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Reducing Inequalities Despite Climate change?

Rethinking ProgressTowards Reducing Income Inequalities and the Impact of Climate Change in Developing Countries

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Reducing inequalities despite climate change?

Rethinking progress towards reducing income inequalities and the Impact of Climate Change in developing countries

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Résumé

Dans cette étude, nous intégrons les ressources économiques des pays et mesurons comment les pays combinent leurs ressources pour réduire l'inégalité des revenus.

Nous examinons également les effets du climat - température et précipitations - sur les efforts des pays pour réduire l'inégalité des revenus. Nous utilisons un panel déséquilibré de 160 pays de 1990 à 2020 et l'analyse stochastique des frontières (ASF) pour cet exercice.

Nous constatons qu'en moyenne, les pays n'ont consacré que 50 % de leur effort potentiel à la réduction des inégalités de revenus, mais cet effort diffère d'une région à l'autre.

L'Afrique subsaharienne a enregistré le niveau d'effort le plus faible, soit 39 %, bien que cela varie selon les pays. Cela indique que le potentiel et les possibilités d'amélioration pour réduire l'inégalité des revenus diffèrent selon les pays de l'ASS.

Les résultats montrent que l'introduction de la température et des précipitations dans le modèle frontière a réduit l'effort des pays de plusieurs régions. Cela implique les effets négatifs du climat, car les pays combinent leurs ressources économiques pour réduire l'inégalité des revenus.

L'effet direct du climat sur les efforts des pays pour réduire les inégalités montre que la température et les précipitations diminuent l'effort pour les pays en développement.

Dans l'échantillon de l'ASS, l'effet négatif de la température sur l'effort était significatif alors que celui des précipitations était négligeable.

Mots-clés

Inégalité de revenu, Changement climatique, Pays en développement, Afrique subsaharienne, Efficacité

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Abstract
In this study we incorporate the economic resources of countries and measure how countries are combining their resources to reduce income inequality. We also examine the effects of climate — temperature and rainfall — on effort by countries to reduce income inequality.

We use an unbalanced panel of 160 countries from 1990 to 2020, and Stochastic Frontier Analysis (SFA) for this exercise. We find that on average, countries have exerted only 50 percent of their effort in reducing income inequality, but this effort differs from region to region. Sub Saharan Africa recorded the least average effort of 39 percent, albeit this varies across countries. This is an indication that the potential and scope for improvement to reduce income inequality differs across SSA countries.

The findings show that introducing temperature and precipitation in the frontier model reduced the effort of countries in several regions. This implies the negative effects of climate as countries combine their economic resources to reduce income inequality.

The direct effect of climate on countries' efforts to reduce inequality shows that both temperature and rainfall decrease the effort for developing countries. In the SSA sample, the negative effect of temperature on effort was significant whilst that of rainfall was negligible..

Keywords
Income Inequality, Climate Change, Developing Countries, Sub Saharan Africa, Efficiency

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1. Introduction

In the past few years, the negative impact of the Covid-19 pandemic has intensified discussions on income inequality across the globe. The pandemic has caused the largest increase in income inequality between countries in the last three decades with an average increase of 4.4 in 2019-2020 compared to the 0.8 projection before the pandemic (SDG report, 2023). A recent review by Osakwe & Solleder (2023) identified three main classes of literature on income inequality. According to the authors, the first class concentrates on measurement and extent of income inequality, the second considers its impact on growth whilst the third focuses on its drivers or determinants. The measurements literature which dominates studies on income inequality, shows that most of the studies concentrate on obtaining accurate measure of the Gini index from the Lorenz curve Fellman, 2018; 2021, Mettle *et al.*, 2016; Milanovic, 2016; Bourguignon, 2016).

Despite the important contributions of the literature on measurements, the adoption of Sustainable Development Goal 10 (SDG10 - which seeks to reduce inequality within and among countries) and its connection with the other SDGs makes a shift in the literature essential, particularly with regards to the importance of quantifying progress towards reducing inequalities across countries.

Many of the measures on quantifying progress by countries towards reducing income inequality have focused on indices that measure trends in inequality over time and compare countries without considering the differences in economic resources or structural endowments. These indices do not paint the complete picture about how countries are performing, especially when compared to one another in achieving SDGs and what policies and investments may be needed to support them.

To complement the measurement, monitoring, and projections to 2030 using the Gini Index, the literature could focus more on assessing which countries are on track (Tandon, 2005), thus, countries reducing their inequalities given their economic resources or structural endowments. Kumbhakar *et al.* (2020) provides two main justifications of the need for this paradigm shift towards the focus on assessing countries' performance in reducing inequality given their economic resources or structural endowments. First, Kumbhakar *et al.* (2020) argue that the temptation of practitioners manipulating set of comparators to prove different points in different countries necessitates the need for the change. Again, the identification of different levels of development and different economic resources and endowments in countries make such measurement trends in the literature very biased. These arguments point to the fact that the current literature does not portray the true picture of progress in reducing income inequality and do not provide the scope and the potential for improvements of a country, which tends to be an essential guide to decisions making (Kumbhakar *et al.*, 2020). This therefore calls for the use of international benchmarking methodologies which can provide a true representation of progress in tackling income inequality, especially in developing countries.

With respect to determinants of inequality, several factors such as social cohesion and conflict, distribution of income and asset through land tenure system, underdeveloped capital market and political economy channels among others have been identified as drivers of income inequality (Odusola *et al.*, 2017). But these notwithstanding, the literature identifies climate change (extreme weather conditions) as a major driver of inequality (Palagi *et al.*, 2022; Cevik & Jalles, 2023). The review by Jones & Olken (2014) reveals several channels through which climate change affects economic outcomes. The authors observed that poor countries recorded a decrease in labor productivity, industrial output, and economic growth due to climate change.

This shows the severe effects of climate change in developing countries (Millward-Hopkins & Oswald, 2020). With the overdependence on weather for agricultural productivity characterizing most developing countries, climate change reduces labor productivity and incomes in such countries therefore widening the gap between the rich and poor which affects the performance of countries in reducing income inequality (Green & Healy, 2022).

In this paper, we use stochastic frontier methods to firstly examine the performance or effort of countries in reducing income inequality given their economic resources. Given that countries have different economic resources and endowments, structural or predetermined conditions, we evaluate their performance (output) given a country's economic, demographic, political and governance (inputs) conditions.

By this approach, the paper provides an alternative measurement of progress in reducing income inequality. In other words, it computes countries' effort, that is, how countries are combining their inputs to tackle inequality. So, in effect, instead of comparing the performance (say Gini coefficient or Palma ratio) of one country with another as it is usually done, it compares each country with its potential.

Secondly, we investigate how climate – temperature and precipitation, influence the efficiency of countries in combining inputs to reduce income inequality. Thirdly, we looked at the impact of shocks in temperature and rainfall on efforts by countries to reduce inequality. The findings of the study, which show the ranking of efficiency scores (not the raw Gini or Palma indicator) per country measures the scope for improvement for each country every year.

This indicates a country's potential for improvements in reducing income inequality which is vital for effective policy-making and investments. Considering a country's performance and characteristics, appropriate investments can be put in place to support improvements in reducing inequality which can make development partners more realistic in their expectations for a country's improvement.

Also, following the substantial changes in climate, understanding the impact of climate on a country's potential for improvements in reducing income inequality is essential for policy and investments especially in developing countries.

The remainder of the study is organized as follows: Section 2 provides a literature review. Section 3 discusses data and methodology of the study. In section 4, we discuss the empirical results. Section 5 presents the conclusion and policy suggestions of the study.

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2. Literature Review

The issue of inequality has been a centuries long challenge due to its huge economic cost on almost every aspect of an economy. Apart from its detrimental effects on health, education, investment, criminal behaviors, political stability and economic growth among others, income inequality has been described as the defining challenge of our time (Obama, 2013). However, the subject of inequality had formerly been seen as a subsidiary to poverty issues with little attention, especially considering its exclusion in the Millennium Development Goals (MDG). The introduction of inequality in the sustainable development goals (SDGs) SDG 10, tends to make it a global issue demanding peculiar attention. Therefore, making its achievement the objective of every nation across the globe.

Ever since the adoption of inequality in the SDGs, several authors have highlighted pathways of overcoming such a challenge. Generally, the inequality literature can be divided into three main classes, that is, the measurement, the growth, and the drivers (see Osakwe & Solleder, 2023). Majority of the growth and the driver's literature identified redistributive policies as the key to overcoming inequality (Shupp, 2002; Leibbrandt *et al.*, 2011; Handenborn *et al.*, 2018). Leibbrandt *et al* (2011) identified labour market income and rising unemployment as key determinants of inequality. They further explained that inequality is the rearrangement of the positions of the poor and the rich in the income distribution of a country. By this understanding, several income measurements as well as human development indexes have been utilized in measuring inequality.

One novel contribution towards the measure of reducing inequality is the Commitment to Reducing Inequality (CRI) index adopted by Development Finance International (DFI) and Oxfam Research in 2017. The index measures government policies on three main indicators, that is, social spending, tax, and labour rights. This approach to measuring and understanding inequality has received huge endorsement in the literature (Handenborn *et al.*, 2018; Leibbrandt *et al.*, 2011; Brandolini & Carta, 2016). The complex nature of inequality tends to make this wave of literature a solution to one aspect of the subject, that is, within country inequality.

With the advent of globalization and the adoption of the SDGs, implementing within country inequality remedies in a cross-country analysis tend to be very difficult especially pertaining to data. Therefore, the need for cross-country or between-country measures (Milanovic & Roemer, 2016). This has become a major concern not only for academics but also for governments, professionals, activists, and media among others (Brandolini & Carta, 2016).

For a better understanding of inequality between country drivers, several factors have been identified. Nolan *et al.* (2019) utilized meta regression techniques to identify globalization, technological change, institutions, and market forces as the major sources of inequality. According to the authors, market forces which comprises of labour income and labour related issues tend to be the main driver of income inequality. Similarly, Asterious *et al* (2014) after analyzing 27 EU countries from 1995 to 2009, identified that globalization occurs in the form of foreign direct investment (FDI), capital account openness, stock market accumulation and trade openness are the driving force of inequality. This finding does not deviate from that of Milanovic (2002) who asserted that the effect of globalization on income inequality is dependent on the level of income of a country.

