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What determines the magnitude of the economic impact of climate finance in recipient countries? A structural decomposition of value-added creation between countries

María Victoria Román[a], Iñaki Arto[a] and Alberto Ansuategi[b]

International climate finance flows are increasing year after year, and will continue to increase in the future if the financial goal agreed in Copenhagen (USD 100 billion per year by 2020) is to be reached. Apart from the climate mitigation and adaptation benefits, these monetary flows generate economic impacts via the purchase of goods and services. Due to the role of international trade, impacts not only happen where climate finance is disbursed but in all economies involved in the production chain of purchased goods. Climate finance recipient countries have different abilities to retain locally the generated economic benefits. Climate finance donor countries differ also in their ability to capture the benefits of climate finance disbursed in other countries. This paper helps to understand the drivers of the differences between several recipient and donor countries. Results identify the most relevant drivers for each country, and those sectors where largest potentials to increase the economic benefits of climate finance are. This is a valuable input of information for the design of general national strategies and sectoral plans aimed at maximizing the synergies between climate action and economic development.

Keywords: climate finance; spillover effects; structural decomposition analysis; input-output models.

JEL Classification: R11, F18, Q54, C67

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1. Introduction

In order to avoid climate change and its impacts, countries have a variety of instruments, but lack of financial resources is a barrier for many countries to a successful implementation of the appropriate mix of policies. This leaves a big share of the world population exposed to the dangerous consequences of climate change, resulting in a very unfair situation where the most affected coincide with the least responsible. For this reason, in an attempt to compensate this "climate" injustice, the Copenhagen Accord fixed in 2009 a specific goal of finance as support for developing countries to undertake climate actions: USD 100 billion per year by 2010. The Paris Agreement announces the increase of this collective goal by 2025, without specifying any number (COP15, 2009; COP21, 2015).

This is the context where the term "climate finance" appeared. There is not a single definition for it. According to the Standing Committee of Finance of the UNFCCC *"climate finance aims at reducing emissions, and enhancing sinks of greenhouse gases and aims at reducing vulnerability of, and maintaining and increasing the resilience of, human and ecological systems to negative climate change impacts"* (UNFCCC, 2014). There are different types of institutions channelling climate finance: multilateral funds (like the Adaptation Fund), Multilateral Development Banks (like the World Bank through initiatives like the Forest Carbon Partnership Facility) and carbon funds in both recipient and donor countries. In the Cancun Agreements (COP16, 2010) parties to the UNFCCC agreed to create the Green Climate Fund (GCF). So far, the GCF has been able to mobilize USD 10.2 billion, becoming the main channel of climate finance (GCF, 2015).

The climate finance literature encompasses different aspects, covering the climate finance architecture (Buchner et al., 2015; Schalatek & Nakhooda, 2014), the estimation of climate finance needs (UNEP, 2014a, 2014b), the assessment of climate finance effectiveness (Chaum et al., 2011; Rübbelke, 2002; UNDP, 2012), the compatibility of climate finance with countries' interests (Buob & Stephan, 2013; Heuson et al., 2012; Schenker & Stephan, 2014), the role of climate finance in international agreements on climate change (Barrett, 2010; Barrett & Stavins, 2003; de Zeeuw, 2015; Pittel & Rübbelke, 2013; Rübbelke, 2011), and the assessment of different options for climate finance mobilization and disbursement (Hof et al., 2011; Weitzman, 2013).

The present paper aims to contribute to this body of literature by studying the factors determining the magnitude of economic benefits of climate finance, something that is related to climate finance effectiveness. According to the IPCC, effectiveness of climate finance would increase if developing countries could manage the available sources of finance in favour of their national development strategies and needs (Edenhofer et al., 2014). Country ownership which, as defined by the World Bank, means that "there is sufficient political support within a country to implement its developmental strategy, including the projects, programs, and policies for which external partners provide assistance" was already recognized to be a condition for aid effectiveness in the 2005 Paris Declaration on Aid Effectiveness and the Accra High-Level Forum of Aid Effectiveness (Gomez-Echeverri, 2013). At the same time, development strategies are considered a key element to reduce vulnerability to the impacts of climate change (Andreoni & Miola, 2014). Thus, maximizing domestic economic gains of climate finance yields, at least, two co-benefits: first, it contributes to align the interventions with development strategies, increasing the effectiveness of climate finance; and second, it increases resiliency in the recipient economy, regardless of the type of climate action implemented (i.e. mitigation or adaptation).

Value-added creation, which reflects the remuneration of primary factors of production (i.e. labour and capital), can measure the economic benefits of a certain intervention. In our case, the studied intervention consists of climate finance disbursements generating new demand of goods and services. In order to respond to the new demand, industries involved in the production compensate employees and capital owners, creating value-added. The entire amount of financial resources transferred to the recipient country is finally transformed into value-added in different countries of the world to remunerate the production factors involved. The share of this value-added creation that is retained domestically is the local impact of climate finance. The remaining share constitutes the spillover effect resulting from international trade.

The relative size of spillover and the local impact change from one country to another due to country-specific characteristics. For example, if the spillover generated by climate finance disbursements in China amounts to 30%, that means that out of every 10 million dollars of climate aid to China, the benefits for China would be only 7 million dollars, and the remaining 3 million would go to other countries. In another recipient country, for example India, spillovers might be larger or lower. In a previous paper (Román et al., under review), we have quantified the domestic impact and spillovers of different types of climate actions in different countries. The present paper completes the former research by explaining the differences observed between countries.

The remainder of the paper is structured as follows: Section 2 specifies the research questions, the scope and the utility of results; Sect. 3 describes the methodology, which is further detailed in Appendix; Sect. 4 contains the results both at aggregated and sectoral level; Sect. 5 discusses main outcomes and Sect. 6 concludes this work.

2. Objective

With this work we aim to disentangle the relative importance of the factors determining the magnitude of value-added creation in both the countries receiving and transferring climate finance. Our specific research questions are: (1) Which are the factors determining the magnitude of the economic impact of climate finance? (2) What is the contribution of each of these factors to the differences observed between countries? (3) Which industries offer larger potential to increase the economic impact of climate finance in each country?

Departing from the quantification of value-added created by similar interventions in several recipient countries, the aim is to explain the differences by disaggregating the contribution of each component. The scope of our analysis is restricted to a group of countries: India (IND), Brazil (BRA), China (CHN)[1], Indonesia (IDN) and Mexico (MEX) as climate finance recipients; Germany, UK, Japan and USA represent donors of climate finance.

The results of this exercise provide policy recommendations about how to maximize the economic impact of climate finance in the examined countries. The exercise identifies, for each of them, those areas with larger potential to increase the local impact of climate finance. This constitutes valuable input of information for the design of national strategies that aim at maximizing synergies between climate change action and economic development.

3. Methodology

To quantify the contribution of each factor producing differences between countries in the magnitude of value-added impact, we apply a Structural Decomposition Analysis (SDA) within a global multi-regional IO framework (GMRIO). This technique is based on Input-Output Tables and is normally used to analyse the change of a variable in time. For example, Xu & Dietzenbacher (2014) and Arto &

[1] Note that China appears only as recipient although it is also an important donor of South-to-South cooperation (Buchner et al., 2015; Zadek & Flynn, 2013).

Dietzenbacher (2014) used this method to quantify the driving forces behind the growth of carbon emissions comparing input-output data from different years. Similar to Alcántara & Duarte (2004), de Nooij et al. (2003) and Hasegawa (2006), we perform a spatial decomposition analysis, consisting in comparing different locations instead of different years.

The data source for this exercise is the World Input-Output Database (WIOD) for 2011, which provides a GMRIO with 34 sectors in 40 countries and the rest of the world (RoW) region (Timmer et al., 2012). The information in these tables (transactions between industries, purchases of final products, remuneration of labour and capital, and total output of each industry in each country in monetary terms), enables to trace value-added creation associated to a specific demand shock back to the country where it is created.

Demand shocks are defined for different types of climate actions as a specific distribution of the budget between the different industries of the economy, or cost structure. Types of climate actions studied include the most extended globally renewable energy (RE) technologies: wind onshore, solar thermal and hydropower. Data from the German Institute for Economic Research (DIW Berlin), reflecting the cost structures of projects in Germany in 2011, is taken to define cost structures of these types of climate action. Another mitigation action studied is energy efficiency measures in buildings. Data to define the cost structure of building insulation are taken from Markaki et al. (2013). Finally, two different types of adaptation actions are considered: soft and hard adaptation. In this case, the sources of information are Priority Project Profile documents of National Adaptation Programmes of Action (NAPAs) [2]. As Table 1 shows, broad categories of adaptation actions are classified as hard or soft adaptation. Each broad category encompasses different sub-categories. One specific project has been selected for each sub-category and information about the budget allocation has been used to estimate cost structures. An average of those is taken as the representative cost structure for hard and soft adaptation.

Since some sources of information report budget allocations in terms of commodities, the correspondence reported in Table 2 is used to express cost structures in terms of industries. We use the same classification as the WIOD (NACE) in order to connect this information with the GMRIO framework. Figure 1 illustrates the sharing out of the expense in each type of climate action between the different industries.

