Total Factor Productivity in African Agriculture

Measures & determinants

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Introduction
African Agricultural productivity

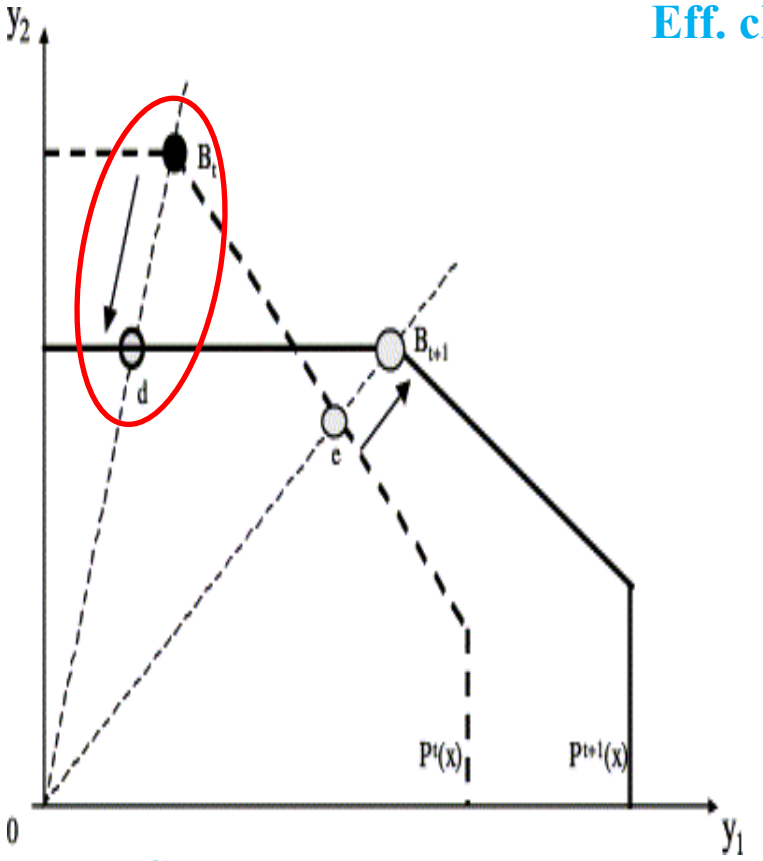
- Productivity gains in the 1960s
- Poor aggregate performance in the 1970s and early 1980s
- Recovery since mid-1980s— weak (e.g. Nkamleu, 2004) + strong evidence
  - Traditional Malmquist approach (DEA) – Non-sequential technology
  - Underlying cost shares are also implausible (Nin-Pratt and Yu, 2008)
  - Reassess productivity growth using sequential Malmquist approach
- Limited empirical evidence - Sources of productivity growth
  - Explain productivity differentials—beyond correlations
  - The length and shape of the R&D lag implied by available evidence
  - Exploiting latest, comprehensive datasets on R&D, rainfall, trade, etc

Malmquist TFP Indices

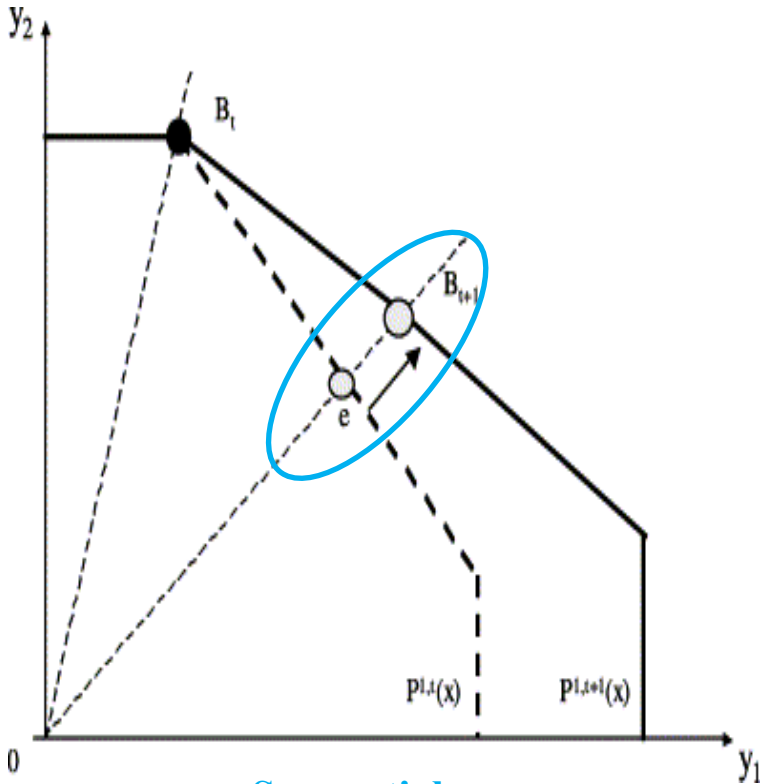
Non-parametric distance functions—LP solutions

$$M_o = (y^t, x^t, y^{t+1}, x^{t+1}) = \frac{D_o^{t+1}(y^{t+1}, x^{t+1})}{D_o^t(y^t, x^t)} \left(\frac{D_o^t(y^{t+1}, x^{t+1})}{D_o^{t+1}(y^{t+1}, x^{t+1})} \times \frac{D_o^t(y^t, x^t)}{D_o^{t+1}(y^t, x^t)} \right)^{1/2}$$

Eff. change **Tech. progress**



Contemporaneous



Sequential

Source: Nin-Pratt et al. (2003), Journal of Development Economics.

