales of sector i in country r to sector j in country s and $(\hat{\mathbf{x}}^s)^{-1}$ is the inverse of the diagonal matrix of the gross outputs vector. $(\mathbf{I} - \mathbf{A})^{-1}$ is also known as the matrix of production multipliers or Leontief inverse matrix \mathbf{L} , where each element l_{ij}^{rs} indicates the increase in the production of sector i in country r due to a unitary increase of demand of sector j in country s . \mathbf{f}^{st} is the column vector with the final demand, with elements f_j^{st} indicating the final demand in country t for products of sector j produced by country s . This model is called demand-driven

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2
3 because for any new exogenous final demand \mathbf{F}' , the total output \mathbf{x}' can be estimated as
4 $\mathbf{x}' = \mathbf{L}\mathbf{F}'$.

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6 Value-added reflects the contribution of an industry to an economy (Miller & Blair,
7 2009). Using value-added coefficients it is possible to differentiate the contribution of
8 each country to the value-added embodied in a certain new expenditure (Dietzenbacher,
9 Guilhoto, & Imori, 2013). To calculate value-added coefficients the row vector of
10 value-added in country r \mathbf{w}^r , with elements w_i^r indicating the value-added created in
11 each sector i of that country, is used. With this information and the inverse of the
12 diagonal matrix of the gross outputs, value-added coefficients are obtained as
13 $\mathbf{v}^r = (\hat{\mathbf{x}}^r)^{-1} \mathbf{w}^r$. The vector of value-added effects is calculated as $\mathbf{w} = \hat{\mathbf{v}}\mathbf{x}' = \hat{\mathbf{v}}\mathbf{L}\mathbf{F}'$. Thus,
14 the value-added created in the country r as a consequence of a demand shock in country
15 t is $w^{rt} = \sum_s \mathbf{v}^r \mathbf{L}^{rs} \mathbf{f}^{st}$.

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Table 1. Types of adaptation projects and sources of information

	Climate action	Type of intervention	NAPA Project
Adaptation	Coastal protection	Beach nourishment	GAMBIA #9
		Coastal protection structures	CAPE VERDE #3
		Rehabilitation of coastal areas	SIERRE LEONE #18
	Disaster risk reduction	Early warning or emergency response systems	GAMBIA #1
		Construction or improvement of drainage systems	BHUTAN #5
		Flood protection	BHUTAN #7
		Hazard mapping and monitoring technologies	BHUTAN #9
		Improved climate services	SIERRE LEONE #2
	Water supply and management	Rainwater harvesting and storage	SUDAN #2
		Rehabilitation of water distribution networks	SIERRE LEONE #12
		Desalinization, water recycling and water conservation	TUVALU #3
	Human settlements, infrastructure and spatial planning	Energy security (hydropower)	TANZANIA #5
		Energy security (solar energy)	SIERRE LEONE #8
		Energy security (biomass)	GAMBIA #6
		Transport and road infrastructure adaptation	MALDIVES #10
		Protection of infrastructure	BHUTAN #6
		Zoning	SAMOA #6
		Improving the resilience of existing infrastructures/buildings	MALDIVES #8
	Social protection	Livelihood diversification	MALAWI #1
		Food storage and preservation facilities	LESOTHO #8
Health, vaccination programmes		SIERRE LEONE #23	
Waste and wastewater	Sanitation	SIERRE LEONE #22	
	Storm and wastewater	MALDIVES #5	
Mitigation & adaptation	Forestry and land use, Terrestrial Ecosystems	Afforestation and reforestation	ERITREA #3
		Ecological restoration and soil conservation	LESOTHO #6
		Protection of biodiversity	TUVALU #5
		Forest management, management of slopes and basins	BURUNDI #3
		Forest fires reduction	BHUTAN #11
	Capacity building	Awareness raising and integrating into education	BURUNDI #11
		Technical assistance	MALAWI #5
		Planning, policy development and implementation	SIERRE LEONE #19
	Agriculture, fishing and livestock	Crop / animal diversification	SIERRE LEONE #5
		Crop, grazing land, livestock and fisheries enhanced management	ERITREA #2
Research		MALDIVES #9	
Irrigation and drainage system		SIERRE LEONE #7	

Source: Own work.

