African Agricultural R&D and Productivity Growth in a Global Setting

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Food Security and the Environment
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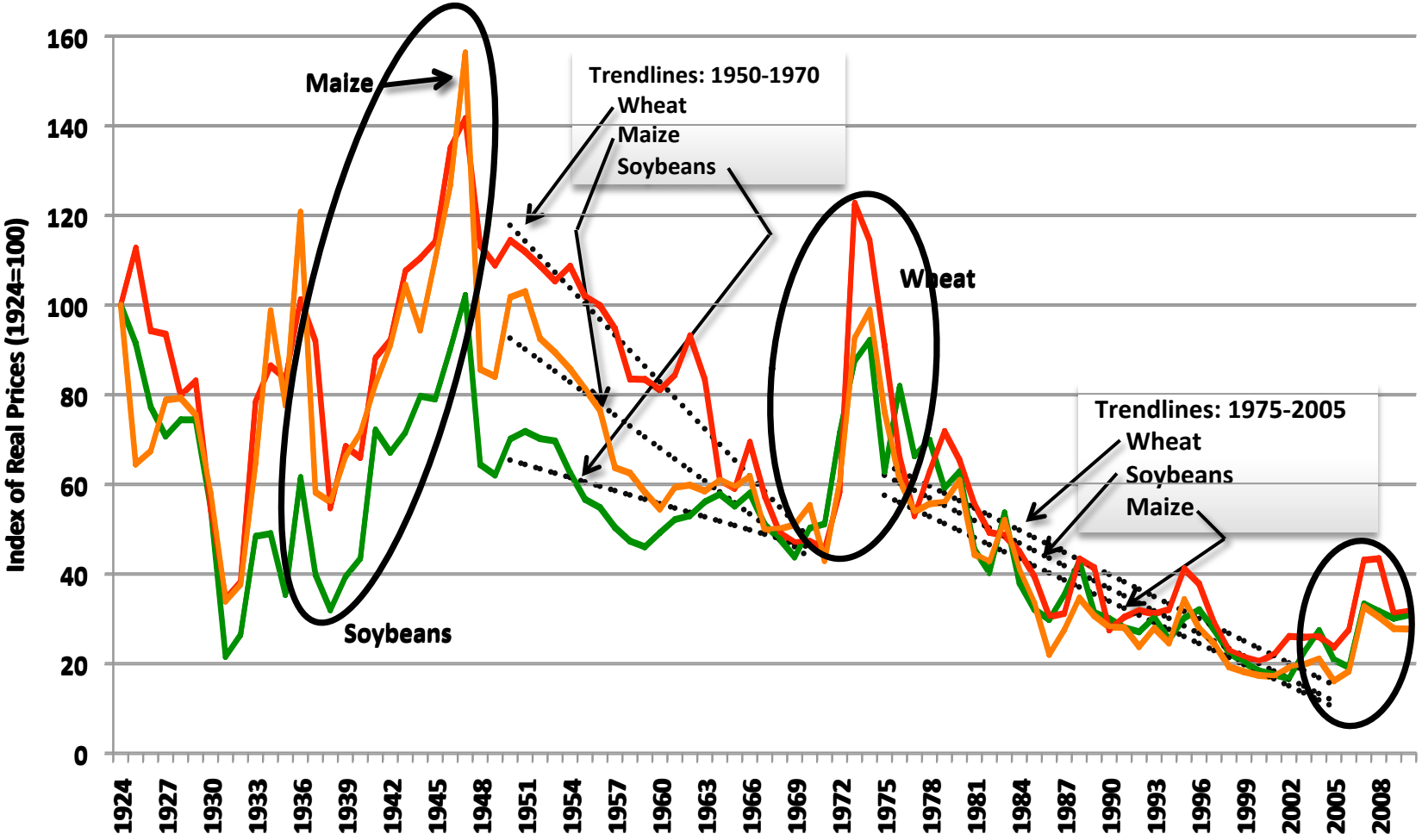
INSTEPP INTERNATIONAL SCIENCE & TECHNOLOGY PRACTICE & POLICY

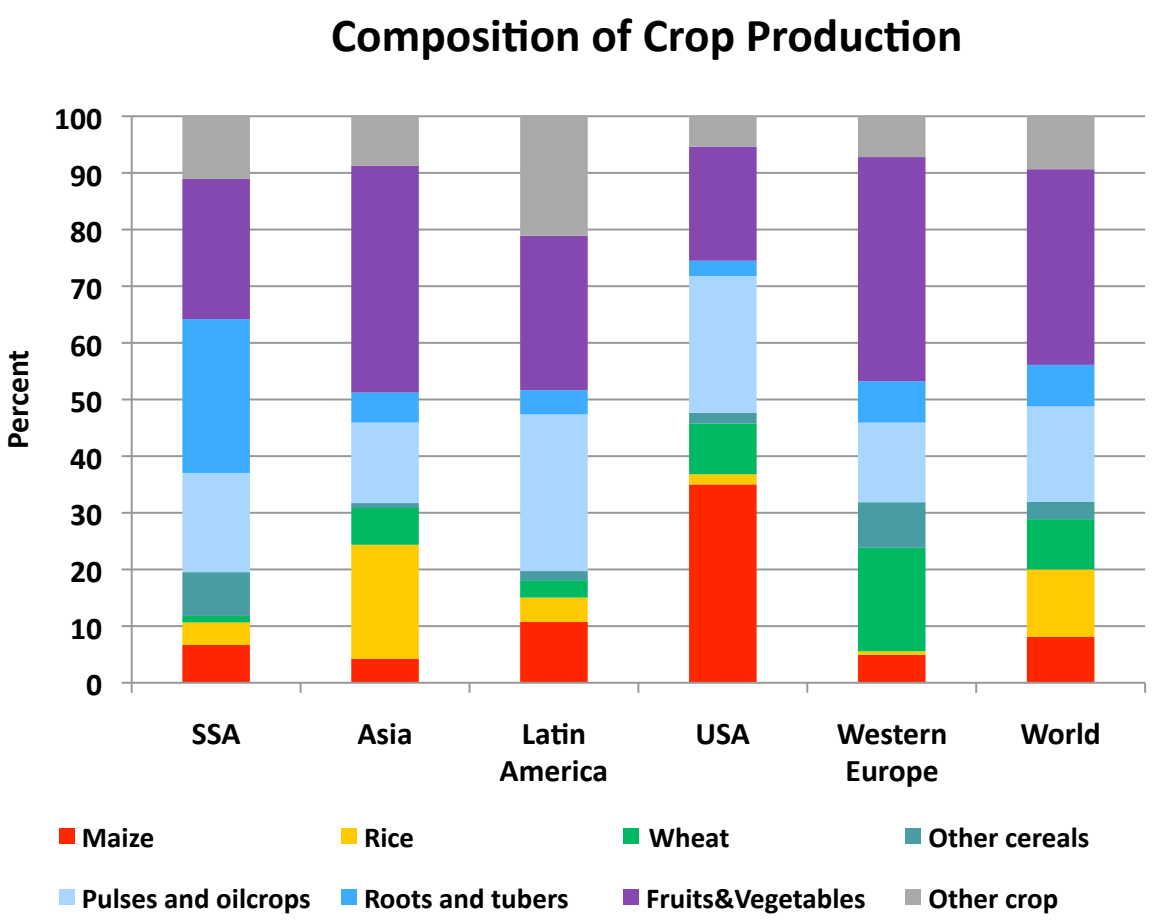
HarvestChoice Better Choices, Better Lives

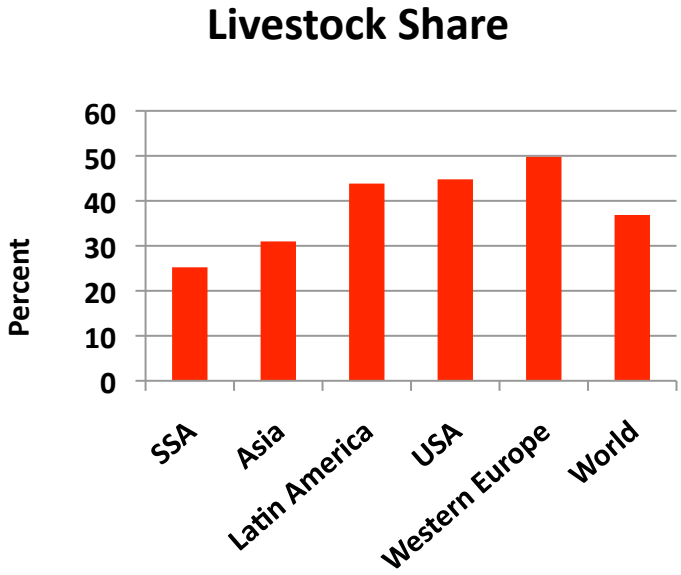
Deflated U.S Commodity Prices, 1924-2010 (CPI deflator)



Production and Productivity
Relativities and Trends

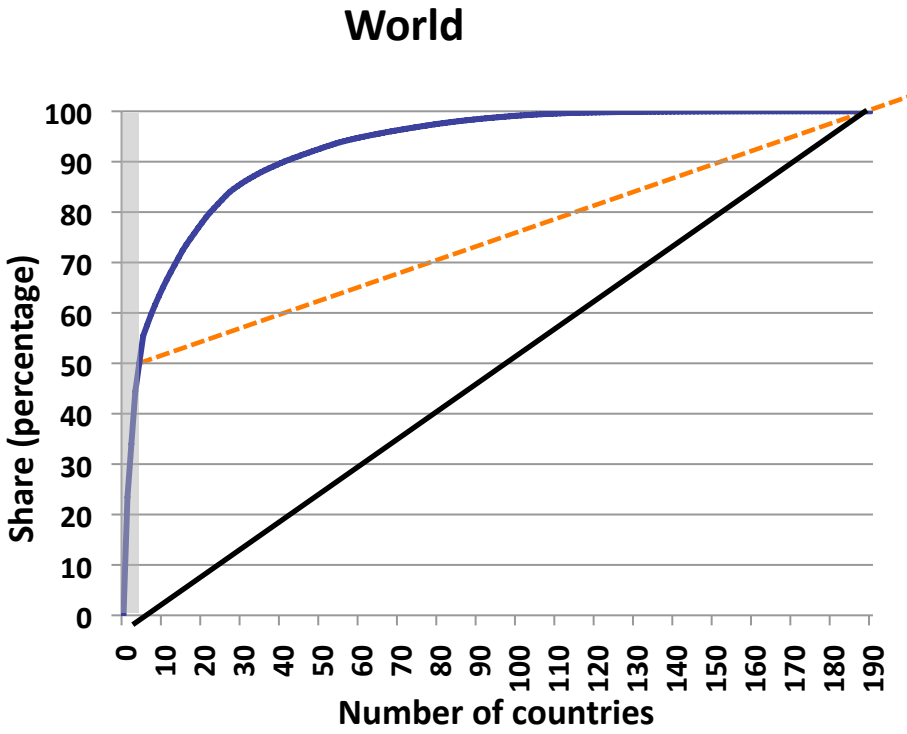
Global Structure of Production, 2007-2009 average



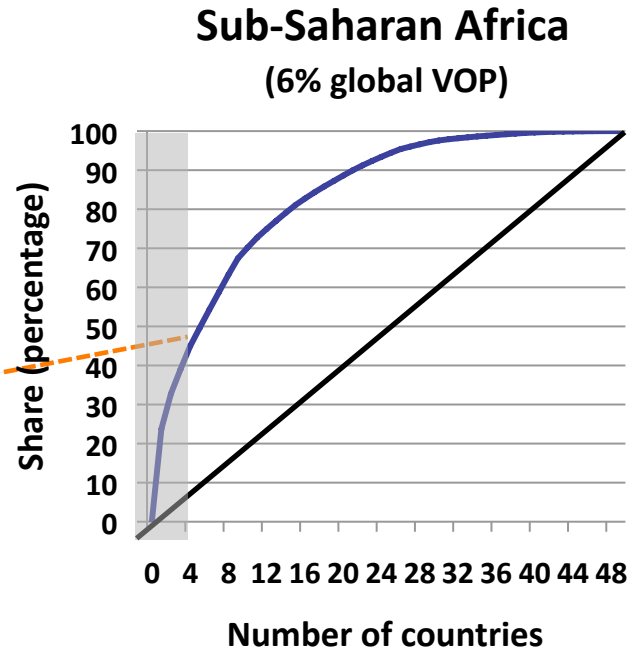


Shares of value of production (1999-2001 PPP prices)