Milanovic (2002) identified that globalization made poor countries worse off but some low- and middle-income countries had an improved income distribution. Similarly, education has also been observed to influence inequality depending on the level of education (Wood, 1994).Abdullah *et al.* (2015) asserts that education reduces the income share of the top earners and increases the income share of the bottom earners hence its importance in reducing income inequality. This was also confirmed in the study by Anyanwu *et al.* (2016). Anyanwu *et al.* (2016) studied 17 West African countries from 1970 to 2011 and identify population density and natural resource rent among others as positive determinants of income inequality. Thus, countries with high population density as well as natural resource rent tend to increase income inequality. These observations as explained by Odusola *et al.*, 2017, may be attributed to the increase in rural population who because of scarcity of land may not be able to earn more income compared to the urban folks who may have access to major natural resources.

Forster *et al.* (2018) assessed the over three-decade increased income inequality observed in 135 low- and middle-income countries for the period 1980 to 2014 to identify the role of international institutions like the IMF in this phenomenon. Their study revealed that the conditionalities attached to the lending programmes of the fund increased income inequality just within a year after the programme. They attributed these observations to four main policies promoted by the fund which included fiscal policy reforms curtailing government expenditure, external sector reforms stipulating trade and capital account liberalization, financial sector reforms entailing inflation-control measures and conditions restricting external debt. Adom *et al.* (2021) investigated the mediating effect of income inequality in the energy efficiency-growth nexus using a panel of 51 African countries from 1991 to 2017. The study showed that countries with lower income inequality recorded higher growth through energy efficiency while countries with higher income inequality also recorded lower growth. Other observed drivers that reduce income inequality include government spending, especially in the area of health and education (Anderson *et al.*, 2017; Sanchez *et al.*, 2018; Younsi *et al.*, 2018), economic growth (Odhiambo, 2022; Anyanwu *et al.*, 2011) and remittance (Novignon, 2017; Anyanwu *et al.*, 2011) Inflation tends to have a positive influence on income inequality (Anyanwu *et al.*, 2011; Younsi *et al.*, 2018).

Despite the development of the literature on the drivers of inequality, the literature on the measurement of inequality continues to lag. The Gini coefficient and Palma ratios are the dominant measure of inequality. In addition to its challenges, Brandolini & Carta (2016) identified the neglect of national borders in the form of the different levels of development, economic resources and endowments in countries (for global analysis) in its estimation as a fundamental issue that needs to be addressed. Several authors have utilized measures such as human development index (Parente, 2018), wellbeing measures (Phen & O'Brien, 2019), Better life index (Decancy, 2015) and several other welfare measures (Brandolini & Carta, 2016) as alternative measures. But almost all these measures use weights in adjusting for national borders in inequality analysis without accounting for the different economic resources and structural endowments of the countries involved. According to Kumbahkar et al (2020), this neglect in the literature makes policy recommendations not tailored to countries challenges, hence the observed persistence in inequality crisis across the globe. Using the stochastic frontier Analysis (SFA) model, Kumbahkar *et al* (2020) explained how the model could bridge the gap of national borders in the literature. Therefore, creating the need for the application of the model in inequality analysis to ascertain the true picture of the performance of a country in reducing inequality.

This has become necessary especially considering the recent observed exogenous shocks which have been observed to compound the issue of inequality in literature. Paudel (2023) examined the impact of natural disaster on economic inequality using NASA's information for resource management system. His study revealed that natural disasters proxied by the number of wildfires and fire radiative power increase income inequality in rural areas by 13.72 percent and 22.02 percent respectively and tend to reduce economic growth by US$294.56.

Contrary, Palagi *et al.* (2022) analyzed the issue of climate change and income inequality. They asserted that precipitation impairs income inequality as well as economic growth, but the effect tends to be a vicious cycle in agricultural dependent countries. Considering the agricultural dominance in developing countries, this finding indicates the need for a thorough study of this challenge in the literature. Similarly, Cevik & Jalles (2023) studied 158 countries from 1995 to 2019 and identified that climate vulnerability in developing countries increases income inequality while climate resilience observed in developed countries improves income inequality. The above studies coupled with the gap in measuring progress by countries towards reducing inequality in literature makes this study on climate change and inequality very crucial. In developing countries, extreme climatic conditions are likely to influence negatively how countries combine their economic resources and endowments to tackle income inequality. Addressing these issues would help to provide the needed decisions to guide countries to effectively combine their economic resources and endowments to tackle inequality and understand the observed impact of climate change in most developing countries. This is very significant for policy makers and development partners.

3. Methodology and Data

Following Kumbhakar *et al.* (2020), we use variants of the stochastic frontier model to examine the above objectives. Accounting for a country's economic resources and structural endowments, the stochastic frontier approach allows us to estimate the performance or effort for reducing income inequality for each country and year. We use panel data of 160 countries, including developed and developing countries from 1990-2020 for this exercise. We rely on existing literature on inequality for the analytical framework and selection of relevant indicators for our modelling. The SFA approach specifies functional forms in the form of production functions which can be expressed as:

$$Y_{it} = f\,(X_{it;}\ \beta) \qquad (1)$$

where Y_{it} represents output (income inequality variable for country *i* at time t, X represents the vector of input variables. These input variables include GDP per capita, total natural resource rent, population density, labour force, average years of education and institutional quality. β are the unknown parameters to be estimated.

The base case pooled SFA can be written as:

$$y_{it} = \beta_0 + x'_{it}\beta + u_{it} + v_{it} \ (2)$$

Where v_{it} is the random stochastic error $v_{\text{it}} \sim \text{N}[0,\sigma_v^2]$, which is *Independent and identically distributed (iid)* noise term while u_{it} is the non-negative one-sided inefficiency term, $u_{\text{i}} \sim \text{N}^+[0, \sigma_u^2]$.

$x'_{it}\beta + v_{it}$ is the optimal frontier and u_{it} is the shortfall of y_{it} from the frontier for each country. This is termed as inefficiency. There are variants of the SFA model that can be applied to estimate inefficiency. To capture the panel structure of the datasets, SFA models such as Random Effects (RE), Battese and Coelli (BC), True Random effects (TRE) can be applied.

In order to ascertain the preferred SFA model for capturing the performance or effort by countries to reduce income inequality, we estimate the base pooled model in addition to RE, BC, and TRE. The estimates from these SFA models are assessed to determine the preferred model given the outputs and inputs employed in the study. The estimates of the preferred SFA model is then used for further analysis in this paper.

The baseline specifications for the RE model is generally specified as:

$$y_{it} = \alpha + \beta' x_{it} + v_{it} + u_{it} u_{it}{=}|U_i| \ (3)$$

$$v_{\text{it}} \sim \text{N}[0, \sigma_v^2]$$

$$u_{\text{i}} \sim \text{N}^+[0, \sigma_u^2]$$

We note that u_{it}=$|U_i|$, therefore, no time-invariant element is modelled here.

The BC model is also specified as:

$$y_{it} = \alpha + \beta' x_{it} + v_{it} + u_{it} \ (4)$$

$$u_{it} = exp[-\eta(t - T)]|U_i|,$$

$$v_{\text{it}} \sim \text{N}[0, \sigma_v^2]$$

$$u_{\text{i}} \sim \text{N}^+[0, \sigma_u^2]$$

With the BC model, the time-invariant random component is still a major influence on the model and, therefore, the random parts of the BC model do not vary with time. The time-invariant element in the model, u_{it} is intended to capture all (and only) the country-specific inefficiency and does not treat unobserved time-invariant effects such as heterogeneity in the data. There is always the likelihood that U_i absorbs large amounts of cross-country heterogeneity that would be inappropriately measured as inefficiency (Greene, 2004; 2005, Kumbhakar, 2015). In the TRE model, a random part that varies with time is introduced to separate unobserved time-invariant heterogeneity from inefficiency. The model is extended to accommodate time invariant unobserved country specific institutional or policy environment that can help explain the gap between the benchmark and observed outcome. The TRE is specified as:

$$y_{it} = (\alpha + \omega_i) + \beta' x_{it} + v_{it} + u_{it}, (5)$$

$$v_{it} \sim N[0, \sigma_v^2]$$

$$u_{it} = |U_{it}| \text{ and } \quad U_{it} \sim N^+[0, \sigma_u^2],$$

$$\omega_i \sim N^+[0, \sigma_\omega^2]$$

where $(\alpha + \omega_i)$ is a time-invariant and country-specific random term meant to capture time-invariant unobserved heterogeneity. Estimation is by *maximum simulated likelihood* (MSL) by integrating out $\omega_i$using the Monte Carlo method.

An important issue regarding the estimation of the stochastic frontier equations is the functional form of the production frontier. As a result of the questions raised over the suitability of the Cobb–Douglas functional form and the inclination for the Translog stochastic frontier specification (see Danquah and Ouattara 2015; Duffy and Papageorgiou 2000; Kneller and Stevens 2003), we apply the Translog specification to characterize the production frontier. In this case, we have an interaction of the inputs in order to adequately explain the relationship between the inputs and the output. Using the Translog production function and including regional dummies, we fit the models and estimate the inefficiency terms in the stochastic frontier, u_i by observation. The Jondrow *et al.* (1982) estimator $\hat{E}[u_i|\varepsilon_i]$ is the standard estimator for inefficiency u_i. This is:

$$\hat{E}[u_i|\varepsilon_i] = \left[\frac{\sigma\lambda}{1+\lambda^2}\right]\left[\frac{\phi(w)}{1-\Phi(w)} - w\right], \varepsilon_i = v_i - u_i, w = \frac{S\lambda\varepsilon_i}{\sigma} (6)$$
$$\sigma = \sqrt{\sigma_v^2 + \sigma_u^2}, \lambda = \frac{\sigma_u}{\sigma_v}$$

The properties of the estimated inefficiencies are then examined to determine the preferred model. The inverse of the estimated inefficiencies gives us efficiency, which represents a country's efforts in reducing inequality.

To investigate how climate – temperature and precipitation, influence the efficiency of countries in combining inputs to reduce inequality, we introduce the climatic variables in all stochastic frontier specifications. We analyze the difference in a country's effort to reduce inequality with and without climate as an input in the production function.

To examine the impact of climatic shocks, we recast the SFA models and introduce temperature and precipitation (h_{it}).

h_{it} enters the second stage of the model separately with a set of control variables – corruption, unemployment, and dependency ratio. The dependent variable in the second stage is inefficiency, the inverse of that is efficiency or effort to reduce inequality.

Data

The frontier methodology requires the breakdown of data into inputs, outputs, and other covariates. The output variables (income inequality), that is, Gini coefficient and Palma ratio were sourced from the companion data of World Income Inequality Database (WIID). This was due to the advantages of the WIID data over the SWIID data identified by Jenkins (2014). In the estimations, we used the Palma ratio to capture income inequality. Following from the literature, the input variables used for the study were GDP per capita, labor force, education, natural resource rent, population density and institutions. To help linearize relationships and reduce skewness, we take logarithms of the input variables. These input variables were sourced from the world development indicators (WDI) database, the VDEM dataset and the WIID dataset. Temperature and precipitation were also sourced from University of Alabama Huntsville, UAH, and Remote sensing Systems, RSS. Temperature and precipitation deviations were estimated from the temperature and precipitation data. The other indicators are sourced from the World Development Indicators. The description, source of variable and descriptive statistics are available in Appendix A2 and A3.