Table 2. Correspondence between NAPA categories and NACE codes

NAPA expenditure categories	NACE code
Breeding animals, forage seeds, planting, crop management	1
Forest nurseries, re/afforestation, rehabilitation, beach stabilization, plantations	2
Materials, reporting, communication, awareness creation, training	22
Chemicals, drugs, raw materials	24
Materials for construction and rehabilitation	26
Tools	28
Machinery and installation	29
Office equipment	30
Transmission and distribution network	31
Laboratory/field/data processing eq., hydro/meteorology stations, telecom., remote sensing	33
Vehicles	34
Construction, rehabilitation, beach stabilisation, improve facilities/infrastructure	45
Logistics	60
Communication (campaign, networks, workshops)	63
Communication (telephone, internet and postal charges)	64
Micro-credit fund	65
Vehicle hiring charges	71
Research, experimentation, mapping	73
Technical support, design, management, planning, training	74
Institutionalisation of policies, support to collaborating agencies	75
Sanitary inspections, vector control measures, medical/veterinary services	85
Waste collection, sanitation	90

Source: Own work. NACE classification is reported in Supplementary Material.

Table 3. Portion of impact captured by each country by climate action (%)

Column number	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	IND	BRA	CHN	IDN	MEX	AVG Recipient	EU	USA	EA	ODC	AVG Donor
Coastal (A)	86	88	80	83	82	84	4	3	2	1	2
B_insulation (EE)	82	89	81	81	83	83	3	3	2	2	2
Forest (M&A)	87	87	80	79	78	82	4	4	2	1	3
Capacity (M&A)	86	87	78	78	76	81	5	4	2	1	3
T_RE (RE)	89	84	83	77	68	80	4	4	2	1	3
Social P (A)	84	85	73	75	74	79	6	4	2	1	3
Agriculture (M&A)	85	84	78	76	74	79	5	4	2	1	3
Waste (A)	81	84	77	72	72	77	6	4	3	2	4
Geo_deep (RE)	81	83	76	67	71	76	5	4	3	2	4
Biomass_big (RE)	80	80	74	66	63	73	6	5	4	2	4
CSP (RE)	83	77	72	70	60	72	6	5	5	2	4
Water (A)	75	78	73	65	62	71	8	5	3	2	5
Infrastr (A)	80	78	70	65	60	70	8	5	4	2	5
Wind_off (RE)	81	77	71	65	57	70	7	6	4	3	5
T_infrastr (EE)	79	74	70	70	53	69	8	6	4	2	5
Biogas (RE)	80	76	71	58	57	68	7	6	4	2	5
Industry (EE)	79	76	72	60	53	68	8	6	4	2	5
DRR (A)	78	76	67	63	55	68	8	6	4	2	5
Biomass_small (RE)	75	77	68	56	59	67	7	5	5	3	5
Solar_PV (RE)	73	75	65	67	55	67	6	5	5	2	5
Hydro (RE)	80	71	68	54	44	63	9	7	5	2	6
Wind_on (RE)	79	71	65	57	45	63	8	7	5	3	6
Geo_surface (RE)	77	74	68	50	47	63	9	7	5	3	6
B_RE (RE)	79	69	68	57	42	63	9	7	6	2	6
Solar_thermal (RE)	70	73	66	54	52	63	9	6	5	3	6
Ocean (RE)	68	68	65	44	39	57	11	8	6	3	7
Average M&A	86	86	79	78	76	81	5	4	2	1	3
Average A	80	81	73	70	66	75	7	5	3	2	4
Average EE	82	81	77	72	64	73	6	5	3	2	4
Average RE	77	75	69	59	53	68	8	6	5	2	5

