Drought and its Effects on Economy

Monika Novackova

University of Sussex

December 2017

My research interest:

Effects of droughts on economy in Kenya

Outline

Definition of Drought

Drought Indices

Effects of Droughts

Effects of Climate

My Suggestion

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

(Heim, 2002; Trenberth et al., 2007)

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 (Schneider and Hare, 1996)*
- **Operational definitions:** Foundation for an effective early warning system
  - e.g. Standardized Precipitation Index (SPI), Palmer Drought Severity Index (PDSI)

(Wilhite and Glantz, 1985; Wilhite, 2000)

Types of Drought

operational drought

1. **Agricultural drought:** moister 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

(Heim, 2002; Trenberth et al., 2007; American Meteorological Society, 2013)

Drought Indices

Early measures of drought

- Length of period without 24-h precipitation of 1.27mm (Munger, 1916)
- Length of drought in days, end of drought defined as 2.54mm of precipitation in 48 hours (Blumenstock, 1942)
- Measure of precipitation over a given time period (Wilhite and Glantz, 1985)
- Antecedent Precipitation Index (API) based on amount and timing of precipitation, inverse drought index - for flood forecasting (McQuigg, 1954)

Drought Indices

- **Palmer Drought Severity Index** (PDSI, Palmer, 1965)
  - 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, McKee et al., 1993)
  - Can be interpreted as the number of standard deviations by which the observed value differs from the long-term mean
  - Standardized departure of observed precipitation from a chosen probability distribution function which models the precipitation data (John Keyantash and National Center for Atmospheric Research Staff (Eds.), 2016)

Drought Indices

- **Standardized Precipitation Evapotranspiration Index** (SPEI, Vicente-Serrano et al., 2010)
  - 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)
- *For a detailed overview of drought indices see e.g.:* Monacelli et al. (2005), Svoboda et al. (2016) or Zargar et al. (2011)
- Keyantash and Dracup (2002): The quantification of drought: an evaluation of drought indices

Effects of droughts on economy

Computable General Equilibrium (CGE)

- Consists of equations describing model variables and a database (input-output tables, SAM matrix)
- Assuming optimizing behaviour (cost minimizing producers, optimal households demands)
- **Robinson et al. (2010)**
  - Ethiopia, Social Accounting Matrix (SAM)
  - Model drought as a 20% reduction in crop productivity and 20% reduction of livestock capital
  - Effects of shocks in production on cereal prices and food consumption
  - Results in 2.3% decrease in total GDP
  - Includes a scenario with large-scaled inflow of wheat financed by rest of the world

Effects of droughts on economy

Computable General Equilibrium (CGE)

- **Robinson et al. (2010)**
  - 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

Effects of droughts on economy

Computable General Equilibrium (CGE) Models

- **Willenbockel (2011)**
  - 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
  - Climate change (incl. drought) modelled as changes in factor productivity (usually negative)

Effects of droughts on economy

Computable General Equilibrium (CGE)

Willenbockel (2011)

- Solves the within-country models and between-country trade relationships simultaneously
- 19 region, 12 sector/commodity group, 8 commodity groups

Fixed (inputs)	**Determined by model (outputs)**
Agricultural productivity growth	Production volumes of food commodities
Commodity shares in hh. expenditure	Production vol. per capita
Shares of import in demand (commodities)	World market food prices (change)
GDP growth rates	Domestic food price (change)
Population growth	Volumes of global trade
Shares of food in hh. expenditure	Aggregate index of consumption p.capita

Effects of droughts on economy

- **Lesk et al. (2016)**
  - National production losses per disaster (droughts, floods and extreme temperatures)
  - Worldwide, superposed epoch analysis
  - On average 10.1% reduction of cereal production can be linked to drought
- **Mehrabi and Ramankutty (2017)**
  - Cumulative production losses linked to extreme heat and drought events
  - Per years (53), countries (131), commodities (6)
  - Most severe losses in Botswana (5.7%), Paraguay (5.5%), Nigeria (4.8%)

Effects of climate and weather on economy

- Effects on food prices
  - **Brown and Kshirsagar (2015)**
    - Climate measured by NDVI vegetation index
    - Effects of NDVI and world food prices on local food prices
    - 20% prices affected by weather, 9% by international prices
- Effects on production (production function approach)
  - **Ochieng et al. (2016)**
    - Effect of climate variability and change on crop revenue
    - Augmented production function, Kenya
    - Household FE
  - **Deschenes and Greenstone (2007):** US county level, positive effect of global warming
- Effects on land prices or yields/acre (Ricardian analysis)
  - **Kabubo-Mariara and Karanja (2007):** Kenya, warming harmful
  - Seo et al. (2008) and Kurukulasuriya et al. (2008): mild and wet warming - positive, dry more severe warming - negative

My suggestion - panel estimation

My interest: **Effects of drought on economy in Kenya**

- **Response variable**
  - Volumes of production (crop specific, total)
  - Profit per acre (Deschenes and Greenstone, 2007)
    - (Value of agricultural products - prod. expanses)/acres (crops, pasture, grazing)
- **Units of analysis**
  - Counties in Kenya $\times$ year
- **Explanatory variable of interest**
  - Dummy variable (0/1) drought occurred in a particular county and year or not
  - Several varieties - various specifications of drought:

My suggestion - panel estimation

My interest: **Effects of drought on economy in Kenya**

- **Explanatory variable of interest**
  - Dummy variable (0/1) drought occurred in a particular county and year or not
  - Several varieties - various specifications of drought:
    - Drought index monthly - NDVI, SPI, SPEI
    - Drought index below a specific value (-1, -2 or -3)
      - At least for one month during a specific year
      - At least for one month during growing season in a specific year
      - At least for one month during long rains in a specific year
      - At least for two (three) consecutive months during a growing season in a specific year
      - At least for one month during two (three) consecutive growing seasons

My suggestion - panel estimation

My interest: **Effects of drought on economy in Kenya**

- **Explanatory variable of interest**
  - Dummy variable (0/1) drought occurred in a particular county and year or not
- **Units of analysis:** Counties in Kenya $\times$ year
- **Control variables ? - subject to availability**
  - GDP, soil quality data, population,average land area, average value assets, climate, degree days?
- **Estimation methods**
  - Fixed effects, SURE, Kalman filter, Box-Jenkins

My idea - panel estimation

$$Y_{i,t} = \alpha_i + \gamma_t + \delta D'_{i,t} + \beta \boldsymbol{X_{i,t}} + \epsilon_{i,t}$$

$Y_{i,t}$	=	Response variable (food production/price), county i in year t
α_i	=	Fixed effects, county i
δ	=	Effect of drought on economy
$D_{i,t}$	=	Indicator variable
		$D = 1$ if drought in county i in year t, $D = 0$ otherwise
β	=	Vector of effects of other covariates
$X_{i,t}$	=	Matrix of values of other covariates in county i in year t
$\epsilon_{i,t}$	=	Error term
γ_t	=	Year specific indicator?

Thank you for attention

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