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The effect of Climate Finance on Greenhouse Gas Emission: A Quantile Regression Approach

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ABSTRACT

Climate finance plays a primary role in international climate change agreements. It is a way to involve flows of funds from developed to developing countries that aims to help poorer countries shift toward low-emission, climate-resilient development pathways. In this paper, we study the flow of funds intended to promote energy generation and supply and biosphere protection in order to identify preferential channels in "Fast-start finance" distribution. We analyze the flow of funds among countries and the relationship between climate finance and a composite indicators that summarize and rank the greenhouse gas emissions by using a quantile regression model. Our results revealed a strong heterogeneity in the way the funds are being allocated by donors and show that close attention should be paid to the analysis of political contexts.

Keywords: Climate Funds, Composite Indicator, Developing Countries
JEL Classifications: C31, Q48

1. BACKGROUND AND INTRODUCTION

To combat the effects of climate change, the international community recently signed a climate agreement during the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). It is balanced with regard to adaptation and mitigation, and durable, with a periodical ratcheting-up of ambitions.

A period of the negotiations during the COP21 conference was reserved for climate finance. Climate finance involves flows of funds from developed to developing nations to enable poorer countries to shift towards low-emission, climate-resilient development pathways. In particular, developed countries (or donor countries) have made a commitment to collectively mobilize USD 100 billion/year by 2020 for climate action in developing countries (UNFCCC, 2014). To launch this project, they promised immediate "fast-start finance" of up to $30 billion over 2010-2012.

Following the findings of Pickering et al. (2015) and Bigsten and Tengstam (2015), we aim to prove the existence of preferential channels in "fast-start finance" distribution among donor and recipient countries and to determine whether these preferences could undermine the effectiveness of such measures[1] in acting against contrasting the deterioration of environmental conditions. More specifically, we analyze the flow of funds among countries and the relationship between climate finance and greenhouse gas emissions (GHG) to assess whether funds primarily reach the main polluting developing countries despite the presence of preferential financial channels. In this way, we can provide a useful measure of the ex-post effectiveness of "fast-start finance." Our intention is to make suggestions regarding useful alternatives to climate funds programming and international coordination.

To this end, we follow a two-step procedure.

In the first step, we summarize and rank the countries' GHG emissions by means of a composite indicator (CI) (OECD, 2008).

1 By aid effectiveness, we mean ensuring that aid reaches the developing countries, which, due to their rapid growth, have become the main emitters of greenhouse gases.

We analyze a large dataset of 176 countries[2], considering the most important GHGs resulting from anthropogenic activities in 2012. The dataset includes developing and developed countries. In other words, following the UNFCCC, our dataset includes Annex-II, non-Annex-I (including the least developed countries - LDC), and economies in transition.

In the second step, to investigate the relationship between climate funds and GHG emissions, we concentrate our attention only on other countries (non-Annex-I, a sample of 149 countries), distinguishing between those that have received or have not received financial aid (hereafter treated and untreated, respectively) and analyze the determinants of environmental index and the effectiveness of "fast-start finance" in order to assess the distribution of climate funds based on the degrees of pollution of recipient countries. To reach this goal, we use a quantile regression model to investigate the usefulness of climate finance in limiting GHG emissions and in distributing funds provided by developed countries. We also identify factors promoting environmental performance. To assess this, the quantile regression[3] is conducted on disbursed funds in 2010 (to evaluate the effectiveness of "fast-start finance") in a sample of 149 countries (including the treated and untreated developing countries and excluding the Annex-II countries). The time lag is a way to make observable the effects of the donations on creating an adequate system of energy production and on reducing GHG emissions (Kim et al., 2008).

In particular, we show that "fast-start finance" is a useful instrument to contrast the worsening of environmental conditions.

The remainder of the paper is organized as follows: Section 2 reports a brief literary review; Section 3 describes our data while Section 4 reports the methodology employed; in Section 5, we discuss the results obtained. Section 6 offers some concluding remarks.

2. LITERATURE REVIEW

Climate finance has been explored previously. Ellis et al. (2013) explore how different communities view climate finance effectiveness, the policies or institutional pre-conditions that facilitate effectiveness, and how effectiveness is currently monitored and evaluated.

Tirpak et al. (2014) present nine technical, political, and capacity challenges faced by developing countries that were discussed during three workshops in Asia, Africa, and Latin America. Participants in these workshops discussed some of the steps that developing countries and their international partners can take toward monitoring and tracking climate finance more effectively.

Bird et al. (2013) describe an approach to measuring the effectiveness of the national systems that support climate finance delivery. They assess three interlinked elements of government administration: The policy environment that supports climate change expenditures, the institutional architecture that determines relevant roles and responsibilities, and the public financial system through which climate change-related expenditures are channeled.

Bazilian et al. (2011) conclude that poverty is one of the major problems that must be overcome to improve drastically the investment climate for energy access. Furthermore, Marquardt et al. (2016), in a study of financial aid for the transition to an energy-efficient and low-carbon economy in the Philippines and in Morocco, argue that while climate finance cannot be imposed on these countries, it may be necessary to lead them through a process of gradual change - through niche level projects - to test the effects of changes.

In a recent report, the OECD (2015), in collaboration with climate policy initiatives, provided a status check on the level of climate finance mobilized by developed countries in 2013 and 2014.

Keeley (2016) focuses his attention on the importance of attracting funding from donors to develop resources, given the importance of international financial recourses for many developing countries or those that are heavily dependent on fossil fuels and that are subject to significant fluctuations in oil prices.

Pickering et al. (2015) investigate the intra-governmental dynamics of climate finance decision-making in some donor countries (Australia, Denmark, Germany, Japan, Switzerland, the United Kingdom and the United States). They highlight the importance of intra-governmental coordination in the management of climate aid. Bigsten and Tengstam (2015) seek to quantify the effects of improved donor coordination on aid effectiveness. They find that aid coordination efforts may reduce donor transaction costs and increase the possibilities of achieving donor objectives in recipient countries, but there will also be political costs to the extent that the donor loses some political control over aid transfers.

International cooperation on finance has the potential to help countries manage such trade-offs and create new incentives for low carbon development. Climate finance can support the policies that can build resilience against the threats posed by climate change (Nakhooda et al., 2015).

Developing countries' governments are rightly concerned about potential tensions between sustaining the economic growth needed to generate jobs and reduce poverty and reducing GHG emissions. As argued by Espagne (2016), these countries face the difficulty of improving their economic systems without access to carbon (due to high carbon prices) and without strong financial support from developed countries. Moreover, electricity access remains a key question for many developing countries, as argued by Bhattacharyya (2013). All this results in a lack of resilience, the importance of which becomes even more basic if we consider that the economic development of a country depends not only on the improved coordination of aid but also on the way aid is organized and distributed.

2 We make joint use of two datasets: One from the WRI's Climate Analysis Indicators Tool (CAIT) and one from AidData (flow of funds).

3 Quantile approach has been previously employed in the identification of the key factors in renewable investments (see, e.g.,, Marques et al., 2011) or to individuate the impact of several factors on residential electricity consumption (Niu et al., 2016).

As stated by Urmee and Md (2016), renewable sources can improve the living conditions and economic development of developing countries, but this process depends on the socio-economic factors that create environmental consciousness, such as the demographic structure and the level of education.

Countries can indeed increase their energy sustainability, as academic reviews suggest. The sustainability and impact of RES generation largely depend on its suitability for potential end users. In these countries, the lack of electricity transmission networks requires the installation of off-grid RES power plants that could be financed by international organizations and governmental subsidies without inhibiting the development of commercial renewable energy technologies markets (Chaurey et al., 2012; Sovacool and Drupady, 2012).

3. DATA

The aim of this paper is to analyze the determinants of countries' environmental performance and the effectiveness of climate funds. In other words, we want to investigate whether countries can progress towards more environmentally sustainable development using the flow of funds provided by donor countries and by increasing the resilience of their environmental, social and economic systems to either endogenous or exogenous shocks. Our results contribute to the debate on the vulnerability and resilience of receiving countries as part of the UN Framework Convention on Climate Change agreement.