The production induced by demand shocks initiates a sequence of requirements of intermediate goods across different industries and countries that is known as the production multiplier effect. Total production requirements are contained in the Leontief matrix. Value-added associated with new production requirements is computed with value-added coefficients. The GMRIO framework differentiates where goods are demanded and produced, enabling the computation of value-added created in one particular country associated to the demand of another (or the same) particular country.

After computing the local value-added derived from climate finance in each country, the country where impacts are larger is identified as benchmark against which other countries are compared. Within the recipient countries group, the benchmark is the country able to retain the largest share of the total value-added creation. Donor countries are compared against the country able to attract the largest share of spillover effects. Next, differences in the share of captured impact between each country and the corresponding benchmark are calculated. SDA is applied to quantify the contribution to these differences of four effects:

[2] http://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/4585.php

- The value-added intensity effect (VAiE) reflects the difference in value-added per unit of domestic output between the benchmark and each studied country. For example, comparing the benchmark country A with another country B, if the VAiE is positive (negative), that means that country A produces more (less) value-added per unit of product, something that contributes to (decreases) the difference in the economic impact of climate finance between both countries. High value-added intensities are typical from countries specialized in the production of high technology commodities requiring highly qualified manpower.
- The domestic multiplier effect (DME) reflects the difference in domestic production per unit of domestic demand between both countries. Using the same example, if the DME is positive (negative) that means that the domestic demand in country A generates more (less) output domestically that the domestic demand of country B. Again, this positive (negative) effect would contribute to (decrease) the difference between both countries in the economic impact of climate finance. High domestic multiplier effects are typical from very integrated economies, characterized by the presence of sectoral clusters for different commodities that are relatively independent from foreign production.
- The foreign multiplier effect (FME) reflects the difference in domestic production per unit of demand of foreign products between two countries. Again, if the FME is positive (negative), that means that the demand of foreign products generates more (less) domestic products in country A than in country B, contributing to (decreasing) the difference in countries' ability to retain economic impact of climate finance. High foreign multiplier effects are typical from countries that participate in global supply chains of many products and services.
- The trade structure effect (TSE) reflects the difference in final demand of domestic products generated by climate finance between two countries. We assume that the level of final demand, distribution between final demand categories, and composition of commodities is the same, but consider differences in the shares corresponding to domestic production and imports from each other country. If the TSE is positive (negative), that means that climate finance transfers generate more (less) domestic demand in country A than in country B, something that contributes to (decreases) the difference in the economic impact of climate finance between A and B. High TSE are typical from big and relatively self-sufficient countries that do not need to import many goods and services.

Appendix provides details on the application of SDA technique.

Table 1: List of NAPAs used to characterize demand shocks of climate change adaptation

Hard adaptation		NAPAs
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
Waste and wastewater	Sanitation	SIERRE LEONE #22
	Storm and wastewater	MALDIVES #5
Soft adaptation		NAPAs
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
Social protection	Livelihood diversification	MALAWI #1
	Food storage and preservation facilities	LESOTHO #8
	Health, vaccination programs	SIERRE LEONE #23

Table 2: Correspondence between industry and commodity codes of NACE classification

Industry	Commodity	Industry	Commodity2	Industry3	Commodity4
c1	1, 2, 5	c13	29	c25	62
c2	10, 11, 12, 13, 14	c14	30, 31, 32, 33	c26	63
c3	15, 16	c15	34, 35	c27	64
c4	17, 18	c16	36, 37	c28	65, 66, 67
c5	19	c17	40, 41	c29	70
c6	20	c18	45	c30	71, 72, 73, 74
c7	21, 22	c19	50	c31	75
c8	23	c20	51	c32	80
c9	24	c21	52	c33	85
c10	25	c22	55	c34	90, 91, 92, 93
c11	26	c23	60	c35	95
c12	27, 28	c24	61	-	-

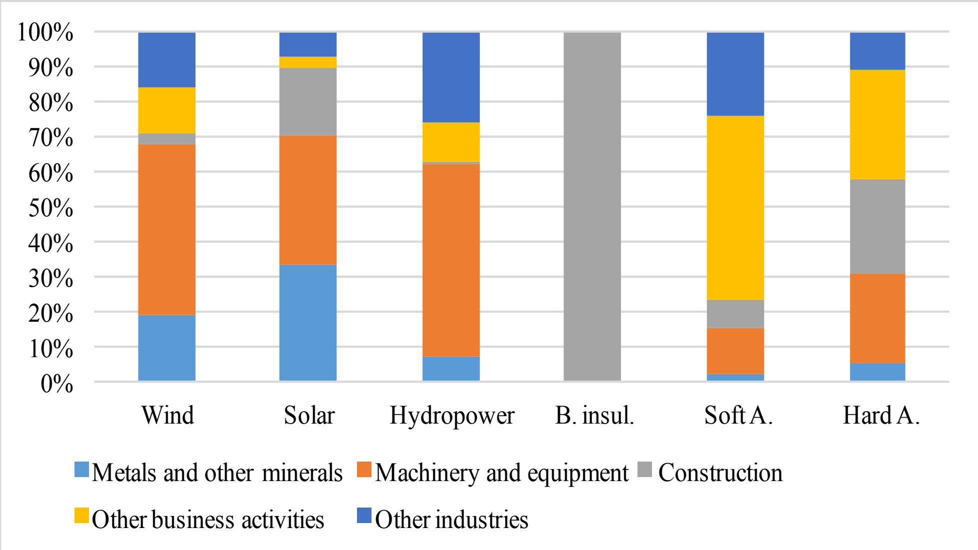


Figure 1: Distribution of expenses to industries by climate action. Source: own work based on DIW (2011), Markaki et al. (2013) and the NAPAs. Note: "Metals and other minerals" includes industries c11 and c12. "Machinery and equipment" includes industries c13, c14 and c15. "Construction" corresponds to industry c18. "Other business activities" corresponds to industry c30. "Other industries" includes industries c1, c2, c7, c8, c9, c10, c17, c20, c23, c26, c27, c28, c29, c31, c33 and c34.

4. Results

This section includes general considerations that apply to all results. Then, results are grouped in two subsections according to their level of detail. Aggregated results for each economy are exposed in the first place, followed by results at industry level. Results for climate finance recipient countries distinguish the type of climate action implemented. In the case of donor countries, the focus is exclusively on climate actions yielding larger spillover effects (i.e. renewable energy technologies). However, since the volume of spillovers varies widely, depending on the country receiving climate finance, results distinguish the destination of transferred resources.

Results reflect the comparison between the benchmark and each of the rest of countries in the group. The benchmark amongst recipient countries varies depending on the climate action implemented. The benchmark amongst countries benefitting from spillovers varies depending on the country receiving climate finance (and deploying renewable energy technologies). Table 3 shows the benchmark country in each case.

By definition, in aggregated results, differences in the economic impact of climate finance between benchmark countries and the rest are positive. This is not necessary the case of sectoral results, since the choice of benchmarks has been made at the aggregated level. Thus, both positive and negative differences might appear when analysing the sectoral level. At both levels, the sign of the different effects can be either positive or negative, depending on whether they positively contribute to the dominant effect or counteract it. In other words, positive effects help explain why benchmarks are benchmarks, and negative effects explain why differences between benchmarks and other countries are not larger.

Table 3: Benchmark countries

Amongst recipient countries (depending on the climate action)	
Climate action	**Benchmark**
Wind	India
Hydropower	India
Solar	Brazil
Building insulation	Brazil
Soft adaptation	Brazil
Hard adaptation	Brazil
Amongst donor countries (depending on recipient country)	
Recipient country	**Benchmark**
Brazil	China
Indonesia	China
India	China
México	USA
China	Japan