Spatial Concentration of Production, 2007-09 average



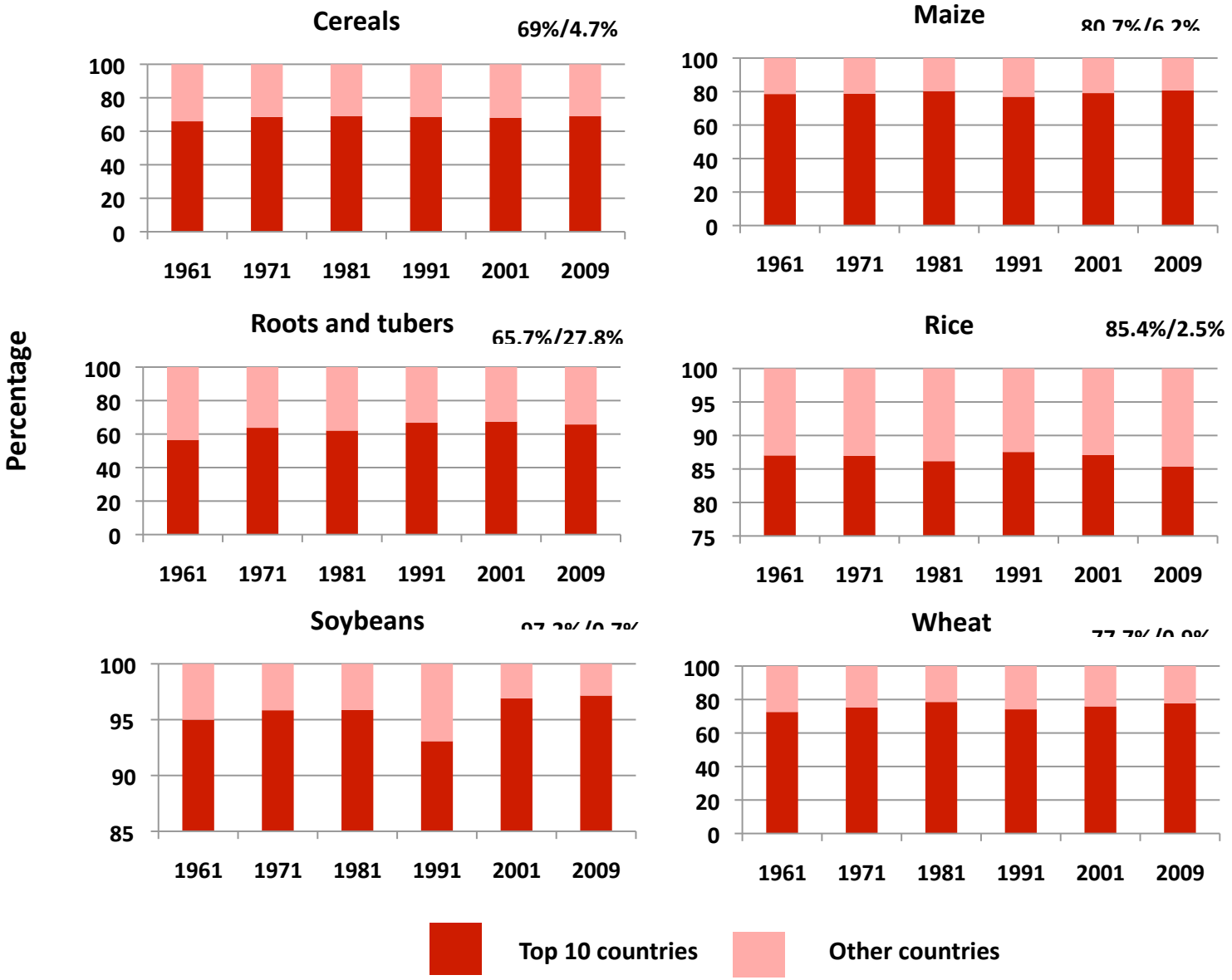
Country	Cumulative Share (%)
China	23.4
USA	34.0
India	44.4
FSU	50.0
Brazil	55.4



Country	Cumulative Share (%)
Nigeria	23.8
Sth Africa	32.8
Ethiopia	39.0
Sudan	44.9
Uganda	49.6
Tanzania	54.2
Kenya	58.7

Source: Pardey (in preparation)

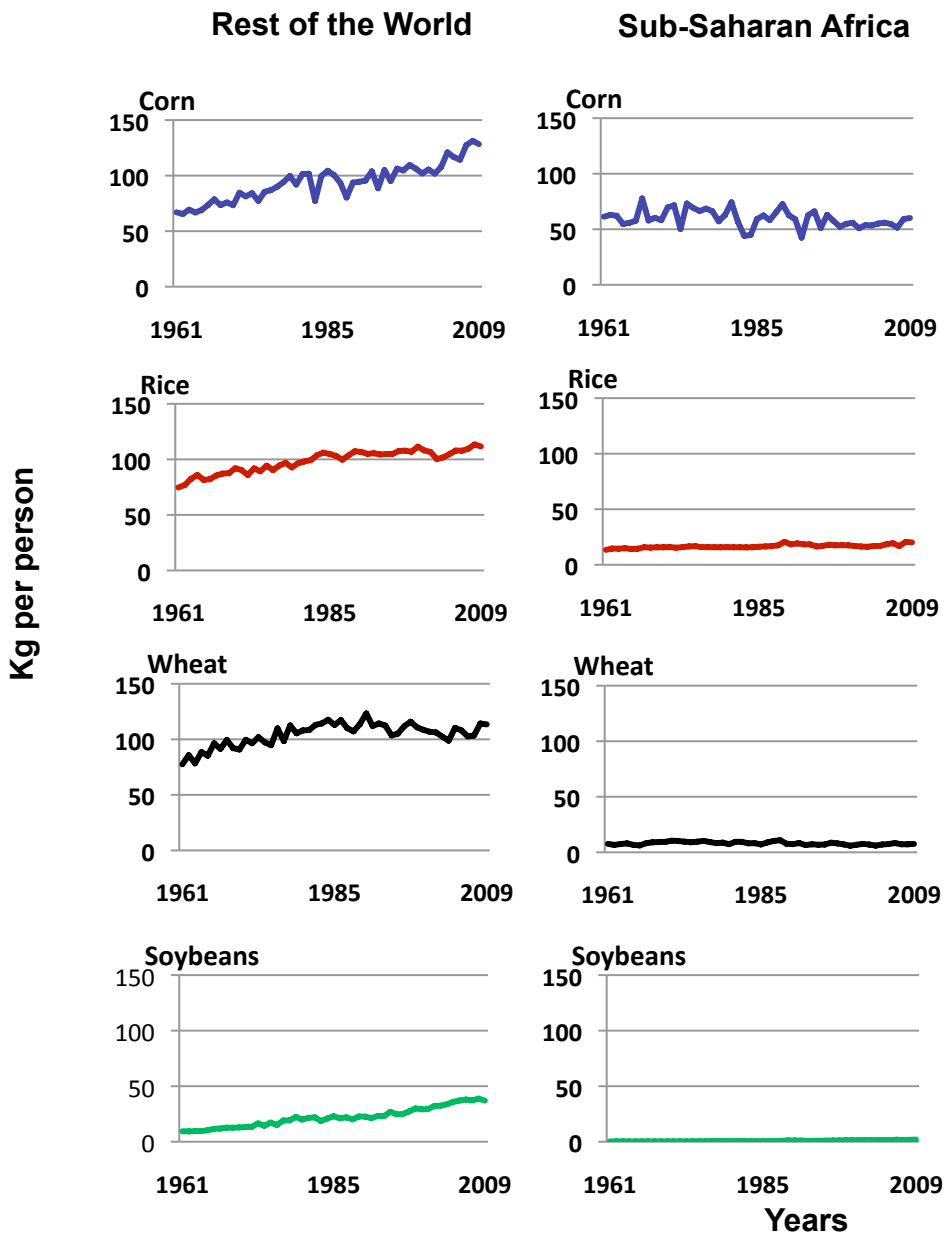
Global Production Quantities, 1961-2009



Note: Percentages are top 10 country share / SSA share

Source: Pardey (in preparation)

Per Capita Production, 1961-2009

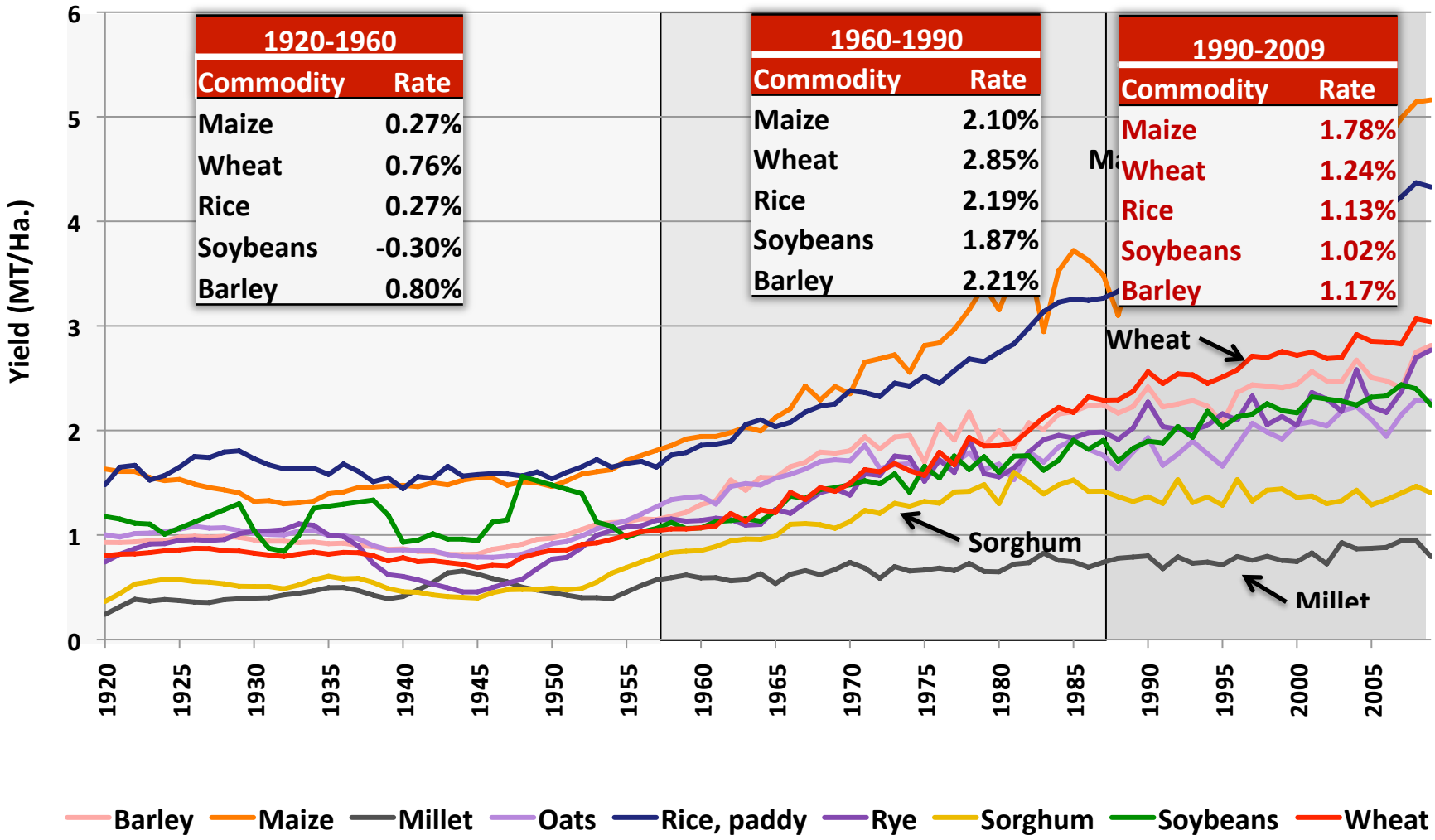


Growth Rates, 1961-2009		
	Popln	VOP
	(percent per year)	
SSA	2.7	2.5
World	1.7	2.3

Source: Pardey (in preparation)

Global and African Agricultural Productivity Trends -- What Do We (think we) Know?

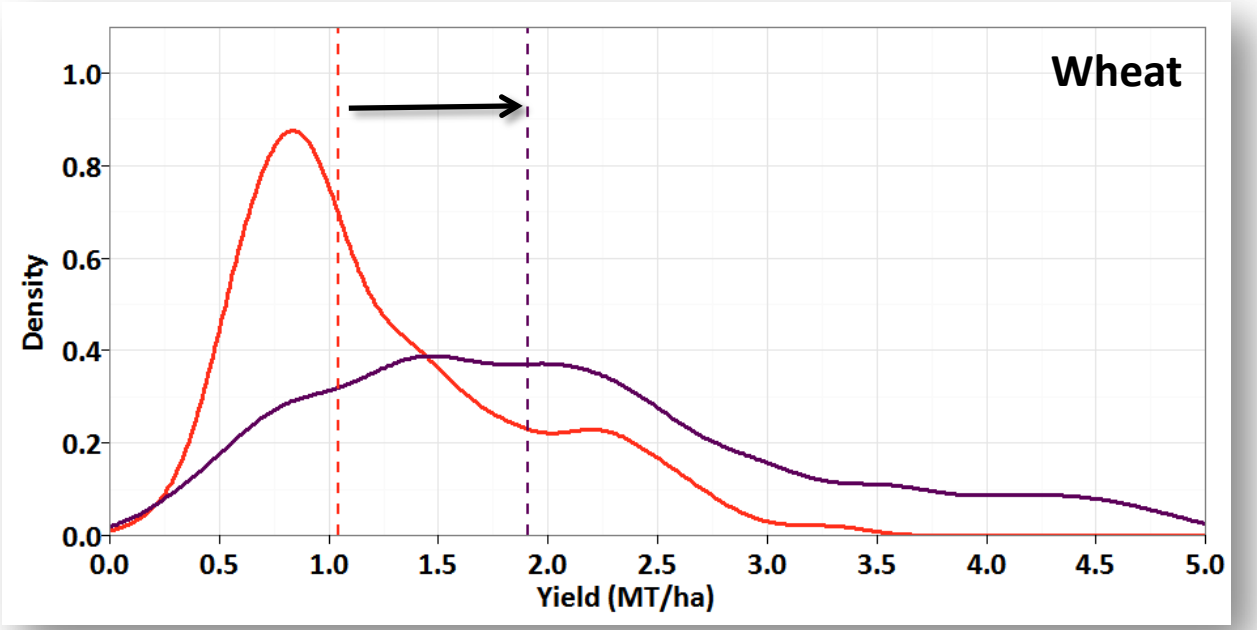
Global Crop Yields Averages, 1920-2009 (beta)

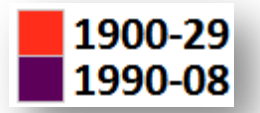


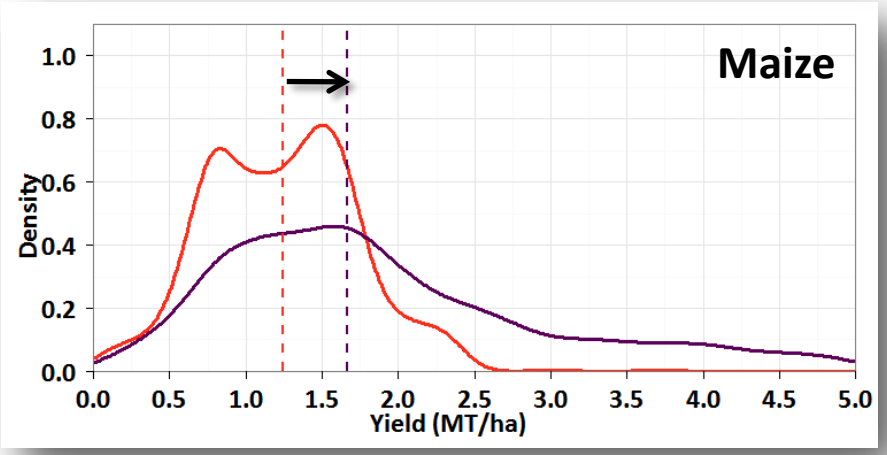
Source: Pardey, Beddow, Xudong and Hurley (forthcoming)

