Lessons from Country Studies of Farm Productivity

presented at pre-conference

"Sustainability, Productivity, and Public Policies:
Synergies to Improve Agricultural Economic Development"

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An Overview

Two investigative approaches:

1. Evaluate the economic policies accelerating or decelerating a country's agricultural productivity

In many cases this requires

- developing new, sub-national (state, provincial, or regional) TFP estimates;
- collecting country-specific economic policy information, such as public investments in agricultural research, transportation infrastructure, and education, as well as how a country's economic policies affect producer incentives;
- collecting international and private agricultural research information.

Coverage: Brazil, Russia, India, Indonesia, China, sub-Saharan Africa

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An Overview

Two investigative approaches:

2. Examine how agricultural structure affects farm productivity across both rich and poor countries
   - Studies draw on new panels of farm-level data to revisit the relationship between farm productivity and size
   - Estimate that relationship using TFP instead of yields;
   - Analyze not only how TFP compares over space but also how TFP changes over time;

Coverage: Australia, the U.S., Brazil, Mexico, Bangladesh, Ghana, Malawi, Tanzania, Uganda, Vietnam

R&D based TFP growth

'Trade' based TFP growth

How has policy affected TFP?

- Brazil
  - Rada and Buccola (2012)
  - Rada and Valdes (2012)
- India
  - Rada and Schimmelpfennig (2015)
  - Rada and Schimmelpfennig (under review)
- China
  - Wang, Rada, and Qin (2014)
  - Rada, Wang, and Qin (2015)
- Indonesia
  - Fuglie (2004) & (2010)
  - Rada, Buccola, and Fuglie (2011)
  - Rada and Fuglie (2012)
- Sub-Saharan Africa
  - Fuglie and Rada (2013) & (2016)
- Russia
  - Rada, Liefert, and Liefert (2016)

Brazil, micro-region census data from 1985,1995,2006

TFP Decomposition:

Crop TC = 2.9%
Live TC = 7.5%
Total TC = 4.5%

EC = - 1.9%

TFP Δ = 2.6%

Efficiency Determinants:

NC = - 2.1%
RR = 0.0%
Road = 0.08%
Credit = 0.06%
School = 0.10%

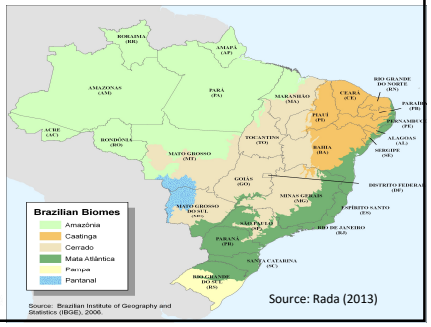
n = 1,617

Variables: NC is a stock of Embrapa's National Commodity Research expenditure stock;
RR is a stock of Embrapa's Regional Resource Research expenditure stock;
Road reflects state-level road density;
Credit reflects state-level, one-year lagged rural credit (value per contract); and
School reflects a state's number of secondary schools per state population.

Source: Rada and Valdes (2012); Rada and Buccola (2012)

