Effects of Weather on Maize Yield in Kenya

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Outline

Introduction

- SSRP project, related to ForPAc project
- Extreme weather → disasters (maybe name some years of drought in Kenya??)
  - Early warning systems have been developed
- Goals: Improve early warning systems in Kenya
- Shifting the disaster management from reactive to protective

- Two predominant rainfall regimes in Kenya:
  1. Arid and semi-arid (ASAL): bi-modal
     - Short rains: March to May
     - Long rains: October to December
  2. non-ASAL: uni-modal
     - March to August
- Perhaps a map of ASAL and non-ASAL

Approach

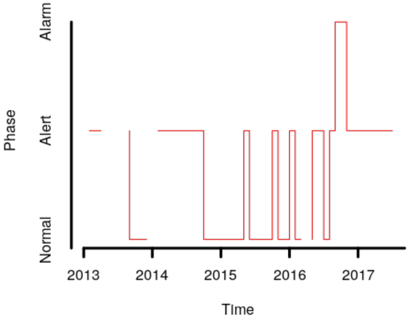
- Various approaches considered including:
  - Relating NDMA Early warning phase classification to weather
  - Relating markets and food prices to weather
  - Relating maize yields to weather to weather
  - Computable general equilibrium (CGE) models

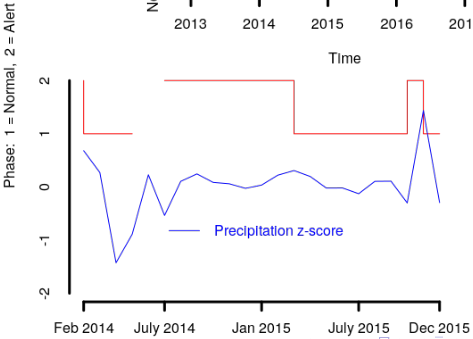
NDMA Early Warning Phase Classification

Example: Kitui county

Normal* → *Alert* → *Alarm

- Bulletins for ASAL counties
- Online since 2013
  - But in pdf format
- For county and month





Approach

- Narrowing the research question:
  - Relationship of maize yield and weather in Kenya
    - What is it about weather that causes drought related disasters?
    - Which particular characteristics of weather are the most 'responsible' for drought related disasters?

Sample:

- Panel of 47 counties of Kenya, 1981 – 2017

Data

- Maize yields
  - source: Famine Early Warning Systems Network (FEWS NET)
  - County level, yearly, tonnes per hectare
- Weather:
  - Daily, 0.25° resolution gridded data
  - Precipitation
    - source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
  - Temperature
    - source: Berkeley Earth
  - Aggregation needed to conform with the yield data

$$\begin{array}{lll} 0.25^\circ \text{ grid} & \to & \text{county level} \\ \text{daily} & \to & \text{yearly} \end{array}$$

add how averaged over seasons ASAL and non ASAL

Precipitation and temperature measures

- Measures typically considered:
  - Total precipitation over rainy seasons
  - Average temperature during rainy seasons
- Less commonly used measures considered:
  - Maximum daily precipitation (floods)
  - Maximum daily temperature
  - Coefficients of variation: precipitation and temperature
  - Maximum length of dry spell during rainy seasons
  - Number of dry spells during rainy seasons
  - Number of heatwave days
  - Cumulative precipitation on days when precip. $> 90th$ percentile

Linear mixed effects models

- Slopes allowed to vary across counties

$$\begin{aligned}
log(y_{1t}) &= \sum_{m=1}^{p} \beta^m x_{1t}^m + \sum_{n=1}^{q} b_1^n z_{1t}^n + \epsilon_{1t} \\
log(y_{2t}) &= \sum_{m=1}^{p} \beta^m x_{2t}^m + \sum_{n=1}^{q} b_2^n z_{2t}^n + \epsilon_{2t} \\
&\vdots \\
log(y_{47t}) &= \sum_{m=1}^{p} \beta^m x_{47t}^m + \sum_{n=1}^{q} b_{47}^n z_{47t}^n + \epsilon_{47t}
\end{aligned}$$

t	=	index for year $(1981 - 2017)$
y_{it}	=	maize yield tones/hectares, county i, year t
β^m, m=1,...p	=	p fixed effects parameters
x_{it}^m, m=1,...,p, i=1,...,47	=	fixed effects regressors, county i, year t
b_i^n, n=1,...q, i=1,...,47	=	q random effects parameters -**vary over county *i***
z_{it}^n, n=1,...,q, i=1,...,47	=	random effects regressors, county i, year t
ϵ_{it}	=	error term