4.1 Aggregated results

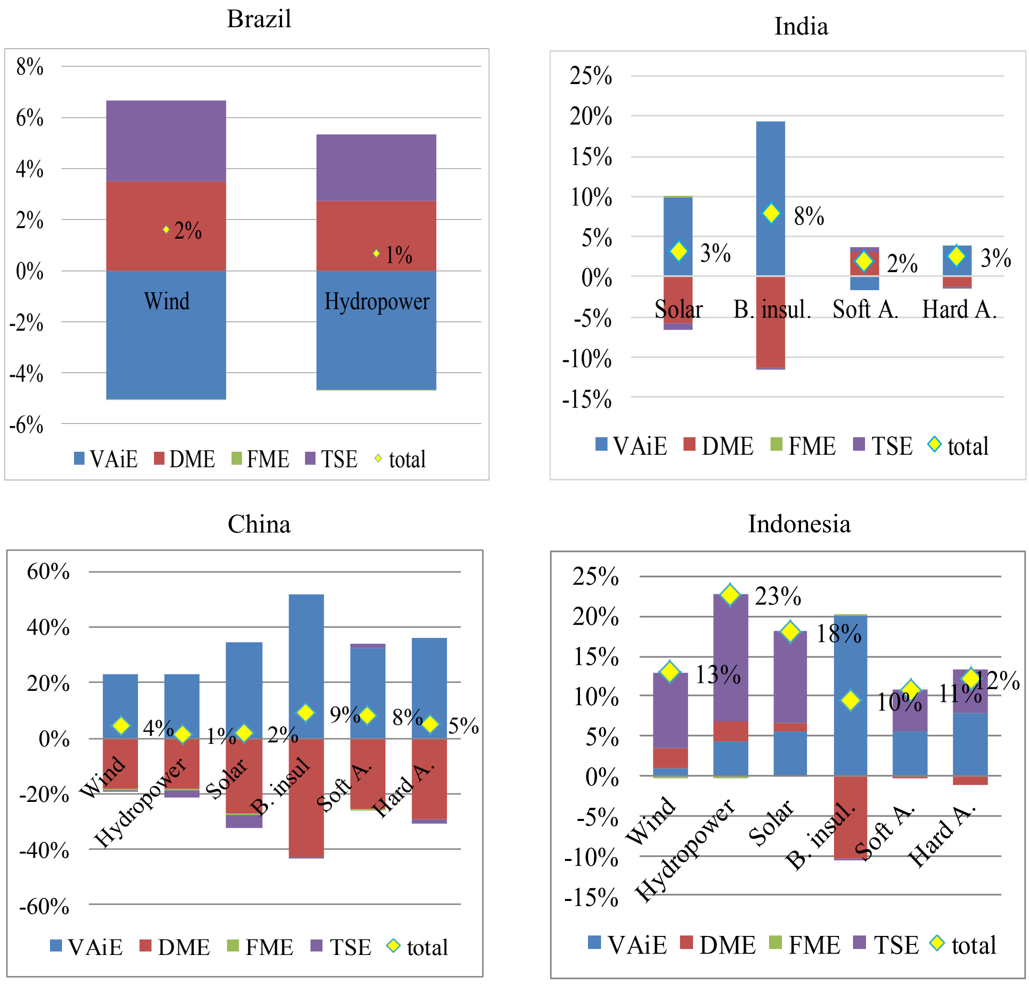
In this section, results for each climate finance recipient country are exposed in first place, followed by results for each donor country. Two figures illustrate the results for both recipients and donor countries (Figs. 2 and 3, respectively).

Brazil is the benchmark for all types of climate actions except in the cases of wind and hydropower. In that cases, India is the country where local economic benefits are larger. However, Brazil is very close to this benchmark, with a share of local impact only 1% lower in the case of hydropower and 2% lower in the case of wind power. In both cases, the effects contributing positively to the difference are the DME and the TSE. Counteracting these two factors is the VAiE.

India is the benchmark for wind and hydropower but is surpassed by Brazil in the rest of climate actions, with a difference ranging of 2% for soft adaptation, 3% for solar and hard adaptation (Hard A.), and 8% for building insulation (B. insul.). In most cases, the VAiE contributes to the difference, while the DME acts in the opposite direction. In the case of soft adaptation (Soft A.) measures the sign of both effects inverts.

China is at a distance of between 1 and 9% of the benchmark countries, depending on the climate action. Larger differences appear for building insulation and soft adaptation (9% and 8% respectively). As observed for India, the dominant factor is the VAiE, and the DME mitigates the differences.

Indonesia is at a larger distance from benchmarks. In particular, between 10–23%, being the larger differences in renewable energy technologies (13–23%). In these cases, three factors contribute positively to the difference: mainly, the TSE, but also the DME and the VAiE. The difference for building insulation (10%) results from a higher value-added intensity in the benchmark that is partially compensated by the DME. In the case of adaptation actions, dominant effects are VAiE and TSE.



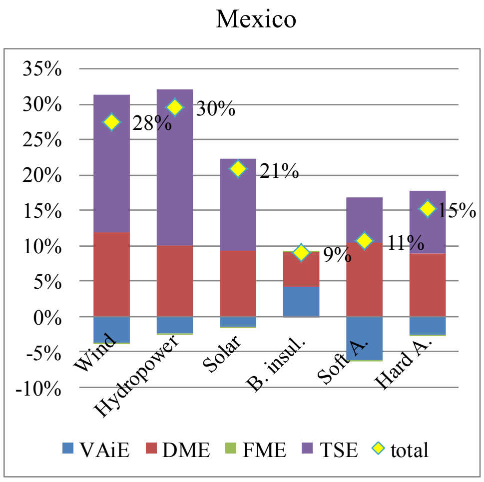


Figure 2: Aggregated results by recipient country and climate action.

México presents the largest differences with benchmark countries: between 9-30%. Again, largest differences appear for renewable energy technologies (21-30%), and the lower is for building insulation (9%). This time, the dominant effect in most cases is the TSE. The DME is the other factor that contributes to the difference. In most cases also, VAiE counteracts these former effects. The case of building insulation is different, with a null influence of the TSE, and both the DME and the VAiE contributing positively to the difference. Before entering in the exposition of the results of the comparison between donor countries, note that the FME does not appear as a relevant factor that can explain the existing differences in the domestic economic impact of climate finance between recipient countries.

Results of the SDA of spillovers depend on three variables: which is donor country, which is the recipient country and which type of climate action is implemented. This triple dimension complicates the presentation and interpretation of results. For this reason, we focus on those that provide more valuable insights for discussion. Results are presented by donor country and distinguish where climate action is undertaken, but do not include different types of climate actions. We concentrate on renewable energy technologies, because these are the actions that yield larger spillovers to donors, and present average results for wind, hydropower and solar.

Spillovers attracted by Germany are only 1% less than the benchmark country (Japan) when the recipient country is China. The difference rises to 17% when the recipient country is Mexico (benchmark country, USA). The relevance and sign of the contribution of the different factors vary depending on the recipient country. In general, the dominant effect is the TSE. Other two factors that also contribute positively to the difference are the DME and FME. Finally, the unique factor that counteracts those effects is the VAiE, showing that value-added intensity is generally higher in Germany and UK than in benchmark countries (with the exception of USA). Results for these two countries are very similar. Differences are slightly larger in the UK (between 3–19%), but the sign and relative relevance of the different factors are the same.

Japan is the benchmark country when China is the country receiving climate finance and deploying renewable energy technologies. But, in other cases, spillovers captured by Japan are between 3% and

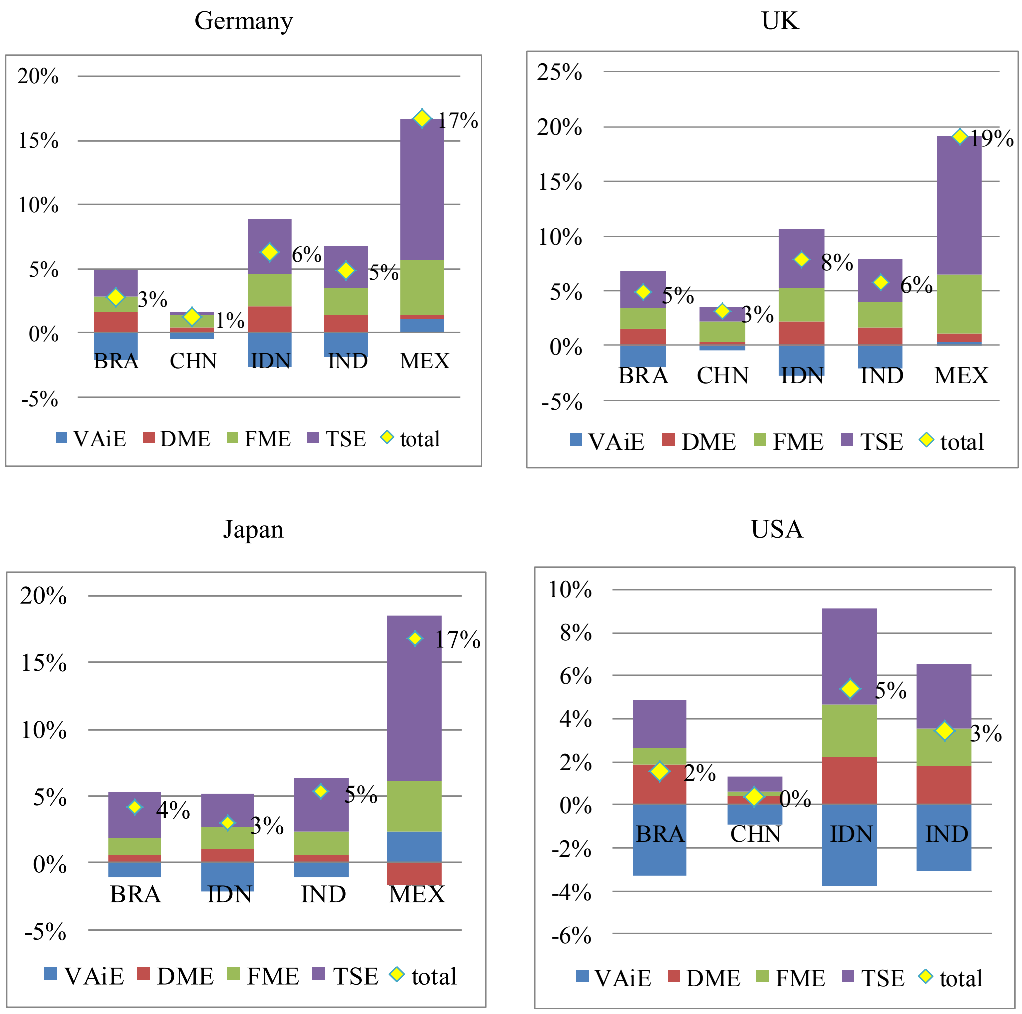


Figure 3: Aggregated results by donor and recipient country.