Brazilian Cerrado, micro-region census data from 1985,1995,2006

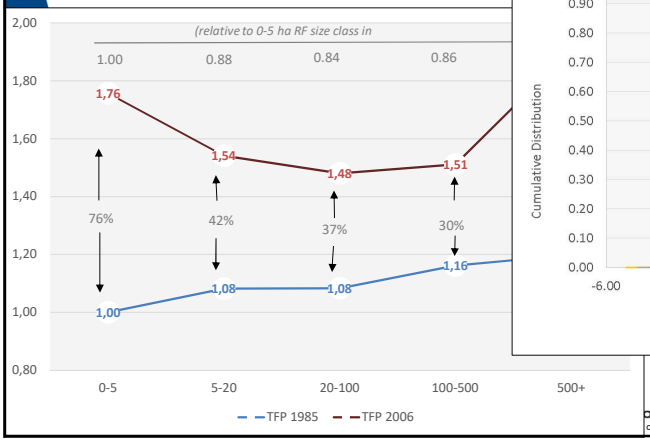
- First to employ environmental (biome) rather than political boundaries to characterize Brazilian agriculture
- Hypothesis: Cerrado's soils require significant investments in the material inputs to improve nutrient health composition for commercial exploitation
  - Fact: The Cerrado's share of national material expenditures rose from 23% in 1985, to 25.8% in 1995, to 43.7% in 2006. By 2006, the Cerrado accounted for 49.2% of national fertilizer expenditures and 48% of national pesticide expenditures.
- Results:
  - Crops technical progress: 4.47% per annum
  - Livestock technical progress: 4.70% per annum
  - Aggregate technical progress: 4.58% per annum
  - Efficiency change: -4.17% per annum
  - Total Factor Productivity Growth Rate: 0.40%
- Factors accelerating agricultural TFP growth:
  - Paved roads boosted technical progress (output elasticity of 0.9)

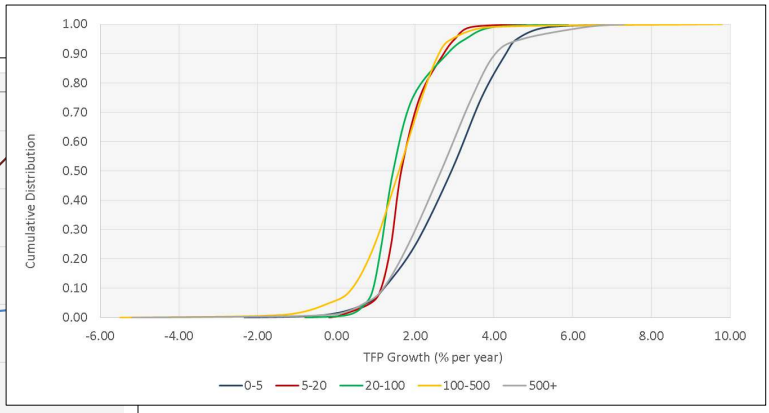


Source: Rada (2013)

Brazil, representative farms (municipality x 5 farm size classes) from census data from 1985,1995,2006

- Which farm size class (0-5 ha; 5-20 ha; 20-100 ha; 100-500 ha; 500+ ha) had the highest TFP levels and growth?





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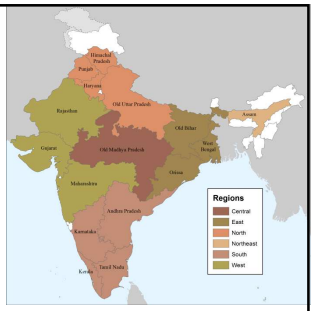
or USDA.

Source: Rada , Helfand, and Magalhães (under review)

India, state-level data, 1980-2008



- Crop growth has been increasingly reliant on irrigation-induced area expansion and output diversification to higher-valued commodities; contribution from yields has long declined.
- Agricultural growth has shifted away from the northern 'grain belt' to broader national participation, led by rapid growth in high-value horticultural and animal products.
- Despite the changing sources of crop growth, public investment in R&D had the largest marginal effect among policies evaluated, followed by irrigation.

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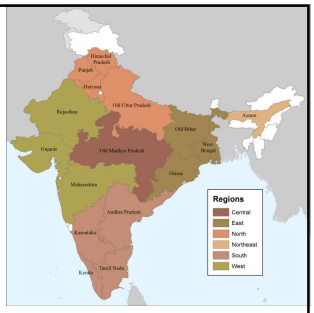
Source: Rada (2016); Rada and Schimmelpfennig (2015)

India, state-level data, 1980-2008



- Regional differences were prominent:
  - The North and West regions had the greatest rate of formal technical change in agriculture; the East the slowest.
  - The North also had the highest rate of return to public research – the East had the least.
  - The South increased TFP primarily through technical efficiency gains, and had the greatest TFP growth.
- Overall, the technical progress and productivity growth easily attributable to government-supported research and university education has been rather low. "Formal TFP" was 0.45%/year. But replacing public research with *t* gives 1.93%/year, nearly identical to Rada's (2016) index number estimates.
- The bulk of growth has come instead from non-research, non-university factors like irrigation, primary education, learning-by-doing, and new farm output mixes.

