Who carries the burden of climate change? Heterogeneous impact of droughts in Sub-Saharan Africa

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October 10, 2022

Paris-Saclay Applied Economics, AgroParisTech / Climate Economic Chair

Roadmap

Introduction

Motivation

- The last IPCC report highlights the necessity to examine equity considerations to distribute mitigation and adaptation efforts (Grubb et al., 2022)
  - → Within-country inequalities are almost not taken into account in the climate justice debate (Islam and Winkel, 2017)
- Risk of a vicious circle of climate change exacerbating existent inequalities (Islam and Winkel, 2017)
  - → Social inequalities are linked to a fall in mitigation and adaptation efforts (Nyiwul, 2021)
  - → Social inequalities are linked with higher CO_2 emissions in low and middle-income countries (Ehigiamusoe et al., 2022)
- How extreme weather conditions affect income inequalities in African countries?

Introduction

Contribution

- Droughts have multidimensional impacts (agriculture, forest, water quality, and availability), which trickles to other socio-economic impacts (education, non-farm income, nutrition, migration) (Gautier et al., 2016)
- To cope with shocks, households use a large range of strategies (Dercon, 2002) that are easier to implement with asset endowment (Bailey et al., 2019; Paumgarten et al., 2020)
- Most vulnerable households which have barriers to the detention of such capital may not be able to cope with droughts
- Only two studies have explored heterogeneity in the impact of extreme weather events in Africa
  → Arslan et al. (2016) compute the elasticity of income over income quantiles in Tanzania
  → Sesmero et al. (2018) compute elasticity of income over household assets in Malawi

Introduction

Contribution

- I isolate the direct causal impact of drought desegregated by household-income level in Ethiopia and Malawi using two original methodologies in a common framework
  - → The quantile treatment effect designed by Callaway and Li (2019)
  - → Inference on counterfactual distribution by distribution regression developed by Chernozhukov et al. (2013)
- Impact of drought is directly measured on household real income: no bias of auto-consumption and share of consumption in income
- I use the Standardized Soil Moisture Index (SSMI) integrating both temperature and precipitation dimensions of drought
- I show the robust heterogeneous impact of drought: poorest households are more impacted than richest households which could even benefit from droughts

Roadmap

Data

LSMS-ISA data

- Three waves of nationally-representative and geo-referenced panel data survey
  - → 2011/2013/2015 for Ethiopia
  - → 2010/2013/2016 for Malawi
- Income from unsold agricultural production is estimated using De Magalhães and Santaeulàlia-Llopis (2018) method and the World Bank protocol
- Real income data are used because the share of consumption in income is not homogeneous across the income level of household

Data

Climate data

- I use the Standardized Soil Moisture Index (SSMI) to capture agricultural drought event
  - → Is directly linked with the defininition of agricultural drought
  - → Allows having both precipitation and temperature dimensions of droughts (precipitation and evaporation data)
  - → Has been validated in both countries as a relevant indicator for drought monitoring (Agutu et al., 2017; Agutu et al., 2020)

Data

Drought occurrence

(a) Ethiopia *(b)* Malawi

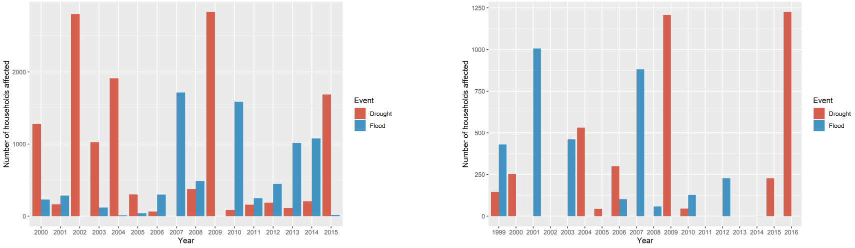

Figure: Number of households affected by drought and flood over time in Ethiopia and Malawi

- One major drought affecting a large proportion of the population occurred just before the last year of the survey
- No major drought occurred between the first wave of the survey to the last wave of the survey

Roadmap

Empirical approach

Framework

- Exploit the time and spatial variability of droughts in Ethiopia and Malawi
- Framework of the Quantile Treatment Effect (QTT) of Callaway and Li (2019)
- Framework:
  - → Three periods: t, t - 1 and t - 2
  - → Individuals have potential outcomes in treated (D=1) and untreated (D=0) group: Y_{Dt}