As our approach is devoted to sketching the features of the receiving countries' development and to exploring the factors behind environmental performance, our empirical analysis employs a wide range of control variables that can be grouped into three homogeneous areas: Energy, demographics, and socio-economic living standards, while the outcome variable summarizes environmental aspects.

Definitions, data sources and descriptive statistics of variables for the sample (149 countries: Treated and untreated) are shown in Table 1.

In the funds group we include the amount of aid from donor to recipient countries. The total amount of aid was retrieved from the AidData database (Tierney et al., 2011), a project that collects all financial flows destined to aid developing countries. The funds received mainly include two types of aid. In this paper, we consider the flows of funds targeted at (i) the general environment, and (ii) biosphere protection (air pollution control, ozone layer preservation and marine pollution control). In general, both types of financial flows are among the aid directed to climate change, and these funds are for both climate adaptation and climate mitigation. These flows of funds represent a contributing factor to investments in alternative green energy usage, as they compensate for credit and liquidity constraints and improve technological progress in environmental protection (Zhao et al., 2012).

The 'energy' group refers to the class of electricity generation factors. It includes the share of non-hydroelectric (sh_nonhydro) and fossil (sh_fossil) generation expressed, respectively, as the ratio of non-hydroelectric generation to total electricity production and the ratio of fossil fuel electricity generation to total electricity production (Romano et al., 2016a).

In this group, we also include energy intensity. As suggested by Romano et al. (2015; 2016b), more developed economies are also oriented to production efficiency improvement and low energy intensity and, for these reasons, the ratio between energy consumption and GDP can be considered as a proxy of technological and economic progress. In the same class of factors, we include the excavation of energy resources. In particular, we investigate the effects of oil supply, which includes the production of crude oil (including lease condensate), natural gas plant liquids and other liquids, and refinery processing gain[4]. With this indicator, we can control for lobbying effects (Marques et al., 2011; Marques and Fuinhas, 2012). Where these resources are used intensively, we expect a lower usage of RES.

Among demographic characteristics, we include the percentage of the female population. Population is based on the de facto definition, which counts all residents regardless of legal status or citizenship - except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. The share of the female population has been inserted as a proxy for preferences for greener policy management. It has been shown, in fact, that women have stronger preferences for environmental issues and protection (Zhao et al., 2012; Romano et al., 2016a).

In the 'socio-economic and living standards' group, we include gross domestic product (in logarithmic scale) to control for the relative level of economic development. In fact, it is commonly assumed that richer countries are able to better promote investments in renewable energy sources (Romano et al., 2015) and to improve environmental conditions. Moreover, GDP is also related to energy consumption, which is considered a proxy for a country's economic development (Toklu et al., 2010).

We also include access to electricity expressed as the percentage of the population with direct access. Access to electricity is essential for social, economic, and political development (Kanagawa and Nakata, 2007; Kanagawa and Nakata, 2008; Onyeji et al., 2012). Despite the enormous potential of most of the developing countries in fossil and renewable energy sources, however, some of these countries still suffer from major energy deficits. For this reason, the World Bank supports policies aimed at relieving energy poverty and thus improving the living conditions of the population in developing countries.

As an outcome variable we built a CI to capture environmental degradation due to economic development. The CI proposed is an index that measures the environmental performance of countries and summarizes the effect of anthropogenic activities on the atmosphere (Singh et al., 2009). We consider the most important anthropogenic emissions of GHG: Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs),

4 Negative refinery processing gain data values indicate a net refinery processing loss.

Table 1: Data: Definitions, descriptive statistics and sources

Variable	Definition	Unit	Observe	Mean±SD	Minimum	Maximum	Source
Exogenous Funds							
Tot_rec	Sum of funds destined to "energy generation and supply" and to "general environmental protection"	M $	149	\$1.110±\$4.714	\$0	\$41.710	AidData.org
Energy							
Ei	Energy intensity using purchasing power parities is calculated by dividing the data on total primary energy consumption in quadrillion British thermal units for each country and year by the gross domestic product using purchasing power parities in billions of (2005) U.S. dollars for each available country and year	Btu per year 2005 U.S. Dollars (PPP)	149	6.759±6.215	199	50.976	U.S. EIA
oil_sup	Total oil supply includes the production of crude oil (including lease condensate), natural gas plant liquids, and other liquids, and refinery processing gain	Thousand barrels per day	149	464±1.429	−0.54	10.908	
sh_foss	Fossil Fuels electricity generation consists of electricity generated from coal, petroleum, and natural gas	Billion Kilowatt-hours	149	0.66±0.34	0	1	
sh_nonhydro	Hydroelectric generation excludes generation from hydroelectric pumped storage, where separately reported.		149	0.02±0.06	0	0.42	
Demographic							
pop_fem	Female population is the percentage of the population that is female. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship-except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of the country of origin	% of total	149	49.74±3.48	24.65	54.31	World Bank
Socio-economic and living standards							
acc_el	Access to electricity is the percentage of population with access to electricity. Electrification data are collected from industry, national surveys and international sources	% of population	149	72.21±32.55	3.5	100	World Bank

(*Contd*...)

Table 1: ***Continued...***

Variable	Definition	Unit	Observe	Mean±SD	Minimum	Maximum	Source
Lgdp	GDP per capita based on PPP. PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States	constant 2011 international $	149	8.83±1.13	6.55	11.76	
ln_elcons	The electric consumption is the electric power consumption equal to the sum of total net electricity generation and electricity imports net of the electricity exports and electricity transmission and distribution losses.	Billion Kilowatt-hours	149	1.55±2.36	−3.84	8.24	U.S. EIA

EIA: Energy Information Administration, PPP: Purchasing power parity

hydro CFCs (HCFCs), hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride, together called F-gases. The concentration of GHG in the atmosphere is increasing and is the main cause of the greenhouse effect, mostly due to the burning of fossil fuels for human activities. All these are expressed in CO_2-equivalents.

4. METHODS

To synthetize the GHG emissions and analyze the relationship between environmental performance and flow of climate funds, we first construct a CI to assess the impact of anthropogenic activities (with the proposed environmental index) and, second, we study the relationship between the index and climate finance using a quantile regression.

4.1. A CI for GHG Emissions

The construction of the index that can summarize the GHG emissions of countries is complex and uses the four variables that have been previously identified. One way to make comparison across space (and time) is to combine the various indicators in a single index. According to the OECD (2008), "A CI is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured."

A CI has the advantage of allowing the ranking of countries because it represents overall environmental performance (Burck et al., 2009) in one number. Nevertheless, building composite indices implies losing a certain amount of information[5]. However, as monitoring GHG emissions often requires overall comparisons across space, composite indices are very useful for specific purposes.

The CO_2, N_2H, CO_4 and F-gases indicators will be combined in a CI[6]. The indicators are measured in the same units and have the same direction. However, following the suggestions of the OECD, we have first normalized the indicators using the min-max method[7]. In this way, we ensure comparability among countries. The data are scaled according to the high and low values, which represent the possible range of a variable for all countries. We obtain an environmental index that puts the "cleaner" countries at the higher levels of the index and the major polluters at the lower levels. In this way, we evaluate the effectiveness of funds (in the following section) at improving the performances of countries. The scores vary between the theoretical lower and upper bounds of 0 and 1.

Once all indicators are transformed into the 0-1[8] interval, the measure of each indicator of the index is computed by aggregating the component indicators following equal weighting (EW).

Using the EW methods, each indicator is assigned the same weight, or:

$$w_q=1/Q \tag{1}$$

Where w_q is the weight for the q^{th} indicators (q =1,…,Q) for each country.