Explaining Total Factor Productivity

$$\ln(TFP) = \beta_0 + \sum_{j=0}^{L} \beta_{1(j)} \ln(\text{R\&D})_{t-j} + \beta_1 \ln(\text{Weather})$$
$$+ \beta_2 \ln(\text{Labor/ha}) + \beta_3 \ln(\text{Labor/ha})^2 + \beta_4 \ln(\text{Literacy})$$
$$+ \beta_5 \ln(\text{Trade})_{t-1} + \beta_6 (t) + \beta_7 (t)^2 + e$$

❑ R&D lag structure

2nd-degree PDL vs. Trapezoid

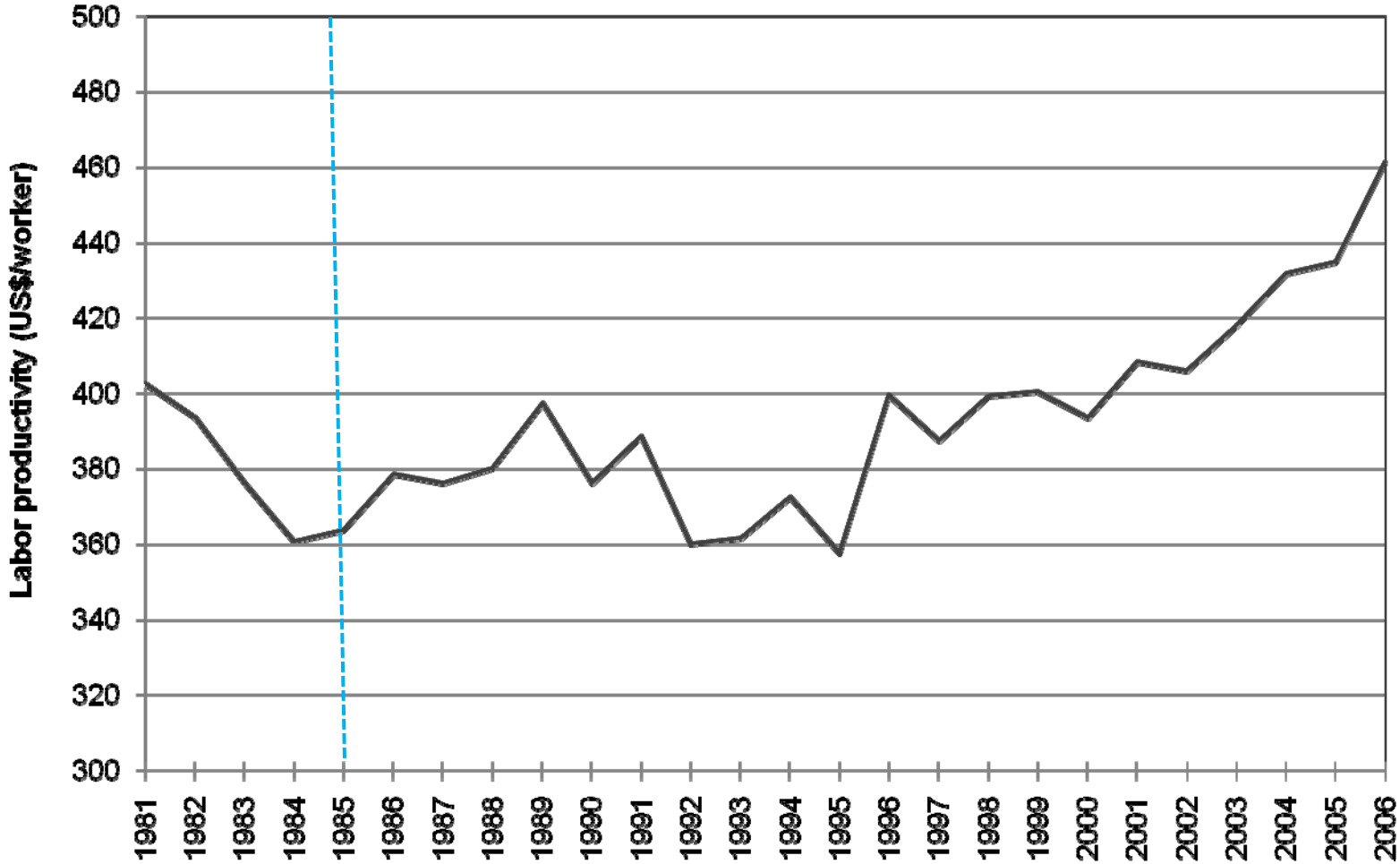
$$\sum_{j=0}^{L} \alpha_j \ln(\text{R\&D/ha})_{t-j} = \sum_{j=0}^{16} (\lambda_0 + \lambda_1 j + \lambda_2 j^2) \ln(\text{R\&D/ha})_{t-j}$$
$$= \lambda_0 \sum_{j=0}^{16} \ln(\text{R\&D/ha})_{t-j} + \lambda_1 \sum_{j=0}^{16} \left(j \times \ln(\text{R\&D/ha})_{t-j} \right)$$
$$+ \lambda_2 \sum_{j=0}^{16} \left(j^2 \times \ln(\text{R\&D/ha})_{t-j} \right)$$