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Source: Rada and Schimmelpfennig (in review)

Indonesia, provincial-level data, 1985-2005

- Decomposing TFP, we find:
  - Perennial crop technical progress: 4.78% per annum
  - Annual crop technical progress: 3.66% per annum
  - Livestock technical progress: 1.48% per annum
  - Aggregate technical progress: 2.45% per annum
  - Efficiency change: -0.20% per annum
  - TFP Growth Rate: 2.2% per annum
- Factor accelerating agricultural TFP growth
  - Economic reforms boosted technical progress

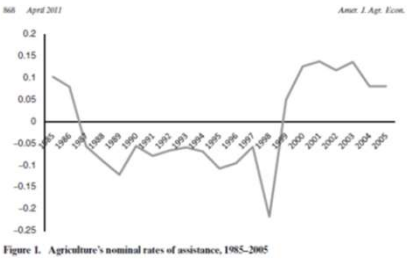

Figure 1. Agriculture's nominal rates of assistance, 1985–2005

- Extended Rada, Buccola, and Fuglie (2011) by examining the role of domestic and international R&D. Economic reforms remained the most influential determinant, but investments in agricultural research (especially for plantation crops), and public investments in agriculture and irrigation were also important.

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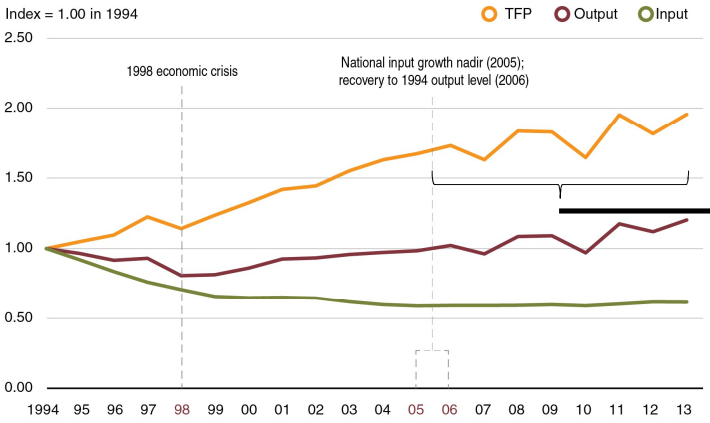
Source: Rada , Buccola, and Fuglie (2011); Rada and Fuglie (2012)

Russia, oblast-level data, 1990-2014

Figure 12
Russia's agricultural TFP growth



TFP = Total factor productivity.
Source: USDA, Economic Research Service using Russian Federal State Statistics Service and Ministry of Agriculture data.