To obtain the environmental index, we aggregate the weights for each indicator using the geometric methods that reduce the compensability of indicators (OECD, 2008):

$$CI \quad \prod_{q=1} \quad {}_{q,c} \tag{2}$$

4.2. Quantile Regression with Cluster Data

Quantile regression, which was originally introduced by Koenker and Basset (1978), extends the linear regression model to conditional

5 Furthermore, composite indices have been criticized because, in a way, they re-introduce unidimensionality. For the pros and cons of using CIs see, e.g.,, Nardo et al. (2005) and OECD (2008).

6 As suggested by OECD (2008), when missing data were detected we employed the imputation method based on regression.

7 There is a wide range of normalization methods (OECD, 2008) and the choice depends on the type of data and on weighting and aggregation (Hudrilikova, 2013).

8 Extreme values (outliers) are identified but not adjusted for, at least not in this first version of the composite. Nor has it been considered necessary at this stage to make any non-linear transformations of any of the underlying component indicators.

quantiles of the dependent variable. In other words, quantile regression models the relationship between X and the conditional quantiles of Y, and it is useful in applications where extremes are important (Ranganai et al., 2014), such as environmental studies. The great advantage of quantile regression is to generalize the concept of a univariate quantile to a conditional quantile given one or more covariates. Furthermore, quantile regression is robust to heavy-tailed distributions and outliers. Other advantages of quantile regression are summarized in Buchinsky (1998).

Koenker and Basset (1978) propose, for the calculation of quantiles, an alternative procedure to the classical one. In particular, this procedure is based on an optimization method. More precisely, analogous to what happens to the sample mean, which can be defined as the solution of the minimization problem of the sum of squared deviations, here we can define each quantile as the solution of the following minimization problem.

For $0 \leq \alpha \leq 1$ the α^{th} quantile of y given x is defined by

$$Q_y(\alpha|x)=\min\{\eta|P(y\leq\eta|x)\geq\alpha\} \quad (3)$$

In addition, assuming that $Q_y(\alpha|x)$ is linear, we obtain that

$$Q_y(\alpha|x)=x'\beta(\alpha) \quad (4)$$

Which is equivalent to

$$y=x'\beta(\alpha)+u(\alpha) \quad (5)$$

$$Q_y(\alpha|x)=x'\beta(\alpha) \quad (6)$$

Parente and Silva (2016) extend the results of Kim and White (2003) and show that the traditional quantile regression analysis is consistent and asymptotically normal when there is intra-cluster correlation of the error terms. Based on this finding, we implement a quantile regression with robust standard errors, which allows controlling for the case in which the error may be clustered (Parente and Silva, 2016).

In other words, let the data be $\{(y_{gi},x_{gi}), g=1,\ldots,G; i=1,\ldots,n_g\}$, where g indexes a set of G clusters, each with n_g elements. We assume that the disturbances are conditionally independent across clusters, but can be correlated within clusters (Parente and Silva, 2016). Therefore, the model to be estimated is:

$$y_{gi}=x_{gi}'\beta(\alpha)+u(\alpha)_{gi} \quad (7)$$

And $\beta(\alpha)$ can be estimated as,

$$\hat{\beta}=\arg\min_b \frac{1}{G}\sum_{g=1}^{G}\left\{\sum_{y_{gi}\geq x_{gi}'b}\alpha\left|y_{gi}-x_{gi}'b\right|+\sum_{y_{gi}<x_{gi}'b}(1-b)\left|y_{gi}-x_{gi}'b\right|\right\} \quad (8)$$

$\hat{\beta}(\alpha)$ is usually estimated by linear programming methods.

Parente and Silva (2016) provide a consistent estimator of the covariance matrix and propose a specification test able to detect the presence of intra-cluster correlation. In particular, in the absence of intra-cluster correlation, the covariance estimator proposed by Parente and Silva (2016) is equivalent to a standard heteroskedasticity robust estimator; this is the case when $n_g=1$ (Powell, 1984; Chamberlain, 1994; Kim and White, 2003; Parente and Silva, 2016).

In this paper, clusters are identified through the World Bank's classification of countries (low-income economies; lower-middle-income economies; upper-middle-income economies; high-income economies).

5. RESULTS AND DISCUSSION

The empirical analysis follows a two-step estimation procedure based on different methodologies. In the first step, we construct a CI for environmental performance on the entire dataset (donor, treated and untreated countries). In the second step we eliminate donor countries and analyze the relationship between the environmental index and climate funds, controlling for a series of other variables. To examine the key determinants of the index and assess the effectiveness of climate aid, we perform a quantile regression analysis.

5.1. A CI for Environmental Performance

Considering the multi-dimensionality of the environmental index, we aggregate the four main GHG[9]. To weigh the indicator we follow the EW.

According to Saisana (2011), the presence of few indicators justifies the use of an EW scheme. In other words, the weight on each single indicator for each group of countries is equal to 0.25, according to equation 1 For a more detailed discussion OECD (2008).

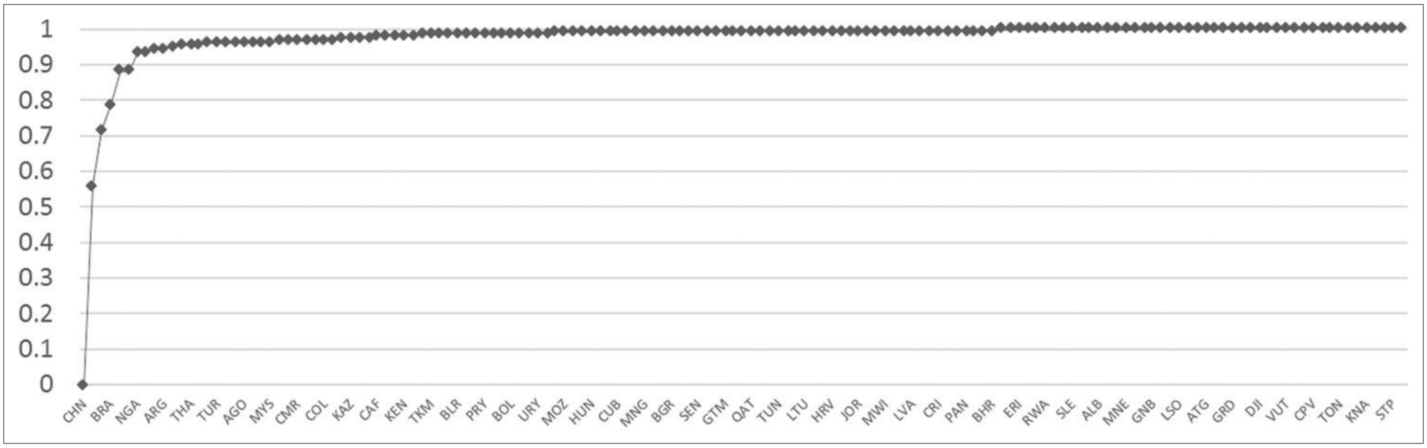
The calculation of the index has been performed following a geometric aggregation (Appendix 1). Figure 1 reports the graphical representation of the index obtained.

Based on the methodology described in Section 4.1, the selected indicators, which quantify the concept of environmental performance in countries, will be employed for the construction of the CI for countries for the year 2012. This indicator (i) captures the interactions and interdependencies of the selected indicators, and (ii) facilitates the comparability of countries based on their index.

The environmental index is between zero (China and the United States) and 0.9999 (Kiribati). Higher values of the index indicate countries that have a lower level of GHG emissions. This does not imply that these countries have paid great attention to environmental problems. Most of the countries with higher index levels are generally underdeveloped, and they receive mitigation funds to promote their economic growth and development along a green path in which investments are concentrated on green electricity generation plants and supporting low-emission transport. These countries use financial resources to improve the living conditions of their populations and have a low share of generation from

9 CO_2, CH_4, N_2O and F-gases.

Figure 1: Environmental index following equal weighting



renewable sources. In poor countries, scarce resources are unlikely to be invested in technologies that do not meet high expectations (Mulugetta, 2008; Bhattacharyya, 2013; Desjardins et al., 2014).

On the opposite side, we observe developed and developing countries that have high or increasing economic and social development and contribute to the deterioration of the quality of the environment.