Source: Own work. Abbreviations: BRA (Brazil), CHN (China), EA (East Asia), EU (European Union), IDN (Indonesia), IND (India), MEX (Mexico), ODC (other developed countries), USA (United States of America), AVG (average), A (adaptation), Agriculture (agriculture, fishing and livestock), B_insulation (building insulation), B_RE (renewable energy in buildings), Biogas (biogas power), Biomass_big (biomass energy large scale), Biomass_small (biomass energy small scale), Capacity (capacity building), Coastal (coastal protection), CSP (concentrated solar power), DRR (disaster risk reduction), Forest (forestry and land use/ terrestrial ecosystems), EE (energy efficiency), Geo_deep (deep geothermal energy), Geo_surface (surface geothermal power), Hydro (hydropower), Industry (energy efficiency in industry), Infrastr (human settlements, infrastructure and spatial planning), M&A (mitigation and adaptation), ocean (ocean power), RE (renewable energy), Social P. (social protection), Solar PV (photovoltaics), Solar_thermal (solar thermal energy), T_infrastr (infrastructures for transport), T_RE (renewable energy in transport, biofuels), Waste (waste and wastewater), Water (water supply and management), Wind_off (offshore wind power), Wind_on (onshore wind power).

Table 4. Impact captured by donor country, location and climate action (%)

	USA					EU					EA					ODC					AVG
	IND	BRA	CHN	IDN	MEX	IND	BRA	CHN	IDN	MEX	IND	BRA	CHN	IDN	MEX	IND	BRA	CHN	IDN	MEX	
Ocean	3	5	3	5	24	7	11	13	12	13	2	3	6	11	6	2	2	4	4	4	7
Geo_surface	2	4	3	4	22	5	9	11	10	11	2	2	6	11	5	2	2	4	3	3	6
B_RE	2	4	3	4	22	4	10	11	9	11	2	4	7	9	7	1	1	3	3	3	6
Hydro	2	4	3	4	21	4	9	11	9	11	2	3	7	9	6	1	1	3	3	3	6
Wind_on	2	5	4	4	19	4	9	11	7	10	2	3	7	9	6	2	2	4	3	4	6
Solar_thermal	2	4	3	4	18	6	9	12	9	10	2	2	6	9	5	2	2	4	3	3	6
Industry	2	3	3	3	19	4	9	9	8	9	2	2	5	8	5	2	1	3	3	3	5
T_infrastr	2	4	3	2	21	4	10	11	5	8	2	3	5	6	7	2	1	3	2	3	5
DRR	3	4	4	3	15	5	9	11	8	8	2	2	7	6	5	1	1	3	2	2	5
Biomass_small	2	3	3	3	15	5	7	10	7	7	2	2	5	10	4	2	2	5	3	3	5
Biogas	2	3	3	3	17	4	8	10	8	8	2	2	5	8	5	1	1	3	3	2	5
Infrastr	2	3	3	3	15	4	8	10	8	8	1	2	6	6	4	2	1	3	2	2	5
Wind_off	2	4	3	3	16	4	8	9	5	8	2	2	5	7	4	2	2	4	2	3	5
Solar_PV	2	3	4	2	14	5	6	10	5	6	2	3	7	6	6	2	2	4	2	2	5
Water	2	3	3	3	16	5	8	10	8	8	2	1	4	6	3	2	1	2	2	2	5
Biomass_big	2	3	3	2	14	4	7	7	6	7	1	2	5	7	4	2	1	3	2	2	4
CSP	2	3	3	2	14	3	7	8	4	6	1	3	6	6	6	1	1	3	2	2	4
Waste	2	2	3	2	12	4	6	7	6	6	1	1	4	5	2	2	1	3	2	2	4
Geo_deep	2	2	3	2	12	3	6	7	5	5	1	1	4	6	3	2	1	3	2	2	4
Social P	2	2	4	2	11	3	6	9	5	6	1	1	4	4	2	1	1	2	2	1	3
Agriculture	2	2	3	2	11	3	6	7	5	5	1	1	4	4	2	1	1	2	2	2	3
Capacity	2	2	4	2	12	3	5	7	4	5	1	1	3	4	2	1	1	2	2	1	3
T_RE	1	2	2	2	15	2	5	5	4	5	1	1	2	4	2	1	1	2	2	2	3
Forest	2	2	3	2	10	2	4	6	4	4	1	1	3	4	2	1	1	2	2	1	3
Coastal	1	2	2	1	7	3	5	5	3	3	1	1	4	2	2	1	1	2	1	1	2
B_insulation	1	1	2	1	7	3	4	4	3	3	1	1	3	3	2	2	1	3	2	1	2

