

Drought and its Impacts on Economy in East Africa

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Outline

Defining drought

Drought indices

Effects of Drought on Economy

Methods

Results-Knowledge

Results-WTP

Conclusion

Definition of Drought

- Prolonged absence or marked deficiency of precipitation
- Deficiency of precipitation that results in water shortage for some activity or for some group
- Period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance

(??)

Categories of Definition of Drought

- **Conceptual definitions:** dictionary types, usually defining boundaries of the concept of drought
e.g. *An extended period - a season, a year, or several years of deficient rainfall relative to the statistical multi-year mean for a region (?)*
- **Operational definitions:** Foundation for an effective early warning system
e.g. SPI, PDSI

(??)

Types of Drought

operational drought

1. **Agricultural drought:** moisture deficits in upper layer of soil up to about one meter depth
2. **Meteorological drought:** which refers to prolonged deficit of precipitation
3. **Hydrological drought:** relates to low stream flow, lake and levels of groundwater
4. **Socioeconomic drought:** associates the supply and demand of some economic good with elements of meteorological, agricultural and hydrological drought

(???)

Drought Indices

Early measures of drought

- Length of period without 24-h precipitation of 1.27mm (?)
- Length of drought in days, end of drought defined as 2.54mm of precipitation in 48 hours (?)
- Measure of precipitation over a given time period (?)
- Antecedent Precipitation Index (API) based on amount and timing of precipitation, inverse drought index - for flood forecasting (?)

Drought Indices

- **Palmer Drought Severity Index (PDSI, ?)**
 - Significant milestone in history of drought severity quantification
 - Based on a hydrological accounting system
 - Incorporate antecedent precipitation, moisture supply and moisture demand
- **Standardized Precipitation Index (SPI, ?)**
 - Can be interpreted as the number of standard deviations by which the observed value differs from the long-term mean
 - Standardised departure of observed precipitation from a chosen probability distribution function which models the precipitation data (?)

Drought Indices

- **Standardized Precipitation Evapotranspiration Index (SPEI, ?)**
 - Extention of SPI
 - Accounts for potential evapotranspiration (hence captures impacts of increased temperature on water demand)
- Number of other drought indicators and indices exist
 - E.g.: Percent of Normal Precipitation, Drought Area Index (DAI), Soil Moisture Anomaly (SMA), Standardized Water-level Index (SWI), Normalized Difference Vegetation Index (NDVI)
- ???: Overview of number of drought indices
- Quantification and evaluation of drought indices for each of the three physical types of drought (?)

Data

mozna taky trochu popsat data?? nebo az u napadu, co budu delat??

Effects of drought on economy

Generalized Computable Equilibrium (CGE) Models

- ?
 - Exploring range of scenarios for food price increase in 2030
 - 1. Baseline 2. Climate change 3. Climate change with adaptation 4. Adaptation only in sub-Saharan Africa
 - Global coverage, set of individual country models, linked through international trade
 - Effects of climate change (incl. drought) modelled as changes in factor productivity (usually negative)
- ?
 - Ethiopia
 - Social Accounting Matrix (SAM)

Recent Relevant Literature

- ? : CGE
 - Ethiopia. Udelat tabulku, v jednom sloupci co je fixed, v jednom co determined by model
 - ktere promenne se tam dosadi a ktere vylezou
- ? CGE global
 - probably also describe this CGE, how does it work, inputs, outputs maybe it is like not that production is exogenous and price endo. but interdependent. and we have production shock as input → it gives price shock as output → it has again effect on production volumes
- ?
 - Analyse preferences of distributing the burden of reducing CO₂
 - Higher educated people have higher WTP for distribution that is less costly for their country