4. Discussion of Findings and Results

As indicated in the methods section, we employ the following frontier models: pooled, random effect, Battese and Coelli, and true random effect model. In Table A1 in the appendix, we display the estimates of the stochastic frontier models. Under each model, we present estimates for the base case (I) as well as estimates (II) that include climatic factors. The association between the inputs and income inequality varies across models. The relationship between GDP per capita and income inequality is largely positive in all models except the TRE. Across all models, natural resource rents seem to increase income inequality. The correlation between population density, educational attainment, institutions, and income inequality are also mixed across models. The relationship between labour force and income inequality is negative in the TRE model but positive in the other models. With respect to climate variables and income inequality, we observe that increases in temperature leads to an increase in income inequality, but the effect of precipitation is negligible. It is worth emphasizing that the focus is on efficiency or effort by countries to reduce income inequality and therefore the estimates of the production function are loose correlations of income inequality and the inputs emanating from the stochastic frontier estimation.

Based on the frontier estimation in Table A1 in appendix, we can now analyze which models is preferred, that is, which of the models best captures the efficiency or effort of countries. In this case, we investigate which models' best capture the estimate of countries' effort at reducing income inequality. To do this, we first examine the descriptive statistics of the estimated inefficiencies followed by correlation analysis across all models. The descriptive statistics of the estimated inefficiencies show a very low mean inefficiency for the pooled model (Table 1). This indicates that the pooled model is not adequately capturing inefficiency due to the inability to account for the panel structure of the dataset. The means of the RE and the BC model show very high mean inefficiencies, an indication of the inability of these models to account for unobserved heterogeneity. The TRE model seems more reasonable and has a tight variance compared to the RE and BC models.

Table 1: Descriptive statistics of Inefficiency estimates

Model	Mean	Std. Dev.	Min	Max
Pooled	0.031	0.003	0.006	0.031
RE	1.957	1.987	0.108	14.620
BC	1.903	2.214	0.065	23.176
TRE	0.739	0.314	0.020	1.004

Source: Authors' calculation

A further examination of the estimated inefficiencies for all models using correlation analysis (Table 2) shows that the pooled model is not correlated with any of the three models. The RE and BC models that attempt to account for the panel structure are highly correlated. However, the two models have no correlation with the TRE model. The mean inefficiency of the TRE shows that the TRE is removing or disentangling unobserved heterogeneity from our inefficiency estimates, whilst the RE and BC panel models are not able to treat this. The RE and BC models carry both the inefficiency and any time-invariant country-specific heterogeneity, thus the high mean inefficiencies. This shows that the unobserved time invariant heterogeneity ends up in the inefficiency estimates of the RE and BC models. In effect, the fact that the random component of the RE and BC models is still time-invariant remains a substantive and detrimental restriction when applying these models to our analysis (see Greene, 2004). The TRE model is most suitable and therefore employed for this analysis.

Table 2: Correlation matrix for Inefficiency estimates

Model	Pooled	RE	BC	TRE
Pooled	1	0,096	.07938	0,088
RE	0,096	1	0,870	0,188
BC	0,079	0,870	1	0,212
TRE	0,088	0,188	0,212	1

Source: Authors' calculation

Analysis of effort by countries and the influence of climate in combining inputs to reduce income inequality:

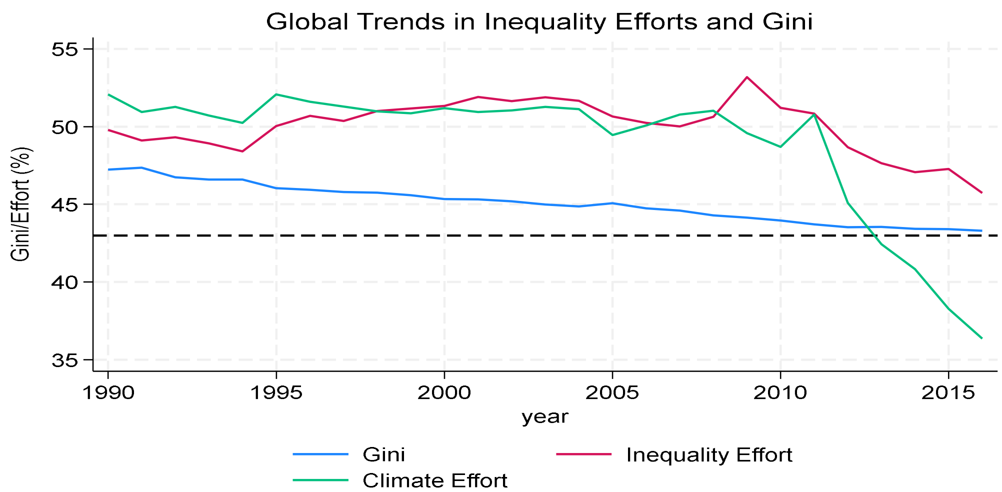
In this section, we present the estimated efforts by countries and the influence of climate in reducing income inequality using efficiency from the TRE model. We first show the effort at the global level and subsequently focus our analysis on sub–Saharan Africa (SSA).

Although there is a downward trend of the Gini coefficient in the past few years, averaging 45.03 over the study period, the global effort (also averaging 50.03 over the period) has been falling over the last ten years.

From figure 1, the Gini showed a decline throughout the period but with some periodic fluctuations while the effort increased from 1990 to 2004, fluctuated slightly between 2004 and 2011 after which it declined. The increases in effort over the 2004-2012 period have some influence on the decline in the global Gini index. The subsequent fall in effort shows in the levelness and lack of decline of the global Gini index. The issue of climate had not been a challenge on global effort to reduce income inequality until 2011 when its actual impact can be observed throughout the years.

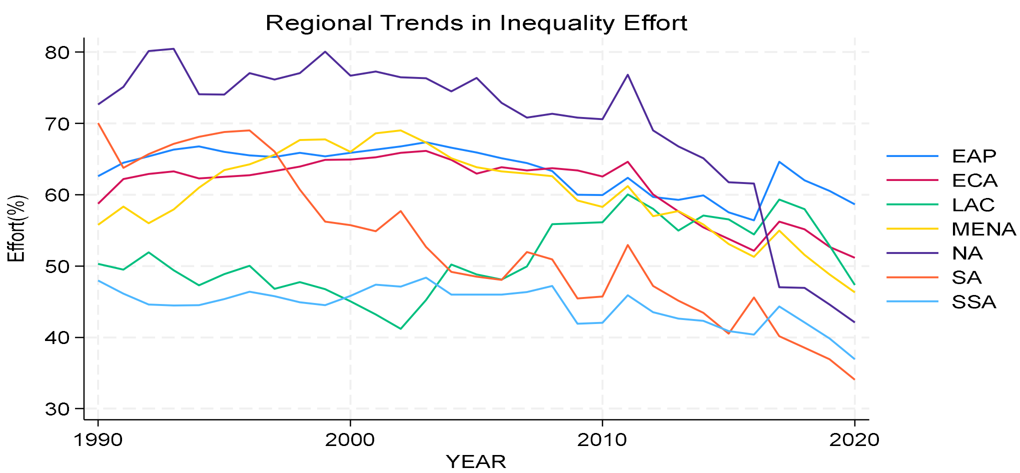
Figure 1 reveals that in the period 1990 to 1998 the climate variables improved the effort of countries by making the climate effort more than the actual effort. Thus, temperature and precipitation during the period led to an increase in effort on the globe. Contrary, from 1998 to 2009, climate variables began to have impact of country's effort to reduce inequality. This process intensified after 2011 when the climate variable dragged inequality effort down below the actual efforts of countries. The influence of climate on the efficiency of combining inputs to reduce income inequality shows that climate effects have significantly dampened the effort by countries, particularly from 2012. The global effort to reduce income inequality reduces when we account for climatic factors (see figure1).

Figure 1: Global trends in efforts to reduce inequality.



Source: Authors' calculation

Figure 2: Regional trends in Effort to reduce Income inequality.



Source: Authors' calculation

The regional trends in the effort to reduce income inequality show a variation in effort across regions. Whereas many of the regions including East Asia and Pacific (EAP), Europe and Central Asia (ECA), Latin American and Caribbean (LAC), Middle East and North Africa (MENA), and North America (NA) have shown significant increases in effort over the years, there has been a decline in effort for all regions from 2012- 2020 period (figure 2).

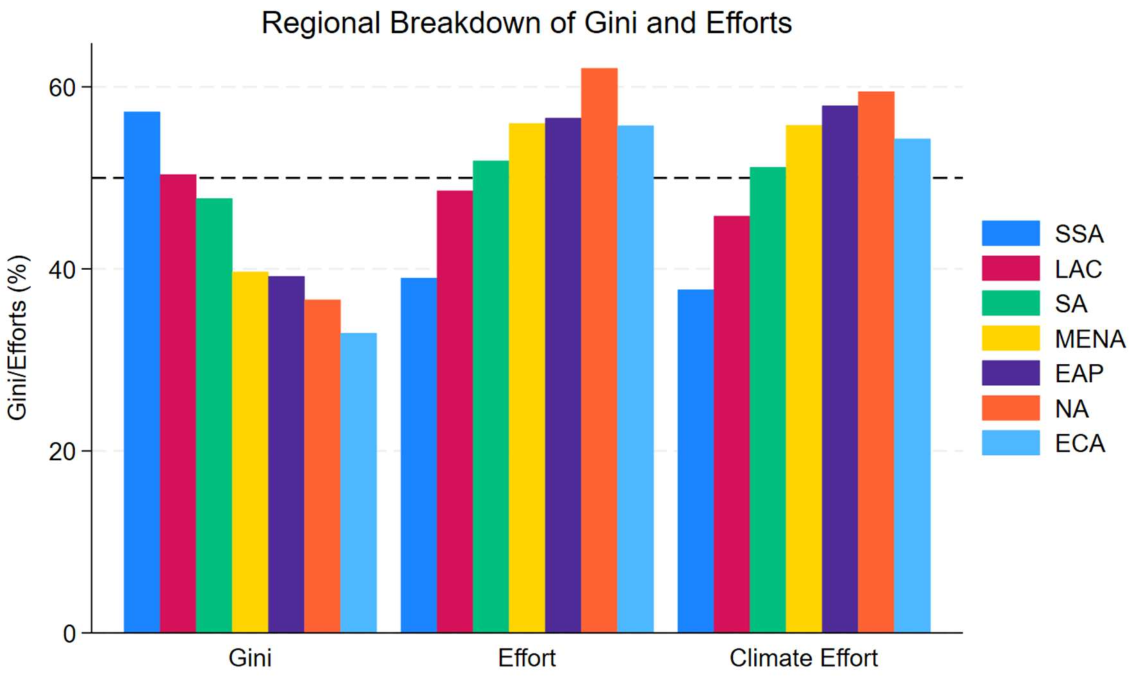
Two regions, however, stand out, South Asia has seen a consistent decline in effort over the period whilst the effort for SSA has largely been flat with no significant changes over the period.