Source: Own work. Abbreviations: BRA (Brazil), CHN (China), EA (East Asia), EU (European Union), IDN (Indonesia), IND (India), MEX (Mexico), ODC (other developed countries), USA (United States of America), AVG (average), Agriculture (agriculture, fishing and livestock), B_insulation (insulation of buildings), B_RE (renewable energy in buildings), Capacity B. (capacity building), Coastal (coastal protection), CSP (concentrated solar power), DRR (disaster risk reduction), Forestry (forestry and land use/ Terrestrial Ecosystems), Geo_deep (geothermal deep), Geo_surface (geothermal surface), Hydro (hydropower), Infrastr (human settlements), infrastructure and spatial planning), Ocean (ocean power), Social P. (social protection), Solar PV (photovoltaics), T_infrastr (transport infrastructure), T_RE (renewable energy in transport), Waste (waste and wastewater), Water (water supply and management), Wind_off (offshore wind), Wind_on (onshore wind).

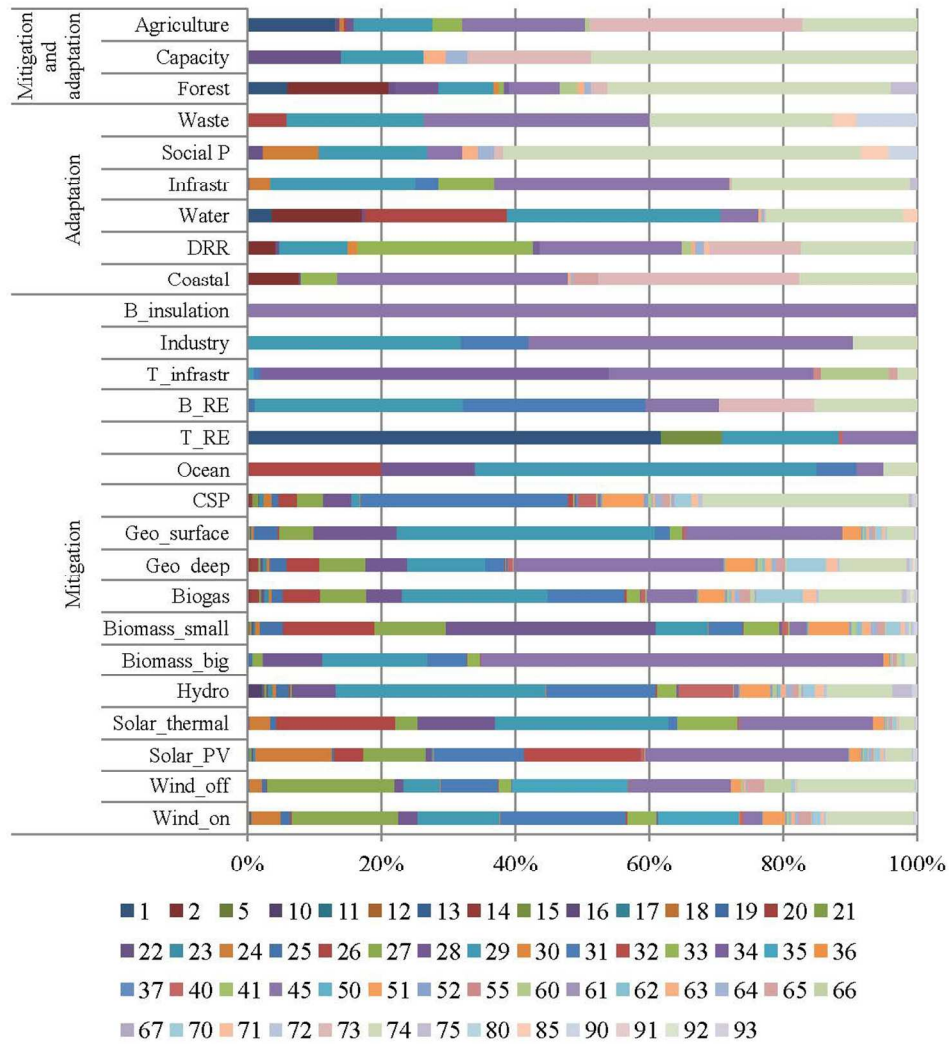


Figure 1. Cost structure per climate action.
 Source: Lehr et al. (2012, 2008), Allan et al. (2008), Markaki et al.(2013), and UNFCCC (2014b). The description of commodity codes of the NACE classification is detailed in Table A.1. of the Appendix.