Annual average TFP growth over 2005-2013 period was 1.7%

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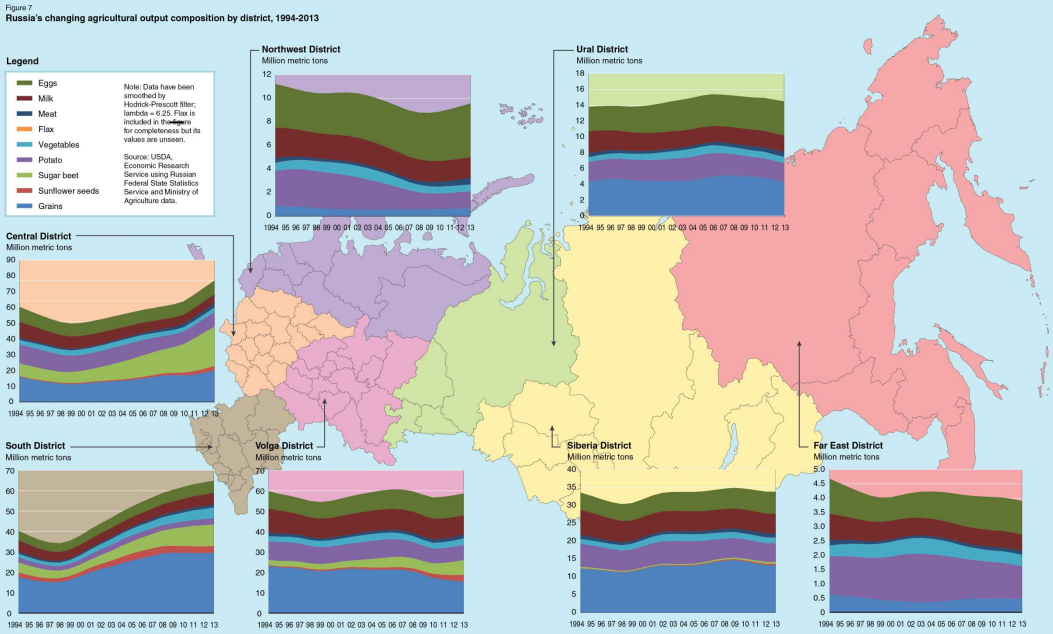
Source: Rada , Liefert, and Liefert (2017)

Figure 7
Russia's changing agricultural output composition by district, 1994-2013

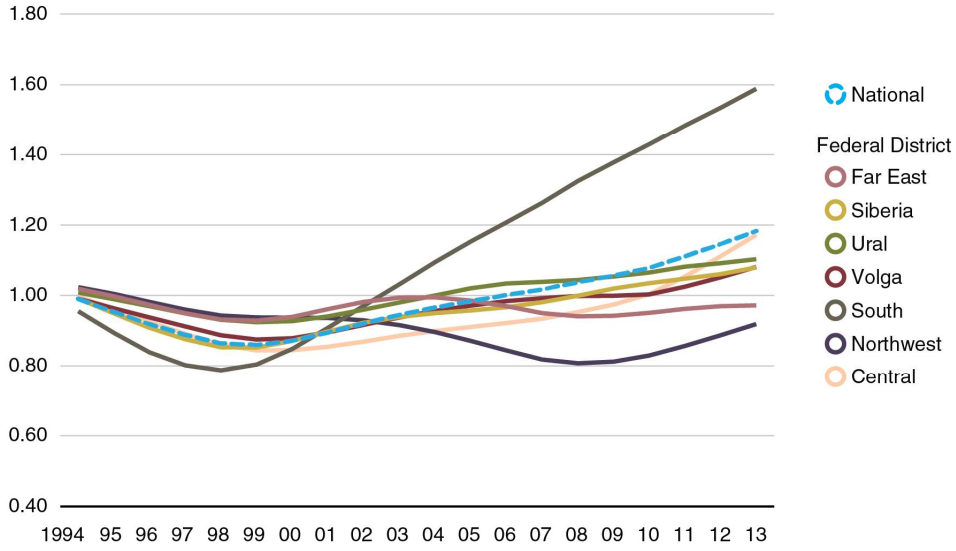


Source: Rada , Liefert, and Liefert (2017)