From figure 3, the lowest effort (below 50 percent) is recorded by Sub-Sahara Africa (SSA), and this is accompanied by the highest Gini coefficient. This is followed by LAC.

Thus, in the fight to reduce inequality these regions have not been combining their economic resources and endowments efficiently. On the contrary, North America (NA) had the highest effort, but their inequality level is higher than that of Europe and Central Asia (ECA). This indicates that despite the effort of NA countries there exist some fundamental issues aggravating inequality in the region. Appendix, Table A4 provides the inequality effort of each country in the sample to provide clearer picture as to the scope of improvement required by each country in reducing inequality.

A breakdown of the impact of climate change by regions in figure 3 showed that the influence of climate cut across regions. From figure 3, SSA, LAC, NA and ECA were the regions that had their effort reduced due to climate change. But NA had the highest decline in effort followed by LAC, then SSA before ECA. Identifying NA as the region with the highest effort as well as the region with the worst decline due to climate change indicate climate change as a major hindrance to the fight of inequality in the NA sub region.

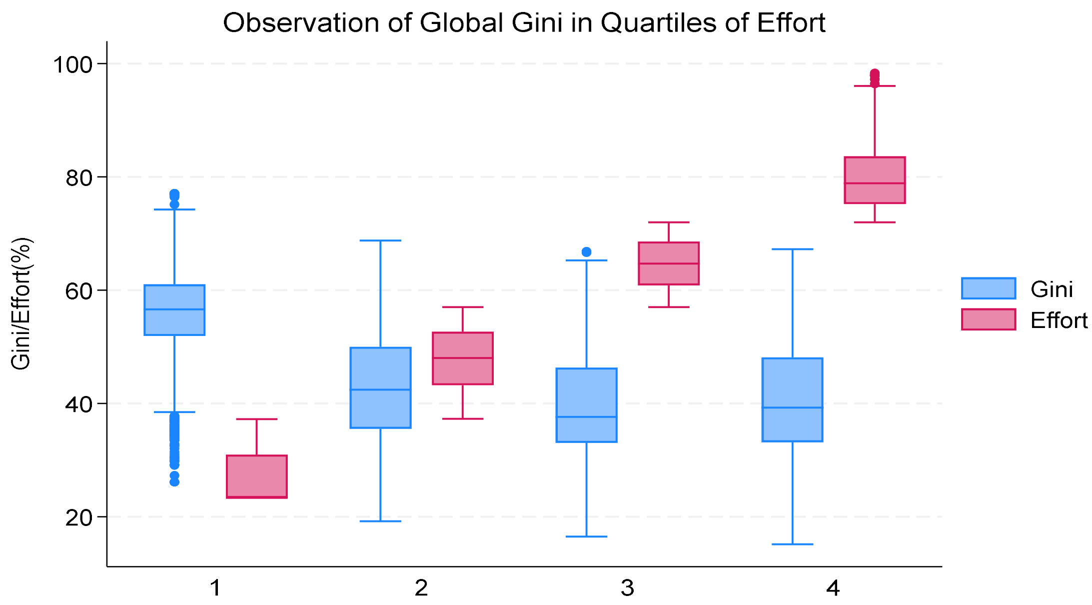
Figure 3: Regional breakdown of Efforts to reduce Income inequality.



Source: authors' calculation

A further analysis of effort using income quantiles, that is, dividing the countries into four equal groups based on income, from lowest to highest clearly shows that low-income countries are lagging far behind in terms of their performance in reducing inequalities given their economic, demographic, political and governance conditions (Figure 4). This is very significant, and it is important to understand how best to support them to effectively combine their economic resources and endowments to tackle inequality.

Figure 4: Efforts to reduce income inequality by income quintiles.



Source: authors' calculation

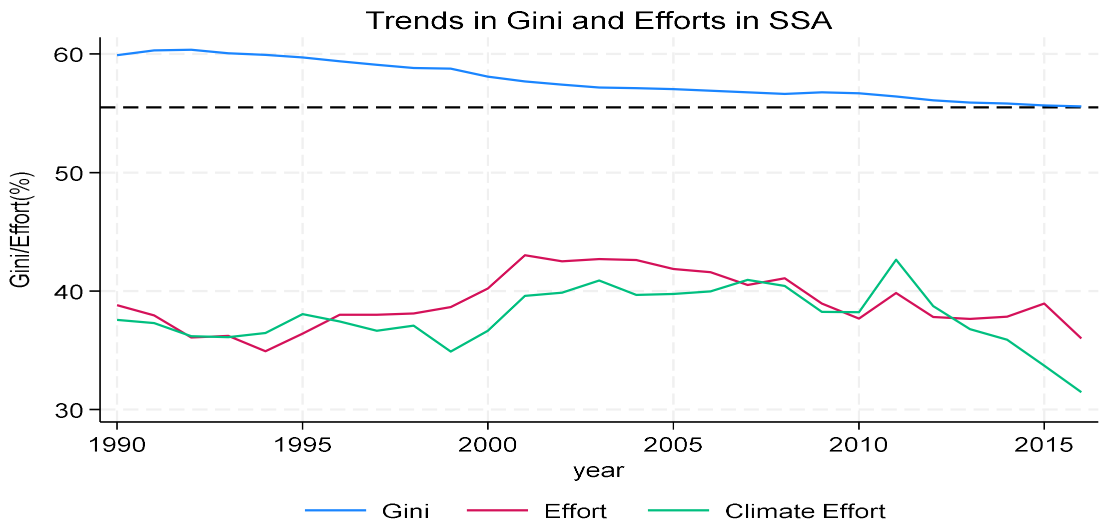
4.1. Focus on SSA:

SSA had the least inequality effort and with the introduction of climate its effort still decreased amidst a general stagnation in its Gini coefficient (see Figure 5). This indicates that SSA countries are further away from their frontier or potential and therefore have more scope for improvement and investments. This requires a better understanding of the SSA phenomenon in order to help formulate appropriate policies to support improvements in reducing inequality.

In this analysis on SSA, we grouped the SSA countries into three main classes based on the estimated effort, that is, countries that have effort greater than 50 percent (above average), between 35-50 percent (moderate) and below 35 percent (low effort). The three categories implies different responses in terms of policies and investments. From these grouping, we attempt to classify countries that are on a sustained path, those catching up and those who need to be reset.

We classify countries whose efforts were high and need to maintain such level of efficiency as "sustained-path countries". Those with declining effort were classified "reset path countries" while those showing signs of improved effort are referred as "catching pp countries". These classifications and subsequent analysis are very important as we seek to understand how best to effectively assist these countries to reduce income inequalities.

Figure 5: Trends in Effort to reduce income inequality, SSA.



Source: authors' calculation

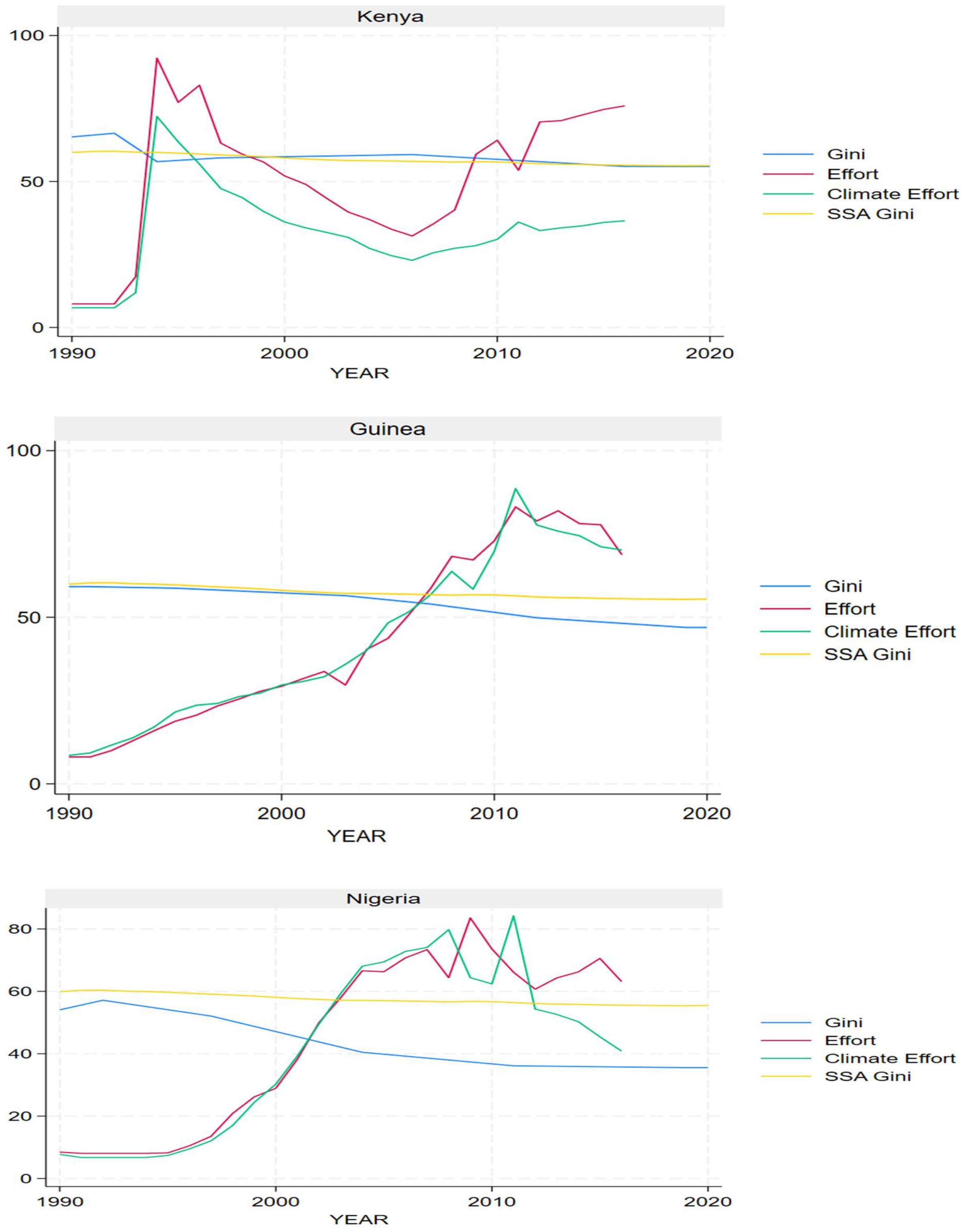
From table 3, more than 70 percent of the countries were in the reset path, 18 percent were catching up while 9 percent were on the sustained path. Countries such as Kenya, Gabon, Guinea and Nigeria were observed to be on a sustained path. The position of Nigeria tends to contradict the findings of the CRI of DFI and Oxfam research who observed Nigeria as the least country in terms of commitment to reducing inequality. This difference can be attributed to the national borders not properly accounted for in the CRI estimations. Countries such as Cape Verde, Chad, Comoros, Gambia, Guinea-Bissau, Lesotho, Rwanda and Togo were classified as catching up countries. The remaining countries in the sample were classified reset path countries albeit some countries have an average effort greater that 50 percent over the period.