5.2. Effectiveness of Climate Finance in Contrasting GHG Emissions

In this subsection, we discuss the key factors of the environmental index, the divergences based on the environmental impact of each group of countries analyzed, and the effectiveness of the flow of funds received by developing countries.

Figures 2 and 3 present the histograms of the environmental index for countries that receive climate funds (treated), countries that are not included in Annex-II, countries that have received financial aid (treated), and untreated countries. A first remark concerns the high values of the environmental index for the untreated countries, which therefore do not have a significant impact on climate change. This is in contrast to the treated countries, which show lower levels of the index and an increase in heterogeneity due to the presence of large polluters such as China and India. This confirms that climate finance is mainly directed towards large-scale polluters. The proposed index is characterized by much higher values in the upper-half of its distribution. Due to the high skewness of the index distribution, the analysis is conducted by means of a quantile regression by focusing on the first quantiles (Neumayer et al., 2014) and on the total amount of funds directed to promote Clean Energy according to AidData (Tierney et al., 2011).

To individuate the key factors of the GHG emissions and the effect of climate funds in contrasting the climate change, we estimate the following model:

$$Q_{EPI}(\alpha|X_{gi})=\beta_0(\alpha)+\beta_1 Tot\text{-}rec(\alpha)+\beta_2 pop\text{-}fem(\alpha)+\beta_3 ei(\alpha) +\beta_4 oil\text{-}sup(\alpha)+\beta_5 sh\text{-}foss(\alpha) +\beta_6 sh\text{-}nonhydro(\alpha)+\beta_7 lgdp(\alpha) +\beta_8 lnel\text{-}cons(\alpha)+\beta_9 acc\text{-}el(\alpha)+u(\alpha) \quad (9)$$

Figure 2: Histogram of environmental index in treated countries

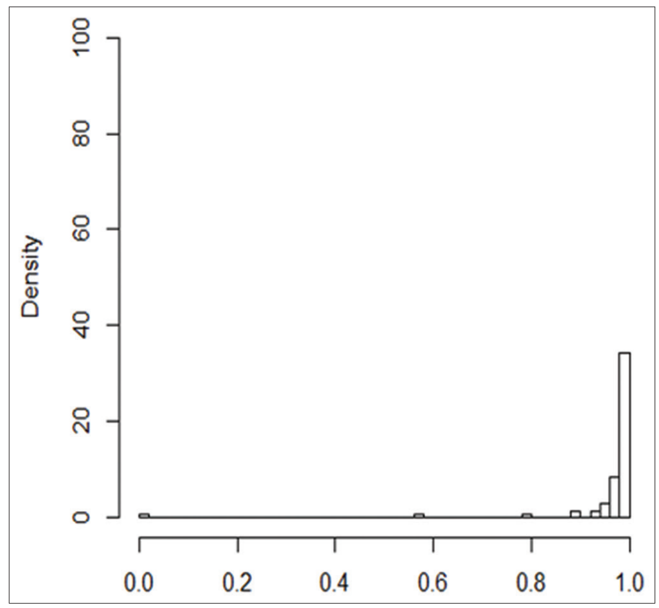
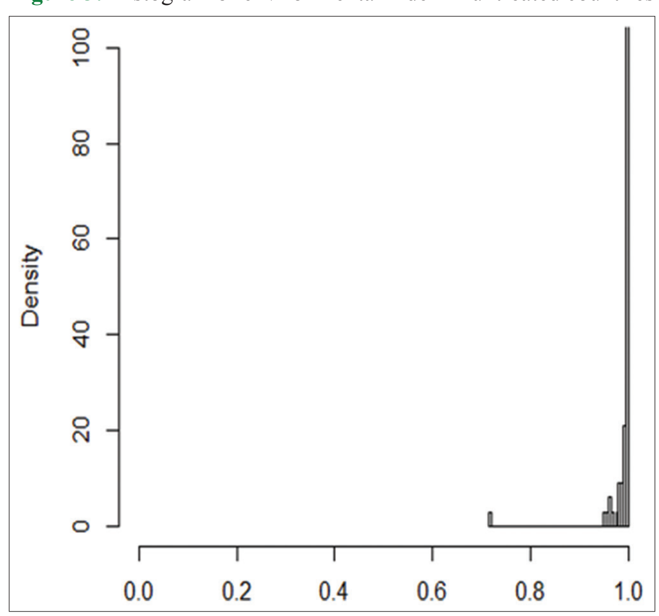


Figure 3: Histogram of environmental index in untreated countries



Where α shows the α^{th} quantile and $0<\alpha<1$, β_0 is the intercept, and β_1 to β_9 are the slopes of the independent variables. In particular, pop_fem is the percentage of the female population; ei is the energy intensity; oil supply includes the production of crude oil, natural gas plant liquids and other liquids, and refinery processing gain; sh_nonhydro is the ratio of non-hydroelectric generation to total electricity production while sh_fossil is the fossil generation expressed as the ratio of fossil fuel generation to total electricity production; lngdp is Gross Domestic Product (in logarithmic scale) expressed in 2011 US$ PPP; lnel_cons is the energy consumption (in logarithmic scale) while acc_el is the access to electricity. Finally, u is the error term that allows the disturbance conditionally to be independent across clusters but can be correlated within clusters to vary. The constant β_0 and the coefficients β_1 to β_9 are estimated for different quantiles ($\alpha = 0.25, 0.50, 0.75, 0.95$) using the entire dataset each time. Moreover, to account for the presence of clusters in the observed countries, we conduct a quantile regression that estimates the robust covariance matrix with within-cluster dependence (Parente and Silva, 2016). By clustering the sample by income group variable[10] to account for the economic and social structure of the countries, we accept the null hypothesis of the Parente-Silva test of no-intra-cluster correlation. Therefore, we have estimated three different models with the latter method to obtain confidence intervals for quantile regression estimators at any single quantile.

Tables 2 reports the vector of coefficients estimated both by OLS and by quantile regression (for α = 0.25, 0.50, 0.75, 0.95). Figures 4-8 report the quantile coefficients plots. The table reports the estimated coefficients of the amount of received flow of funds (Tot_rec,) as sum of its two components: Those directed to power generation and renewable sources and those targeted at the biosphere protection.

Focusing on Table 2, we observe that the total flow of funds presents a significant relationship with the proposed environmental index. Estimated coefficients on control variables are generally significant and in line with our hypotheses.

The estimated coefficients for the total flow of funds (for total energy aid and for total biosphere protection) are higher in magnitude for the lower quantiles. This confirms the intuition that the countries with a lower level of the index (generally the treated countries) are also the ones that receive more funds, while an increase in the index leads to a potential reduction in the received funds.

The estimated coefficients of the control variables, as shares of fossil fuels or the oil supply, also decrease with the increasing quantiles of the index, and the relation is stronger for the first quantiles. On the other hand, although the relation of energy intensity is positive for the bottom-half of the index distribution, it becomes negative for the central quantiles, and it becomes positive for the top-half distribution. Therefore, almost all of the control variables are mean reverting while the flow of funds, oil supply,

10 We follow the income group distribution proposed by the World Bank (https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups).