Quantile treatment effect

$$QTT(\tau) = F^{-1}_{Y_{1t}|D=1}(\tau) - F^{-1}_{Y_{0t}|D=1}(\tau)$$

QTT under Copula Stability Assumption

Assumptions

Distributional difference-in-differences assumption

$$\Delta Y_{0t} \perp\!\!\!\perp D$$

Generalize the common parallel trend assumption to the entire distribution

Copula stability assumption

$$C_{\Delta Y_{0t}|D=1, \Delta Y_{0t-1}|D=1}(.,.) = C_{\Delta Y_{0t-1}|D=1, \Delta Y_{0t-2}|D=1}(.,.)$$

Income mobility is constant over time

- Assumptions are tested in pre-treatment periods
  - → Kolmogorov-Smirnov test for the Distributional Difference-in-Differences assumption
  - → Evolution of the period-over-period income dependence (Spearman's rho) for the Copula Stability assumption

QTT under Copula Stability Assumption

Results

Estimation of counterfactual distribution

Main result of Callaway and Li (2019):

$$\hat{F}_{Y_{0t}|D=1}(y) =$$

$$\sum_{i \in D} \mathbb{1}\{\hat{F}^{-1}_{\Delta Y_t|D=0}(\hat{F}_{\Delta Y_{t-1}|D=1}(\Delta Y_{it-1})) \leq y - \hat{F}^{-1}_{Y_{t-1}|D=1}(\hat{F}_{Y_{t-2}|D=1}(Y_{it-2}))\}$$

- The result can be extended considering a Conditional Difference-in-Differences assumption
  - → Estimation of the QTT relies on a first-step estimation of a propensity score
  - → The Hilbert-Schmidt independence criterion cluster permutation conditional independence test is used

Dynamic panel model on treated group

Motivation

The treatment might impact the control group

- Threshold definition problem
- Spillover effects impacting my control group
  - → Local food markets (Brown and Kshirsagar, 2015)
  - → Migration (Becerra-Valbuena, 2021)
  - → Energy production (hydroelectricity) (Nhamo et al., 2018)
- Use of the method of Chernozhukov et al. (2013) to infer counterfactual distribution with past observations of the treatment group

Dynamic panel model on treated group

Model description

- The counterfactual distribution is computed with a predictive model of distribution regression built on period $t-1$
- Covariables include human capital (education), natural capital (water proximity and forest cover), social capital (female household head, nb of household members), and physical capital (rural household, access to market)
- Placebo test is used on the pre-treatment period to test the predictive performance of the model

Distribution regression model

For a range of possible income values w:

$$P(Y_{1t-1}|D = 1 \leq w) = \beta_0 + \alpha Y_{1t-2} + \gamma X_{1t-1} + \epsilon_{1t-1}$$