Table 3: Effort groupings: SSA Countries

Effort >50%	**Effort > 50%**	**Effort 35-49%**	**Effort 35-49%**	**Effort below 35%**	**Effort below 35%**
'Sustained Path'	**'Reset Path'**	**'Catching Up'**	**'Reset + Decline Path 1'**	**'Catching Up'**	**'Reset + Decline Path 2'**
Kenya	Cameroon	Cape Verde	Botswana	Chad	Angola
Gabon	Congo		Benin	Comoros	Burkina Faso
Guinea	Mauritius		Cote d'Ivoire	Gambia	Burundi
Nigeria	Mauritania		Equatorial Guinea	Guinea-Bissau	Central African Republic
	Ethiopia		Eswatini	Lesotho	Ghana
	Senegal		Liberia	Rwanda	Madagascar
	Sudan		Namibia	Togo	Malawi
	Eritrea		Sao Tome		Niger
			Sierra Leone		Somalia
			Tanzania		South Africa
					Uganda
					Zambia
					Zimbabwe

With respect to the countries on sustained path, we see a gradual rise in effort over the period (Figure 6). However, one major challenge with the sustained path countries is climate change. Nigeria and Kenya showed a lot of positive efforts, but climate keeps dragging their effort down especially after the year 2010. Receiving financial assistance for climate related challenges can help sustain the inequality effort which would decrease their inequality.

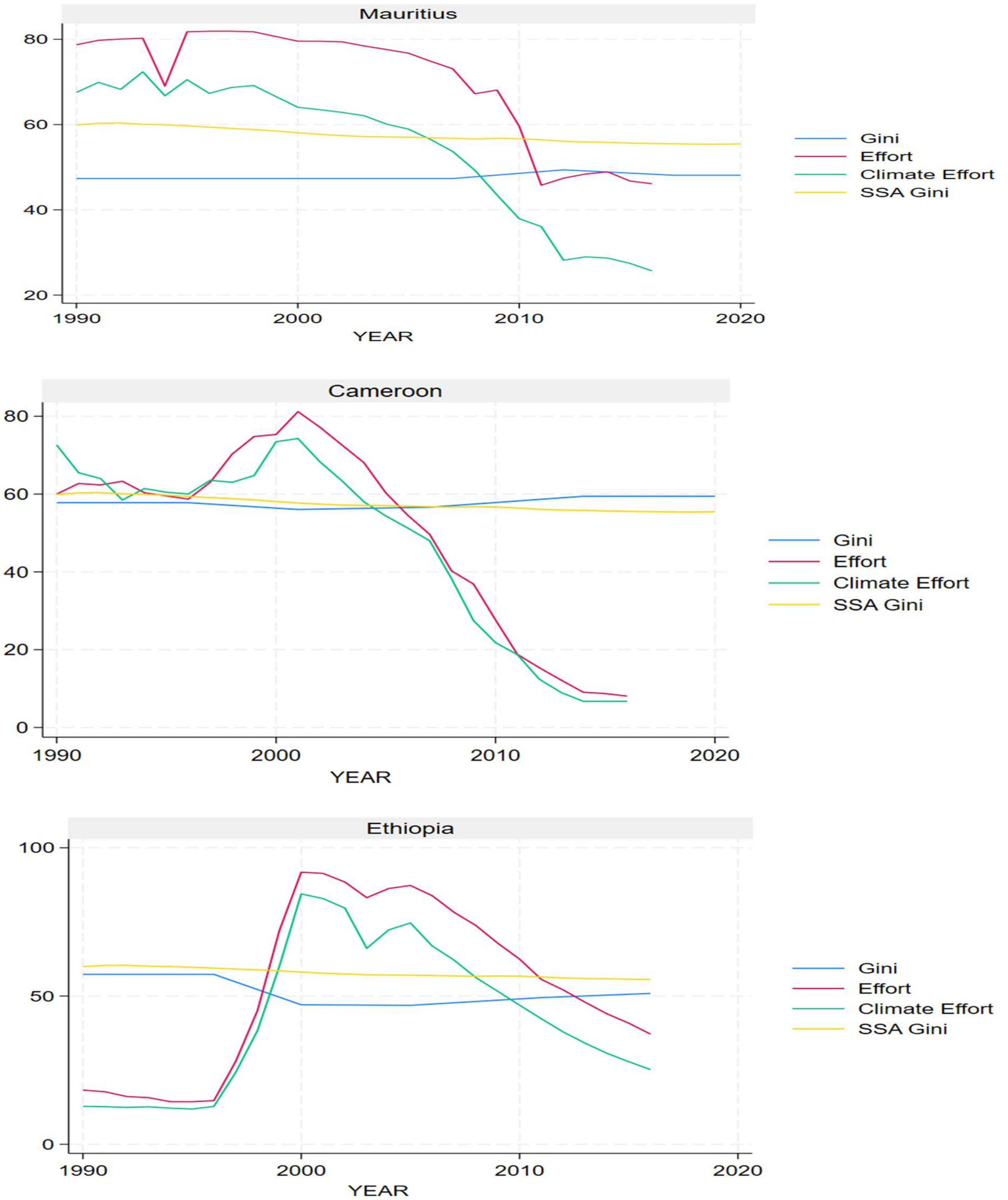
Figure 6: Countries on sustained path



Source: authors' calculation

Countries with an effort above effort average and are reset countries had an initial high effort but could not sustain such effort hence the need to reset (Figure 7). However, careful observation showed that these were hugely affected by climate change. This therefore shows that aside economic factors like low GDP per capita, poor institutions, high population density, and low education among others (table 1A), with respect to technical assistance for these countries, support to build climate resilience is also critical for their reset.

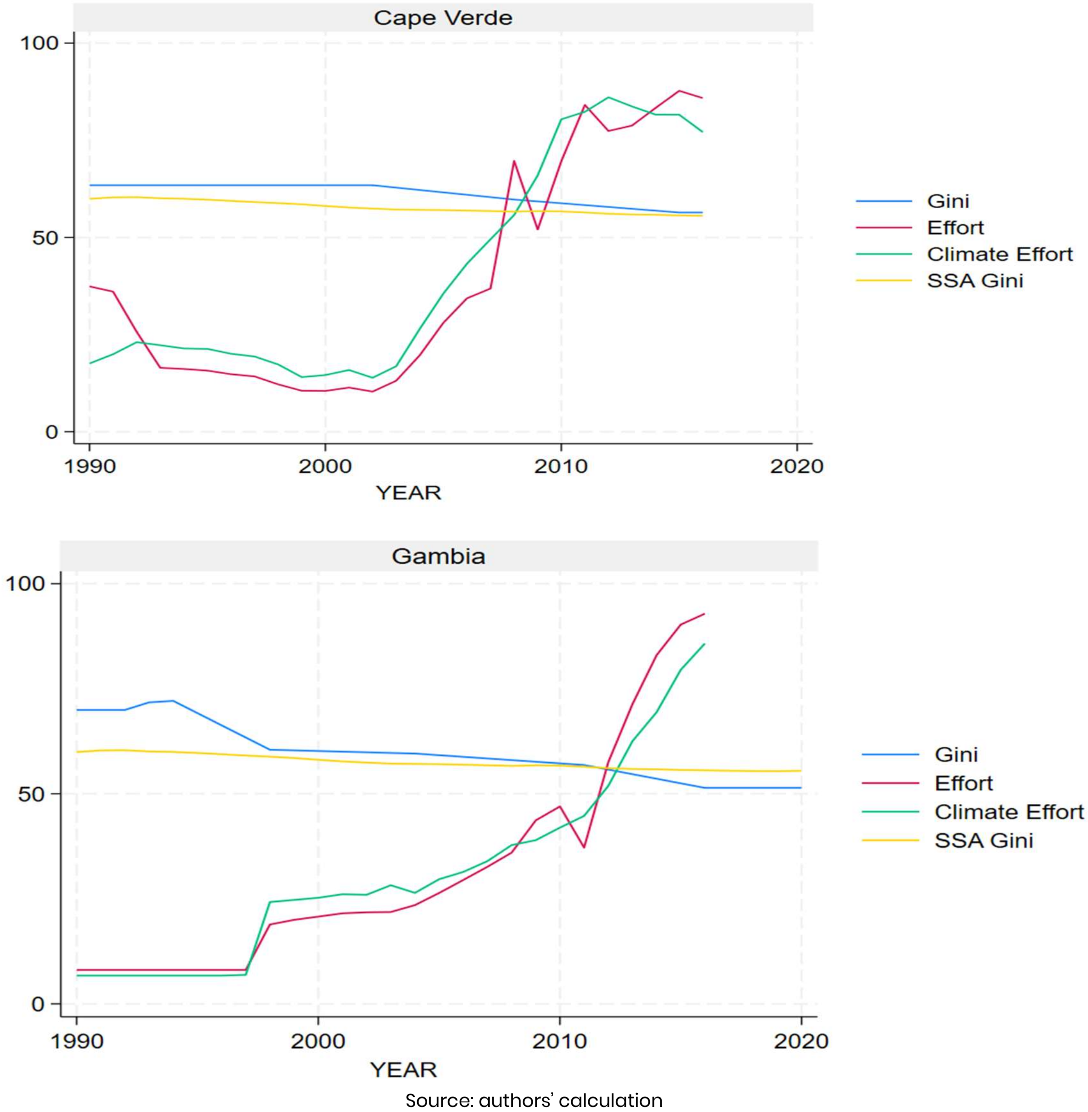
Figure 7: Above-effort average reset countries



Source: authors' calculation

With respect to the catching up countries, figure 8 shows that such countries are reducing their inequality due to their increased inequality effort. Gambia moved from a low effort of below 15 percent to a maximum of 90 percent in 2016 indicating a strong and stable inequality effort across the period. Such countries have shown efficient management of their resources in tackling inequality but to sustain and catch up in performance, these countries must endeavor to intensify their redistribution policies in the form of social spending, progressive tax, and labour rights in their respective countries.