Data

n=4592

Age	20	30	40	50	60	70	80
Frequency	805	1113	812	791	657	361	53

Gender	Freq.
Male	2250
Female	2310

Education

Occupation

Methods

Lasso = Least Absolute Shrinkage and Selection Operator

- In literature preferred to stepwise procedures (Tibshirani, 1996; Efron et. al, 2003; Yuan and Lin, 2004; Shah, 2012)

$$\hat{\beta}(\lambda) = \arg \min_{\beta} \left(\sum_{i=1}^n (Y_i - \mathbf{X}\beta)_i \right)^2 + \lambda \sum_{j=1}^p |\beta_j|, \quad (1)$$

- i ... index of observations
- j ... index of explanatory variables
- $\lambda \geq 0$...penalty parameter
- The estimator does variable selection in the sense that $\hat{\beta}_j(\lambda) = 0$ for some j 's
- Cross-validation of a series of models with different values of λ
- I choose the largest value of λ such that the mean square error is within 1 standard error of the minimum MSE

Cumulative logits model

Y is a categorical response with M categories ($m = 1 \dots M$)

$$\text{logit}[P(Y \leq m|x)] = \alpha_m + \beta' \mathbf{x}, \quad m = 1, \dots, M-1 \quad (2)$$

Substitute estimates into:
$$\hat{P}(Y \leq m) = \frac{\exp(\hat{\alpha}_m + \hat{\beta}' \mathbf{x})}{1 + \exp(\hat{\alpha}_m + \hat{\beta}' \mathbf{x})}$$

- **Proportional odds assumption**

- Likelihood ratio test for comparison with multinomial logit insignificant \Rightarrow assumption satisfied

Results: Willingness to pay

OLS after selection by lasso Robust std. errors HC ₀ , n=4178		Tax gas		Tax fuel	
		(I)	(II)	(I)	(II)
Demographics	Female	+	+	-	+
	Age	- ***	- ***	- ***	- ***
	Debts	+ ***	+ ***	+ ***	+ ***
	Occupation	vary		Not included	
Numeracy	Understands interest	- ***	- ***	- **	- **
	Understands inflation	- ***	- ***	- ***	- ***
	Cognitive reflection test	Not included		- **	- **
Attitudes, beliefs	Not getting fair share of nation's wealth	- ***	- ***	- **	- **
	Hard work is important	- ***	- ***	- ***	- ***
	Parents + kids have same living standards as me	+ ***	+ ***	+ ***	+ ***
Climate change	Clim. change risk perception	+ ***	Not incl.	+ ***	Not incl.
	Clim. change vs policies risk	+ ***	+ ***	+ ***	+ ***
	How much is gas/fuel tax	+ ***	Not incl.	+ ***	Not incl.
	Female × Clim. policies	- **	- *	-	-
Behavioral	Inequity aversion index	+ then - ***	Not incl.	+ then - ***	Not incl.
	Discount rate yr. 0 vs.1	+ *	Not incl.	+ ●	Not incl.
	Consistent discount rate	+ ***	+ ***	+ ***	+ ***
	Egalitarian	Not included		- ***	- ***

Results: Willingness to pay - robustness

- OLS after selection by lasso
- With additional control variables

Dependent variable:	Tax gas	Tax fuel
Demographics	Robust	Robust
Numeracy	Robust	Robust
Attitudes, beliefs	Robust	Robust
Climate change	Robust	Robust
Behavioral	Robust	Robust
Income	-	- **
Climate knowledge	- ●	+
Social value orientation	+	+ *
Risk aversion Kehneman-Tversky	-	+
Government should redistribute income	+ ●	+ ●
Robust standard errors HC ₀	n=4178	n=4184

Average preferred tax rate for **gas** grouped by:

- Understands compound interest

■ Male

■ Female

0 0.5 1

1 = Understands

- Hard work is important

■ Male

■ Female

1 2 3 4 5

1 = Not important at all

5 = Essential

Average preferred tax rate for **fuel** grouped by:

- Cognitive Reflection Test



- Ordinary working people do not get their fair share of the nation's wealth



−2 = Strongly disagree

2 = Strongly agree

Conclusion

- The key factors associated with **climate knowledge**:
 - Female: negative effect
 - Financial literacy: positive effect
 - Score on the Cognitive Reflection Test: positive effect
- The key factors associated with **WTP for climate change mitigation**:
 - Age: negative effect
 - Numeracy, financial literacy: negative effect
 - Attitudes and beliefs about redistribution of income and wealth
 - Climate change risk perception: positive effect (robustness check)

Thank you for attention

Climate change and policies risk perception

Climate care

How serious a problem do you think climate change is at this moment?