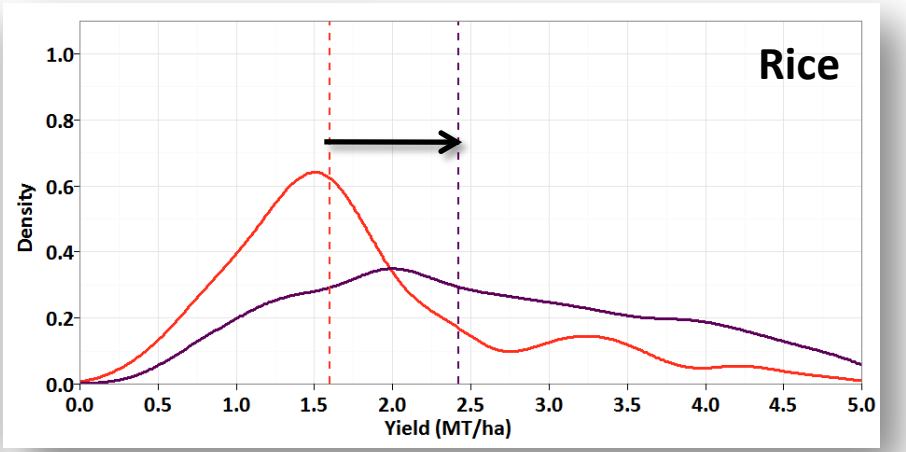
Note: Global growth rates are weighted averages of ln differences

A Century of Global Crop Yield Distributions, 1900-2008 (beta)





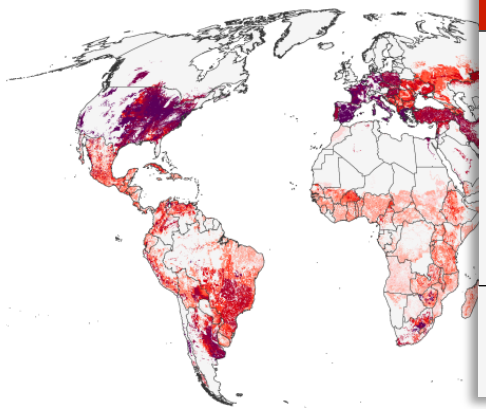




Source: Pardey, Beddow, Rao and Hurley (forthcoming)

Spatial Distribution of Crop Yields, 2000 (SPAM ver 3.0)

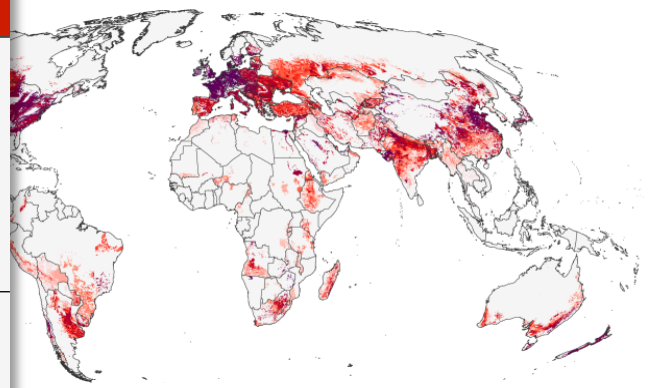
Panel a: Maize



High Yielding Area Shares			
	US	Sth Africa	Africa
		(percent)	
Maize	32	1.7	2.5
Wheat	28	1.4	3.6
Soybean	25	0.5	5.6
Rice	5.3	0	5.7

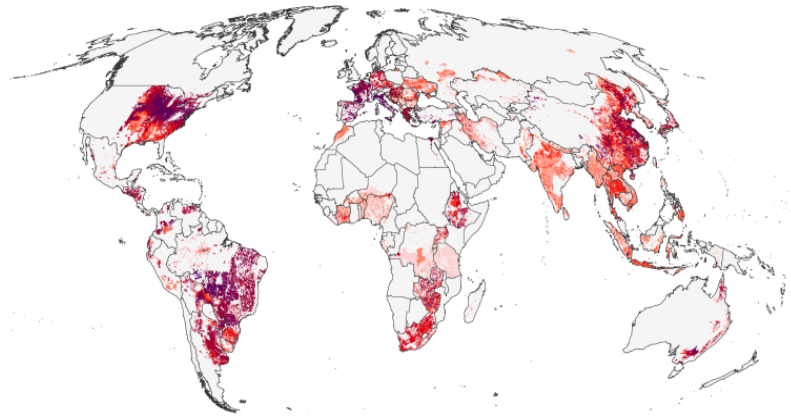
Share of area in top 30 percent of yielding areas worldwide

Panel b: Wheat

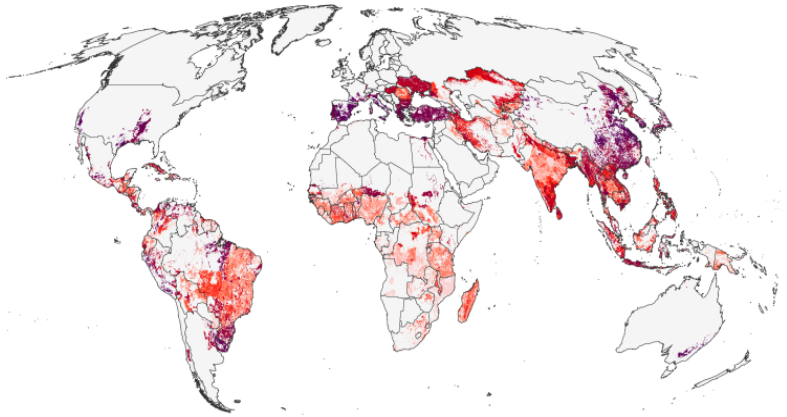


Yield (decile)

Panel c: Soybean

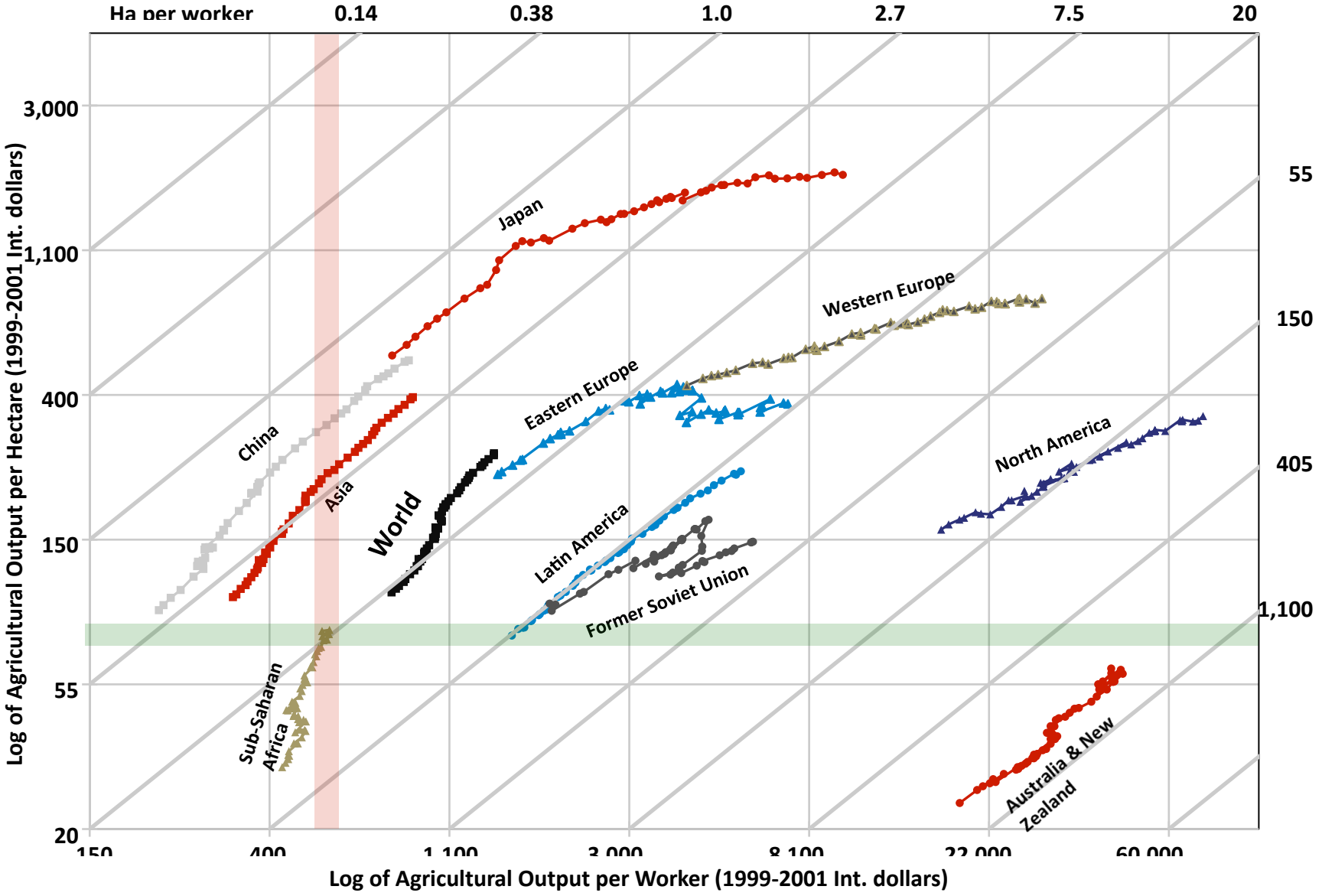


Panel d: Rice

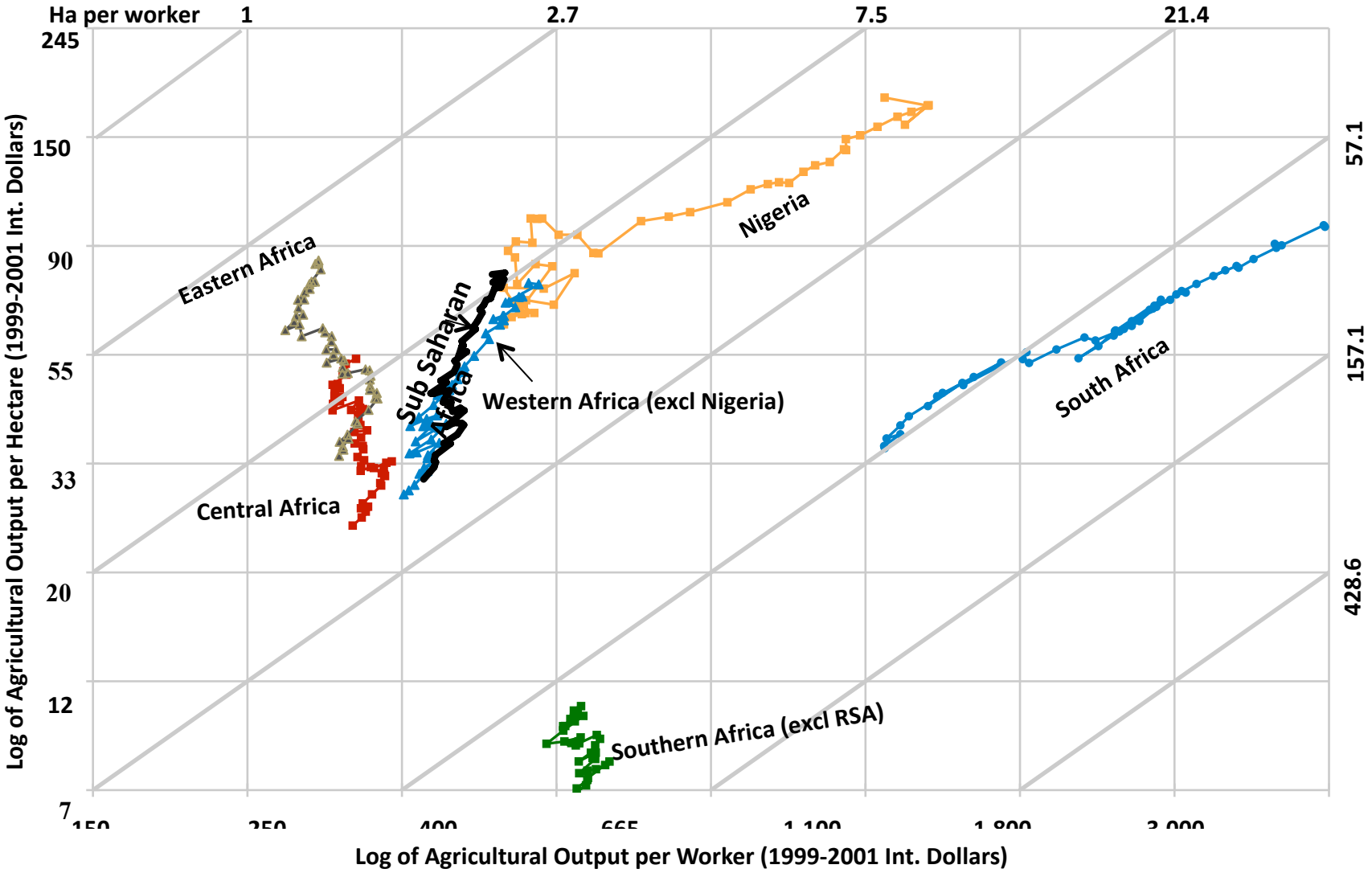


Source: HarvestChoice (2010)