Figure 8: Catching up countries

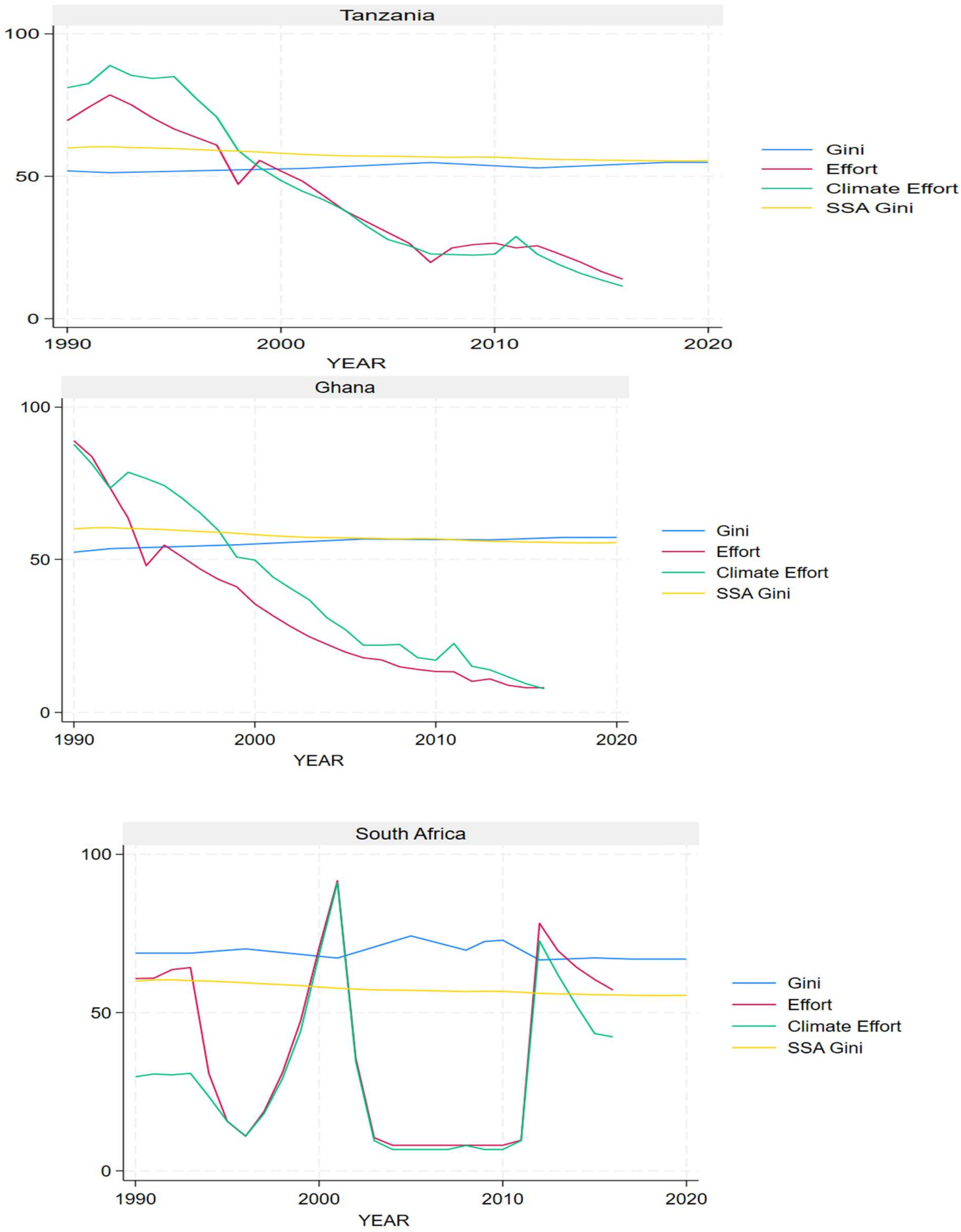


Source: authors' calculation

Figure 9 depicts the Gini and efforts of the below effort average reset path countries. These countries have their Gini coefficient more than 50 percent with inequality efforts declining continuously. From the figure, Ghana, and Tanzania without any major effect of climate had their inequality declining throughout the period. South Africa on the other had sharp fluctuations with more years of low effort during the period.

A critical look at the relationship between Gini and Effort showed that efforts have a direct effect on the Gini. Thus, when effort declines the Gini increases and vice versa. These groups of countries require technical assistance on improving some factors such as institutions, education and low economic growth which tend to be inconsistent over the years. Generally, technical assistance focusing on support to develop diagnostic tools to properly identify the key issues in reducing income inequality are needed by countries in the reset phase.

Figure 9: Below effort average reset countries



Source: authors' calculation

4.2. Impact of climate shocks on effort to reduce Income Inequality:

We recast the SFA model where temperature and precipitation enter the model separately at the second stage with a set of control variables – corruption, unemployment and dependency ratio. Here, the relationship is between temperature, rainfall, and effort by countries (that is, the inverse of our dependent variable, inefficiency) to reduce income inequality. Table 4 shows these relationships for the developing countries sample (SSA, LAC, SA, MENA), and the SSA sample. For the developing country sample, the results show that temperature and rainfall have a positive and significant association with inefficiency. This shows that increases in temperature and rainfall increase inefficiency or reduces the performance and effort of countries to reduce inequalities. In other words, increases in climatic conditions negatively affect the efforts by countries to reduce inequality. The effect of temperature is more pronounced than that of rainfall. In the SSA sample, temperature is positively correlated with reducing the effort to tackle income inequality whilst the effect of rainfall is not significant.

These findings support our earlier observations when we introduced temperature and rainfall as additional inputs in the stochastic frontier model. The positive correlation between temperature, rainfall, and income inequality indicates the negative influence of these climatic conditions as countries strive to combine their inputs to reduce income inequality. The low estimated climate induced efforts especially in SSA countries such as Ethiopia, Kenya and Tanzania show the negative impact of particularly temperature on efforts to reduce income inequality.

In SSA, the effect of temperature is largely due to persistent drought in many SSA countries, particularly in East Africa. The greater frequency of droughts leads to human losses, damage to public and private assets, and disruption of economic activities, particularly agriculture (World Bank 2022). In many SSA countries, drought has caused crops to fail and cattle to die, whilst the lack of clean water has increased the threat of cholera and other diseases. The lack of support and investments in climate resilience activities heightens the vulnerability and risk in many countries. The Intergovernmental Panel on Climate Change (IPCC) sixth assessment report on impacts, adaptation, and vulnerability in Africa indicates that Africa is expected to lose about $50 billion per year due to climate change by 2040 (IPCC 2022). This is a huge drain on SSA governments 'budgets and expenditures on redistributive policies and social spending to support low-income households. The increases in vulnerability and risk due to climate and the lack of support from central governments dampens the efforts to reduce income inequality.

Table 4: Relationship between temperature, climate and Effort in reducing Income inequality.

Dep var: Inefficiency	Model 1	Model 2	Model 1	Model 2
	Developing countries		**SSA countries**	
Constant	-0.822*** (0.187)	-3.098*** (0.528)	-2.035*** (1.026)	-2.657*** (0.797)
Temperature Dev.	0.034*** (0.004)	0.040*** (0.005)	0.060*** (0.021)	0.023*** (0.005)
Precipitation. Dev.	0.001*** (0.000)	0.001*** (0.000)	-0.000 (0.000)	-0.000 (0.000)
CONTROLS	No	Yes	No	Yes
SigmaSQ	0.298*** (0.032)	0.303*** (0.029)	0.684*** (0.237)	0.465*** (0.085)
Gamma	0.896*** (0.012)	0.897*** (0.011)	0.931*** (0.022)	0.909*** (0.016)
Observation	**4 114**	**4 114**	**4 114**	**4 114**

Note: ***, ** and * denote significance at 1%, 5% and 10%, respectively. Estimated standard errors in parentheses.

Source: authors' calculation

5. Conclusion and Policy suggestions

The issue of income inequality has received a lot of attention in literature. Many of the studies that look at measures of income inequality to help understand the quantifiable progress by countries have concentrated on indices which do not account for the structural endowment of countries.

In this study we incorporate the structural endowment of countries and measure how countries are combining their resources in tackling or reducing income inequality. This represents their effort at reducing income inequality. Again, with the advent of climate change and its deleterious effect, it is important to understand how it influences countries' effort to reduce inequality. Is there an intensification of climate change which can hinder the fight of reducing income inequality? Using an unbalanced panel of 160 countries from 1990 to 2020, we use the Stochastic Frontier Analysis (SFA) model to examine the effort by countries to reduce income inequality, and the effects of climate on efforts to reduce inequality.

It was observed that on average, countries have exerted only 50 percent of their effort in reducing inequality, but this effort differs from region to region. SSA, which has the highest inequality recorded the least average effort of 39 percent. This varies across countries. Countries such as Mauritius, Gabon, Kenya have efforts above 50 percent, whilst many countries including South Africa, Ghana, Angola among others have efforts below 35 percent. This indicates that the potential and scope for improvement and investments to reduce income inequality differs across SSA countries.

The findings show that introducing temperature and precipitation in the frontier model reduced the effort of countries in several regions. This implies the negative effects of climate as countries combine their resources to reduce income inequality. The direct effect of climate on countries' effort to reduce inequality show that both temperature and rainfall decreases the effort of developing countries to reduce income inequality. In the SSA sample, the negative effect of temperature on effort was significant whilst that of rainfall was negligible. With respect to policy suggestions, the low efforts particularly for SSA countries indicate the high potential and scope for policies and investments given their endowment to reduce income inequality. The question is, how can countries identify the pathways and policies that would improve their use of resources to reduce inequality?

Here, countries with such poor performance may need some technical assistance in building their capacity, particularly from development partners to be able to identify the right combination of redistributive policies and social spending given their circumstance to reduce their income inequality. For these countries, technical support to conduct in-depth country specific research and develop in-country diagnostic tools on how best to use available resources to reduce income inequality are crucial.