Table 2: OLS and quantile regression results

Variable	OLS	Coefficient/sec			
		25th	50th	75th	95th
Tot_rec	−8.74e-09*** (1.65e-09)	−1.28e-08*** (2.42e-10)	−1.69e-09 (4.92e-09)	−7.24e-10*** (8.31e-11)	−7.60e-10*** (1.19e-11)
pop_fem	−0.000902 (0.00130)	−0.000670 (0.00111)	−0.00104*** (0.000260)	−0.000605* (0.000321)	−0.000105* (0.0000543)
ei	0.000000223 (0.000000107)	−4.71e-08 (8.52e-08)	−0.000000115* (5.99e-08)	0.000000109 (0.000000171)	−2.84e-09 (2.82e-08)
oil_sup	−0.0000229 (0.0000146)	−0.0000262*** (0.000000247)	−0.0000153*** (0.00000389)	−0.00000969** (0.00000463)	−0.00000245*** (7.09e-08)
sh_foss	−0.0180* (0.00698)	−0.00252 (0.00204)	−0.00247 (0.00166)	−0.00244 (0.00183)	−0.00109*** (0.000230)
sh_nonhydro	−0.0331 (0.0475)	−0.00777 (0.0114)	−0.00471 (0.0128)	0.00115 (0.00536)	−0.00383** (0.00175)
lgdp	0.0153 (0.0150)	0.00180* (0.000924)	0.00130 (0.000995)	0.00120** (0.000471)	0.000386 (0.000357)
lnelcons	−0.00906** (0.00259)	−0.00174*** (0.000519)	−0.00169*** (0.000274)	−0.00196*** (0.000649)	−0.00145*** (0.0000825)
acc_el	−0.0000986 (0.000267)	0.0000204 (0.0000237)	0.0000377 (0.0000305)	0.0000266** (0.0000115)	0.0000286*** (0.00000674)
Constant	0.937*** (0.170)	1.015*** (0.0589)	1.038*** (0.00975)	1.019*** (0.0171)	1.001*** (0.00524)
R^2	0.482	0.452	0.369	0.348	0.459
Number of cases	149	149	149	149	149
Parente-santos silva test P value		0.273	0.628	0.358	0.0719

*P<0.1, ** P<0.05, *** P<0.01. Heteroskedasticity-robust standard errors are in parenthesis. *Denote statistical significance at 10%. **Denote statistical significance at 5%. ***Denote statistical significance at 1%

Figure 4: Quantile plots show the estimated coefficients for all different quantiles for the quantile regression model. The two figures present the coefficients $\beta_0(\alpha)$ (Constant) and $\beta_1(\alpha)$ (Amount of funds) for different quantiles ($\alpha \in \{0.01, \ldots 0.99\}$) for the full regression model. The x-axis represents the location in the distribution (i.e. quantile) of the environmental index; the y-axis represents the magnitude of the parameter estimates at each point of the outcome distribution for each covariate (holding all other covariates constant), with zero representing the null value (i.e. no difference between covariate values at a given quantile in the distribution). Again, the respective values are connected as a the dotted line; the grey shading indicates the 95^{th} point-wise confidence intervals about the coefficients, with the least squares result added as a horizontal dashed line. Note that there is an additional solid line at zero

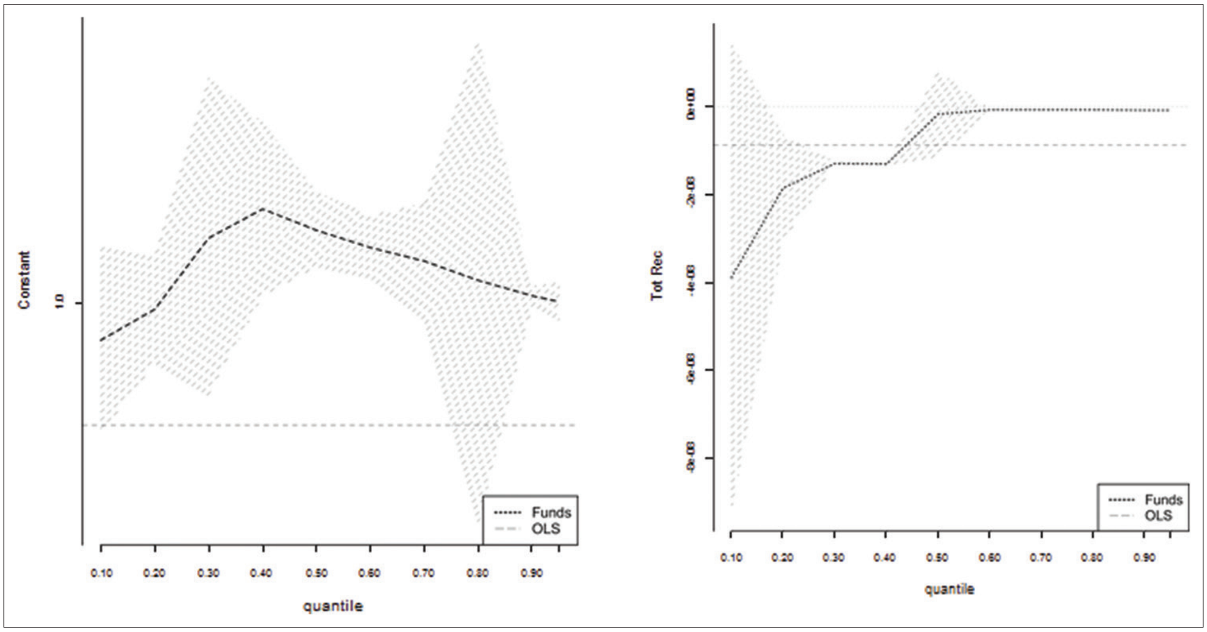
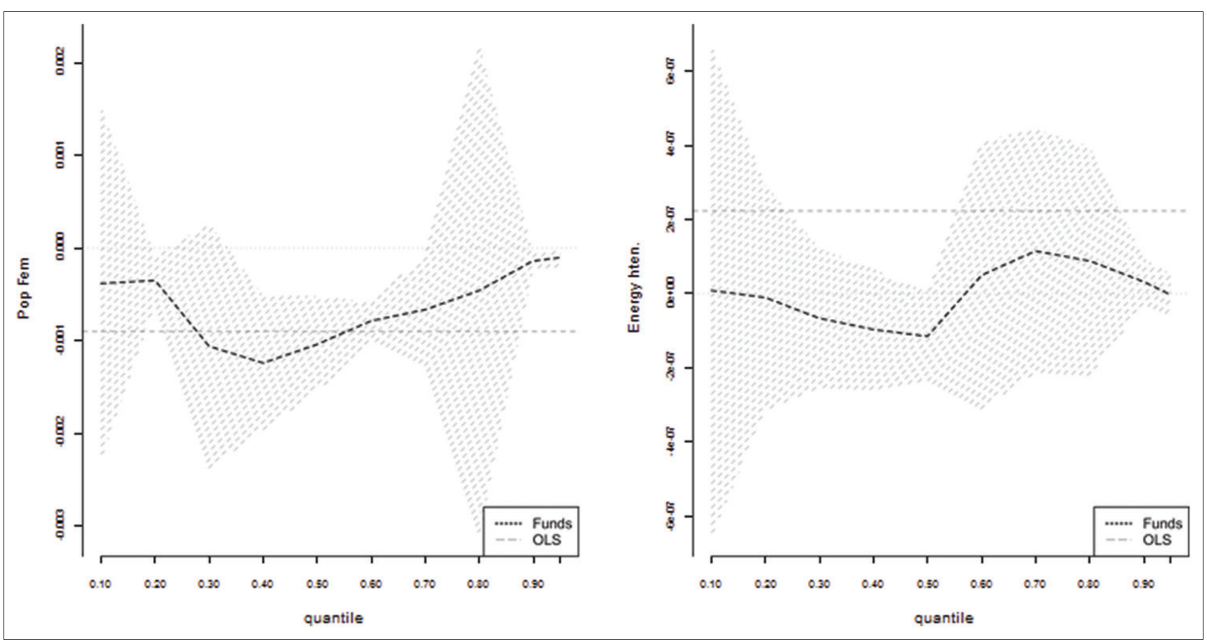


Figure 5: Quantile plots show the estimated coefficients for all different quantiles for the quantile regression model. The two figures present the coefficients $\beta_2(\alpha)$ (% of female population) and $\beta_3(\alpha)$ (energy intensity) for different quantiles ($\alpha \in \{0.01, \ldots 0.99\}$) for the full regression model. The x-axis represents the location in the distribution (i.e. quantile) of the environmental index; the y-axis represents the magnitude of the parameter estimates at each point of the outcome distribution for each covariate (holding all other covariates constant), with zero representing the null value (i.e. no difference between covariate values at a given quantile in the distribution). Again, the respective values are connected as a the dotted line; the grey shading indicates the 95^{th} point-wise confidence intervals about the coefficients, with the least squares result added as a horizontal dashed line. Note that there is an additional solid line at zero



electricity consumption and GDP show a stronger relationship with the more polluting countries and with the first quantile of the index distribution.