Global Land and Labor Productivity Patterns, 1961-2009



African Land and Labor Productivity Patterns, 1961-2009



Note: Values of antilog (natural) values shown on axes

Understanding Productivity

Sample of Regional and Global Productivity Studies

Authors	Publication year	Data		Method
		Year(s)	Countries	
Hayami and Ruttan	1970	1955, 1965 & 1970	38	Econometric
Antle	1983	1965	45	Econometric
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Craig, Pardey & Roseboom	1997	1961-1990	98	Econometric
Fulginiti & Perrin	1998	1961-1985	18	Econometric Malmquist
Coelli & Rao	2005	1980-2000	93	Malmquist/DEA
Fuglie	2008	1961-2006	171	Growth accounting
O'Donnell	2010	1970-2001	88	Hicks–Moorsteen/ DEA

Common Denominator – FAO and World Bank Data

FAO and World Bank Data

Land – count of arable, permanently pastured and cropped area

Labor – head count of economically active population in agriculture

Capital – count of tractors in use/on farm

– percent of irrigated acres

Livestock – weighted head count of buffalo, cattle, pig, sheep, and goat

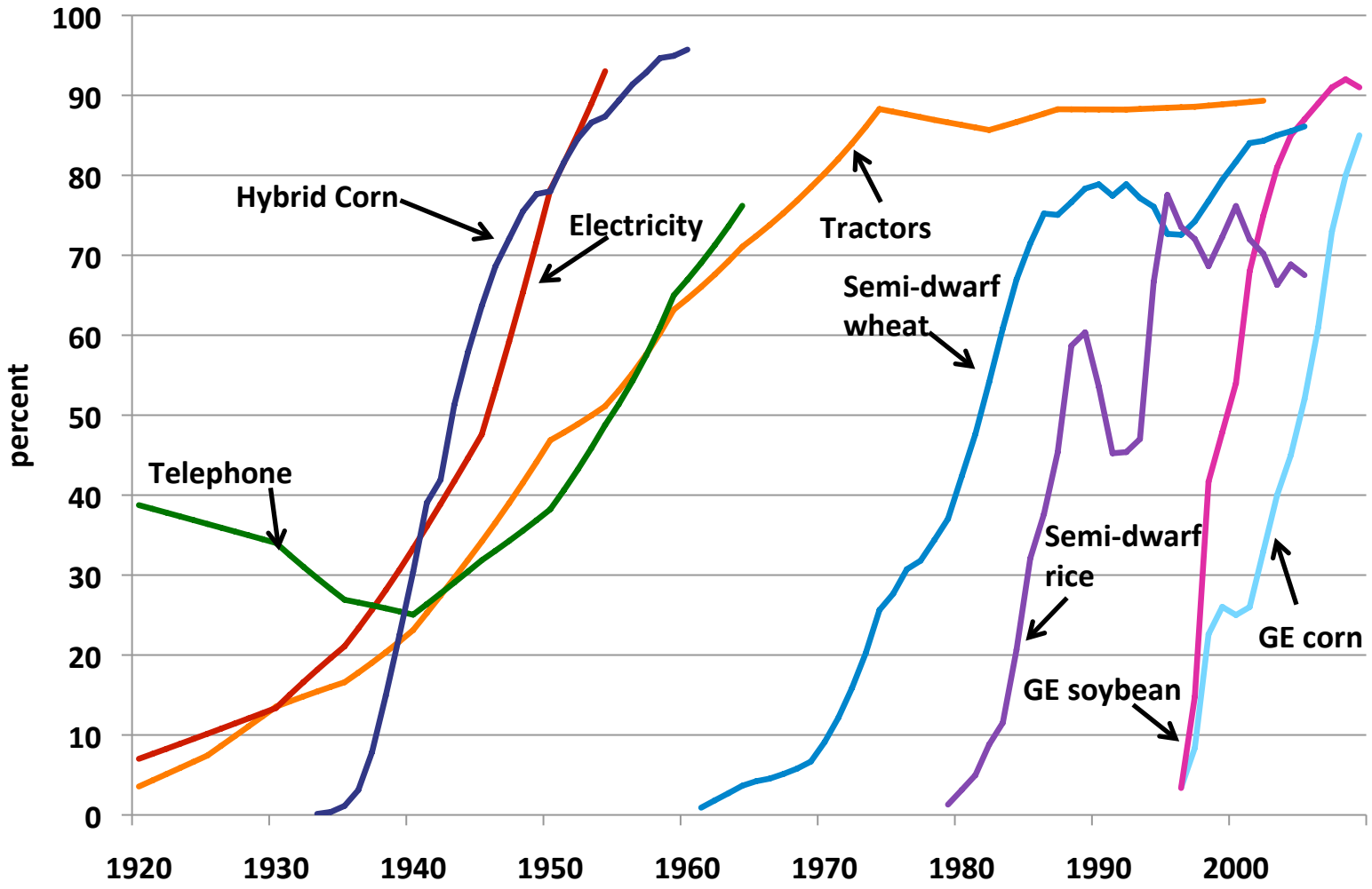
Materials – fertilizer (nitrogen, phosphate and potash and use in units of active ingredients)

Sources of Measured Productivity Growth

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

1. Technical change (attributable to R&D)
2. Scale effects (gains from specialization and integration)
3. Intermediate or "inside" inputs
4. Mismeasured or omitted inputs (e.g., labor quality, land quality)
5. Natural (typically omitted) inputs
   - Weather (rainfall, temperature, day length, wind, incl. timing)
   - Soil attributes
   - Pests and diseases ("exputs")
   - Location, location, location!

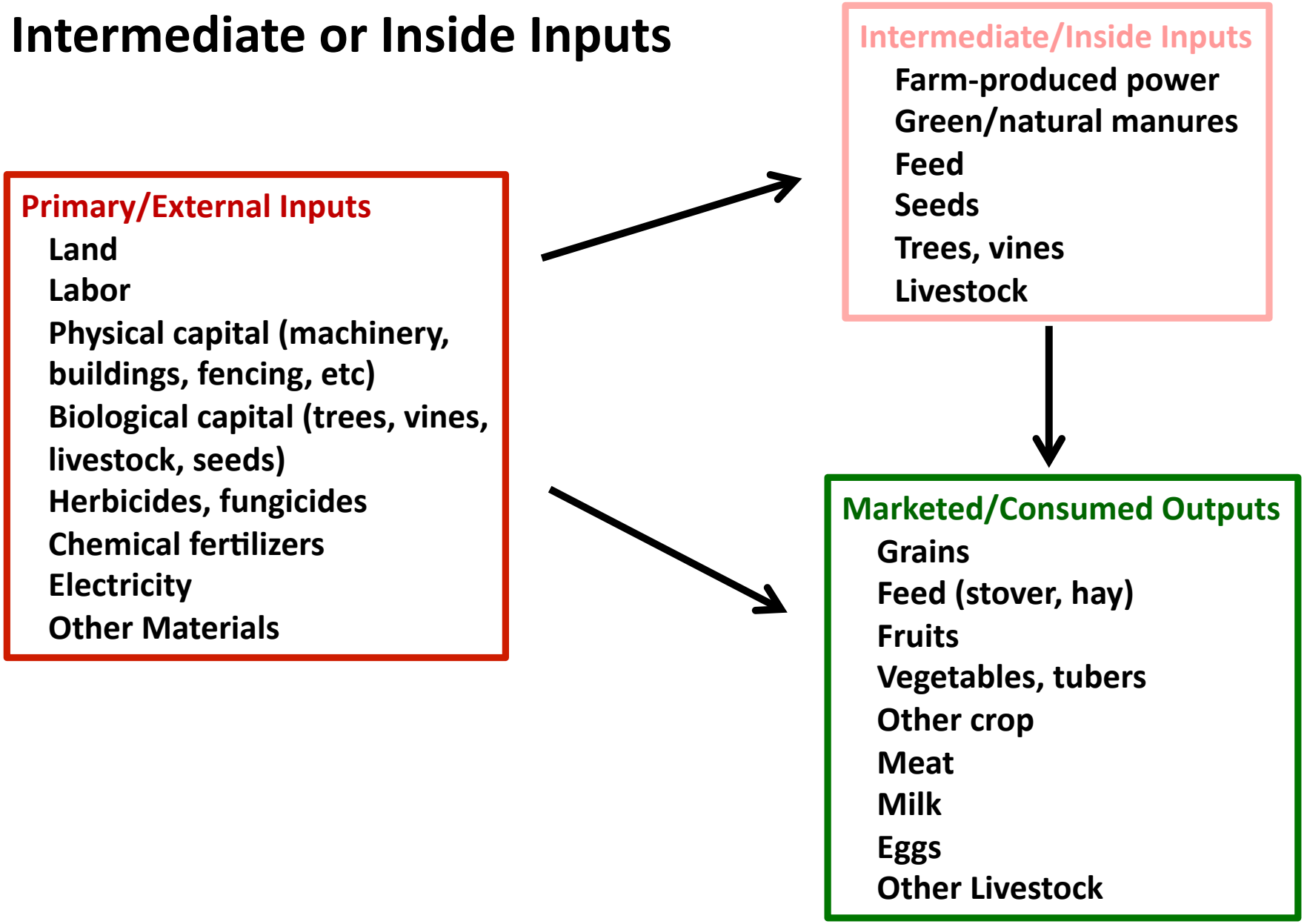
Changing Structure of US Farm Inputs and Technologies, 1900-2009



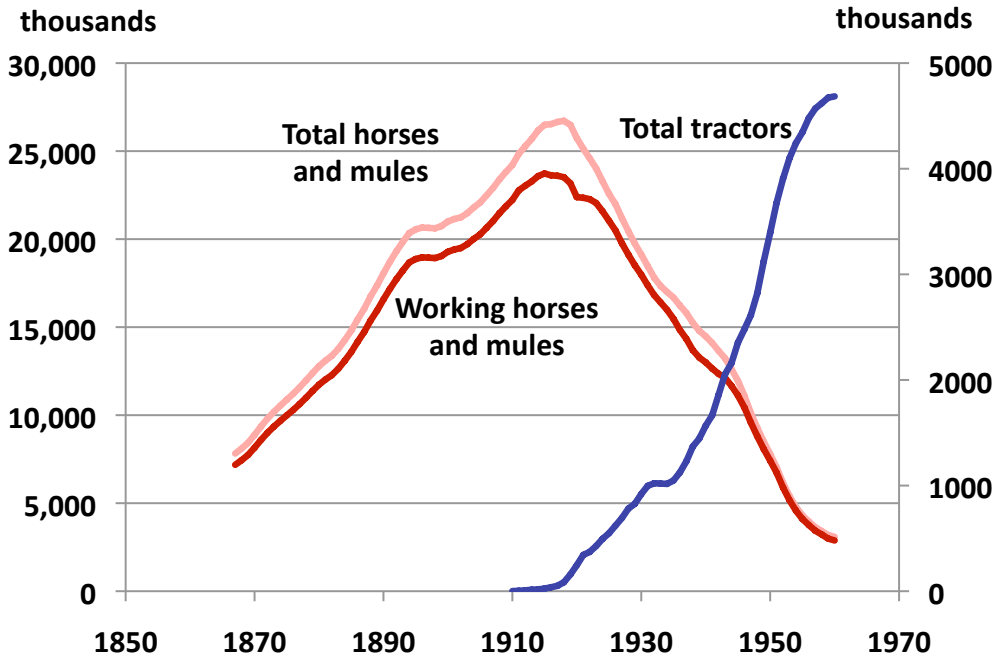
Source: Pardey et al. (in preparation)

Note: Percentages are crop area shares for crop varieties, farm shares for all other entries

Intermediate or Inside Inputs



Intermediate or Inside Inputs – US Farm-produced Power



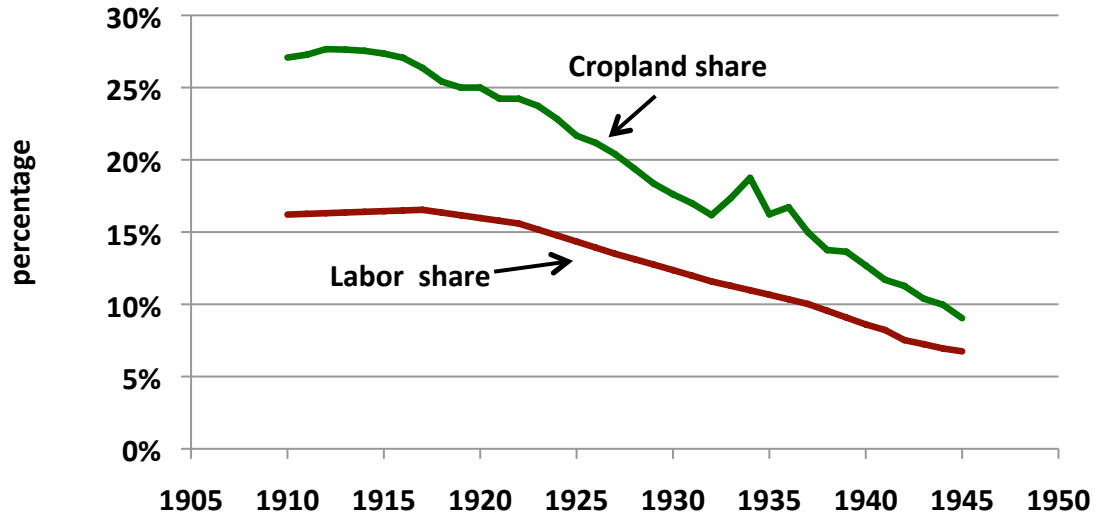
Farm Power, 1867-1970

Change from 1915-1945

1915: 25.7 mil. work animals, 25,000 tractors
1945: 11.9 mil. work animals, 2.4 mil. tractors

Freed up 61 million crop acres (66% reduction)
Freed up 2.3 million hrs labor (63% reduction)

Land and Labor Shares used to Feed and Maintain Traction Horses and Mules, 1910-1945



Source: Hurley and Pardey (in preparation)

Structure of African Agricultural Inputs, various years

Country	Year	Number of Holders	Area per Holder	Percent of Farm Households Who Use				
				Fertilizers			Improved / purchased	
				Natural	Chemical	Pesticides	Seed	Irrigation
		million	*ha*			*percentage*		
Ethiopia	2008/9	12.9	0.97	66.8	20.7	23.6	11.8	8.5
Ghana	2005	3.3	3.7	8	26	35	31	1
Kenya	2005	4.4	1.2	42	32	15	50	5