17% below the benchmark country: an average of 4% when then benchmark country is China, and 17% when it is USA. Again, the dominant factor is the TSE. The FME also contributes positively to the difference. The sign of the other two factors are different when the benchmark country is China and when it is USA. In the first case, the DME increases the difference and the VAiE decreases it. In the second case, the contrary occurs.

USA is the benchmark when Mexico is the recipient country. In other cases differences with the benchmark countries are not larger than 5%. In this case, the only factor counteracting the rest of effects is VAiE, indicating that value-added intensity is larger in USA than in benchmark countries. Amongst the rest of factors the most relevant is the TSE.

4.2 Sectoral results

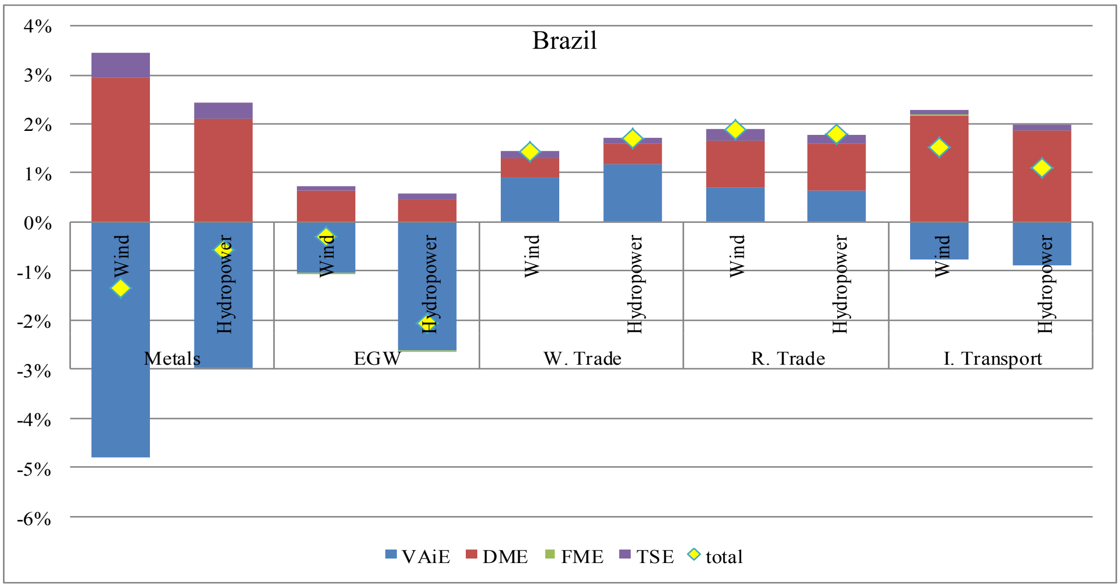
A small group of sectors concentrates the main effects in analysed countries: “Mining and Quarrying”, “Basic Metals and Fabricated Metal”, “Machinery Nec”, “Electrical and Optical Equipment”, “Electricity, Gas and Water Supply” (EGW), “Construction”, “Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles”, “Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods”, “Inland Transport”, “Financial Intermediation” and “Other Business Activities”. Figures 4 and 5 illustrate the results for recipients and donor countries.

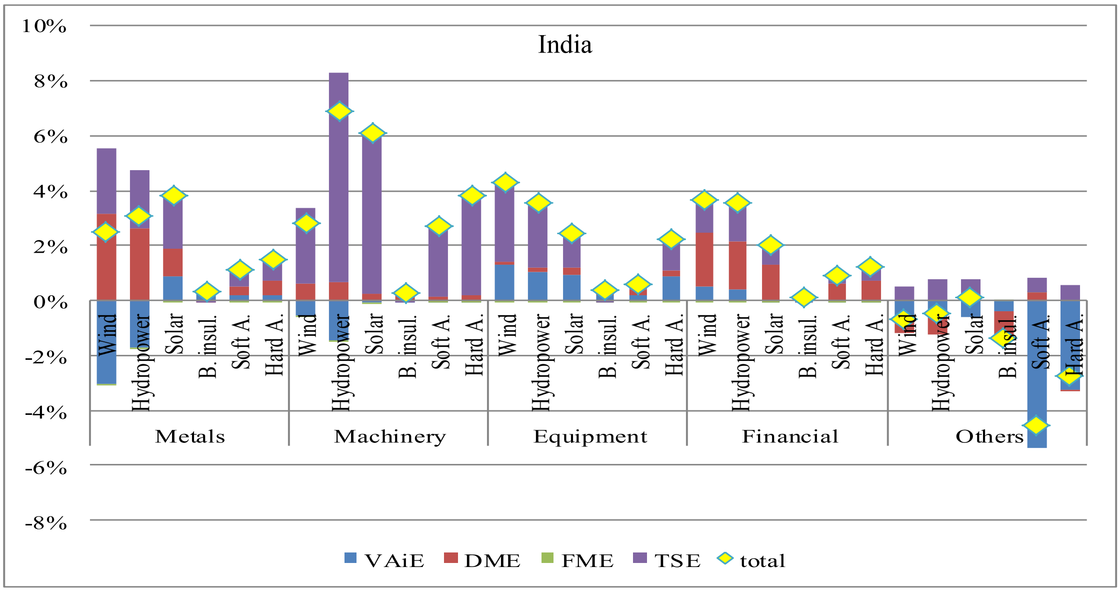
In Brazil, the largest positive differences appear in trade sectors (due to the VAiE, DME and TSE) and the transport sector (especially due to the DME). The sectors with the largest negative differences (around -2%) are the metals and EGW sectors (in wind and hydropower, respectively), especially due to the negative VAiE effect.

When comparing the benchmark with India, the most relevant difference at aggregate level was in building insulation projects. This result can be explain by the large difference (16%) in the construction sector, associated to the VAiE. This effect in the construction sector can also explain the differences in solar and hard adaptation. Negative differences appear in the sectors of metals, retail trade and transport for building insulation projects, and in financial intermediation for all actions types. These negative differences are generally driven by the DME.

Sectoral results for China show that differences observed in building insulation projects are associated with the construction sector (34% of difference), differences in soft adaptation are due to the sector of other business activities (14%), and those observed in hard adaptation are due to both the construction and other business activities sectors (with 9% of difference each). These difference are a consequence of the VAiE. Also remarkable is the positive DME in the retail trade sector regardless of the type of action. This effect is negative at the aggregated level due to sectors as the metals and equipment ones.

In Indonesia the metals and machinery sectors contribute to the large difference in renewable energy projects, especially due to the DME in the first case and the TSE in the second. The difference observed in building insulation projects might be partially explained by the VAiE in the construction sector. This effect in this sector might also influence the aggregated results in solar and hard adaptation projects. The VAiE in other business activities and the TSE in machinery influence the differences in adaptation projects. This latter effect in the machinery sector contributes to the positive difference in all types of actions, except building insulation. Notable negative differences are observed in the mining sector (up to 9%) regardless of the type of action, as a consequence of the DME and VAiE.