Response	0	1	2	3	4	5	6	7	8	9	10
Frequency	77	68	112	171	199	430	858	1025	786	395	471

Climate policy

Which affects you and your way of life more, climate change (10) or policies (0) to reduce greenhouse gas emissions?

Response	0	1	2	3	4	5	6	7	8	9	10
Frequency	130	127	256	374	415	1174	670	621	397	205	223

n=4592

Data

n=4592

Occupation

Survey questions and coding

Financial literacy

Number of correct answers out of three financial questions

0	0.5	1	1.5	2	2.5	3
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Survey questions and coding

Understands interest

1 = Understands compound interest

-1	0	0.5	1
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Understands inflation

1 = Understands inflation

-1	0	0.5	1
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Survey questions and coding

Cognitive Reflection Test

- In survey called numeracy
- Frederick (2005)
- Number of correct answers - max is 3

0	0.5	1	1.5	2	2.5	3
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Survey questions and coding

Not getting fair share of nation's wealth

Ordinary working people do not get their fair share of the nation's wealth

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
-2	-1	0	1	2

Hard work is important

How important is hard work for getting ahead in life?

Not important at all	Not very important	Fairly important	Very important	Essential
1	2	3	4	5

Survey questions and coding

Government should redistribute income

Government should redistribute income from the better off to those who are less well off

Strongly disagree	Disagree	Neutral	Agree	Strongly agree
-2	-1	0	1	2

Survey questions and coding

Better of parents

Compared with your parents when they were about your age, are you better or worse in your income and standard of living generally?

Much worse off	Worse off	About equal	Better off	Much better off
-2	-1	0	1	2

Better of kids

Compared with you, do you think that your children, when they reach your age, will be better or worse in their income and standard of living generally?

Much worse off	Worse off	About equal	Better off	Much better off
-2	-1	0	1	2

My parents and kids have about same living standards as me

1= Both questions above answered ***about equal*** (0)

0= Otherwise

Methods

The Logistic Regression Model:

- Binary response variable Y , explanatory variable X
- $\pi(x) = P(Y = 1|X = x) = 1 - P(Y = 0|X = x)$

$$\pi(x) = \frac{\exp(\alpha + \beta x)}{1 + \exp(\alpha + \beta x)} \quad (3)$$

- **Logit** = Log odds

$$\text{logit}[\pi(x)] = \log \frac{\pi(x)}{1 - \pi(x)} \quad (4)$$

After substituting (3) into (4) and working out:

$$\text{logit}[\pi(x)] = \log \frac{\pi(x)}{1 - \pi(x)} = \alpha + \beta x \quad (5)$$

- Substituting $\hat{\alpha} + \hat{\beta}x$ into (3) we get probability that y is equal to 1 for particular x

Methods

Cumulative Logit Models

- Logits of cumulative response probabilities
- Logistic regression generalized for ordinal response variable
- Y is a categorical response with M categories ($m = 1..M$)

$$P(Y \leq m|x) = \pi_1(x) + \dots + \pi_m(x), \quad m = 1, \dots, M \quad (6)$$

- The **cumulative logits** are defined as:

$$\begin{aligned} \text{logit}[P(Y \leq m|x)] &= \log \frac{P(Y \leq m|x)}{1 - P(Y \leq m|x)} \\ &= \log \frac{\pi_1(x) + \dots + \pi_m(x)}{\pi_{m+1}(x) + \dots + \pi_M(x)}, \quad m = 1, \dots, M - 1 \end{aligned} \quad (7)$$