Roadmap

Results

QTE on Copula stability assumption

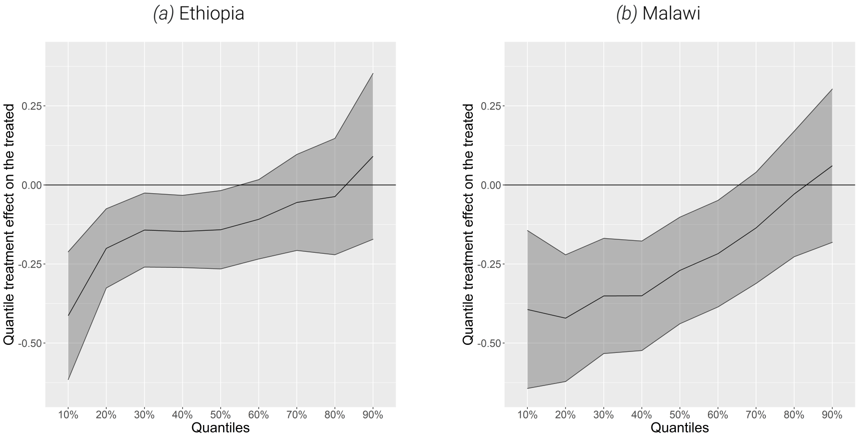

Figure: Quantile treatment effect of income per capita

Results

Distributional difference-in-differences assumption

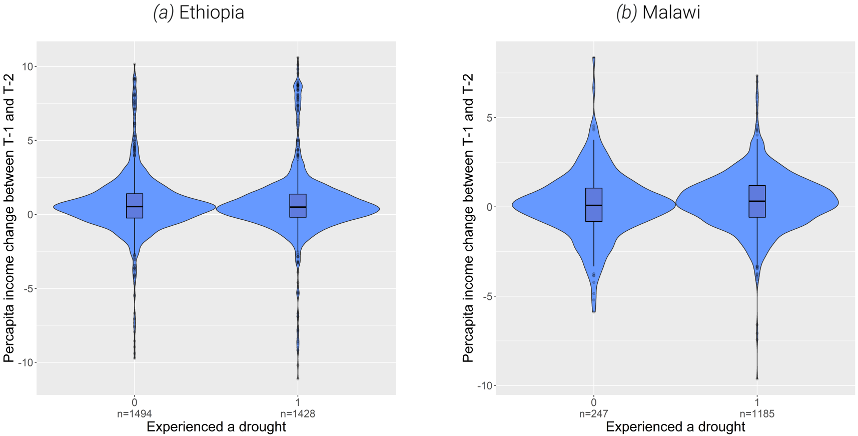

Figure: Distribution of change in the log of per-capita income for the treated and the control group between t - 1 and t - 2

Results

Copula stability assumption

Figure: Evolution of the year-over-year income dependence (Spearman's rho) in Ethiopia and Malawi for the control and treatment group in all panel waves

Results

QTE with counterfactual inference

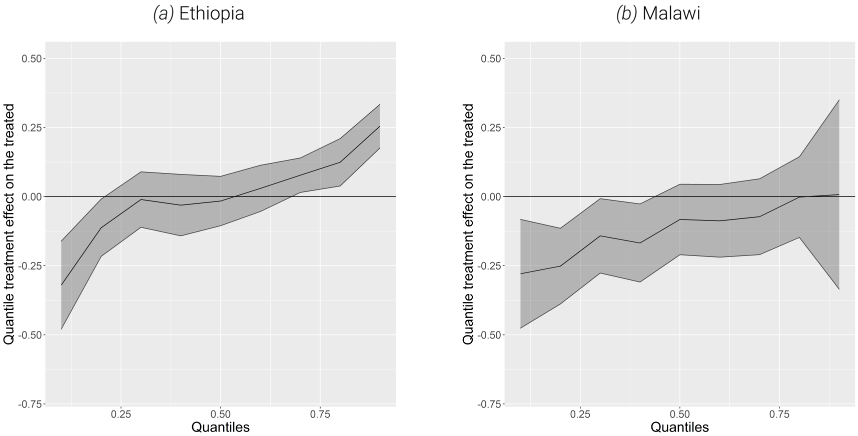

Figure: Counterfactual analysis to build quantile treatment effect of income per capita

Results

QTE with counterfactual inference

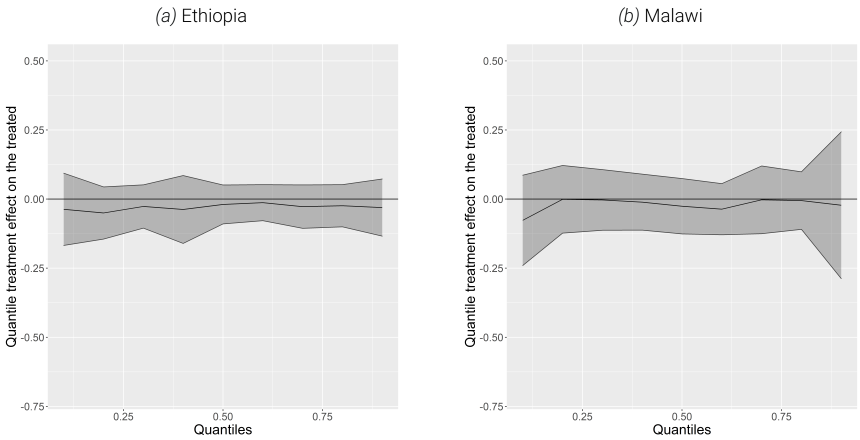

Figure: Counterfactual analysis to build quantile treatment effect of income per capita of placebo for period t - 1

Roadmap

Conclusion

Discussion

- The quantile treatment effect, as defined, is not strictly causal. Causality comes from the fact that income mobility is sufficiently weak and constant over time in both groups
- Inequalities increase in the short term, but a similar analysis could be done in the long term, and the effect on inequalities may be even stronger (Little et al., 2006)

Conclusion

Public policy recommendation

- Public policies implemented to reduce household vulnerabilities to shocks or help them to recover from shocks must be primarily targeted at low-income households
- At the micro-level, low-income households which often are very low-carbon emitters, are more impacted by climate change drawbacks (as droughts will be more frequent and intense)
- It called for a more substantial revenue distribution into southern countries

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