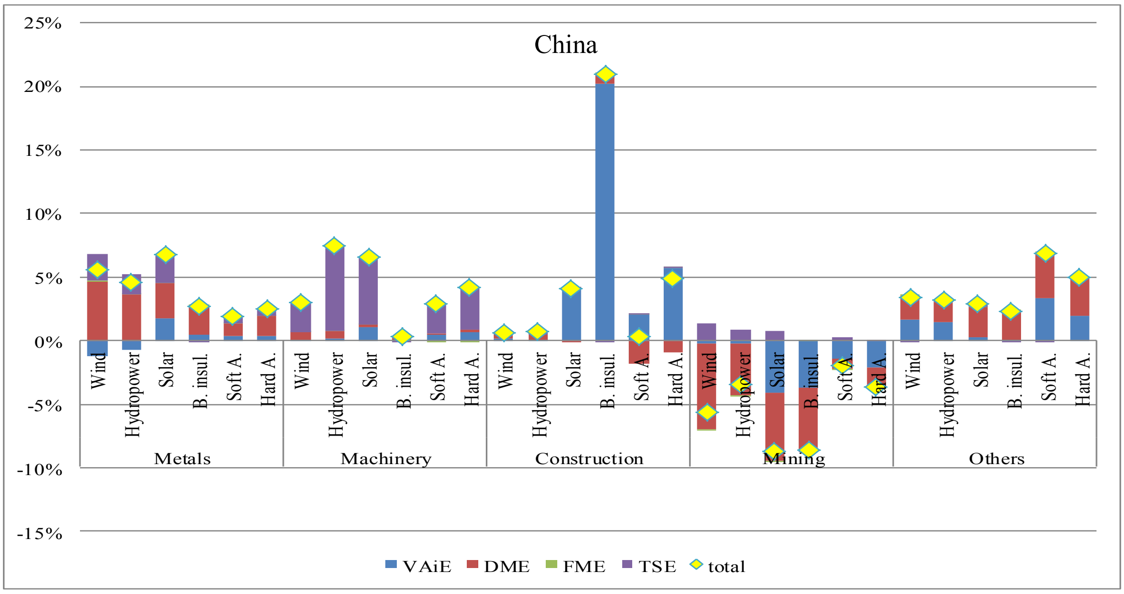
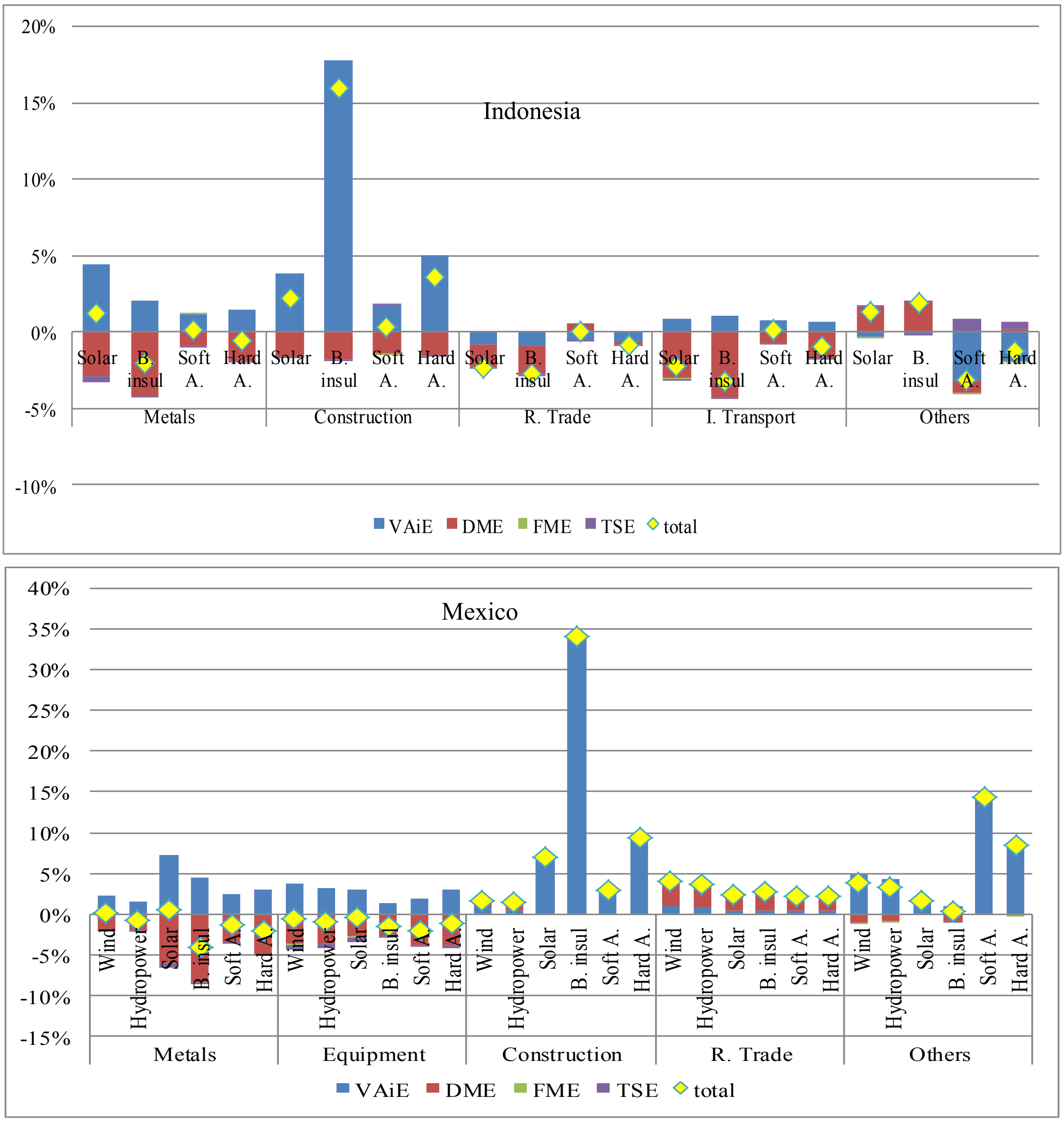


Figure 4: Top five sectoral results by recipient country and climate action (continued on next page).



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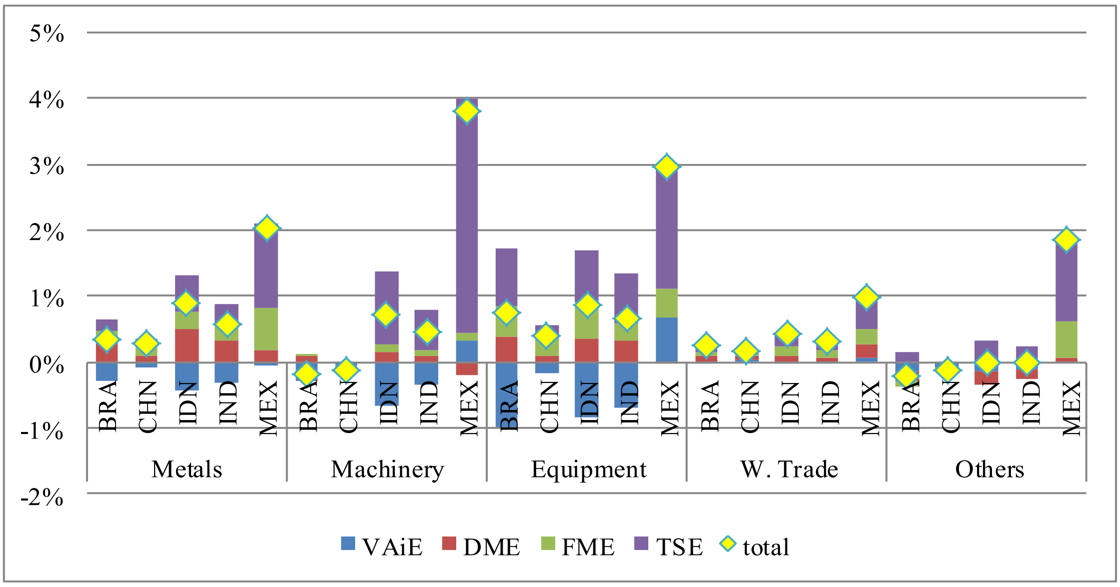
According to the sectoral results, the TSE in the machinery sector contributes with the differences observed for renewable energy projects in Mexico. Actually, this effect in this sector contributes to the difference in all types of projects except building insulation. Other sectors, like metals, equipment and financial intermediation also contribute to the difference in renewables actions due to the TSE and DME. In this type of actions, the role of the VAiE is negative with the exception of the sector of equipment. In building insulation projects the most relevant effect is VAiE in the construction sector. In adaptation actions, the most influential effects are TSE in machinery. Regarding negative differences, the sector encompassing other business activities stands out, especially due to the VAiE in adaptation projects.

Three sectors accumulate the most relevant effects explaining differences between donor countries: “Basic Metals and Fabricated Metal”, “Machinery Nec” and “Electrical and Optical Equipment”. In the case of Germany, the TSE of these three sectors is especially influential, particularly when benchmark countries are China and USA. The only relevant negative effect is the VAiE when the benchmark country is other than USA. In that case, the VAiE is also positive.

The UK presents very similar results regarding the relative importance of sectors and the sign of effects. The only remarkable difference is that, in the case of UK, negative net differences do not occur, while in Germany little negative different appear in the machinery and other business activities sectors in some recipient countries.

Sectoral results for Japan are not very different from Germany and the UK, with the exception of the composition of the most influential sectors. In the case of Japan, the effects on the chemical sector are more relevant than those in the financial intermediation, although both are relatively unimportant.