Figure 13

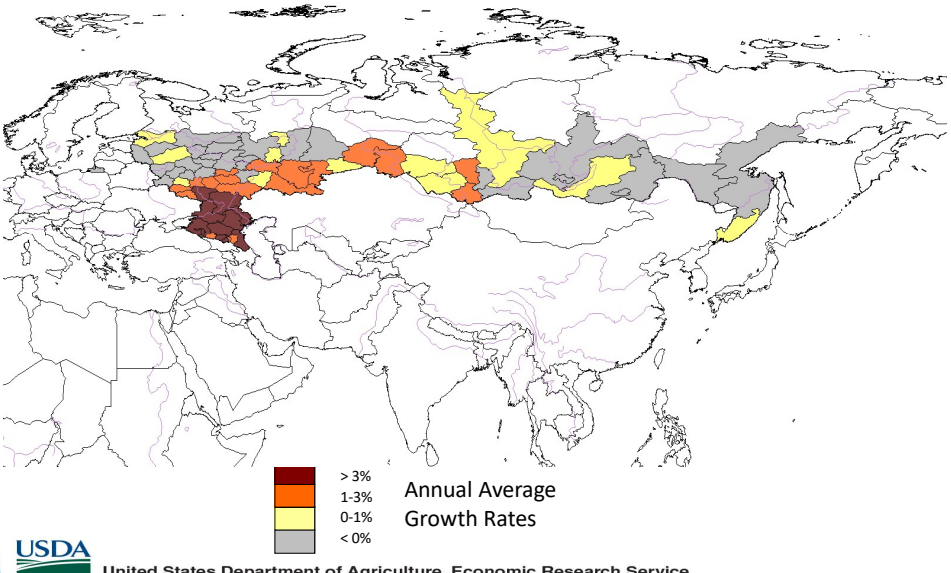
Russia's rebounding agricultural output led by the South district

Index = 1.00 in 1994



Note: Data have been smoothed by Hodrick-Prescott filter; lambda = 6.25.
Source: USDA, Economic Research Service using Russian Federal State Statistics Service and Ministry of Agriculture data.

Russian ag output growth, 1994-13
(highlighted areas account for 99% of Russia's ag output)



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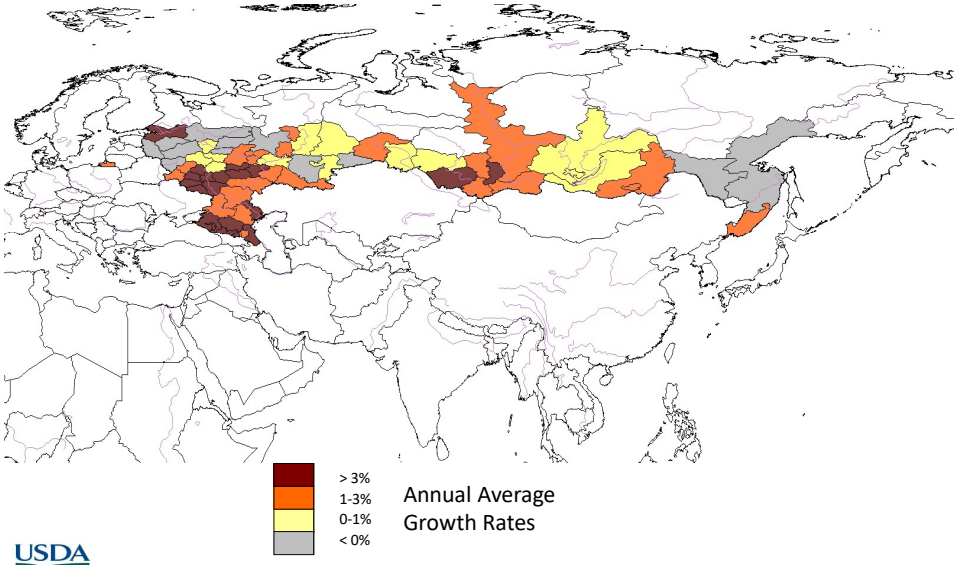

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SSA, national-level FAO data, 1961-2008

- Agricultural TFP growth averaged 0.59% per annum. But, between 1985 and 2008, TFP accelerated to 1.07% per annum
- Factors accelerating agricultural TFP growth
  - Domestic public agricultural research investments
  - International (CGIAR) research investments
  - Economic reforms
  - Education
- Factors decelerating agricultural TFP growth
  - Armed conflict
  - Spread of HIV/AIDS virus
- Internal Rate of Return to Research: 24% without CGIAR; 29% with CGIAR research linkages.
- No systematic differences in the rates of return to agricultural research and development (R&D) among small, midsize, and large countries were found.

Source: Fuglie and Rada (2013) & (2016)

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China, nationally representative house-hold farm data

- Hired labor use on very small-scale farms was surprisingly prevalent, in contrast to previously published data.
- Labor hiring responded strongly to market signals and resource constraints, and the response is particularly robust for wheat, rice, and maize.