Methods

Proportional Odds Model A model, that simultaneously uses all cumulative logits is:

$$\text{logit}[P(Y \leq m|x)] = \alpha_m + \beta' \mathbf{x}, \quad m = 1, \dots, M-1 \quad (8)$$

- Each cumulative logit has its own intercept α_m increasing in m
- The same effect β for each logit
- The odds of response $\leq m$ at $\mathbf{x} = \mathbf{x}_1$ are $\exp[\beta'(\mathbf{x}_1 - \mathbf{x}_2)]$ times the odds at $\mathbf{x} = \mathbf{x}_2$

↪ Thus, log of odds ratio of cumulative probabilities is proportional to distance between \mathbf{x}_1 and $\mathbf{x}_2 \Rightarrow$

PROPORTIONAL ODDS MODEL

- Must satisfy the **proportional odds assumption**
 - Can be tested e.g. by likelihood ratio test against unconstrained multinomial logit

Results: Climate knowledge - Cumulative logits model

Marginal effects, n=4592

Correct answers:	0	2	4
Female	4×10^{-4} *	0.034 ***	-0.013 ***
Financial literacy	-1×10^{-4} ●	-0.014 ***	0.005 ***
Cognitive reflection 1	-3×10^{-5}	-0.003	0.001
Cognitive reflection 2	-2×10^{-4} ●	-0.020 **	0.006 ***
Cognitive reflection 3	-4×10^{-4} *	-0.043 ***	0.005 ●
Climate care	1×10^{-4} ●	0.012 ***	-0.005 ***
Climate policy	5×10^{-5} *	0.005 ***	-0.002 ***

Correct answers:	6	8
Female	-0.024 ***	-3×10^{-4} ●
Financial literacy	0.010 ***	1×10^{-4} ●
Cognitive reflection 1	0.002	2×10^{-5}
Cognitive reflection 2	0.016 **	2×10^{-4}
Cognitive reflection 3	0.044 ***	-5×10^{-4} ●
Climate care	-0.009 ***	-1×10^{-4} *
Climate policy	-0.003 ***	-4×10^{-5} ●

Previous research

- Worldwide: **Education** is the strongest predictor of climate change awareness
- ?
 - Data from 119 countries - global assessment
 - Predictors of climate change awareness:
 - Civic engagement
 - Communication access
 - Education
 - Geographic location
 - Household income
 - Predictors of climate change risk perception:
 - Believes about **anthropogenic cause** of climate change
 - Perception of **local temperature changes**
 - Attitudes towards government efforts for environmental preservation
 - Local water and air quality

● ?

- Warm glow is important for motivating environmentally friendly behavior
- Motivation of good feeling from giving as contrast to 'pure altruism'
- Substantial share of contributions to carbon abatement not dependent on any direct climate effect

● ?

- Preferences of distributing the burden of reducing CO₂
- Discrete choice experiment in USA and China
- WTP varies with socioeconomic characteristics and attitudes
- Educated people higher WTP for rules less costly for their country
- Less costly rules for respondents' country preferred

- ?
 - Focus on risk aversion and willingness to pay for emission reduction
 - If uncertainty over outcomes exists, it is important to consider people's risk preferences.
 - Choice experiment in Scotland
 - Comparison of different specifications arising different assumptions about the way respondent process information on outcome-related risk
 - Significant differences between different specifications can arise in terms of model fit and WTP estimates
 - Outcome related risk matters to respondents

● ?

- Use the same 8 climate knowledge questions mostly to point out problem that what is designed to measure knowledge often measures something else, like cultural identification
- Strong correlation between risk perception from global warming and political outlook (right = small risk)
- Correlation between belief in human cause of global warming and political outlook (left vs right)

● ?

- Relationship between religion and climate change attitudes and behavior
- Differences across religious groups found in terms of:
 - human induced climate change
 - the level of consensus among scientists
 - their own efficacy
 - the need for policy responses
- Ordered logits model
- Buddhists, atheists, and agnostics the most engaged with climate issues, Christian literalists the least engaged

References