The case of the USA is also similar, with some remarkable features, like the negative difference in the other business activities sector regardless of the recipient country, and the large size of effects in the equipment sector. However, the total effect is not especially large as the positive



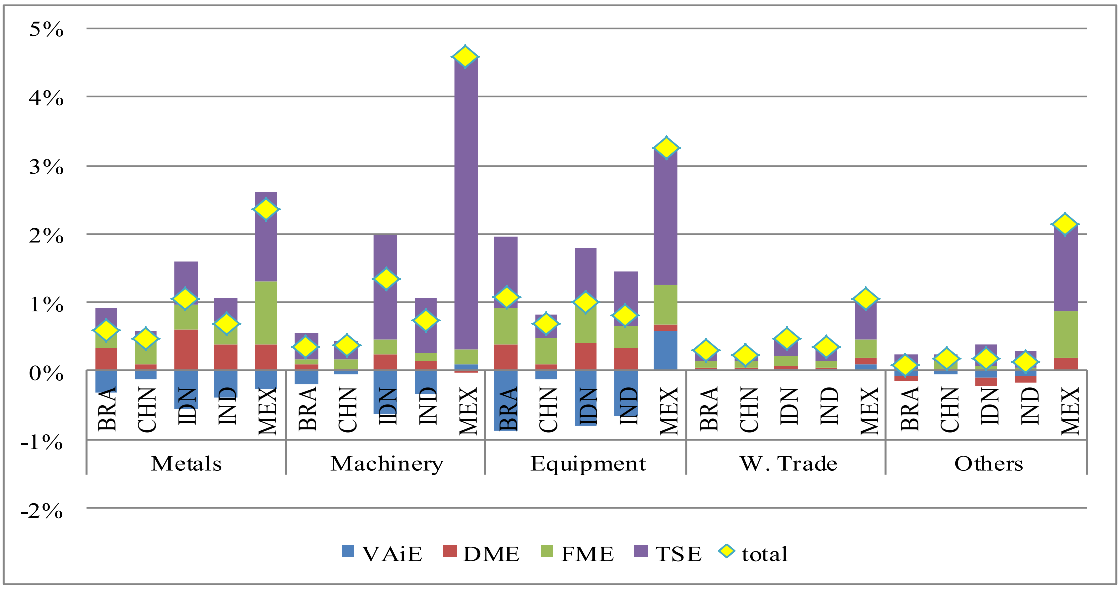


Figure 5: Top five sectoral results by donor and recipient country (continued on next page).

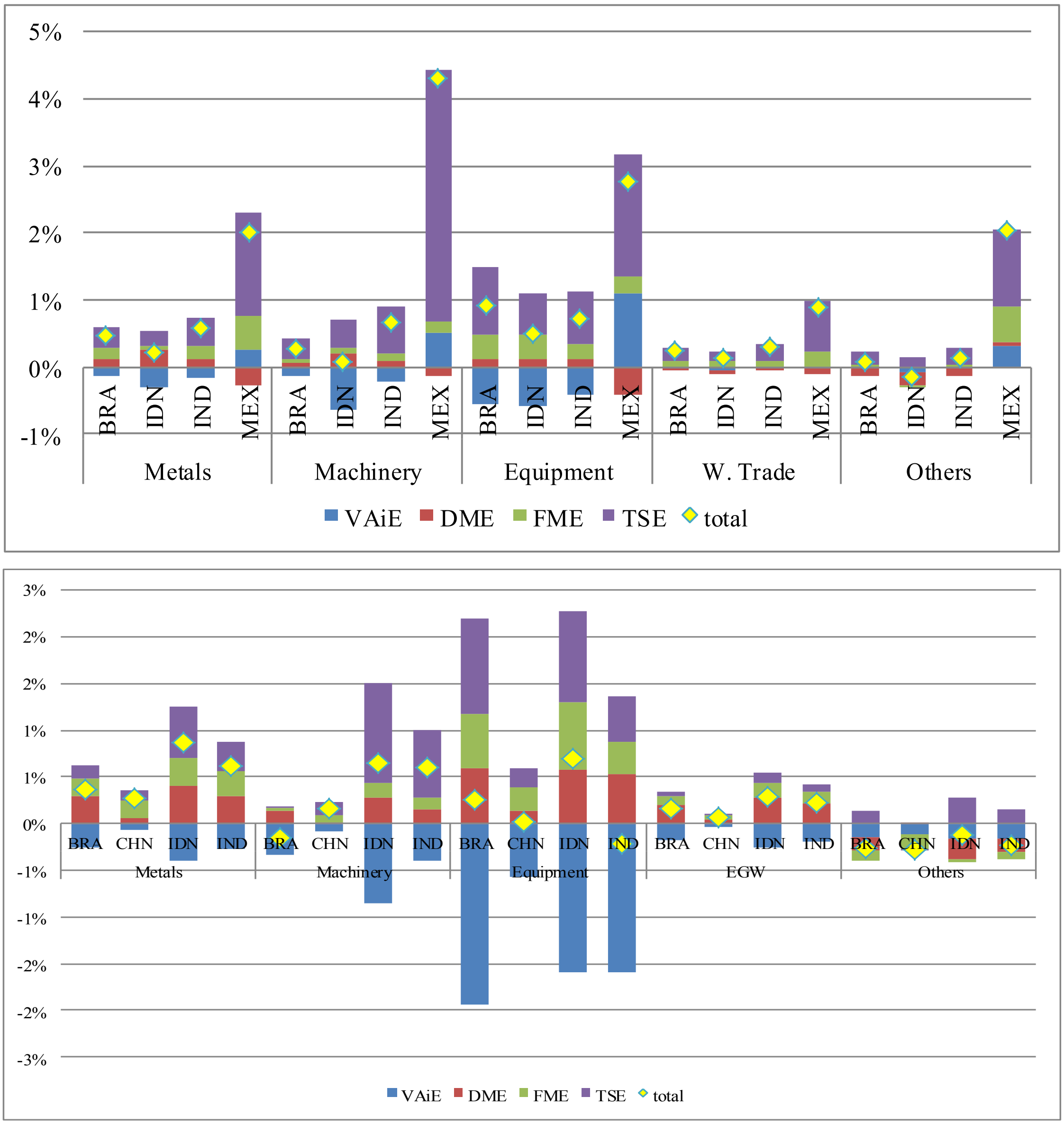


Figure 5: Cont.

effects (DME, FME and TSE) are counteracted by a negative VAiE. Another difference is the composition of the group of most influential sectors. In this case, effects in the EGW sector are more relevant than those in the wholesale trade sector.

5. Discussion

Next, we discuss the main results of each analyzed country in turn, starting with the group of recipient countries.

The main reason why Brazil is, amongst the analysed recipient countries, the one where climate finance produces the largest domestic impact in most cases (i.e. for solar energy, building insulation and adaptation project) is the value-added intensity effect. According to the sectoral results, this effect makes the impact of renewable energy projects up to 5% larger in the Brazilian metals and EGW sectors, and the impact of building insulation projects up to 15% larger in the Brazilian construction sector. Table 4, containing value-added coefficients by country and sector, confirms that these sectors are relatively more intensive in primary inputs in Brazil than in the rest of recipient countries, something that reveals a higher degree of sophistication in the production and the use of high technology and qualified labour. The high value-added coefficient in the Brazilian EGW sector is associated to the large participation of hydropower in the Brazilian energy mix, an energy source with low requirements of intermediate inputs.

When climate finance is spent in wind or hydropower projects, India is the recipient country with the largest domestic impact. According to our results, this is mainly consequence of the fact that India imports less final products than other recipient countries to undertake these types of projects. According to the sectoral results, this effect enables that the impact of these projects is 6% larger in the Indian machinery industry than in other recipient countries. Table 5, containing the share of domestic production in the final demand of recipient countries by industry, confirms that India is, on average, the recipient country with the largest share of domestic production in its final demand. India has also a high degree of self-sufficiency for machinery, equipment and transport equipment, the main components of these types of projects. Besides, the demand of Indian products triggers larger amounts of domestic production (especially in the metals and transport sectors) than in other countries, generating differences of impact up to 4%. Both effects reflect a high degree of self-sufficiency and integration of the Indian economy, a relative developed and independent industrial base and the existence of intraregional communication and transport networks.

China is the other side of the coin compared to Brazil: the lower weight of labour and capital on the total production costs of the Chinese industries is the main reason why China is not able to retain a larger share of the impact of climate finance. According to sectoral results, the value-added intensity effect makes the impact of renewable energy, building insulation and adaptation projects a 5%, 35% and 15% respectively lower in the Chinese metals, construction and other business activities sectors than in the benchmark cases. Table 4 confirms that China is the recipient country with smallest value-added coefficients in almost all industries, including these three.

Indonesia and Mexico are even farther away from benchmarks than China, as result of a combination of factors. First, both countries import a large portion of their final demand. Sectoral results show differences in the impact of renewable energy and adaptation projects of up to 8% in the metals and machinery sectors due to this effect. Table 5 confirms that these two countries are (on average and also in these two sectors) the recipient countries with the higher degree of dependence from others countries' final products. Another factor that contributes to the lower impact of renewable energy projects (up to 5% lower) is the fact that the domestic demand generates less domestic production in the industry of metals (i.e. metals required for domestic production are also more frequently imported).

The strongest point of Indonesia is the domestic multiplier effect of the mining sector, which decreases around 5% the difference with the benchmark in the cases of renewable energy and energy efficiency projects. This effect reflects the fact that Indonesia is relatively self-sufficient in this sector. According to PwC (2014), the mining sector was very important in the Indonesian economy in 2011, accounting for 19.5% of the GDP. In Mexico, the strongest aspect is the value-added intensity, especially in the metals and other business activities sectors (see Table 4), leading to a decrease in the difference with the benchmark up to 5% for renewable energy and adaptation projects, according to the sectoral results.