Countries that are experiencing good performance may have somewhat identify appropriate pathways, such countries can be supported with additional resources to put them on a sustained path. The impact of climate on a country's effort to reduce income inequality is a major challenge. The negative effects of climate on economic activities, particularly agriculture and labour productivity in developing countries in turn reduce their output and economic growth. This hampers a country's ability to implement redistributive policies and increase social spending which are vital in boosting incomes of poorer households.

This calls for increased support and investment from development partners on climate resilient projects in key sectors of these countries. There is also the need to increase contribution by development partners and key stakeholders into the loss and damage fund, and develop mechanisms to target vulnerable countries with low effort and high-income inequality.

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APPENDIX A

Table A1: Estimated Stochastic Frontier Models.

Dep var: Income inequality	Pooled (1)	Pooled (II)	RE (1)	RE (II)	BC (I)	BC (II)	TRE (I)	TRE (II)
Constant	-8.570*** (2.778)	-9.346*** (2.836)	-5.248 (12.274)	-5.788 (12.483)	-35.252*** (5.592)	- 34.677*** (5.588)	25.790*** (2.235)	59.774*** (1.320)
Log GDP/capita	0.345 (0.316)	0.445 (0.303)	3.522*** (1.333)	3.599*** (1.350)	5.951*** (0.647)	5.891*** (0.665)	-2.864*** (0.224)	-4.016*** (0.176)
Res. Rents (Res)	0.209*** (0.040)	0.228*** (0.036)	0.070 (0.071)	0.070 (0.071)	0.021 (0.046)	0.019 (0.046)	0.108*** (0.026)	-0.020* (0.012)
Log pop. Density (Popd)	0.363* (0.197)	0.702*** (0.119)	-1.277 (1.013)	-1.227 (1.0143)	0.192 (0.352)	0.045 (0.377)	-1.260*** (0.160)	-2.388*** (0.098)
Log Education (Educ)	1.582*** (0.176)	1.979*** (0.227)	-0.768* (0.446)	-0.7664* (0.454)	-0.947*** (0.341)	-0.943*** (0.334)	1.769*** (0.171)	0.806*** (0.098)
Log Labour force (Lab)	0.440** (0.206)	0.340* (0.189)	0.616 (1.347)	0.648 (1.387)	1.468*** (0.340)	1.429*** (0.343)	-.630*** (0.161)	-3.735*** (0.066)
Log Institutions (Inst)	0.406 (0.792)	0.825 (0.646)	-1.746 (1.285)	-1.774 (1.281)	-1.188* (0.686)	-1.053 (0.710)	1.170** (0.340)	5.434*** (0.298)
Log GDP^2	-.170*** (0.038)	-0.205*** (0.027)	-0.633*** (0.117)	-0.638*** (0.119)	-.665*** (0.055)	-.664*** (0.055)	0.268*** (0.022)	0.166*** (0.017)
Res^2	0.001*** (0.000)	0.000** (0.000)	-0.000 (0.001)	-0.000 (0.001)	-0.001** (0.000)	-0.001** (0.000)	0.002*** (0.000)	0.000 (0.000)
Log Popd^2	-0.185*** (0.019)	-0.205*** (0.020)	-0.172 (0.116)	-0.177 (0.117)	-0.084*** (0.030)	-0.078** (0.031)	0.192*** (0.014)	0.609*** (0.008)
Log Educ^2	0.006 (0.008)	0.002 (0.005)	0.008 (0.016)	0.008 (0.016)	0.009 (0.009)	0.008 (0.008)	-0.026*** (0.003)	-0.042*** (0.004)
Log Lab^2	-.0422*** (0.014)	-0.052*** (0.013)	-0.043 (0.096)	-0.045 (0.097)	-0.034 (0.021)	-0.027 (0.022)	0.173*** (0.009)	0.176*** (0.006)
Log Inst^2	0.170 (0.202)	0.020 (0.151)	0.145 (0.270)	0.139 (0.269)	0.297* (0.170)	0.429** (0.176)	-0.058 (0.062)	1.151*** (0.039)
Log GDP *Res	-0.008*** (0.002)	-0.007*** (0.002)	-0.012*** (0.004)	-0.012*** (0.004)	0.004* (0.002)	0.004* (0.002)	-0.008*** (0.002)	-0.000 (0.001)
Log GDP *Popd	-0.006 (0.020)	-0.012 (0.017)	0.067 (0.066)	0.065 (0.066)	-0.023 (0.023)	-0.024 (0.023)	0.239*** (0.011)	0.009 (0.008)
Log GDP *Edu	-0.086*** (0.014)	-0.108*** (0.014)	0.108*** (0.033)	0.108*** (0.033)	0.100*** (0.016)	0.097*** (0.017)	-0.125*** (0.014)	-0.115*** (0.008)
Log GDP* Lab	0.059*** (0.019)	0.074*** (0.015)	-0.015 (0.067)	-0.016 (0.068)	-0.102*** (0.024)	-0.104*** (0.025)	-0.138*** (0.010)	0.051*** (0.007)
Log GDP *Inst	-0.202*** (0.033)	-0.171*** (0.023)	-0.044 (0.102)	-0.040 (0.104)	0.100 (0.061)	0.070 (0.062)	-0.392*** (0.027)	-0.482*** (0.021)
Res* Log Popd	-0.016*** (0.002)	-0.016*** (0.002)	-0.003 (0.003)	-0.003 (0.003)	-0.001 (0.002)	-0.001 (0.002)	0.003*** (0.001)	0.017*** (0.001)

Res* Log Edu	0.002 (0.002)	0.002 (0.002)	0.001 (0.003)	0.001 (0.003)	0.001 (0.002)	0.001 (0.002)	0.007*** (0.001)	0.005*** (0.001)
Res *Log Lab	-0.003 (0.002)	-0.006*** (0.002)	-0.000 (0.005)	-0.001 (0.005)	-0.003 (0.003)	-0.002 (0.003)	-0.008*** (0.001)	-0.002* (0.001)
Res *Log Inst	-0.001 (0.005)	-0.010 (0.006)	-0.015* (0.009)	-0.015 (0.009)	-0.027*** (0.005)	-0.023*** (0.005)	-0.011*** (0.003)	0.012*** (0.002)
Log Popd *Educ	0.005 (0.011)	-0.001 (0.013)	-0.012 (0.026)	-0.012 (0.027)	-0.007 (0.020)	-0.007 (0.021)	0.019*** (0.007)	-0.134*** (0.006)
Log Popd* Lab	0.020* (0.011)	0.016** (0.008)	0.031 (0.068)	0.030 (0.068)	0.001 (0.017)	0.007 (0.017)	-0.142*** (0.006)	-0.010*** (0.003)
Log Popd* Inst	-0.187*** (0.050)	-0.128*** (0.043)	-0.259*** (0.068)	-0.259*** (0.069)	-0.306*** (0.005)	-.312*** (0.054)	-0.425*** (0.019)	-0.328*** (0.013)
Log Edu *Lab	-0.049*** (0.008)	-0.052*** (0.012)	0.011 (0.027)	0.011 (0.028)	0.016 (0.011)	0.017 (0.010)	-0.055*** (0.006)	0.045*** (0.006)
Log Edu *Inst	0.141*** (0.025)	0.188*** (0.026)	-0.064 (0.042)	-0.065 (0.043)	-0.047 (0.037)	-0.041 (0.037)	0.040* (0.022)	0.152*** (0.014)
Log Lab* Inst	0.134*** (0.038)	0.039 (0.041)	0.234*** (0.057)	0.234*** (0.058)	0.171*** (0.034)	0.197*** (0.032)	0.285*** (0.013)	0.081*** (0.011)
Time	0.187*** (0.062)	0.190*** (0.057)	-0.569*** (0.087)	-0.575*** (0.088)	-0.002 (0.091)	0.011 (0.091)	-0.221*** (0.049)	-0.051** (0.024)
$Time^2$	-0.004*** (0.001)	-0.004*** (0.001)	-0.002 (0.002)	-0.002 (0.002)	-0.005*** (0.001)	-0.00565*** (0.001)	-0.005*** (0.001)	-0.010*** (0.001)
Time* Log GDP	0.005 (0.005)	0.007** (0.003)	0.053*** (0.004)	0.053*** (0.004)	0.028*** (0.005)	0.02982*** (0.006)	0.030*** (0.00303)	0.035*** (0.002)
Time*Res	-0.002*** (0.000)	-0.002*** (0.000)	0.001** (0.000)	0.001** (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000* (0.000)	-0.001*** (0.000)
Time* Log Popd	-0.003** (0.002)	-0.005** (0.002)	0.014*** (0.004)	0.014*** (0.004)	0.003 (0.004)	0.003 (0.004)	-0.005** (0.002)	0.004*** (0.00)
Time* Log Edu	0.001 (.001)	-0.001 (0.001)	-0.012*** (0.002)	-0.012*** (0.002)	-0.008* (0.004)	-0.008* (0.004)	0.006*** (0.002)	0.008*** (0.002)
Time *Log Lab	-0.005** (.002)	-0.003** (0.001)	0.007*** (0.003)	0.007*** (0.003)	0.003 (0.005)	0.002 (0.004)	0.009*** (0.002)	0.005*** (0.001)
Time* Log Inst	-0.002 (0.006)	0.005 (0.005)	-0.000 (0.005)	-0.000 (0.005)	0.002 (0.006)	-0.001 (0.007)	-0.010** (0.005)	-0.003 (0.002)
Temp. Dev		0.132*** (0.020)		0.035 (0.070)		-0.091*** (0.034)		0.012*** (0.002)
Precp. Dev		-0.001 (0.000)		-0.001 (0.000)		-0.001 (0.000)		0.001*** (0.000)
Regional Dummies	YES	YES	YES	YES	YES	YES	YES	YES
Variance parameters								
Sigma	541.889*** (187.823)	450.091*** (156.978)	2.752*** (0.355)	2.740*** (0.375)	1.612*** (0.404)	1.626*** (0.412)		
Sigma w	-	-	-	-	-	-	3.986*** (0.023)	1.750*** (0.006)
lambda	2.833*** (0.001)	2.815*** (0.001)	2.71529*** .60447	2.702*** (0.638)	1.903*** (0.033)	1.924*** (0.033)	39.148*** (15.150)	431.132 (493.829)
N	*4104*	*4104*	*4104*	*4104*	*4104*	*4104*	*4104*	*4104*

Note: ***, ** and * denote significance at 1%, 5% and 10%, respectively. Estimated standard errors in parentheses.