Source: Rada, Wang, and Qin (2012)

- No statistically significant effect of family members' outmigration on the number of days family laborers worked in rice production.
- Rice-producing households did not invest migrant remittances in labor-saving farming technologies:
  - income from migrant labor only slightly boosted chemical use and had no effect on expenditures for animal draft power or machinery services.

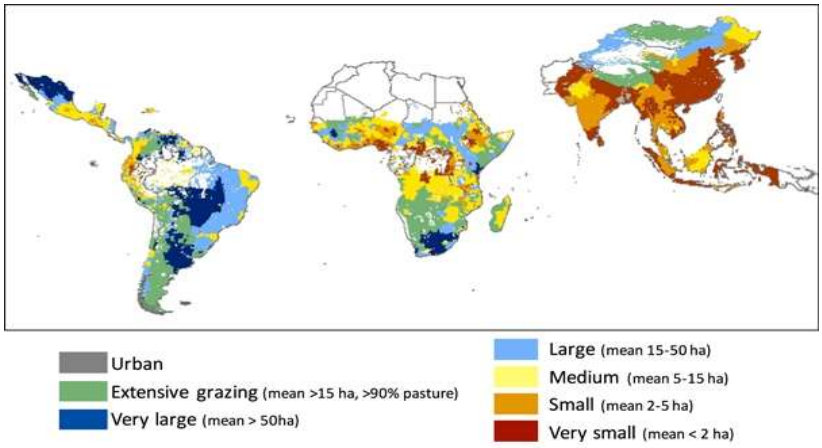
Source: Wang, Rada, Qin, and Pan (2014)

China, nationally representative household farm data

- Ex-ante analysis of whether China's farm-size expansion policy would affect national food security;
- Consolidation opportunities are available in the principal grain-producing regions; consolidation would likely occur without government intervention under minimal transaction costs;
- The substantial subsidies provided to the sector may bring greater mechanization but not necessarily widespread technological progress.

Source: Rada, Wang, and Qin (2015)

Why is agricultural structure important?



Source: Figure 1 from Subnational distribution of average farm size and smallholder contributions to global food production. Leah H Samberg et al 2016 Environ. Res. Lett. 11 124010 doi:10.1088/1748-9326/11/12/124010