Table 4: Value-added intensity by country and sector

	Brazil	China	Indonesia	India	Mexico	Germany	UK	Japan	USA
Agriculture	61%	59%	77%	78%	58%	44%	54%	50%	43%
Mining	44%	47%	82%	79%	82%	47%	71%	20%	57%
Pulp	46%	25%	37%	29%	46%	40%	48%	45%	38%
Coke	26%	19%	59%	17%	16%	19%	18%	38%	28%
Chemicals	36%	21%	31%	31%	31%	39%	40%	28%	35%
Rubber	40%	19%	35%	19%	33%	41%	44%	25%	37%
Non-Metallic Mineral	44%	28%	46%	37%	54%	40%	49%	33%	39%
Metals	41%	21%	31%	26%	37%	35%	40%	27%	33%
Machinery	38%	24%	30%	31%	38%	40%	43%	36%	44%
Equipment	37%	17%	37%	30%	20%	42%	42%	32%	64%
Transport Equip.	29%	20%	41%	29%	35%	27%	32%	24%	22%
EGW	57%	29%	31%	36%	36%	52%	38%	44%	72%
Construction	56%	23%	36%	39%	50%	45%	43%	46%	52%
Wholesale Trade	73%	60%	59%	89%	75%	61%	56%	69%	67%
Inland Transport	57%	52%	39%	41%	66%	50%	53%	63%	49%
Other Transport	57%	39%	78%	54%	73%	42%	49%	58%	65%
Post	50%	59%	65%	70%	63%	50%	51%	65%	58%
Financial	68%	69%	79%	77%	69%	44%	54%	61%	55%
Real Estate	93%	83%	55%	92%	91%	81%	67%	87%	70%
Other Business Activities	64%	41%	58%	70%	73%	67%	68%	51%	68%
Public Admin	68%	55%	56%	100%	71%	68%	53%	69%	60%
Health	62%	35%	55%	66%	74%	72%	44%	62%	63%
Personal Services	65%	45%	54%	83%	71%	62%	56%	60%	54%
Average	53%	39%	51%	53%	55%	48%	48%	47%	51%

Table 5: Share of domestic production in the final demand by country

	Brazil	China	Indonesia	India	Mexico
Agriculture	98%	98%	97%	99%	96%
Mining	96%	98%	98%	97%	97%
Pulp	97%	83%	91%	94%	85%
Coke	88%	85%	40%	97%	57%
Chemicals	88%	62%	89%	88%	80%
Rubber	72%	85%	86%	88%	47%
Non-Metallic Mineral	83%	94%	93%	75%	97%
Metals	90%	93%	66%	94%	78%
Machinery	74%	85%	18%	78%	18%
Equipment	60%	74%	72%	66%	23%
Transport Equip.	84%	85%	81%	94%	40%
EGW	99%	99%	100%	100%	100%
Construction	100%	100%	100%	100%	100%
Wholesale Trade	100%	99%	100%	99%	100%
Inland Transport	99%	98%	96%	100%	100%
Other Transport	99%	98%	94%	100%	99%
Post	97%	98%	99%	99%	100%
Financial	99%	99%	99%	98%	97%
Real Estate	97%	100%	77%	100%	100%
Other Business Activities	99%	95%	100%	97%	99%
Public Admin	100%	100%	99%	100%	97%
Health	100%	100%	99%	100%	100%
Personal Services	99%	98%	98%	99%	98%
Average	92%	92%	87%	94%	83%

Major differences in the distribution of spillovers of renewable energy projects (up to 19%) appear when other donors are compared with the USA, the benchmark country when climate finance is disbursed in Mexico. According to our results, the main driver of these large differences is trade of both final and intermediate commodities. As Table 5 shows, Mexico is relatively dependent from others' countries production to attend its final demand, something that, together with the geographical proximity and accessibility of the USA, explains the relevance of trade of final products (TSE). The relevance of trade of intermediate inputs (FME)[3] is consequence two facts: first, regional trade facilitated by proximity and trade treaties (i.e. NAFTA) also benefits USA indirectly (i.e. via Mexican imports of Canadian products that require American intermediate inputs); second, apart from its commercial links in the region, American industries are well positioned in global markets, something that enables them to participate in global supply chains and capture a share of the economic benefits generated from consumption in many parts of the world. Figure 6 evidences the relevance of American trade connections with the rest of the world, showing that USA is the first market for the world exports and the second exporting country, only behind China. Results also show that the USA is the donor that creates more value-added per unit of output, followed by Germany and the UK. Japan would be in the last position in this aspect. Note that this ranking coincides with the derived from average value-added coefficients contained in Table 4.

[3] In the comparison of recipient countries the FME represents a feedback effect: the recipient country imports final goods that require intermediate inputs from the recipient country. According to our results, and coinciding with previous empirical evidence, feedback effects are rather negligible (Meng, et al., 2007).

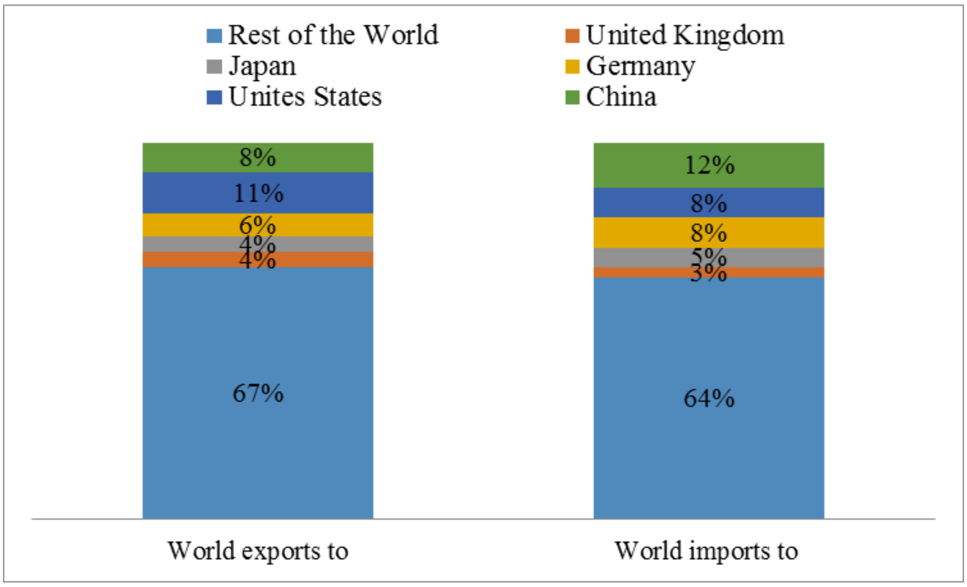


Figure 6: Donors shares of global trade. Source: World Bank (2011)

The fact that largest spill-over effects take place in Japan when the recipient is China also reflects the effect of proximity on trade. However, the main reason why China attracts spillovers between 3–8% larger than any donor country when finance is disbursed in Brazil, Indonesia and India might not be geographical proximity. We see in the prominent position of China regarding global trade (see in Fig. 6 that China is the first exporting and second importing country in the world) a better explanation for that result.

6. Concluding remarks

Putting the results of this exercise in the context of the expected flows of financial transfers between developed and developing countries (i.e. at least $100 billion per year from 2020 onwards) several policy-relevant conclusions can be extracted for both donors and recipients.

First, the extent to which climate finance can contribute to the economic development of recipient countries depends on several characteristics of their economies. In particular, especially important are those sectors most (directly or indirectly) involved in climate change mitigation and adaptation projects: mining, metals, machinery, equipment, construction, transport services and other business activities. Our results show that where these industries are well developed and connected, and offer high-tech and quality products and services, climate actions deliver larger economic benefits to the local population. Therefore, a strategy to juggle the increasingly internationally demanded climate action with the local needs of development would be to develop technologically advanced clusters specialized in climate mitigation and adaptation solutions, able to meet the local demand.

The same conclusion applies to donor countries aiming to profit from the economic co-benefits of global climate action. Our exercise shows that trade interconnections with the recipient countries increase the ability of countries to capture spillovers. Thus, donors would be tempted to focus climate aid on their specific commercial area. However, given the increasing limitations to donors' discretion to decide the destination of climate finance (i.e. the choice of a multi-lateral channel as the Green Climate Fund, with equal participation of developed and developing countries in its government bodies, as the main channel for future financial aid has this purpose), an alternative strategy would be a to promote globally competitive industries in the sectors above mentioned, with the aim to increase the participation in global supply chains of high-quality products and services related to the fight against climate change. Such option would enable to profit from global climate action regardless of where it takes place, and from climate finance flows regardless of who mobilizes them.

To conclude, these conclusions support the idea that climate action might not necessarily mean a sacrifice for the present generation in exchange of a habitable World in the future. Opposite, climate action might have immediate benefits for those countries that make it the core of their development strategy, because that would enable them to discover and profit from existing opportunities.