Table A2: Description and source of variables

Variable	Definition	Source
Output variable		
Gini (y1)	Gini coefficient	WIID
Palma (y2)	Palma ratio (top 10%/bottom 40%)	WIID
Inputs Variables		
GDP per capita (x1)	Per capita mean income (Gross Domestic Product, GDP)	WIID
Natural Resource Rent (x2)	Total natural resources rents (% of GDP)	WDI
Population Density (x3)	people per sq. km of land area	WDI
Education (x5)	Average years of schooling among 15+	VDEM
Labor force (x7)	total labour force	WDI
Institution (x12)	Egalitarian Democracy Index	VDEM
Climate Variables		
Temperature (z1)	Annual temperature	UAH
Temperature Deviations (z1a)	Temperature Deviations from 1950-1959	UAH
Precipitation (z2)	Annual precipitation	UAH
Precipitation deviation (z2a)	Precipitation Deviations from 1950-1959	UAH

Table A3: Descriptive Statistics

variable	Obs	Mean	St. Dev	Min	Max
Inputs					
x1	4,643	15924.45	18168.73	436.72	120647.8
x2	4,643	7.825944	11.24275	0	88.59235
x3	4,643	117.9738	274.9317	1.396781	7965.878
x5	4,643	4.646852	3.518451	.01	13.03
x7	4,643	1.84e+07	7.06e+07	45993	7.81e+08
x12	4,643	.3923358	.2454466	.039	.885
Output					
y1	4,643	44.76271	11.25314	0,7375	77.085
y2	4,643	3.149919	2.58545	.545	31.185
Climate					
z1	4,104	19.10944	7.419158	-2.359226	29.8695
z1a	4,104	.8306955	3.109286	-18.35525	29.01.00
z2	4,104	1125.584	754.3076	13.59713	4978.793
z2a	4,104	-43.86066	489.8665	-5420.824	4315.01.00

Table A4: Inequality Effort estimates for all countries in the sample.

CRTY	Gini	Palma	Effort	Effort Climate	CRTY	Gini	Palma	Effort	Effort climate	CRTY	Gini	Palma	Effort	Effort Climate	CRTY	Gini	Palma	Effort	Effort Climate
AFG	44,2	2,292	0,444	0,552	**DOM**	48,7	3,029	0,398	0,420	**KGZ**	37,5	1,808	0,405	0,51	**QAT**	37,8	1,6	0,472	0,685
ALB	34,8	1,413	0,612	0,530	**ECU**	49,4	3,145	0,542	0,452	**LAO**	37,5	1,668	0,498	0,61	**ROU**	33,7	1,4	0,414	0,486
DZA	36,7	1,586	0,540	0,561	**EGY**	34,8	1,467	0,476	0,685	**LVA**	35,3	1,453	0,527	0,49	**RUS**	40,9	2,1	0,491	0,479
AGO	60,8	6,717	0,314	0,298	**SLV**	47,8	2,914	0,533	0,546	**LBN**	38,9	1,839	0,632	0,58	**RWA**	58,2	5,3	0,246	0,256
ARG	43,8	2,304	0,642	0,609	**GNQ**	55,9	5,153	0,449	0,503	**LSO**	65,0	10,203	0,286	0,31	**STP**	49,9	3,2	0,450	0,345
ARM	37,1	1,661	0,452	0,503	**ERI**	54,6	4,145	0,584	0,449	**LBR**	51,2	3,461	0,394	0,55	**SAU**	37,8	1,6	0,533	0,564
AUS	33,8	1,324	0,615	0,610	**EST**	34,8	1,405	0,613	0,675	**Libya**	40,4	1,926	0,431	0,60	**SEN**	56,3	4,9	0,512	0,511
AUT	29,9	1,094	0,621	0,592	**SWZ**	65,2	9,052	0,426	0,410	**LTU**	34,7	1,422	0,551	0,53	**SRB**	35,7	1,5	0,497	0,428
AZE	28,8	1,137	0,406	0,611	**ETH**	51,2	3,507	0,529	0,427	**LUX**	31,3	1,179	0,641	0,57	**SLE**	57,4	7,5	0,461	0,350
BGD	45,8	2,553	0,619	0,508	**FJI**	43,0	2,236	0,553	0,633	**MDG**	56,3	4,678	0,335	0,37	**SVN**	25,5	0,9	0,610	0,519
BLR	31,1	1,165	0,634	0,595	**FIN**	26,3	0,929	0,444	0,461	**MWI**	61,3	6,464	0,279	0,30	**SLB**	44,1	2,3	0,645	0,542
BEL	29,3	1,072	0,574	0,621	**FRA**	32,5	1,257	0,589	0,679	**MYS**	45,9	2,607	0,545	0,46	**SOM**	52,7	3,9	0,238	0,201
BLZ	54,8	4,307	0,508	0,466	**GAB**	51,8	3,646	0,501	0,573	**MDV**	52,2	3,679	0,493	0,52	**ZAF**	69,5	11,9	0,373	0,295
BEN	54,4	4,208	0,395	0,417	**GMB**	61,0	7,218	0,319	0,312	**MLI**	54,0	4,607	0,272	0,21	**ESP**	34,6	1,4	0,629	0,662
BOL	54,8	4,938	0,301	0,320	**GEO**	46,1	2,676	0,445	0,29	**MRT**	53,9	4,184	0,488	0,41	**LKA**	47,0	2,7	0,537	0,557
BIH	32,7	1,274	0,518	0,515	**DEU**	30,0	1,102	0,607	0,63	**MUS**	47,8	2,763	0,697	0,54	**SDN**	53,3	3,9	0,580	0,615
BWA	63,1	7,502	0,186	0,380	**GHA**	55,4	4,520	0,331	0,42	**MEX**	51,6	3,540	0,523	0,54	**SUR**	56,6	5,4	0,271	0,194
BRA	54,4	4,270	0,515	0,296	**GRC**	34,4	1,366	0,686	0,56	**MDA**	35,9	1,513	0,652	0,45	**SWE**	26,6	0,9	0,600	0,642
BGR	33,4	1,335	0,622	0,608	**GTM**	53,6	4,120	0,444	0,47	**MNG**	36,2	1,541	0,648	0,55	**CHE**	33,7	1,3	0,606	0,573
BFA	70,9	13,910	0,225	0,237	**GIN**	55,0	4,583	0,432	0,43	**MNE**	35,0	1,430	0,405	0,51	**SYR**	36,7	1,6	0,612	0,423
BDI	52,2	3,645	0,357	0,346	**GNB**	56,9	5,166	0,354	0,38	**MAR**	42,4	2,132	0,569	0,46	**TJK**	34,0	1,3	0,655	0,453
KHM	40,3	1,966	0,441	0,586	**GUY**	46,5	2,716	0,476	0,49	**MOZ**	55,8	4,489	0,397	0,45	**TZA**	53,0	3,8	0,428	0,455
CMR	57,5	5,102	0,500	0,471	**HTI**	59,7	5,933	0,359	0,32	**MMR**	38,0	1,738	0,576	0,59	**THA**	41,9	2,1	0,466	0,656
CAN	33,1	1,282	0,525	0,686	**HND**	52,3	3,750	0,491	0,52	**NAM**	67,2	10,206	0,387	0,41	**TGO**	56,5	4,8	0,493	0,308
CPV	61,2	6,662	0,390	0,410	**HUN**	30,2	1,130	0,640	0,50	**NPL**	50,1	3,248	0,566	0,43	**TTO**	40,2	1,9	0,619	0,614
CAF	64,4	9,129	0,246	0,230	**ISL**	27,0	0,966	0,543	0,47	**NLD**	29,5	1,064	0,647	0,61	**TUN**	44,1	2,3	0,627	0,530
TCD	53,7	4,067	0,277	0,283	**IND**	49,6	3,122	0,504	0,46	**NZL**	33,8	1,341	0,665	0,57	**TUR**	45,9	2,6	0,627	0,627
CHL	51,4	3,471	0,598	0,545	**IDN**	37,0	1,645	0,611	0,51	**NIC**	52,8	4,027	0,295	0,31	**TKM**	40,1	1,9	0,511	0,289

CRTY	Gini	Palma	Effort	Effort Climate	CRTY	Gini	Palma	Effort	Effort climate	CRTY	Gini	Palma	Effort	Effort Climate	CRTY	Gini	Palma	Effort	Effort Climate
CHN	41,8	2,064	0,427	0,474	**IRN**	44,4	2,379	0,674	0,65	**NER**	53,3	3,9	0,318	0,362	**UGA**	56,1	4,6	0,409	0,326
COL	54,8	4,390	0,456	0,432	**IRQ**	40,0	1,878	0,565	0,44	**NGA**	44,5	2,6	0,439	0,408	**UKR**	31,9	1,2	0,466	0,612
COM	63,7	7,767	0,273	0,342	**IRL**	34,0	1,359	0,508	0,57	**NOR**	26,9	1,0	0,709	0,677	**ARE**	32,5	1,2	0,571	0,663
COG	60,2	6,176	0,494	0,366	**ISR**	40,2	1,896	0,511	0,41	**OMN**	42,1	2,1	0,643	0,698	**GBR**	35,5	1,5	0,575	0,628
CRI	48,1	2,897	0,354	0,476	**ITA**	35,2	1,436	0,572	0,44	**PAK**	45,3	2,5	0,468	0,554	**USA**	40,2	1,9	0,716	0,504
CIV	57,6	5,199	0,425	0,454	**JAM**	48,5	3,012	0,737	0,40	**PAN**	54,1	4,3	0,462	0,510	**URY**	43,4	2,3	0,624	0,530
HRV	30,9	1,165	0,485	0,515	**JPN**	32,7	1,278	0,397	0,58	**PNG**	44,1	2,3	0,656	0,583	**UZB**	37,2	1,6	0,562	0,472
CUB	48,9	2,943	0,736	0,644	**JOR**	42,3	2,144	0,536	0,51	**PRY**	54,3	4,3	0,347	0,445	**VEN**	39,4	1,8	0,587	0,567
CYP	31,1	1,195	0,679	0,547	**KAZ**	34,2	1,370	0,603	0,61	**PER**	54,2	4,8	0,329	0,336	**VNM**	38,1	1,7	0,689	0,668
CZE	25,7	0,908	0,401	0,515	**KEN**	58,8	5,688	0,510	0,33	**PHL**	47,1	2,7	0,596	0,617	**YEM**	39,2	1,8	0,626	0,544
DNK	24,8	0,849	0,502	0,634	**KOR**	33,4	1,301	0,591	0,60	**POL**	33,6	1,3	0,498	0,556	**ZMB**	63,3	8,5	0,233	0,196
DJI	45,8	2,600	0,558	0,520	**KEWT**	40,5	1,912	0,503	0,52	**PRT**	36,4	1,5	0,606	0,542	**ZWE**	65,0	10,1	0,325	0,334

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