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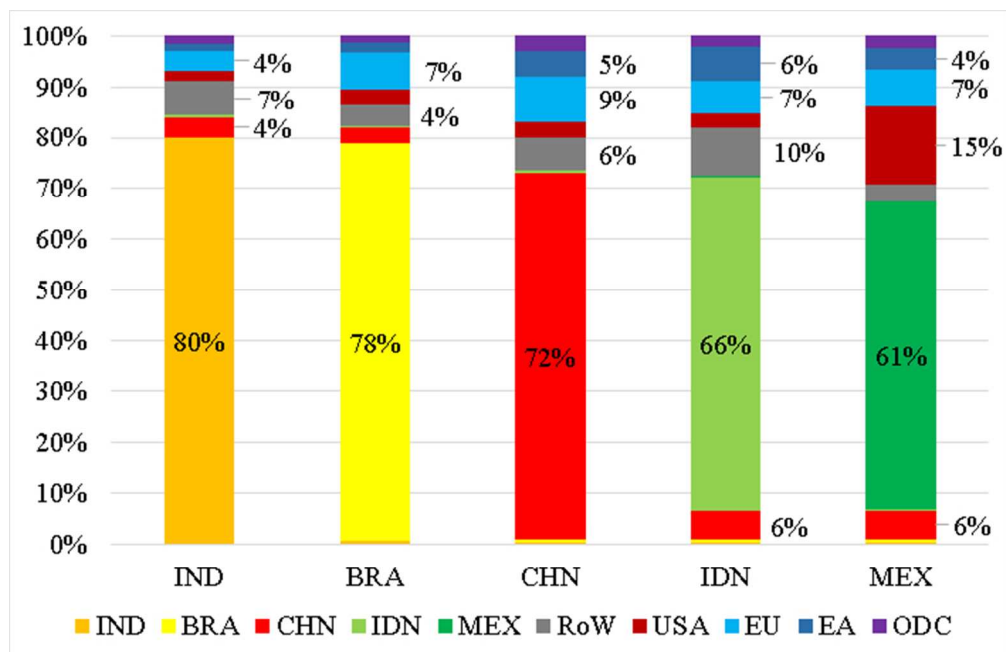


Figure 2. Geographic distribution of the impact by recipient country.

Source: Own work. Abbreviations: BRA (Brazil), CHN (China), EA (East Asia), EU (European Union), IDN (Indonesia), IND (India), MEX (Mexico), ODC (other developed countries), USA (United States of America).