Source: HarvestChoice (2011)

Omitted or Mis-measured Inputs

$$MFP = Q_i / X_i \qquad TFP = \frac{Q_i + Q_e}{X_i + X_e} = Q / X$$

where *TFP* is total factor productivity, *MFP* is multifactor productivity, *i* designates included inputs and outputs, and *e* designates excluded quantities

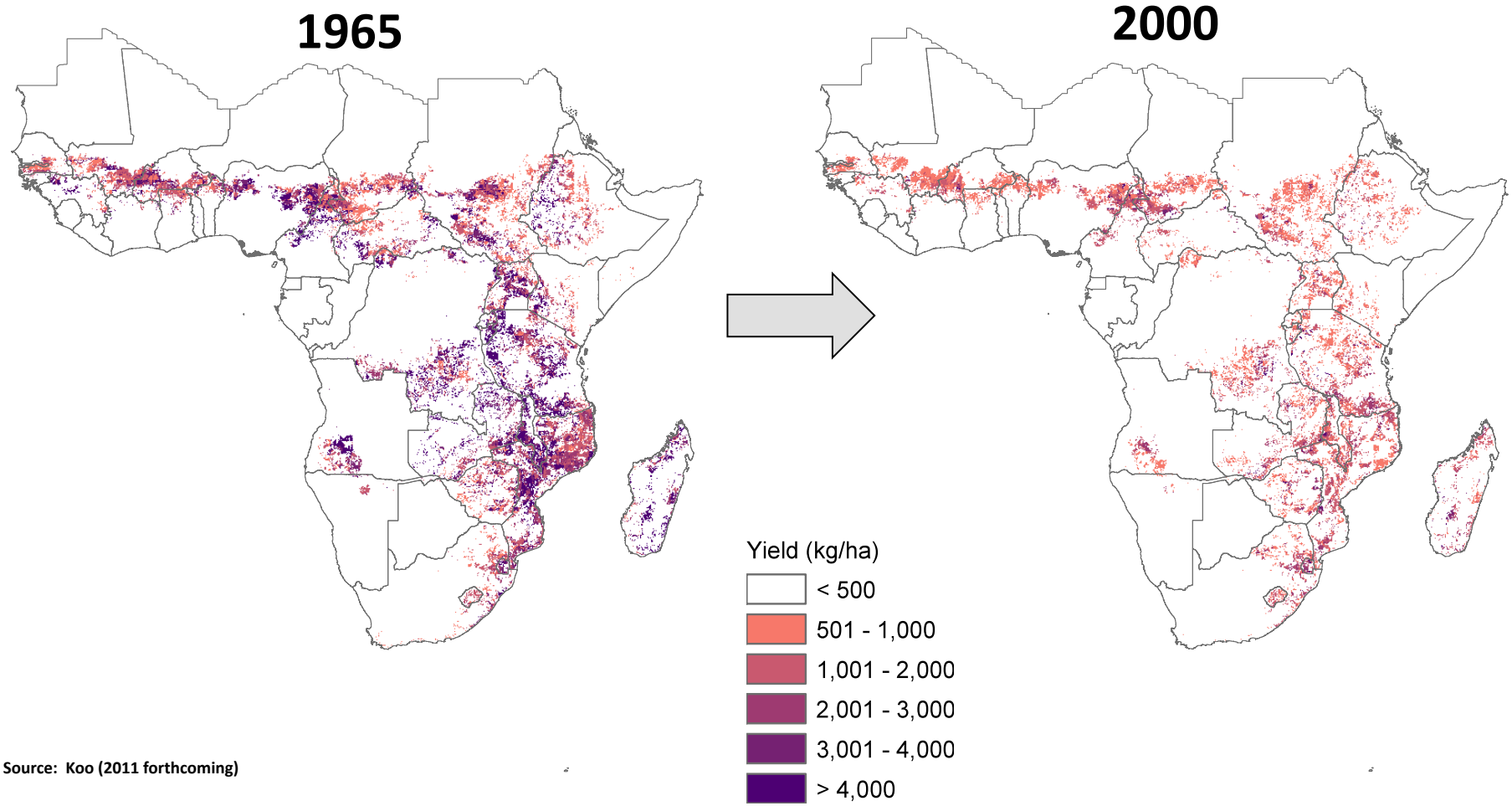
Difference between growth in TFP and growth in MFP is

$$d\ln TFP - d\ln MFP = q_i\,(d\ln Q_e - d\ln Q_i) - x_e\,(d\ln X_e - d\ln X_i)$$

- q_i: Relative rates of growth of total and excluded outputs as a share of total outputs
- q_e: excluded outputs as a share of total outputs
- x_e: excluded inputs as a share of total inputs
- $(d\ln Q_e - d\ln Q_i)$, $(d\ln X_e - d\ln X_i)$: Rate of growth of excluded minus included quantities

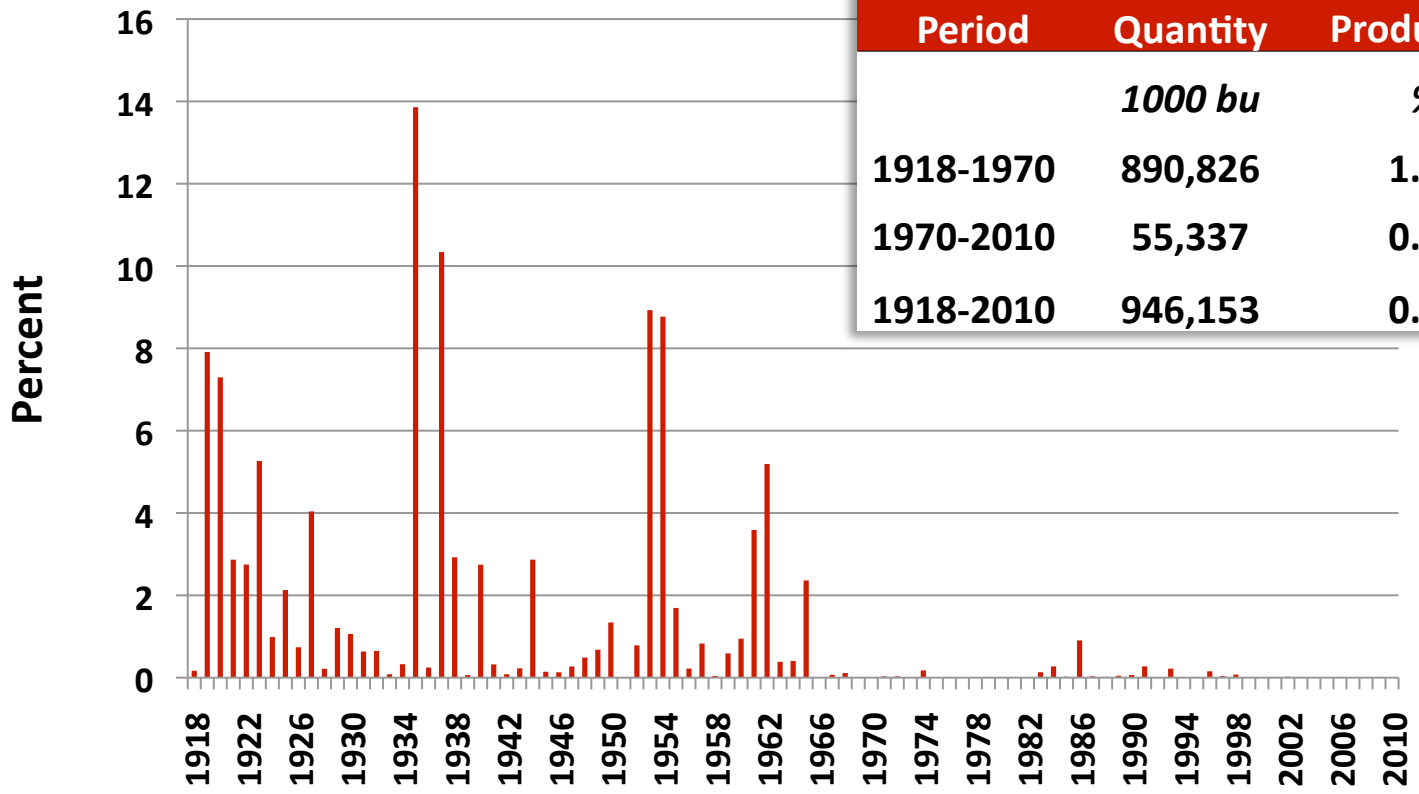
Mismeasured Land/Soil Services -- Effects on Maize Yields

of Changes in Soil Fertility



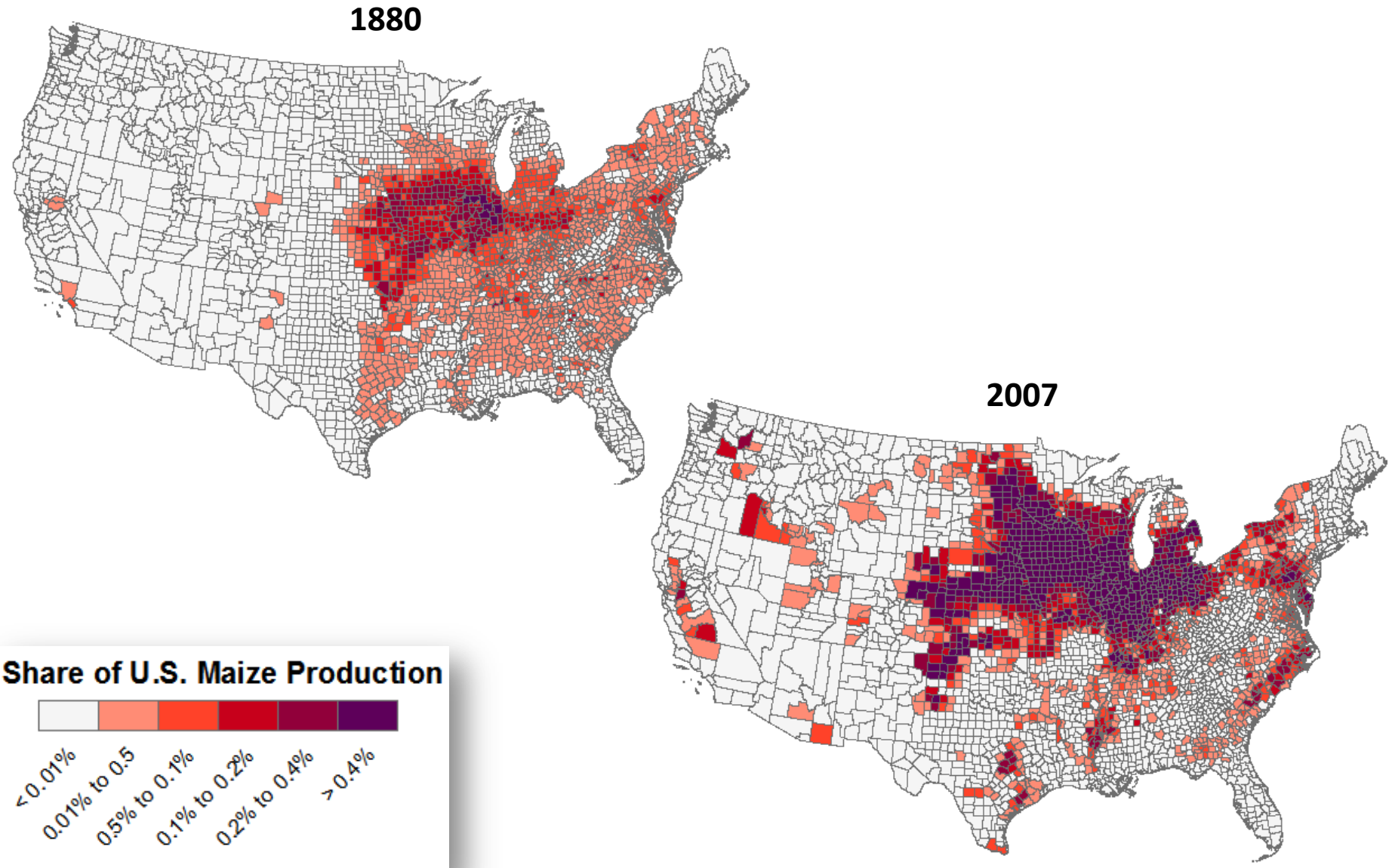
Source: Koo (2011 forthcoming)

Exputs -- U.S. Wheat Production Losses to Stem Rust, 1918-2010



Period	Losses to stem rust	
	Quantity	Share of Production
	1000 bu	*%*
1918-1970	890,826	1.82
1970-2010	55,337	0.06
1918-2010	946,153	0.70

Spatial Dynamics of Agriculture -- U.S. Maize Production, 1880 and 2007



Source: Beddow (2011 forthcoming)

Productivity Slowdown?