In the estimated model, the coefficients of the flow of funds are overall significant and decrease as the quantiles increase.

Figure 6: Quantile plots show the estimated coefficients for all different quantiles for the quantile regression model. The two figures present the coefficients $\beta_4(\alpha)$ (oil supply) and $\beta_5(\alpha)$ (share of fossil generation) for different quantiles ($\alpha \in \{0.01, \ldots 0.99\}$) for the full regression model. The x-axis represents the location in the distribution (i.e. quantile) of the environmental index; the y-axis represents the magnitude of the parameter estimates at each point of the outcome distribution for each covariate (holding all other covariates constant), with zero representing the null value (i.e. no difference between covariate values at a given quantile in the distribution). Again, the respective values are connected as a the dotted line; the grey shading indicates the 95th point-wise confidence intervals about the coefficients, with the least squares result added as a horizontal dashed line. Note that there is an additional solid line at zero

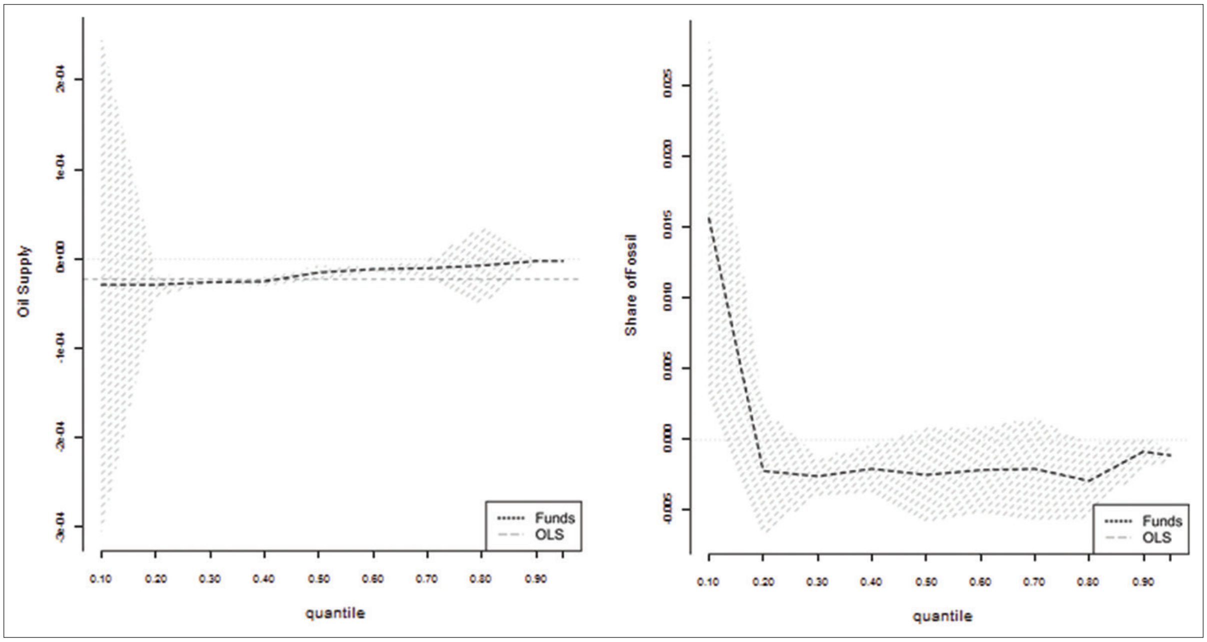
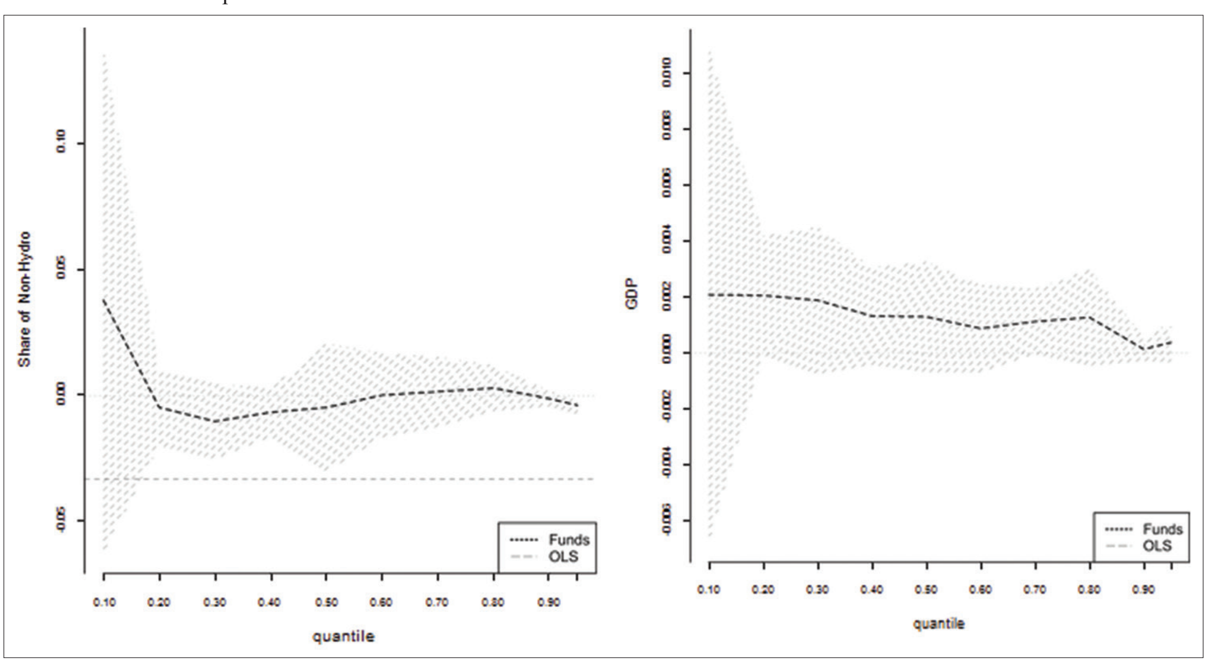
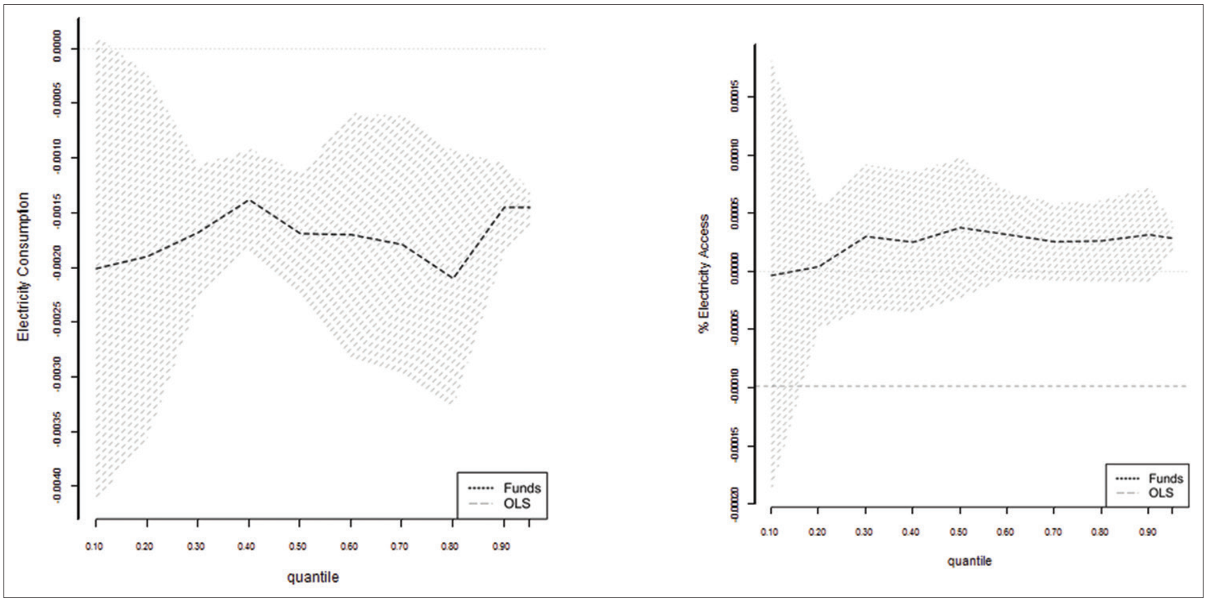