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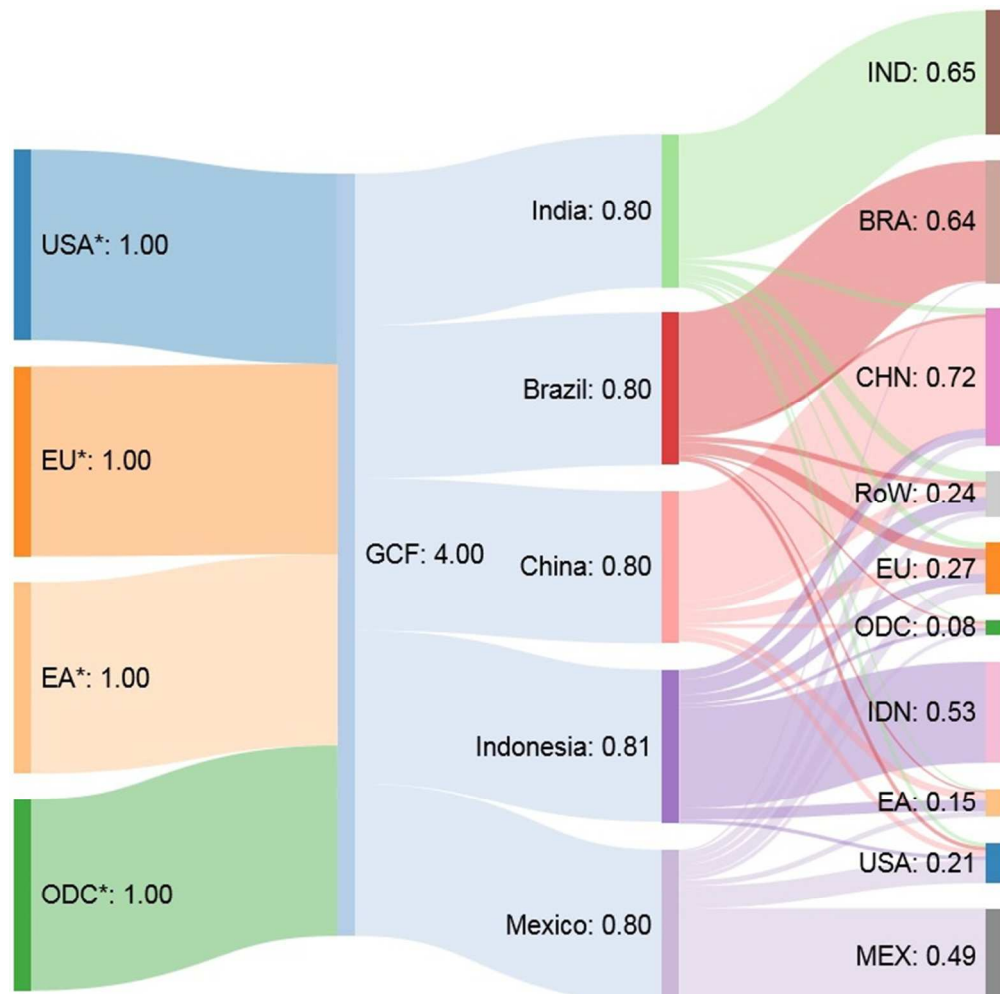


Figure 3. Example of financial flows from donors to recipients.

Source: Own work. Abbreviations: BRA (Brazil), CHN (China), EA (East Asia), EU (European Union), GCF (Green Climate Fund), IDN (Indonesia), IND (India), MEX (Mexico), ODC (other developed countries), USA (United States of America), ROW (rest of the world).

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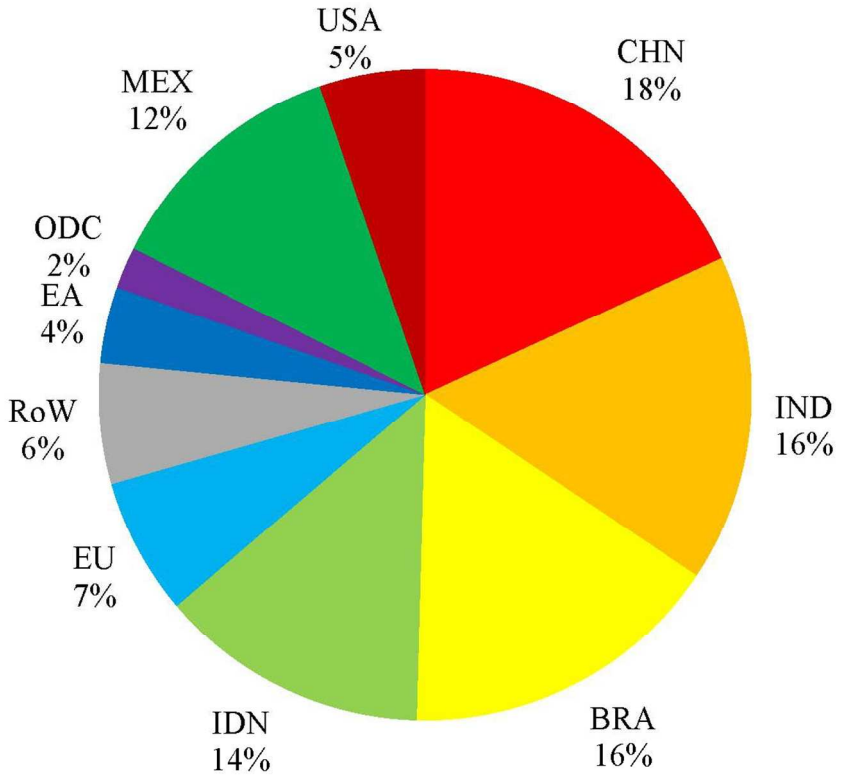