Global Crop Yield Growth Rates, 1961-2009

	Maize		Wheat		Rice		Soybeans	
Group	61-90	90-09	61-90	90-09	61-90	90-09	61-90	90-09
World	1.34	1.71	2.41	0.91	1.31	1.03	1.46	0.74
Sub-saharan Africa	0.75	0.87	1.65	0.67	1.59	0.31	1.42	-0.32
Top 20 producers	2.22	2.05	2.65	1.06	1.72	1.59	1.92	1.21
Other Producers	1.20	1.65	2.36	0.87	1.22	0.91	1.32	0.59

Note: Growth rates are simple averages of year to year log differences

Share of Countries with Slower Yield Growth since 1990

Grouping	Maize	Wheat	Rice	Soybeans
		(percent)		
All Countries	49	73	57	59
Top 10 Producers	50	100	60	80
High Income	61	88	71	67
Sub-Saharan Africa	44	65	58	65

Note: Annual average growth during 1961-1990 vs 1990-2009

Share of Countries with Slower Productivity Growth since 1990

	Productivity Growth*	
	Land	Labor
	(percent per year)	
World	1.55	1.79
SSA countries with growth rates < world average		
	(percent)	
Share	80	51

* Annual average, 1961-2009

Grouping	1990-2009+	
	Land	Labor
	(percent)	
All Countries	53	52
Top 10 Producers	70	40
High Income	64	62
Sub-Saharan Africa	53	41

+ Annual average growth during 1961-1990 vs 1990-2009

U.S. Multifactor Productivity, 1949-2007

InStePP Production Accounts

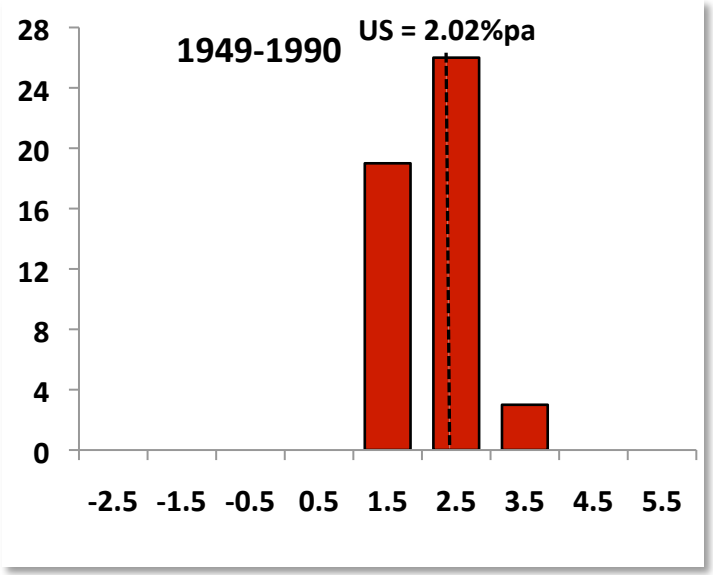
Outputs

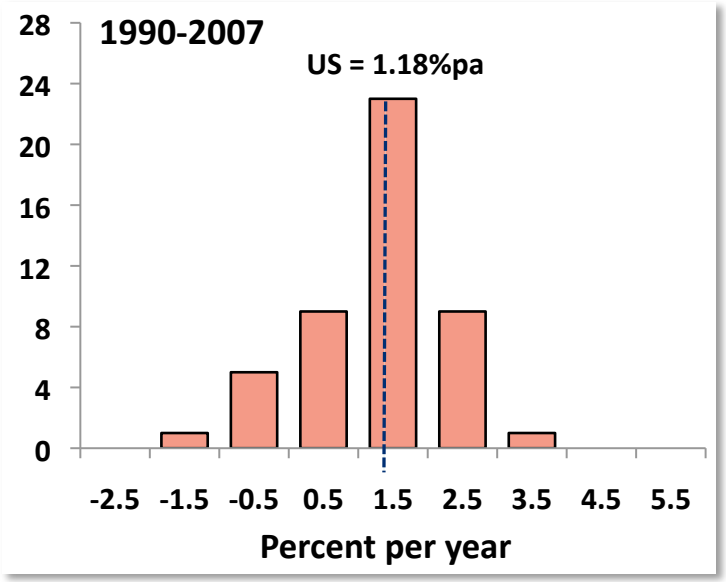
Crops 61
Livestock (9)
Miscellaneous (4)

Inputs

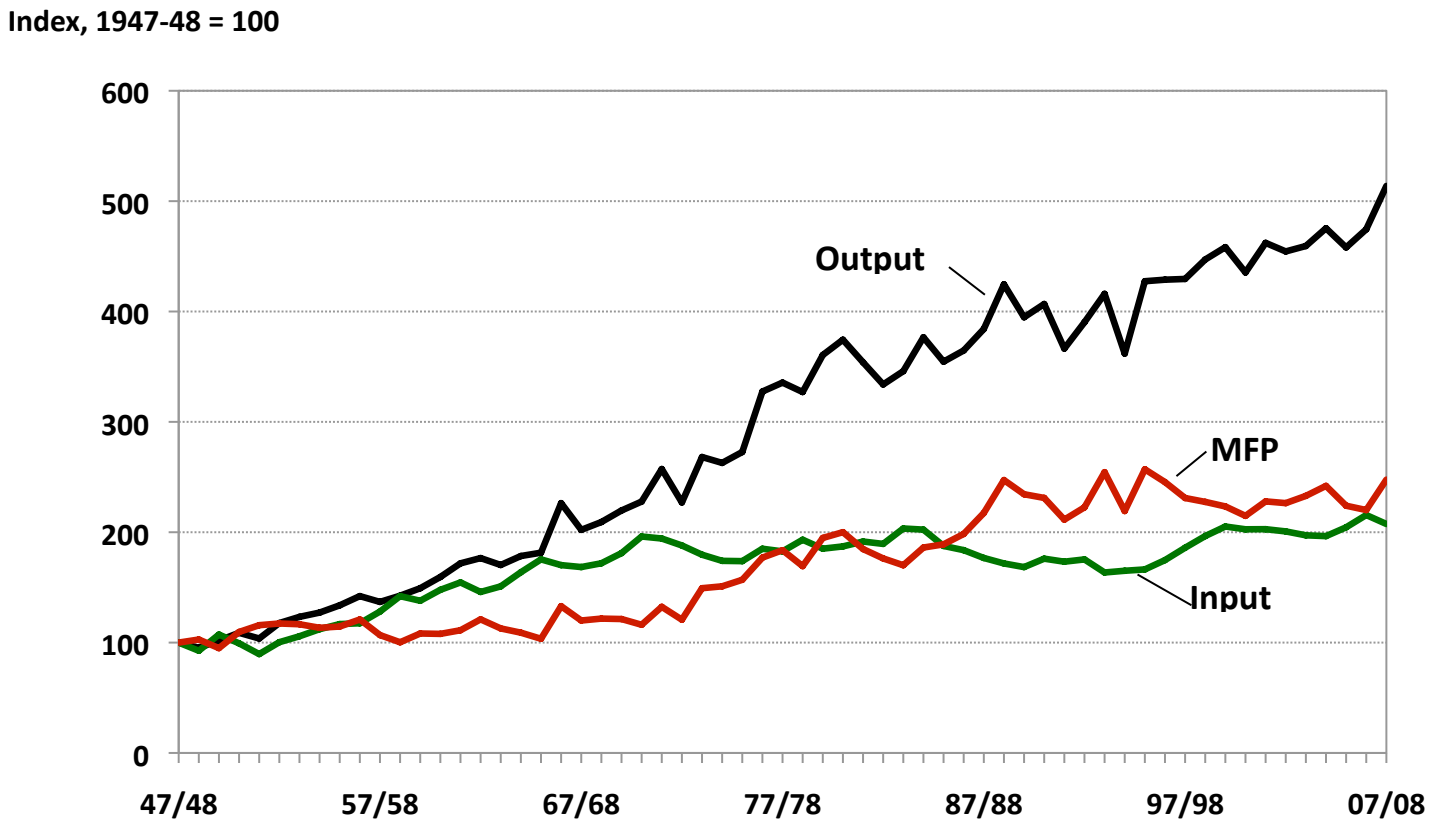
Land (3)
Cropland, irrigated cropland, pasture and grassland
Labor (32)
Family labor
Hired labor
Operator labor (30)
Education: 0–7 years, 8 years, 1–3 years of high school, 4 years of high school, 1–3 years of college, 4 years or more of college
Age: 25–34, 35–44, 45–54, 55–64, or 65 or more years of age
Capital (12)
Machinery (6)
Automobiles, combines, mowers and conditioners, pickers and balers, tractors, trucks
Biological capital (5)
Breeding cows, chickens, ewes, milking cows, sows
Buildings
Materials (11)
Electricity, purchased feed, fuel, hired machines, pesticides, nitrogen, phosphorous, potash, repairs, seeds, miscellaneous purchases

State MFP Growth Distributions





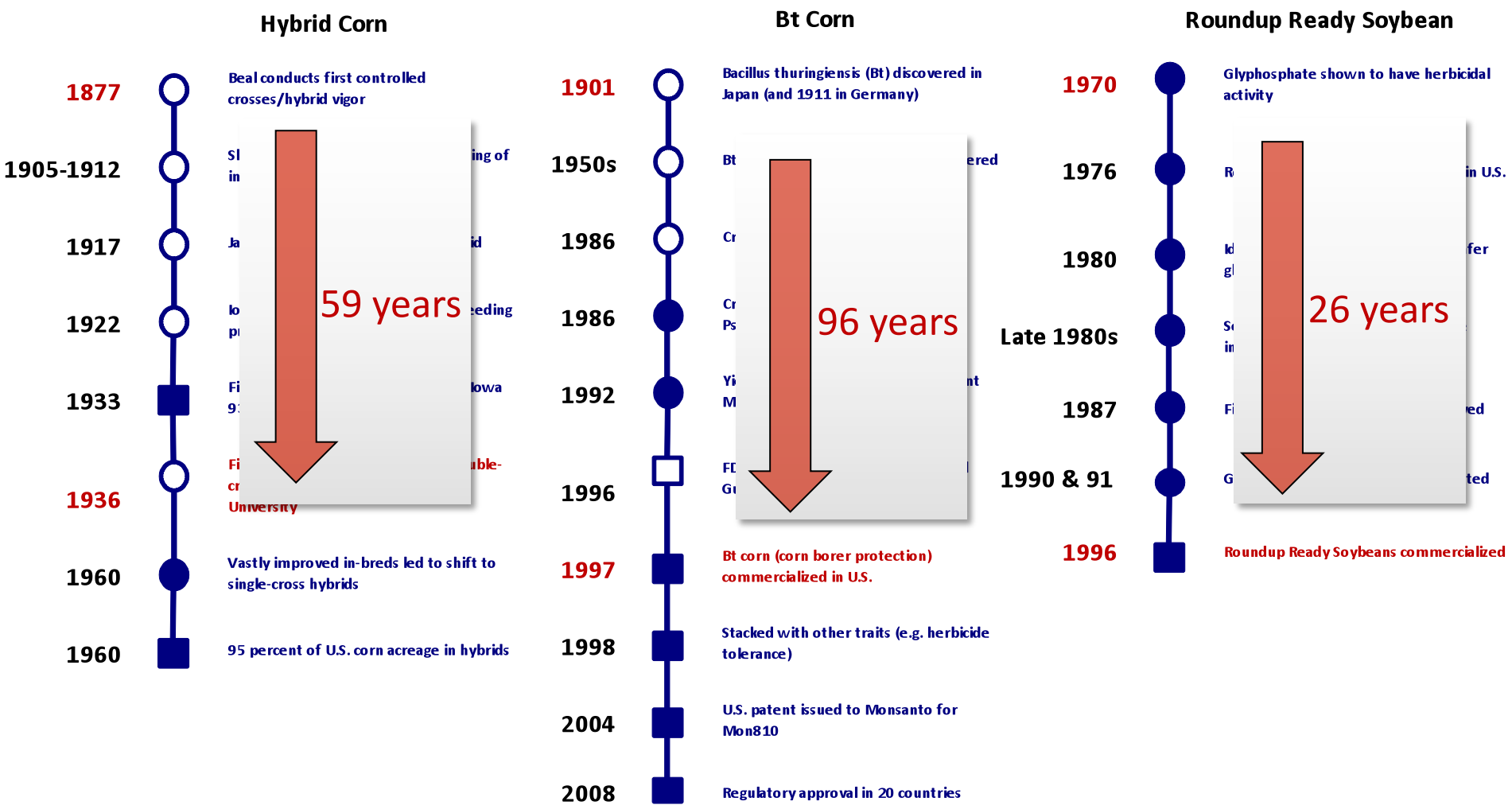
South African MFP Growth



Source: Liebenberg and Pardey (2010)