Figure 7: Quantile plots show the estimated coefficients for all different quantiles for the quantile regression model. The two figures present the coefficients $\beta_6(\alpha)$ (share of non-hydroelectric generation) and $\beta_7(\alpha)$ (gross domestic product (in logarithmic scale)) for different quantiles ($\alpha \in \{0.01, \ldots 0.99\}$) for the full regression model. The x-axis represents the location in the distribution (i.e. quantile) of the environmental index; the y-axis represents the magnitude of the parameter estimates at each point of the outcome distribution for each covariate (holding all other covariates constant), with zero representing the null value (i.e. no difference between covariate values at a given quantile in the distribution). Again, the respective values are connected as a the dotted line; the grey shading indicates the 95th point-wise confidence intervals about the coefficients, with the least squares result added as a horizontal dashed line. Note that there is an additional solid line at zero



Particularly, the estimated coefficients for the flow of funds directed to improve power generation have a negative relationship over all quantiles; after a rapid increase starting at quantile 0.2, the parameters tend to zero. This means that the flow of funds

Figure 8: Quantile plots show the estimated coefficients for all different quantiles for the quantile regression model. The two figures present the coefficients $\beta_8(\alpha)$ (electricity consumption) and $\beta_9(\alpha)$ (% of Electricity access) for different quantiles ($\alpha \in \{0.01, \ldots 0.99\}$) for the full regression model. The x-axis represents the location in the distribution (i.e. quantile) of the environmental index; the y-axis represents the magnitude of the parameter estimates at each point of the outcome distribution for each covariate (holding all other covariates constant), with zero representing the null value (i.e. no difference between covariate values at a given quantile in the distribution). Again, the respective values are connected as a the dotted line; the grey shading indicates the 95th point-wise confidence intervals about the coefficients, with the least squares result added as a horizontal dashed line. Note that there is an additional solid line at zero



decreases when the index increases, in other words, when countries become cleaner and no longer need aid improve their energy production systems. However, these cleaner countries are also the least developed, and they have to adopt the new development pattern. For this reason, we observe that the funds provided by donor countries are mainly directed to and concentrated in countries with economic systems in transition, or to rapidly developing countries in order to combat climate change and promote green growth.

In the same manner, the shape of the oil supply coefficient across the three models is similar. The strength of the negative relation between the index and oil supply decreases gradually with the increase in index and reaches the nearly zero value at quantile 0.95. This is because the recipients of funds are developing countries and require more energy consumption (refer to exception to Kyoto protocol) to promote economic development; they justify the pattern of this latter variable that shows a negative relation over all quantiles. This relationship is stronger for the upper-half distribution of the index variable than for electricity access, for which the relation becomes positive and statistically significant only for the last quantiles. This is in line with the hypothesis that if developing countries can access the electrical grid they can also access renewable sources. For this reason, the positive relation between the percentage of the population with access to electricity and the index is because these populations will ultimately cease their use of traditional fossil fuels, improving the living conditions of rural developing areas (Kanagawa and Nakata, 2007; Khennas, 2012). Many of the funds targeted at climate change are also destined to increase this access through off-grid generation (Kaygusuz, 2012).

The relationship, over all quantiles, between the index and the size of the female population is negative. This contrasts with the literature (Elnakat and Gomez, 2015) that assesses the importance of women in developed countries. Many authors (Cecelski (2001) Martinot et al. (2002), Karekezi and Kithyoma, 2002; Karki et al., 2005; Kanagawa and Nakata, 2007; Walekhwa et al., 2009) argue that women, due to their responsibilities and functions in households, should be the main beneficiaries of aid and programs to improve living conditions (Rao and Reddy, 2007). The discounted negative relation cannot be seen as contrasting with the literature. It is possible that the absolute poverty of the considered countries and the lack of specific programs targeted at women do not allow this improvement.

The share of fossil fuel electricity generation and the share of non-hydroelectric generation seem to have the same pattern, even if the latter is statistically significant only for α=0.95 to both total energy aid and total biosphere protection aid. Pfeiffer and Mulder (2013) argue that non-hydroelectric electricity generation is slowed by aid and by the high use of fossil fuels and accelerated by supportive economic instruments. This can explain its non-significance as a determinant of the environmental index.

6. CONCLUSIONS

The aim of this paper is to demonstrate the existence of preferential channels in "fast-start finance" between developed and developing countries, to examine the funds' distribution based on environmental pollution, and to evaluate whether these preferences could undermine the effectiveness of such measures in combating worsening environmental conditions. To this end, we develop a multi-step procedure using a large dataset of countries.

This study can be used to provide a basis for assessing the effectiveness of the flow of funds for environmental policy and laws, regulations, and economic instruments adopted in decision-making procedures.

The funds directed to "fast-start finance" meet the two requirements of ensuring the reduction in GHG and promoting the sustainable development of developing countries. The effectiveness of this very important tool is very difficult to determine and quantify due to several factors related to the socio-economic structures of developing countries, e.g., the difficulty developing countries face in creating and strengthening the power generation of electricity from RES without an adequate electricity grid, or, additionally, the difficulties they face in developing their economic systems without using carbon fossil sources and without the financial support of developed countries.

The increasing energy hunger of developing countries can only be met through the implementation of an adequate system of energy production, as well as management of the electricity transmission and distribution grid, which is almost completely absent in many areas of these countries.

The quantile regressions, on the other hand, confirm that there is a link between the environmental index, which represents the synthesis of GHG emissions, and climate finance. Particularly, our findings show that there is a relationship between the amounts disbursed and GHG emissions, which is more significant with regard to funds for biosphere protection. The link between the oil supply, electricity consumption, and environmental index, as had been expected, is negative. Indeed, the more polluting developing countries are also energy-intensive "users." These countries receive more funds and highlight the presence of preferential channels with several donor countries.

To evaluate, however, the real environmental effectiveness of climate finance, close attention should also be paid to the analysis of the political context in a broad sense. These include the international negotiations process that enables funds to be directed towards specific needs and priorities.

The analysis of "fast-start finance" revealed a strong heterogeneity in the way the funds are being allocated by donors. To improve the effectiveness of climate funds, we suggest redesigning aid schemes not only to combat climate change but also to promote resilience to extreme events and reduce dependence on preferential channels with developed countries (which some recipients have).