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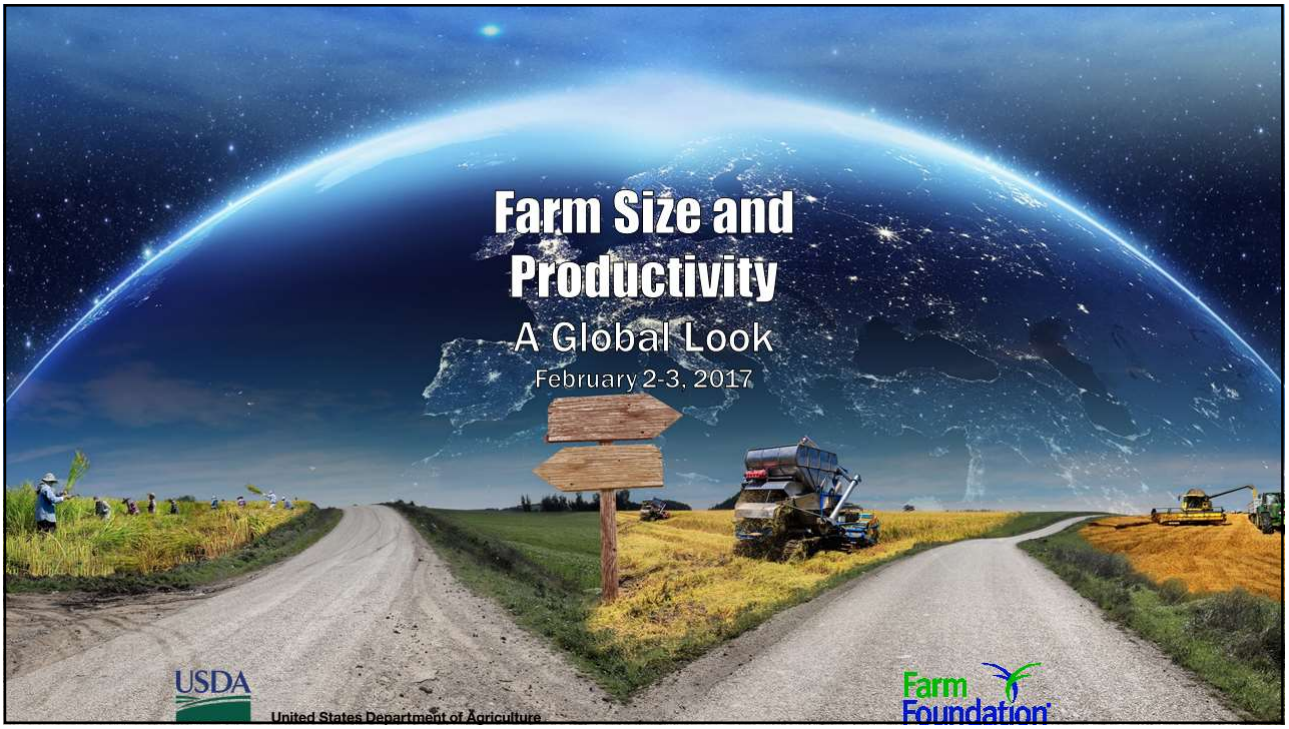
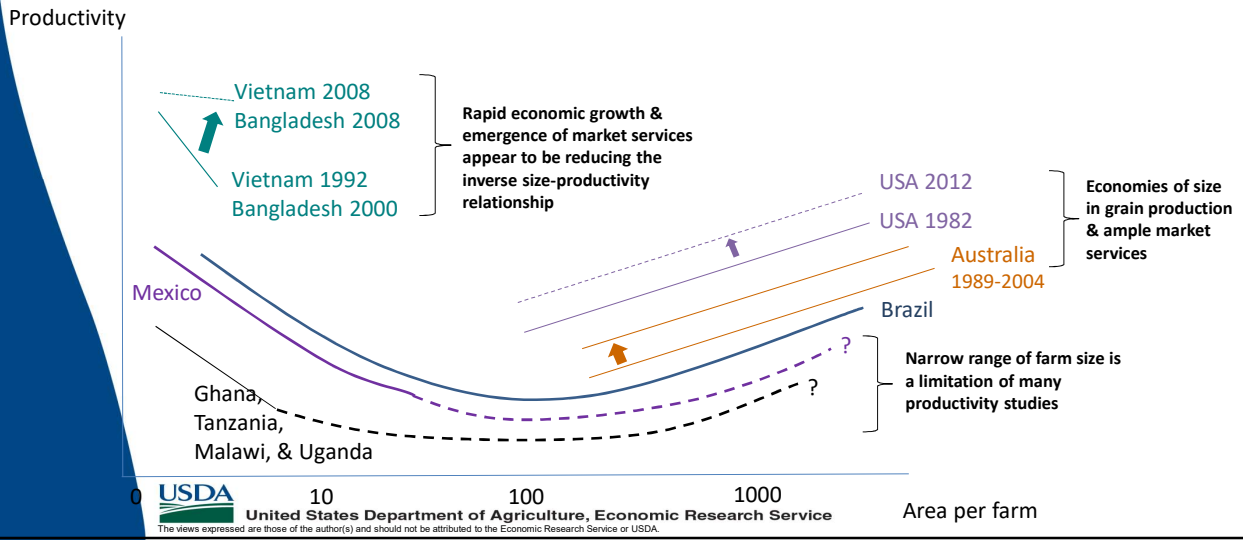


Farm Size and Productivity: A Global Look

Broad Findings



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Questions?

Please visit our website at:
www.ers.usda.gov

ERS' International Agricultural TFP Dataset is available at:
http://www.ers.usda.gov/data-products/international-agricultural-productivity.aspx

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