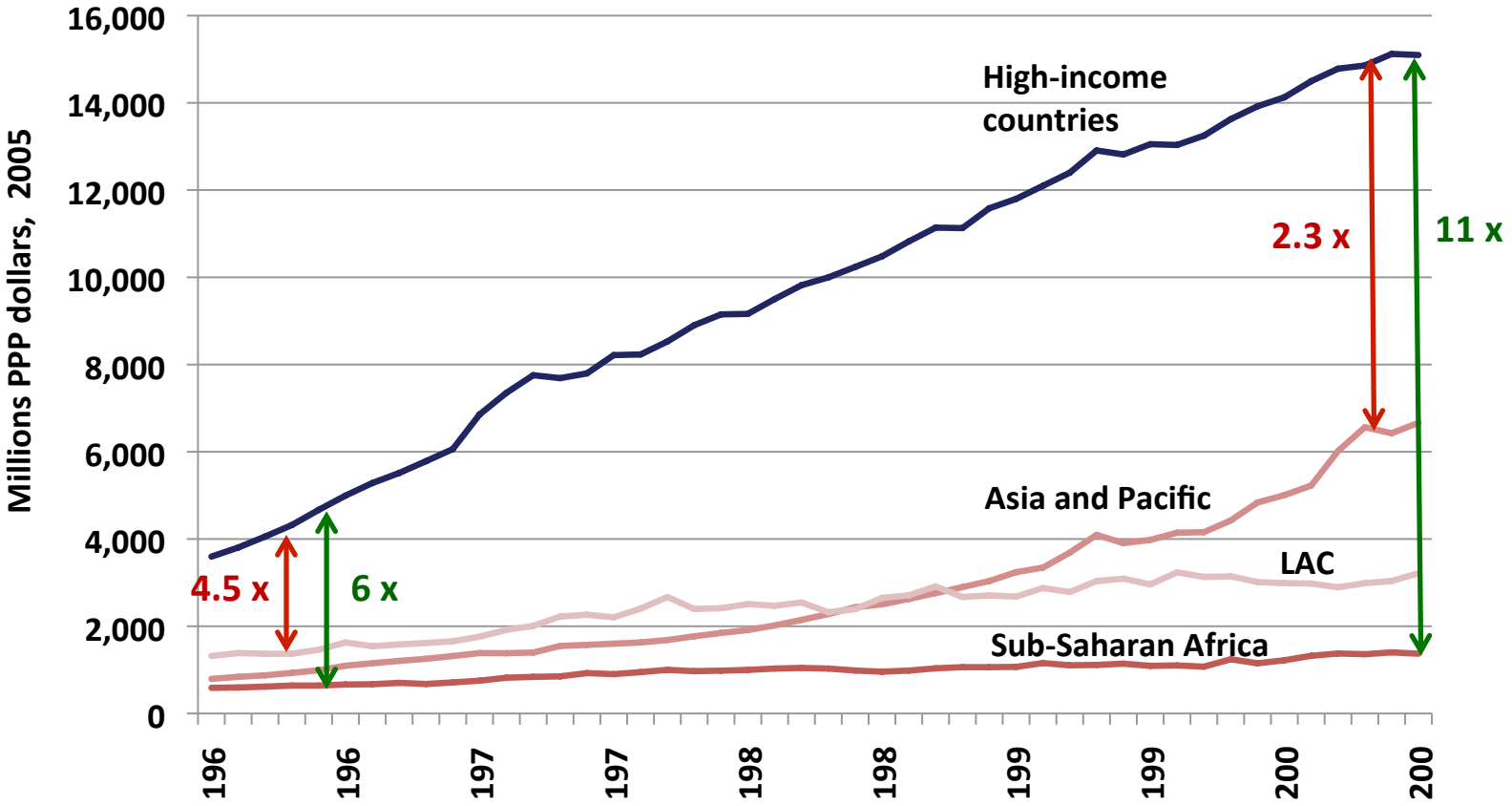
Productivity and R&D

Illustrative Technology Development Lags



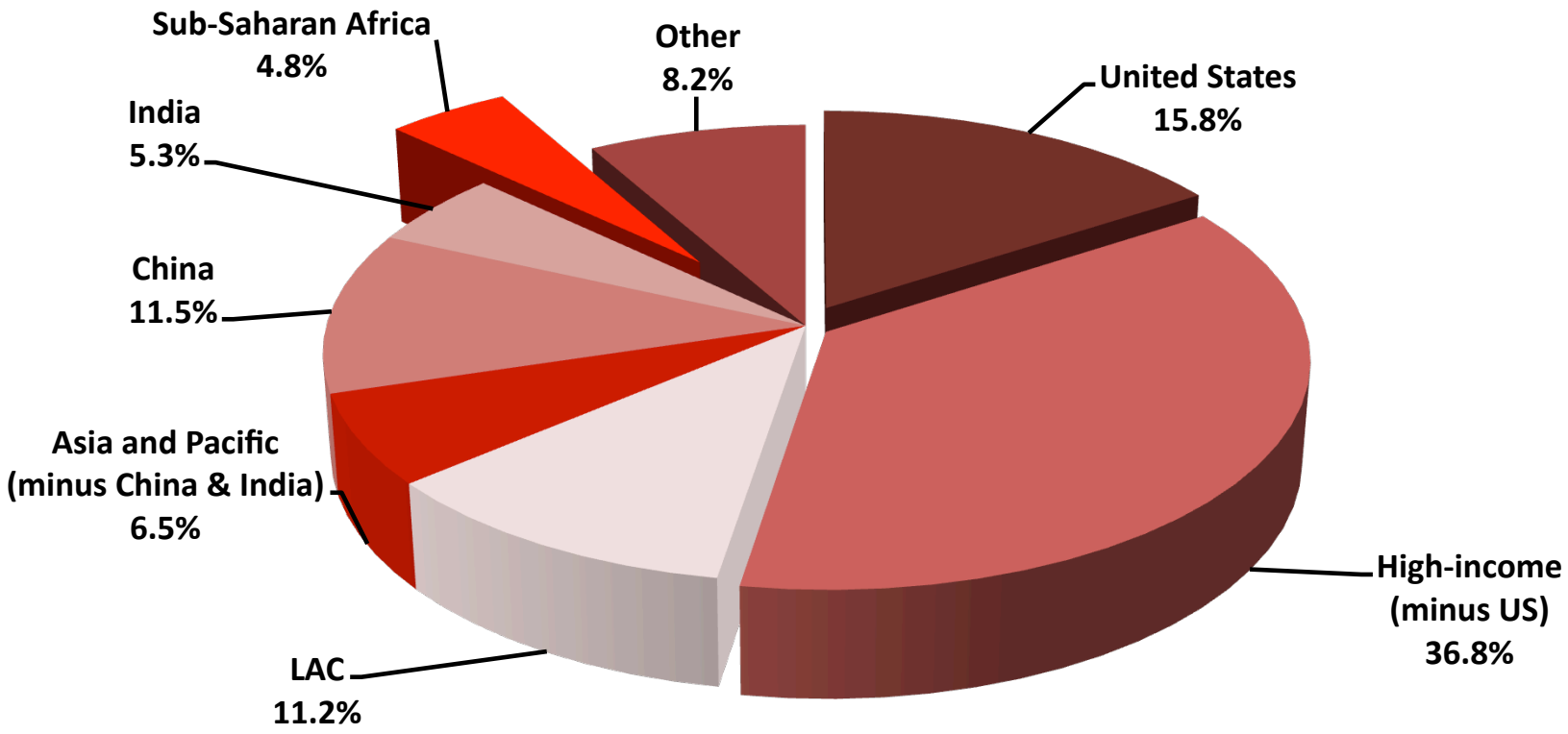
Source: Pardey , Alston and Ruttan (2008) and Alston et al. (2010)

Global Public Agricultural R&D Trends, 1960-2005 (beta)



Source: Pardey and Chan-Kang (2011, beta version)

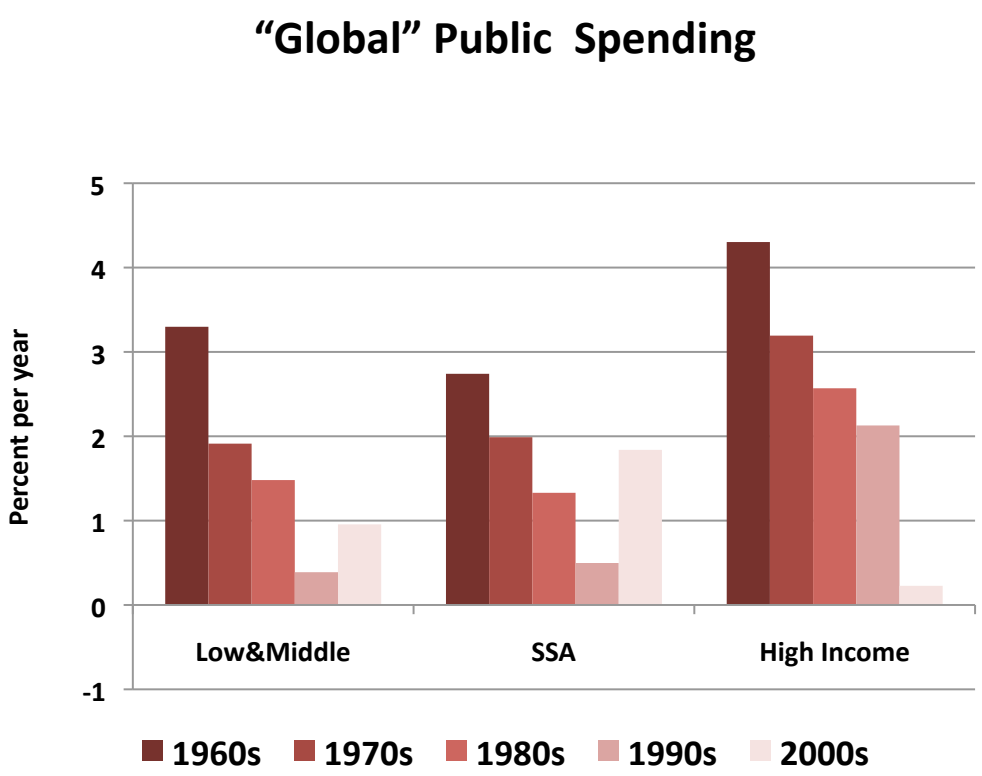
Public Food and Agricultural R&D Spending, 2005 (beta)

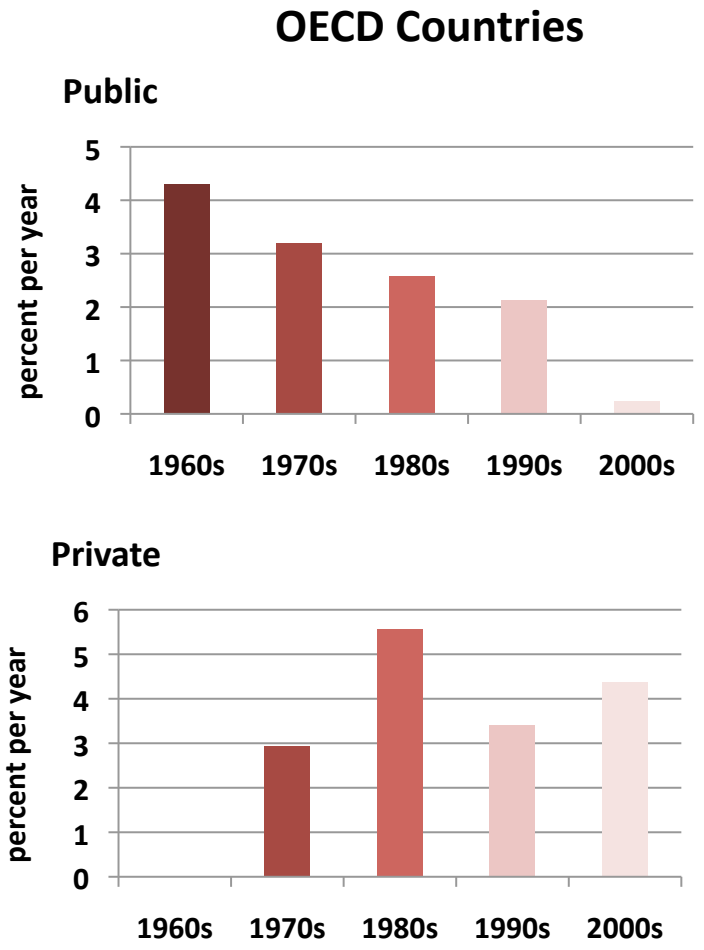


2005 total $28.7 billion (2005, PPP dollars)

Source: Pardey and Chan-Kang (2011, beta version)

Growth in Food and Agricultural R&D Expenditures, 1960-2005 (beta)



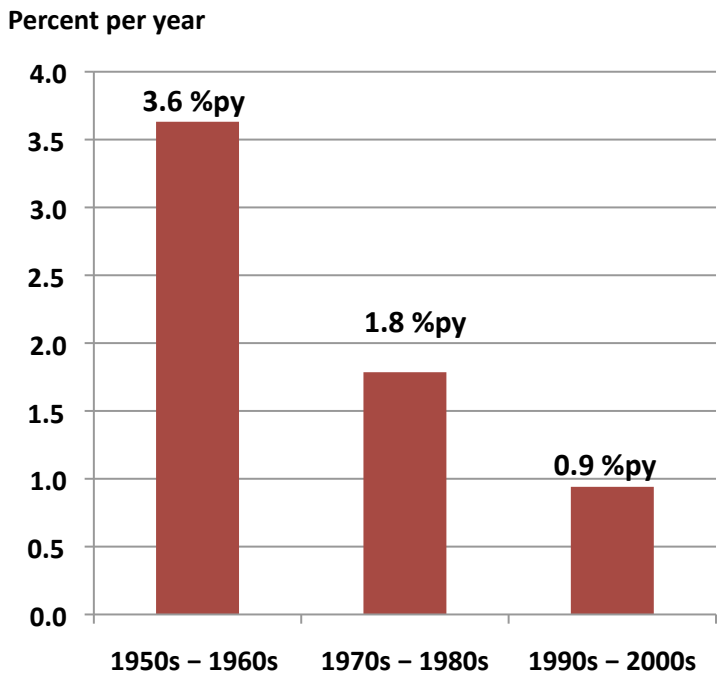


Source: Pardey and Chan-Kang (2011, beta version)

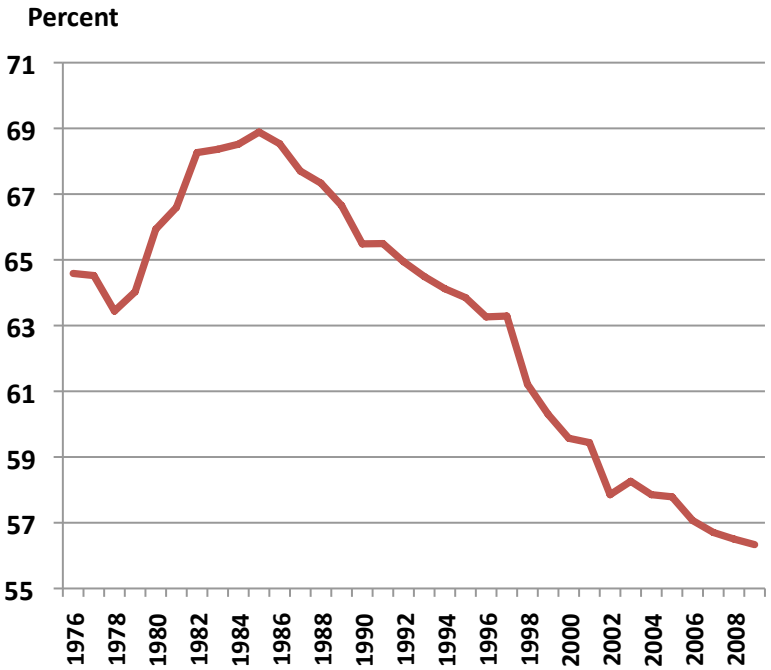
Note: Data represent simple average of country growth rates within each region. 2000s represent 2000-2005.