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Appendix 1

Country	Iso 3	Donor/treated/untreated	Composite indicator
Afghanistan	AFG	Tretated	0.99254
Albania	ALB	Untreated	0.998725
Algeria	DZA	Tretated	0.975688
Angola	AGO	Tretated	0.962244
Antigua and Barbuda	ATG	Untreated	0.999436
Argentina	ARG	Tretated	0.943719
Armenia	ARM	Tretated	0.99853
Australia	AUS	Donor	0.889048
Austria	AUT	Donor	0.992426
Azerbaijan	AZE	Tretated	0.987959
Bahamas, The	BHS	Untreated	0.999757
Bahrain	BHR	Untreated	0.997795
Bangladesh	BGD	Tretated	0.966298
Barbados	BRB	Untreated	0.999367
Belarus	BLR	Tretated	0.987373
Belgium	BEL	Donor	0.989001
Belize	BLZ	Untreated	0.997443
Benin	BEN	Tretated	0.997723
Bhutan	BTN	Untreated	0.999816
Bolivia	BOL	Tretated	0.989949
Bosnia and Herzegovina	BIH	Tretated	0.997229
Botswana	BWA	Tretated	0.99674
Brazil	BRA	Tretated	0.784867
Brunei	BRN	Untreated	0.996453
Bulgaria	BGR	Untreated	0.993349
Burkina Faso	BFA	Untreated	0.993025
Burundi	BDI	Untreated	0.998966
Cambodia	KHM	Tretated	0.993006
Cameroon	CMR	Tretated	0.967426
Canada	CAN	Donor	0.914518
Cape Verde	CPV	Tretated	0.999902
Central African Republic	CAF	Untreated	0.981787
Chad	TCD	Untreated	0.990779
Chile	CHL	Tretated	0.989776
China	CHN	Tretated	0
Colombia	COL	Tretated	0.970694
Comoros	COM	Untreated	0.999924
Costa Rica	CRI	Tretated	0.997526
Cote d’Ivoire	CIV	Untreated	0.99284
Croatia	HRV	Untreated	0.996672
Cuba	CUB	Tretated	0.992686
Cyprus	CYP	Untreated	0.999407
Czech Republic	CZE	Donor	0.990146
Denmark	DNK	Donor	0.993328
Djibouti	DJI	Untreated	0.999675
Dominica	DMA	Untreated	0.999965
Dominican Republic	DOM	Tretated	0.995425
Ecuador	ECU	Tretated	0.992697
Egypt	EGY	Tretated	0.969811
El Salvador	SLV	Tretated	0.99757
Equatorial Guinea	GNQ	Untreated	0.995627
Eritrea	ERI	Tretated	0.997923
Estonia	EST	Untreated	0.998036
Ethiopia	ETH	Tretated	0.961461
Fiji	FJI	Untreated	0.999565
Finland	FIN	Donor	0.992837
France	FRA	Donor	0.939076
Gabon	GAB	Untreated	0.999379
Gambia, The	GMB	Untreated	0.998068
Georgia	GEO	Untreated	0.99703
Germany	DEU	Donor	0.92129
Ghana	GHA	Tretated	0.994691
Greece	GRC	Donor	0.991673
Grenada	GRD	Untreated	0.999523
Guatemala	GTM	Tretated	0.994989
Guinea	GIN	Untreated	0.995367
Guinea-Bissau	GNB	Untreated	0.999355
Guyana	GUY	Untreated	0.999269
Haiti	HTI	Tretated	0.997913
Honduras	HND	Tretated	0.995995
Hungary	HUN	Untreated	0.991939
Iceland	ISL	Donor	0.999555
India	IND	Tretated	0.560014
Indonesia	IDN	Tretated	0.882877
Iran	IRN	Tretated	0.943113
Iraq	IRQ	Untreated	0.962057
Ireland	IRL	Donor	0.990769
Israel	ISR	Untreated	0.982969
Italy	ITA	Donor	0.953287
Jamaica	JAM	Untreated	0.998735
Japan	JPN	Donor	0.871739
Jordan	JOR	Tretated	0.996996
Kazakhstan	KAZ	Tretated	0.975621
Kenya	KEN	Tretated	0.982847
Kiribati	KIR	Untreated	0.999993
Korea, Dem. Rep. (North)	PRK	Untreated	0.988797
Korea, Rep. (South)	KOR	Donor	0.929427
Kuwait	KWT	Untreated	0.963969
Kyrgyzstan	KGZ	Tretated	0.997889
Laos	LAO	Tretated	0.997015
Latvia	LVA	Untreated	0.997346
Lebanon	LBN	Tretated	0.997793
Lesotho	LSO	Tretated	0.99938
Liberia	LBR	Untreated	0.999569
Libya	LBY	Untreated	0.975507
Lithuania	LTU	Untreated	0.996133
Luxembourg	LUX	Donor	0.999293
Macedonia, FYR	MKD	Untreated	0.997388
Madagascar	MDG	Tretated	0.991808
Malawi	MWI	Tretated	0.997034
Malaysia	MYS	Tretated	0.964568
Maldives	MDV	Tretated	0.999943
Mali	MLI	Tretated	0.990379
Malta	MLT	Untreated	0.999491
Mauritania	MRT	Untreated	0.997187
Mauritius	MUS	Untreated	0.999213
Mexico	MEX	Tretated	0.881368
Moldova	MDA	Untreated	0.998261
Mongolia	MNG	Tretated	0.992912
Montenegro	MNE	Tretated	0.99908
Morocco	MAR	Tretated	0.991569
Mozambique	MOZ	Tretated	0.991746
Namibia	NAM	Tretated	0.995872
Nepal	NPL	Tretated	0.990549
Netherlands	NLD	Donor	0.982099
New Zealand	NZL	Donor	0.983135
Nicaragua	NIC	Tretated	0.996674
Niger	NER	Tretated	0.991823

(*Contd*...)

Appendix 1 Continued...

Country	Iso 3	Donor/treated/untreated	Composite indicator
Nigeria	NGA	Tretated	0.93274
Norway	NOR	Donor	0.994249
Oman	OMN	Untreated	0.986424
Pakistan	PAK	Tretated	0.938314
Panama	PAN	Tretated	0.99757
Papua New Guinea	PNG	Tretated	0.996202
Paraguay	PRY	Tretated	0.98938
Peru	PER	Tretated	0.985482
Philippines	PHL	Tretated	0.971461
Poland	POL	Donor	0.96607
Portugal	PRT	Donor	0.992968
Qatar	QAT	Untreated	0.99559
Russian Federation	RUS	Untreated	0.71649
Rwanda	RWA	Tretated	0.998085
Saint Kitts and Nevis	KNA	Untreated	0.999955
Saint Lucia	LCA	Untreated	0.999777
Saint Vincent and Grenadines	VCT	Untreated	0.999973
Samoa	WSM	Untreated	0.999911
Sao Tome and Principe	STP	Tretated	0.999973
Saudi Arabia	SAU	Untreated	0.96773
Senegal	SEN	Tretated	0.994075
Serbia	SRB	Tretated	0.994221
Seychelles	SYC	Untreated	0.999947
Sierra Leone	SLE	Untreated	0.998303
Singapore	SGP	Untreated	0.99369
Slovakia	SVK	Donor	0.996441
Slovenia	SVN	Donor	0.998071
Solomon Islands	SLB	Untreated	0.999893
South Africa	ZAF	Tretated	0.951351
Spain	ESP	Donor	0.96571
Sri Lanka	LKA	Tretated	0.992422
Sudan	SDN	Untreated	0.953046
Suriname	SUR	Untreated	0.999474
Swaziland	SWZ	Untreated	0.999413
Sweden	SWE	Donor	0.993315
Switzerland	CHE	Donor	0.995168
Syria	SYR	Tretated	0.98728
Tajikistan	TJK	Tretated	0.997561
Tanzania	TZA	Tretated	0.978226
Thailand	THA	Tretated	0.954946
Togo	TGO	Untreated	0.998476
Tonga	TON	Tretated	0.999926
Trinidad and Tobago	TTO	Untreated	0.998105
Tunisia	TUN	Tretated	0.995896
Turkey	TUR	Tretated	0.960223
Turkmenistan	TKM	Untreated	0.985629
Uganda	UGA	Tretated	0.989767
Ukraine	UKR	Tretated	0.957511
United Arab Emirates	ARE	Untreated	0.982603
United Kingdom	GBR	Donor	0.946788
United States	USA	Donor	0
Uruguay	URY	Tretated	0.990651
Uzbekistan	UZB	Untreated	0.959177
Vanuatu	VUT	Tretated	0.999811
Venezuela	VEN	Tretated	0.964524
Vietnam	VNM	Tretated	0.96563
Yemen	YEM	Tretated	0.995981
Zambia	ZMB	Tretated	0.982392
Zimbabwe	ZWE	Untreated	0.993995

(*Contd*...)