Natural Disasters,
Financial Crisis and Global Agriculture

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Introduction

- There will be more, and more intense, extreme events such as droughts, floods and hurricanes;
- There is a lot of uncertainty about the location and magnitude of these changes;
- Developing countries are particularly vulnerable;
- Climate change has the potential to act as a ‘risk multiplier’ in some of the poorest parts of the world;

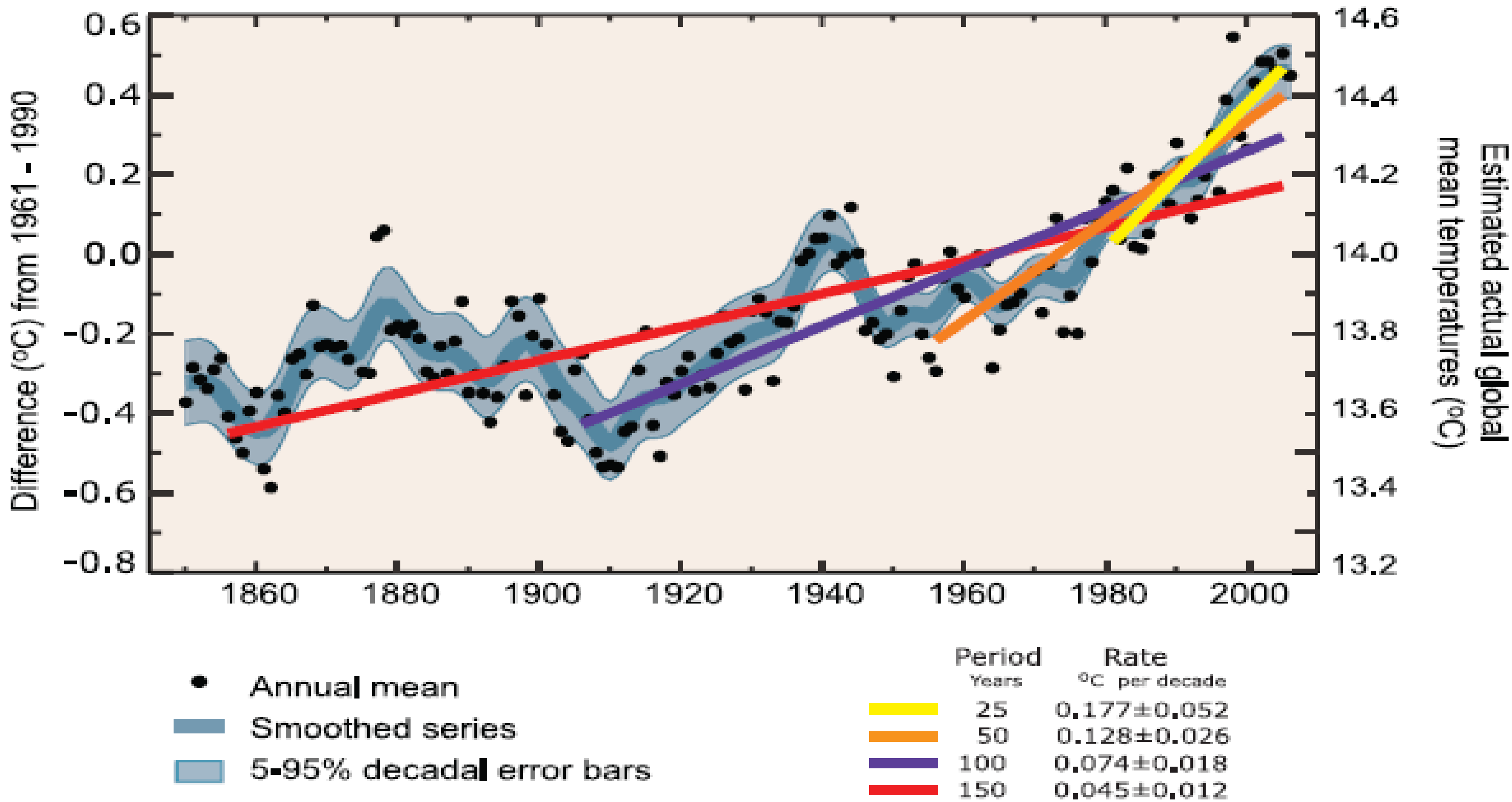
Introduction

- **Most development activities are sensitive to climate**
  - Current climate variability
  - Future climate change
- **Examples:**
  - Rain-fed agriculture is highly dependent on rainfall patterns
  - Agroforestry and forestry are sensitive to wind storms
  - Forest productivity depends on rainfall
  - Drinking water supply is highly dependent on rainfall and temperature
  - Infrastructure is sensitive to flooding

Source: www.cifor.org

Introduction

- Global Mean Temperature



Source: IPCC, 2007 Source: IPCC, 2001

Introduction

- Described as a change of climate which is attributed to human activity that transforms the composition of the global atmosphere;
- Climate change adds an extra burden to the attainment of the sustainable development objectives;
- Almost every sector is likely to be adversely impacted by climate change;
- The poorest people will likely suffer the most from climate change;
- The evidence clearly shows that ignoring climate change will eventually damage economic growth;

Background

- The intergovernmental panel on climate change: The climate of Earth would be 2–6 C warmer than in the pre-industrial era by the end of the 21st century, due to increases in greenhouse gases.