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Appendix

This appendix provides details on the application of the SDA technique to GMRIO tables for the decomposition of value-added creation associated to climate finance disbursements between two countries. The departing point is the quantification of the impacts in the recipient (domestic impact) and donor countries (spillover effects) obtained from a previous exercise (Román et al. under review). That paper details the procedure for the calculation of the impact of climate finance in terms of value-added creation. Next, the recipient country with the maximum domestic impact and the donor country with the maximum spillover effect are designated as benchmark countries. The figures to be decomposed are the differences between the impact in the benchmark country and each of the other countries in its group (recipients or donors). The decomposition provides a quantification of the contribution of each factor to the differences in impact between the benchmark and each country.

We depart from the following information contained in GMRIO tables: x_r is the column vector of gross outputs in country r. The inverse of the diagonal matrix of this vector is denoted as $\left(\hat{\mathrm{x}}^{\mathrm{r}}\right)^{-1}$. w^{r} is a row vector of value-added in country r with elements w_i^r indicating the value-added created in each sector i of that country. With those elements, we calculate value-added coefficients as $\mathrm{v}^{\mathrm{r}}=\left(\hat{\mathrm{x}}^{\mathrm{r}}\right)^{-1}\mathrm{w}^{\mathrm{r}}$.

Besides, 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. We calculate the matrix of input coefficients as $\mathrm{A}^{rs}=\mathrm{Z}^{rs}\left(\hat{\mathrm{x}}^{\mathrm{s}}\right)^{-1}$ and the Leontief inverse matrix as $\mathrm{L}\equiv\left(\mathrm{I}\text{-}\mathrm{A}\right)^{-1}$, where I is an identity matrix of the appropriate dimension. L^{rs} contains production multipliers of country r associated to demand in country s.

Next, f^{st} is the column vector with final demand, with elements f_j^{st} indicating the final demand in country t for products of sector j produced by country s. We calculate the fraction of the total final demand in country t for commodities of sector j that is imported from country s (when $s\neq t$) or that is produced domestically (when $s=t$) as (1). The column vector t^{st} indicates the trade structure of country t.

$$t_j^{st}=\frac{f_j^{st}}{\sum_s f_j^{st}} \tag{1}$$

Finally, we define e^{a} as the column vector of the demand shock, with elements e_j^a indicating the portion of expenditure in one specific climate action a expended in sector j. We assume that this expenditure by sector is expressed at basic prices, i.e. excluding taxes and transport and trade margins.

With these elements we can calculate the value-added created in country r as a consequence of the implementation of climate action a in the recipient country t as (2).

$$\mathrm{w}^{rta}=\sum_s \mathrm{v}^{r}\,{}'\mathrm{L}^{rs}\mathrm{t}^{st}\mathrm{e}^{\mathrm{a}} \tag{2}$$

This expression shows that the value-added of country r as the product of a series of four factors. Note that $r=t$ when the local impact of climate finance on recipient countries is calculated, while in the case of spillovers $r \neq t$.

The difference in the value-added created by the implementation of climate action a in country t between two countries A (the benchmark) and B (each of the rest of countries in the group) are given by:

$$\Delta \mathrm{w}^{ta} = \sum_{s} \mathrm{v}_{A}{}' \mathrm{L}_{\mathrm{A}}^{\mathrm{s}} \mathrm{t}^{st} \otimes \mathrm{e}^{a} - \sum_{s} \mathrm{v}_{B}{}' \mathrm{L}_{\mathrm{B}}^{\mathrm{s}} \mathrm{t}^{st} \otimes \mathrm{e}^{a}$$

In order to undertake the decomposition we use the approach proposed by Dietzenbacher and Los (1998), consisting on the average of two of the alternative formulations called polar decompositions. The first polar form is derived by changing the first variable first, then the second and so on. The second polar form is derived by changing the last variable first, etc.

The two polar decompositions (Δw^1 and Δw^2) are:

$$\Delta \mathrm{w}^{1\mathrm{ta}} = \sum_{\mathrm{s}} (\Delta \mathrm{v}') \mathrm{L}_{A}^{\mathrm{s}} \mathrm{t}^{st} \otimes \mathrm{e}_{a}^{a} + \sum_{\mathrm{s}} \mathrm{v}_{B}{}'(\Delta \mathrm{L}^{\mathrm{s}}) \mathrm{t}^{st} \otimes \mathrm{e}^{a} + \sum_{\mathrm{s}} \mathrm{v}_{B}{}' \mathrm{L}_{B}^{\mathrm{s}} (\Delta \mathrm{t}^{t}) \otimes \mathrm{e}^{a}$$

$$\Delta \mathrm{w}^{2ta} = \sum_{\mathrm{s}} (\Delta \mathrm{v}') \mathrm{L}_{B}^{\mathrm{s}} \mathrm{t}^{st} \otimes \mathrm{e}^{a} + \sum_{\mathrm{s}} \mathrm{v}_{A}{}'(\Delta \mathrm{L}^{s}) \mathrm{t}^{st} \otimes \mathrm{e}^{a} + \sum_{\mathrm{s}} \mathrm{v}_{A}{}' \mathrm{L}_{A}^{\mathrm{s}} (\Delta \mathrm{t}^{\mathrm{t}}) \otimes \mathrm{e}^{a}$$

And the average of the polar decomposition is $\Delta \mathrm{w} = \frac{1}{2}\left(\Delta \mathrm{w}^{1} + \Delta \mathrm{w}^{2}\right)$ or

$$\Delta \mathrm{w}^{\mathrm{ta}} = \frac{1}{2} \sum_{\mathrm{s}} \Delta \mathrm{v}' \left(\mathrm{L}_{\mathrm{A}}^{\mathrm{s}} \mathrm{t}^{st} \mathrm{e}^{\mathrm{a}} + \mathrm{L}_{\mathrm{B}}^{\mathrm{s}} \mathrm{t}^{st} \mathrm{e}^{\mathrm{a}} \right) + \frac{1}{2} \sum_{\mathrm{s}} \left(\mathrm{v}_{A}{}' + \mathrm{v}_{\mathrm{B}}{}' \right) \Delta \mathrm{L}^{\mathrm{s}} \mathrm{t}^{st} \mathrm{e}^{\mathrm{a}} + \frac{1}{2} \sum_{\mathrm{s}} \left(\mathrm{v}_{\mathrm{A}}{}' \mathrm{L}_{\mathrm{A}}^{\mathrm{s}} + \mathrm{v}_{\mathrm{B}}{}' \mathrm{L}_{\mathrm{B}}^{\mathrm{s}} \right) \Delta \mathrm{t}^{\mathrm{t}} \mathrm{e}^{\mathrm{a}} \tag{4}$$

In order to disentangle the differences in domestic multipliers ΔL_{rr} from differences in spillover effects ΔL_{rs} ($r \neq s$), the second component is subdivided into:

$$\Delta \mathrm{L}_{rr} = \frac{1}{2} \left(\mathrm{v}_{A}{}' \right) \left(\mathrm{L}_{AA} - \mathrm{L}_{\mathrm{BB}} \right) \left(\mathrm{t}_{\mathrm{B}}^{\mathrm{t}} \right) \mathrm{e}^{\mathrm{a}} + \frac{1}{2} \left(\mathrm{v}_{B}{}' \right) \left(\mathrm{L}_{AA} - \mathrm{L}_{\mathrm{BB}} \right) \left(\mathrm{t}_{\mathrm{A}}^{\mathrm{t}} \right) \mathrm{e}^{\mathrm{a}} \tag{5}$$

$$\begin{aligned} \Delta \mathrm{L}_{rs} &= \frac{1}{2} \left(\mathrm{v}_{A}{}' \right) \left(\mathrm{L}_{AB} - \mathrm{L}_{\mathrm{BA}} \right) \left(\mathrm{t}_{\mathrm{A}}^{\mathrm{t}} \right) \mathrm{e}^{\mathrm{a}} + \frac{1}{2} \left(\mathrm{v}_{B}{}' \right) \left(\mathrm{L}_{AB} - \mathrm{L}_{\mathrm{BA}} \right) \left(\mathrm{t}_{\mathrm{B}}^{\mathrm{t}} \right) \mathrm{e}^{a} \\ &+ \frac{1}{2} \sum_{r \neq A,B} \left(\mathrm{v}_{A}{}' \right) \left(\mathrm{L}_{\mathrm{A}}^{\mathrm{s}} - \mathrm{L}_{\mathrm{B}}^{\mathrm{s}} \right) \left(\mathrm{t}^{\mathrm{st}} \right) \mathrm{e}^{\mathrm{a}} + \frac{1}{2} \sum_{r \neq A,B} \left(\mathrm{v}_{B}{}' \right) \left(\mathrm{L}_{\mathrm{A}}^{\mathrm{s}} - \mathrm{L}_{\mathrm{B}}^{\mathrm{s}} \right) \left(\mathrm{t}^{\mathrm{st}} \right) \mathrm{e}^{\mathrm{a}} \end{aligned} \tag{6}$$

Expressions 4–6 decompose the difference in value-added created into the following four components: the difference in value-added intensity (VAiE), the difference in domestic multipliers (DME), the difference in foreign multipliers (FME) and the difference in trade structure (TSE).

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