U.S. Agricultural Research Developments, 1950-2009

Slowing Growth in Spending

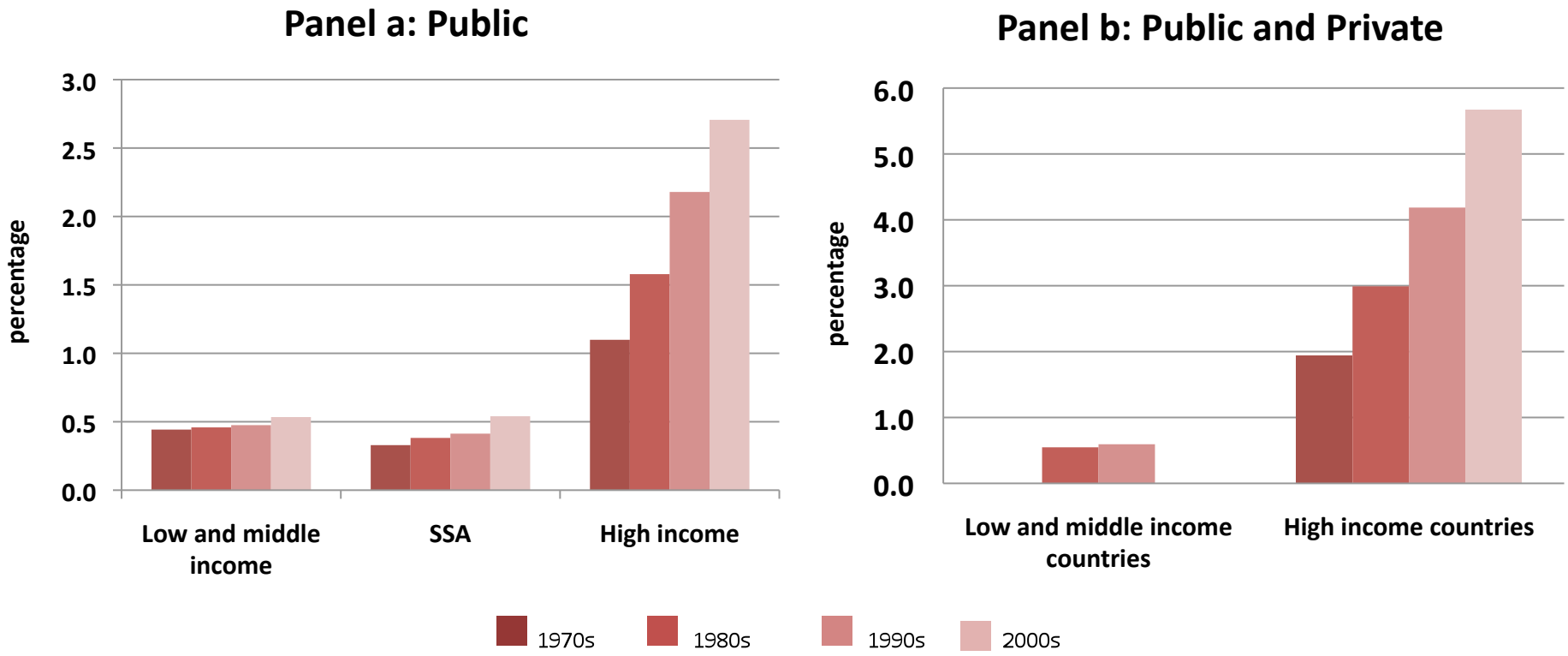


Declining Emphasis on Farm Productivity



Source: Pardey and Chan-Kang (2011)

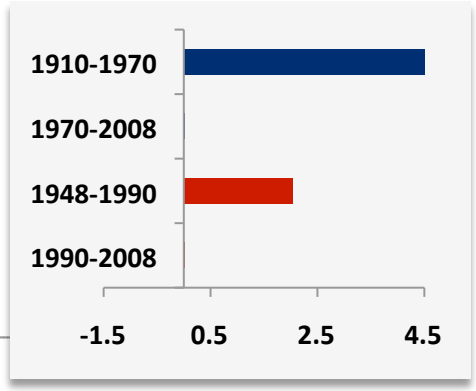
Agricultural Research Intensity Ratios, 1970-2005 (beta)

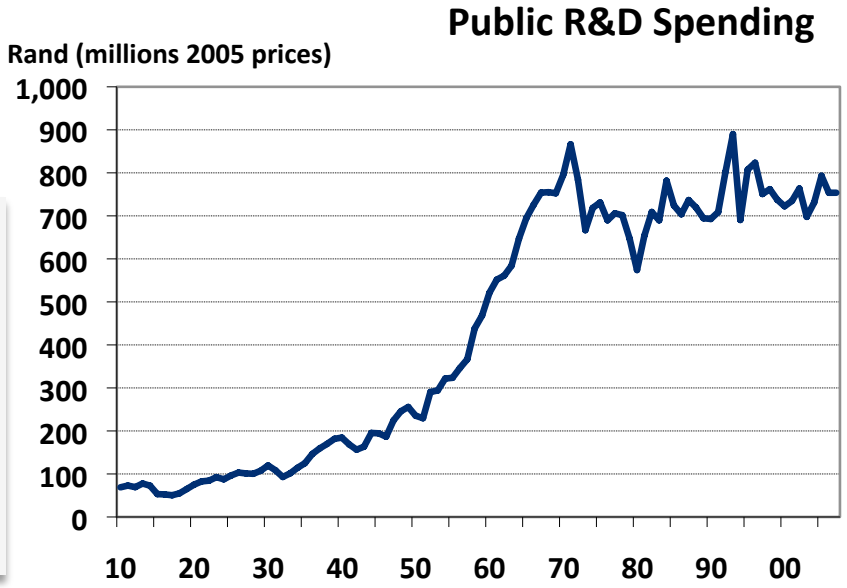


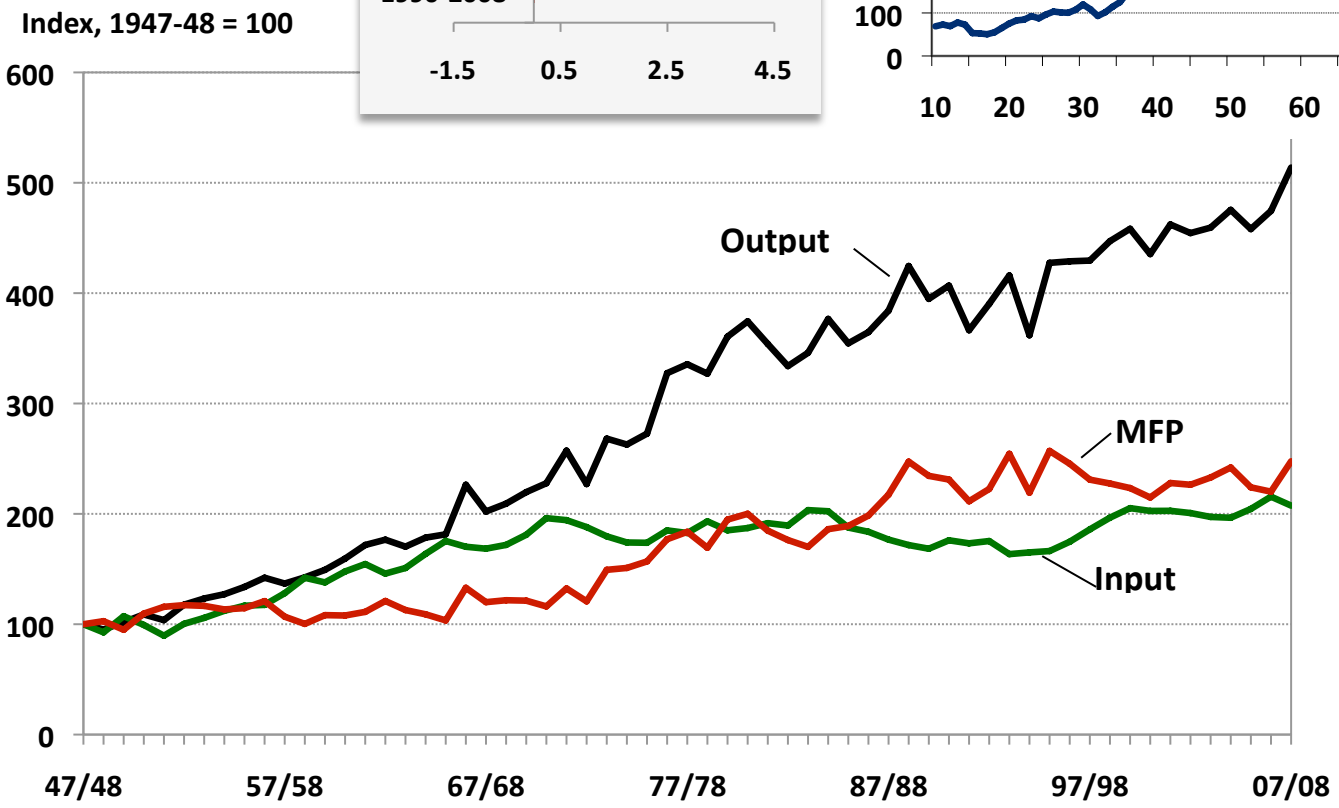
Source: Pardey and Chan-Kang (2011, beta version)

Note: Data represent weighted average of country intensity rations within each region. 2000s represent 2000-2005.

South African R&D and MFP Growth





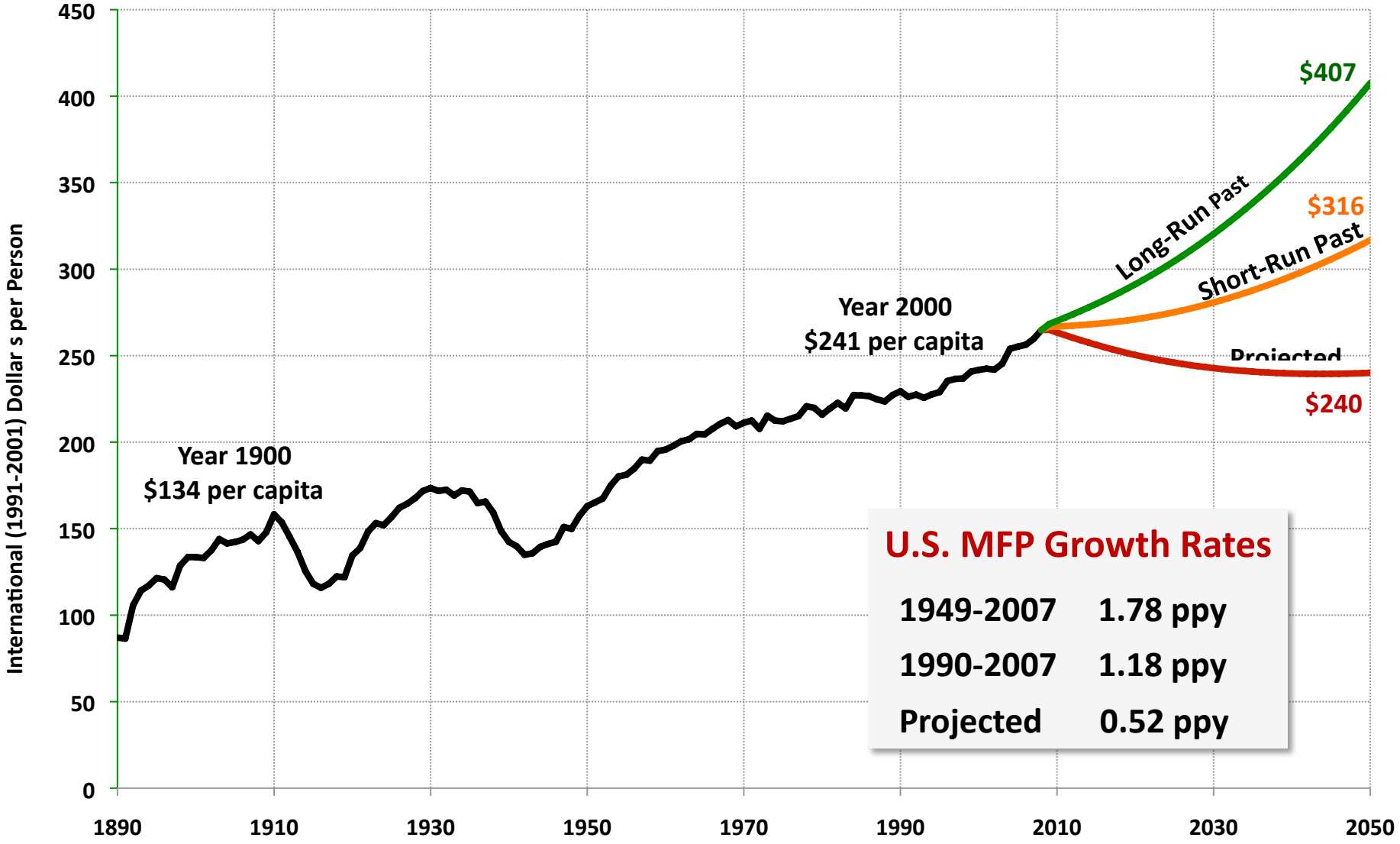


Source: Liebenberg and Pardey (2010 and 2011)

In Closing

- Large and persistent spatial differences in agricultural productivity
  - Levels
  - Paths (factor intensities)
  - Rates of growth
- African productivity levels generally lag ROW
- Large variation in productivity performance within Africa
- Compelling evidence of a slowdown in the rate of global agricultural productivity growth (substantial in some important instances)
- Slowdown especially evident in world's richest countries, but fairly widespread in ROW
- Evidence mounting that a significant culprit for the slowdown is a reduction in the rate of growth of productivity-oriented R&D spending
- Agricultural transformation processes take considerable time, but have profound consequences

Per Capita Agricultural Output—Past, Present and Future?

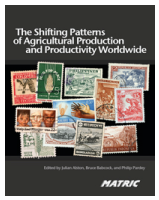


Source: Pardey (in preparation)

Thanks!

Selected Sources

Alston, J.M., M.A. Andersen, J.S. James, and P.G. Pardey. ***Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending.*** New York: Springer, 2010.



Alston, J.M., BA. Babcock and P.G. Pardey. ***The Shifting Patterns of Agricultural Production and Productivity Worldwide,*** 2010. (Especially chapters 2, 3, 13 and 15)

Pardey , P.G. and P.L. Pingali. "**Reassessing International Agricultural Research for Food and Agriculture.**" Report prepared for the Global Conference on Agricultural Research for Development (GCARD), Montpellier, France, 28-31 March 2010.

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