  - the warmest period on Earth for at least the last 1000 years, and probably the last 100 000 years.

- The large-scale warming is expected to be accompanied by increased frequency and/or intensity of extreme events, such as heat waves, heavy rainfall, and floods.

- The agricultural sector in both developing and developed countries is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms.

- Despite tremendous improvements in technology and crop yield potential, food production remains highly dependent on climate, because solar radiation, temperature, and precipitation are the main drivers of crop growth.

Background

- The financial crisis had a direct impact on commodity markets. For instance, declines in farm income and agricultural production values was a consequence of the commodity price declines.

- The speed with which global economic conditions have altered has been unprecedented, and has left many in agriculture uncertain about future prospects.

- High agricultural commodity prices fell during the second half of 2008, and many markets have since struggled to recover. That agricultural commodity prices would be suddenly impacted by a crash in world stock markets was a big surprise.

- However, economists showed close linkage between grain and oil prices, as the world turns to biofuels as a source of energy.

Objectives

- Various impact studies have considered the effects on global food production and prices of projected long-run trends in temperature, precipitation and CO^2 concentrations caused by climate change.

- Against a background of multiple crises—climate, fuel, food—the global financial crisis of 2007–09 has caused enormous damage to the world economy, resulting in the most severe global recession in generations.

- The financial crisis spread rapidly around the globe. Nearly all stock markets experienced bursts of volatility. Lin (2009, p. 2) points out that the current economic downturn is “possibly turning a short-run macroeconomic adjustment into a long-term development problem.” But empirical evidence on the impact of economic volatility on global agricultural production remains sparse.

- This study looks at whether inflation and output volatility (financial crisis indicators) as well as drought and flood (extreme weather indicators) have a significant impact on global agricultural production and technical efficiency

Methodology: Stochastic Frontier Analysis

- The object is to estimate not the average production or average cost, but the maximum possible production given a set of inputs or the minimum possible cost of a set of outputs.
- OLS regression estimates the mean of the dependent variable conditional on the explanatory variables;
- It is a *parametric* technique that uses standard production function methodology.
- The approach explicitly recognizes that production function represents technically maximum feasible output level for a given level of output.

Stochastic Frontier: Model Specification

OLS: $q_i = \beta_0 + \beta_1 x_i + v_i$

Deterministic : $q_i = \beta_0 + \beta_1 x_i - u_i$

SFA: $q_i = \beta_0 + \beta_1 x_i + v_i - u_i$

where

v_i = “noise” error term - symmetric (eg. normal distribution)

u_i = “inefficiency error term” - non-negative (eg. half-normal distribution)

- We start with the general production function as before and add a new term that represents technical inefficiency.
  - This means that actual output is less than what is postulated by the production function specified before.
  - We achieve this my subtracting *u* from the production function
  - Then we have $$\ln q_i = \beta_0 + \beta_1 \ln x_i + v_i - u_i$$

Stochastic Frontier: Model Specification

$$q_i = \exp(\beta_0 + \beta_1 \ln x_i) \times \exp(v_i) \times \exp(-u_i)$$

deterministic component — noise — inefficiency

In general, we write the stochastic frontier model with several inputs and a general functional form (which is linear in parameters) as

$$\ln q_i = \mathbf{x}_i' \boldsymbol{\beta} + v_i - u_i$$

- We stipulate that u_i is a non-negative random variable
- By construction the inefficiency term is always between 0 and 1.
- This means that if a firm is inefficient, then it produces less than what is expected from the inputs used by the firm at the given technology.
- We can define technical efficiency as the ratio of “observed” or “realized output” to the stochastic frontier output

$$TE_i = \frac{q_i}{\exp(\mathbf{x}_i' \boldsymbol{\beta} + v_i)} = \frac{\exp(\mathbf{x}_i' \boldsymbol{\beta} + v_i - u_i)}{\exp(\mathbf{x}_i' \boldsymbol{\beta} + v_i)} = \exp(-u_i)$$

Panel data models

- Data on N firms over T time periods
- Investigate technical efficiency change (TEC)
- Investigate technical change (TC)
- More data = better quality estimates
- Less chance of a one-off event (eg. climatic) influencing results
- Can use standard panel data models
  - no need to make distributional assumption
  - but must assume TE fixed over time
- The model: $i=1,2,\ldots N$ (cross-section of firms); $t=1,2\ldots T$ (time points)

$$\ln y_{it} = x_{it}\beta + v_{it} - u_{it} ; v_{it} \approx N(0,\sigma_v^2); u_{it} \approx N^+(0,\sigma_u^2)$$

Panel data models

Some Special cases:

1. Firm specific effects are time invariant: $u_{it} = u_i$.
2. Time varying effects: Kumbhakar (1990)

$$u_{it} = \left[1 + \exp(bt + ct^2)\right]^{-1} u_i$$

3. Time-varying effects with convergence – Battese and Coelli (1992)

$$u_{it} = \left[\exp\{-\eta(t - T\}\right] u_i$$

Sign of η is important. As t goes to T, u_{it} goes to u_i.

