A HISTORICAL PERSPECTIVE ON AGRICULTURE

David R. Johnson
Assistant Professor of Industrial Engineering and Political Science
Purdue University

June 7, 2019
Outline

• Historic development goals and agriculture
• Cost of agricultural expansion
  - Cropland expansion
  - Intensification
  - Water use in agriculture
• What drives agriculture?
  - Historical validation with SIMPLE
United Nations Development Goals

1960-1970 - 1st Development Decade
1971-1980 - 2nd Development Decade
1981-1990 - 3rd Development Decade
1991-1999 - Human Development Reports
2000-2015 - Millennium Development Goals
2016-2030 - Sustainable Development Goals
Agriculture Is at the Heart of the UN’s Economic Development Goals

- Majority of the world’s rural poor rely on farming for income and livelihood
- Primary source of economic growth from most of the world’s countries
- Precursor for industrialization
- *But because it is closely tied to the environment, agriculture can create both good and bad environmental outcomes*
Agricultural Production Grew Sharply After the 1960s

Historical Corn Production

- U.S.
- Rest of World

Index (1=1961)

Year

Agricultural Production Grew Sharply After the 1960s

Figure 1. Total and per capita agricultural production.
Growth in Agriculture Has Reduced Rural Poverty

Figure 2  Agriculture’s contribution to growth and the rural share in poverty distinguish three types of countries: agriculture based, transforming, and urbanized.
Growth in Agriculture Has Improved Food Security

Figure 5. Food consumption per capita.

Source: FAO (2006a)
However, the Sources of That Growth Have Shifted over Time

Greater Quantities of Marginal Land Have Been Converted to Crops

Cropland cover expansion: 1700-1900

Source: Navin Ramankutty, McGill University
Greater Quantities of Marginal Land Have Been Converted to Crops

Cropland cover expansion: 1900-1950

Source: Navin Ramankutty, McGill University
Greater Quantities of Marginal Land Have Been Converted to Crops

Cropland cover expansion: 1950-2000

Source: Navin Ramankutty, McGill University
Greater Quantities of Marginal Land Have Been Converted to Crops

Cropland cover expansion: 2000

Source: Ramankutty et al (2008), Global Biophysical Cycles
The Cost of Growth: Agricultural Land Use Expansion

• Lepers *et al* (2005) surveys “hotspots” of change over the period 1980-2000:
  - Changes in cropland cover are small in aggregate, but considerable changes in composition
  - Deforestation
  - Soil degradation

• While deforestation is not new, the current pace is unprecedented and unsustainable
The Cost of Growth: Deforestation Hotspots in the Tropics

Forest cover change, 1980-2000

Source: Lepers et al (2005)
The Cost of Growth: Groundwater Depletion for Irrigation

Irrigated land expansion and water use
The Cost of Growth: Groundwater Depletion for Irrigation

Irrigated land expansion and water use

Nonrenewable groundwater abstraction for irrigation, 2000 (million m³/yr)
The Cost of Growth: Hypoxia from Nitrogen-Use Inefficiency

Change in nitrogen application rate, 1960-2010
The Cost of Growth: Hypoxia from Nitrogen-Use Inefficiency

Nitrogen Use Efficiency by Country over Time, 1960-2010
So, Can We Improve Agriculture Policies and Practices to Reduce These Costs?

As one step toward doing so, we need to understand what drives long-run changes in the agricultural system.
Outline

• Historic development goals and agriculture
• Cost of agricultural expansion
  - Cropland expansion
  - Intensification
  - Water use in agriculture
• What drives agriculture?
  - Historical validation with SIMPLE
SIMPLE provides a tool to understand long-run agricultural patterns

**Crop Demand**
- Income
- Population
- Biofuels

**Crop Markets: Local & Global**

**Crop Supply**
- Land Inputs
- Productivity Growth

**Intensive Margin of Supply**
- Non Land Inputs
- Elasticity of Input Substitution

**Extensive Margin of Supply**
- Land Supply Response
- Non Land Supply Response

**Income Elasticity of Demand**
**Price Elasticity of Demand**

Food Prices
SIMPLE Has Been Validated Against Global Historic Observations

Drivers of world agriculture: 1961-2006

Population (B persons)

- 1961: 3.1
- 2006: 6.6

GDP per pax (K $ 2010)

- 1961: 3.8
- 2006: 9.2

Farm Productivity (1961=100)

- 1961: 100
- 2006: 150

SIMPLE Has Been Validated Against Global Historic Observations

Global Outcomes

Crop Output\(^1\)
- 200% +7.0 B MT

Crop Land\(^2\)
- 16% +164 M ha

\(^1\)Price-weighted output of 135 crops, relative to world corn price

\(^2\)Arable land and permanent cropland
SIMPLE Has Been Validated Against Global Historic Observations

Global Outcomes

Crop Output

% total change: 1961-2006

Actual Data | Total | Subtotals
---|---|---
Crop Output | 200% | 190%

Crop Land

% total change: 1961-2006

Actual Data | Total | Subtotals
---|---|---
Crop Land | 16% | 18%

1 Price-weighted output of 135 crops, relative to world corn price.
2 Arable land and permanent cropland.
Historical drivers of global crop output have varied greatly across regions

- In sub-Saharan Africa, population growth accounted for nearly all output expansion, but in China, this accounted for less than half of the total.
- How would history have differed if the agricultural economy had been globalized?
- Alternatively, how would history have differed without free trade such as NAFTA?
Conclusions

• Agriculture is tied to both economic development and environmental issues
  - Agriculture has helped reduce poverty and improve food security, but at the expense of the environment
  - We are exceeding planetary boundaries in some regions

• Thus, compared to previous UN goals, the SDGs for 2030 emphasize both environmental and economic outcomes
Conclusions

• Historically, agricultural production has been driven by three main forces
  - Population – more mouths to feed
  - Income – more diverse food demands
  - Agricultural productivity – producing more out of available inputs

• Future trends in these global forces will likely reshape agriculture
  - Regional/subnational constraints will also shape agriculture, especially if these are addressed
THANK YOU!