Linear mixed effects models

- Panel: County $\times$ Year
- Slopes allowed to vary over counties

$$log(y_{it}) \;=\; \sum_{m=1}^{p} \beta^m x_{it}^m + \sum_{n=1}^{q} b_i^n z_{it}^n + \epsilon_{it} \qquad i = 1, ..., 47 \quad \text{counties}$$

t	=	index for year (1981 − 2017)
y_{it}	=	maize yield tones/hectares, county i, year t
β^m, m=1,...p	=	p fixed effects parameters
x_{it}^m, m=1,...,p, i=1,...,47	=	fixed effects regressors, county i, year t
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ϵ_{it}	=	error term

Model specification

- AIC
- None of the random slopes significant
- Group autocorrelation structure present
    - Tested by the Lagrange multipliear test developed by Baltagi & Li (1991; 1995)

$\longrightarrow$ The error structure modelled as ARMA(1,1)

- The preferred error structure found using AIC

Results

Table: **Mixed effects model:** exponents of the coefficient estimates Log of maize yield and weather, ARMA(1,1) errors

Fixed effects:	***All counties***	***ASAL***	***non-ASAL***
Intercept	1.296***	1.272*	1.408**
Prec. total	1.081*	1.007	1.277***
Prec. total sq.	0.973*	1.003	0.881***
Prec. c. of var.	0.924$^{\bullet}$	0.970	0.907
Dry spell -length[a]	0.935*	0.834**	0.988
Dry spells $\geq$ 4 d.[b]	0.939*	0.855**	0.989
Temp. - average	0.820***	0.808*	0.880
Temp. c. of var.	1.043$^{\bullet}$	1.032	1.060 $*$
Number of observations:	1300		698 602

Notes: Standard errors in brackets; $^{\bullet}$ $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

ideas

- Plot of dependency of precip or some measure and yields..
- Maybe also general description of the mixed effects models as I have in the draft
- Look at the document on google docs 'Yield and climate' to see if I can use something

Effects of droughts on economy

Computable General Equilibrium (CGE)

- **?**
  - 5 agro-ecological zones,46 production activities (incl. 35 zone specific agricultural production sectors), 22 commodity groups, 15 primary factors of production

Fixed (inputs)	Determined by model (outputs)
Capital stock	Domestic price of each commodity
Land (by region)	Land allocated across crops
Supply of labor per skill type	Real wages
Foreign capital inflow	Real exchange rate
Trade balance	

- The simulation use a 'balanced' macro closure in which aggregate **investment, government demand, and consumption are fixed shares of total absorption**
- Intermediate inputs into production are determined as fixed shares of the quantity of output

Thank you for attention

Precipitation and temperature measures considered I

- Total precipitation over the rainy season
- Coefficient of variation of the precipitation during the rainy season
- Maximum length of dry spell during the rainy season (in number of days)
- Number of dry spells during the rainy season: a dry spell defined as 4 consecutive days without rain or more[1]
- Number of dry spells during the rainy season: a dry spell defined as 10 consecutive days without rain or more[1]
- Number of dry spells during the rainy season: a dry spell defined as 20 consecutive days without rain or more[1]

Precipitation and temperature measures considered I

- Average temperature during the rainy season
- Standard deviation of temperature during the rainy season
- Cumulative degree days during the rainy season (excluding the days when maximum temperature above 30°C or below 10°C
- Number of heatwave days during the rainy season when max. temperature $> 35°C$
- Maximum daily precipitation - to control for possible floods
- Sum of precipitation amount on days where precipitation is above 90^{th} percentile of precip. of the whole period[2]
- Sum of precipitation amount on days where precipitation is above 95^{th} percentile of precip. of the whole period[3]

Precipitation and temperature measures considered I

- Sum of precipitation amount on days where precipitation is above 99^{th} percentile of precip. of the whole period[4]
- Number of days where precipitation is above 90^{th} percentile of precip. of the whole period[2]
- Number of days where precipitation is above 95^{th} percentile of precip. of the whole period[3]
- Number of days where precipitation is above 99^{th} percentile of precip. of the whole period[4]