Inefficiency Effects Model

- Inefficiency effects model (Battese, Coelli 1995)

$$\ln y_{it} = x_{it}\beta + v_{it} - u_{it}; u_{it} = N_{+}(z_{it}\delta, \sigma_u^2)$$

where δ is a vector of parameters to be estimated.

Data Description

- **135 Countries**
- **Dependent variables - “5-year-average“ (FAO DATA 1980-2010)**
  - tvalue - Net agricultural production value (constant 2004-2006 1000 I$, Crops (PIN) + (Total)) (1000 Int. $)
- **Basic repressors - “5-year-average“ (FAO DATA 1980-2010)**
  - labor - Total economically active population in Agriculture, the sum of female and male
  - arable - Arable land (hectares)
  - fert - Fertilizer consumption (UREA in tonnes)
  - mach - Agricultural machinery (total tractors) from FAO
- **Climate Change variables – (International Disaster Database 1980-2010)**
  - dr_damage - estimated damage costs from drought in US$(,000)
  - fd_damage - estimated damage costs from flooding in US$(,000)
- **Financial Crisis variables – (WDR 1980-2010) "volatility or standard deviation over t-year"**
  - vgr - GDP per capita growth (annual %) - output volatility
  - vinfl - Inflation, GDP deflator (annual %) - inflation volatility

Empirical Results and Discussion

Full Sample			High Income Countries		Developing Countries		Low Income Countries		Middle Income Countries	
tvalue	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z	Coef.	P>z
vinfl	-0.048	0.000	-0.045	0.054	-0.041	0.000	0.006	0.743	-0.049	0.000
vgr	-0.050	0.002	-0.080	0.018	-0.038	0.028	-0.046	0.052	-0.019	0.393
dr_damage	0.002	0.472	0.002	0.485	0.004	0.217	-0.017	0.023	0.007	0.035
fd_damage	0.009	0.001	-0.001	0.799	0.008	0.004	-0.003	0.505	0.011	0.002
arable	0.338	0.000	0.182	0.205	0.292	0.000	0.323	0.002	0.310	0.000
labor	0.346	0.000	-0.037	0.644	0.477	0.000	0.816	0.000	0.466	0.000
fert	0.104	0.000	0.111	0.000	0.090	0.000	0.043	0.029	0.094	0.000
mach	0.109	0.000	0.035	0.435	0.070	0.005	-0.014	0.714	0.040	0.206
_cons	6.061	0.000	13.260	0.000	6.303	0.000	3.031	0.007	6.326	0.000
/mu	1.088	0.000	0.883	0.693	1.305	0.000	0.734	0.027	1.010	0.000
/lnsigma2	-0.586	0.008	1.702	0.111	-0.541	0.013	-1.314	0.007	-0.432	0.165
/ilgtgamma	2.877	0.000	6.227	0.000	2.984	0.000	2.779	0.000	3.061	0.000
sigma2	0.556		5.487		0.582		0.269		0.649	
gamma	0.947		0.998		0.952		0.942		0.955	
sigma_u2	0.527		5.476		0.554		0.253		0.620	
sigma_v2	0.030		0.011		0.028		0.016		0.029	
TE	0.625		TE	0.966	TE	0.644	TE	0.889	TE	0.764

Empirical Results and Discussion

	Estimate	Std. Error	z value	Pr(>|z|)				Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	0.063	0.006	10.754	0.000			(Intercept)	0.001	0.000	6.316	0.000
arabledum_high	0.760	0.022	35.073	0.000			arabledum_low	0.692	0.004	154.140	0.000
labordum_high	0.267	0.023	11.627	0.000			labordum_low	0.875	0.030	29.186	0.000
fertdum_high	0.181	0.026	7.025	0.000			fertdum_low	-0.147	0.005	-27.688	0.000
machdum_high	0.062	0.031	2.003	0.045			machdum_low	-0.188	0.020	-9.339	0.000
Z_(Intercept)	-0.916	0.072	-12.696	0.000			Z_(Intercept)	-4.410	0.164	-26.823	0.000
Z_vgrdum_high	0.455	0.048	9.533	0.000			Z_vgrdum_low	1.179	0.036	32.446	0.000
Z_vinfldum_high	0.024	0.046	0.530	0.596			Z_vinfldum_low	1.245	0.043	29.166	0.000
Z_dr_damagedum_high	0.056	0.004	13.004	0.000			Z_dr_damagedum_low	0.019	0.015	1.291	0.197
Z_fd_damagedum_high	0.153	0.004	35.952	0.000			Z_fd_damagedum_low	0.140	0.010	13.482	0.000
sigmaSq	0.09	0.00	25.99	0.00			sigmaSq	0.48	0.02	24.10	0.00
gamma	0.97	0.01	71.94	0.00			gamma	0.99	0.00	8189405.00	0.00