Figure 4. Distribution of the impact of a hypothetical climate fund.
Source: Own work. Abbreviations: BRA (Brazil), CHN (China), EA (East Asia), EU (European Union), GCF (Green Climate Fund), IDN (Indonesia), IND (India), MEX (Mexico), ODC (other developed countries), USA (United States of America), ROW (rest of the world).

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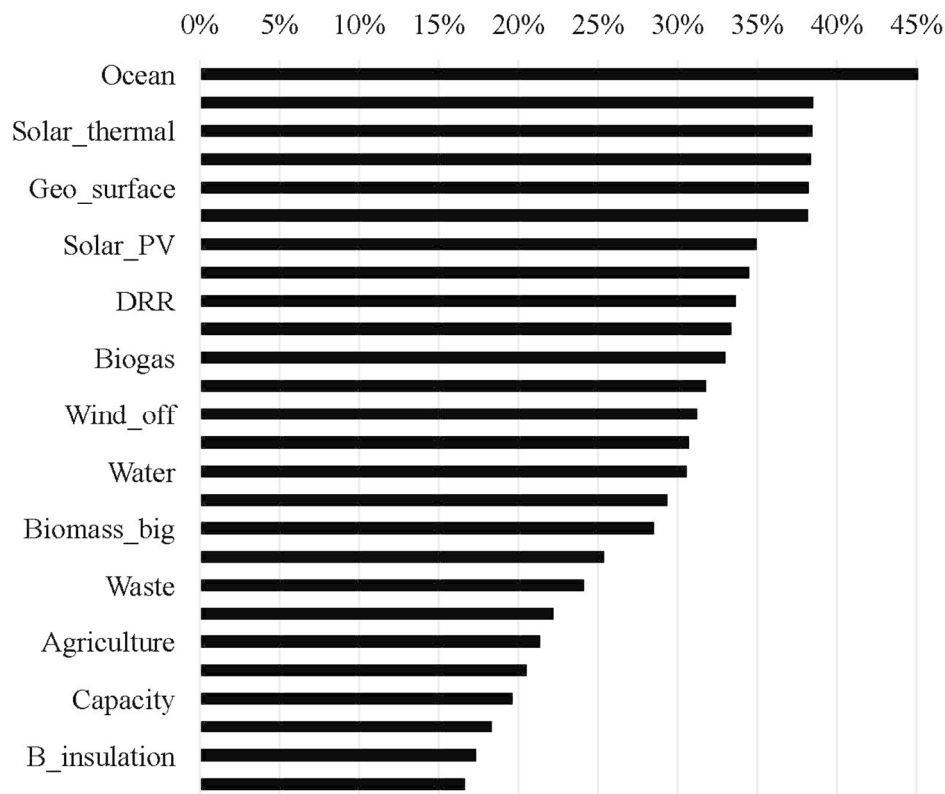


Figure 5. Average spill-overs by type of climate action.

Source: Own work. Abbreviations: Agriculture (agriculture, fishing and livestock), B_insulation (building insulation), B_RE (renewable energy in buildings), Biogas (biogas power), Biomass_big (biomass energy large scale), Biomass_small (biomass energy small scale), Capacity (capacity building), Coastal (coastal protection), CSP (concentrated solar power), DRR (disaster risk reduction), Forest (forestry and land use/terrestrial ecosystems), Geo_deep (deep geothermal energy), Geo_surface (surface geothermal power), Hydro (hydropower), Industry (energy efficiency in industry), Infrastr (human settlements, infrastructure and spatial planning), Ocean (ocean power), Social P. (social protection), Solar PV (photovoltaics), Solar_thermal (solar thermal energy), T_infastr (infrastructures for transport), T_RE (renewable energy in transport, biofuels), Waste (waste and wastewater), Water (water supply and management), Wind_off (offshore wind power), Wind_on (onshore wind power).

170x142mm (200 x 200 DPI)