Data Sources

- FAOSTAT—Input−Output data for TFP estimation
  - Agricultural production (valued at 1999/01 ICPs, I$)
  - Agricultural land (ha)
  - Labor force (economically active labor force in agric.)
  - Fertilizer (tons)
  - Machinery (tractors)
- IFPRI—ASTI data on R&D expenditures
- World Bank—WDI data on Literacy, Trade, etc
- Chris O'Connell—Annual rainfall data 1970−2000

Labor Productivity in African Agriculture

(US$/worker), 1981-2006



Source: African Development Indicators 2010, *World dataBank*, World Bank.

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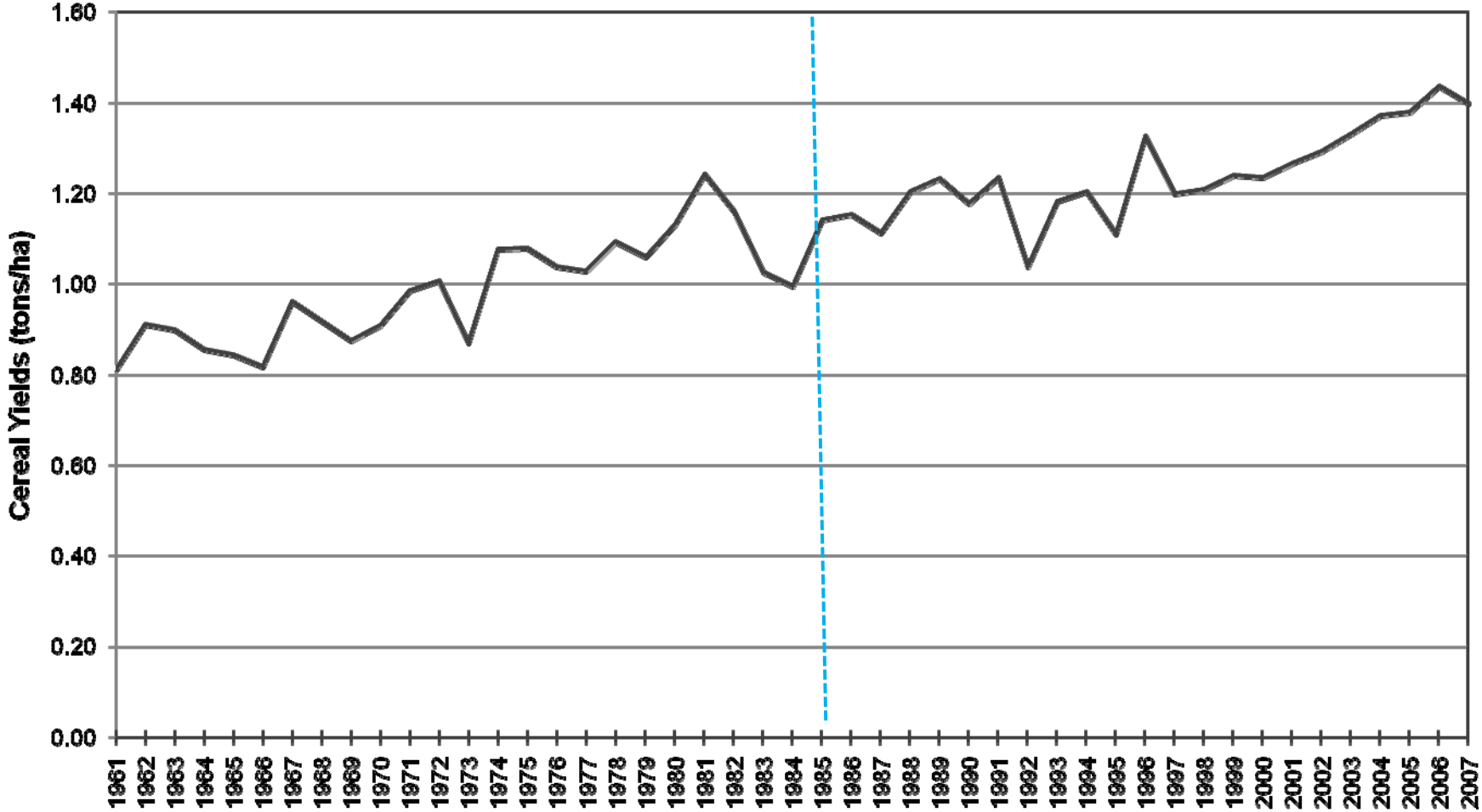
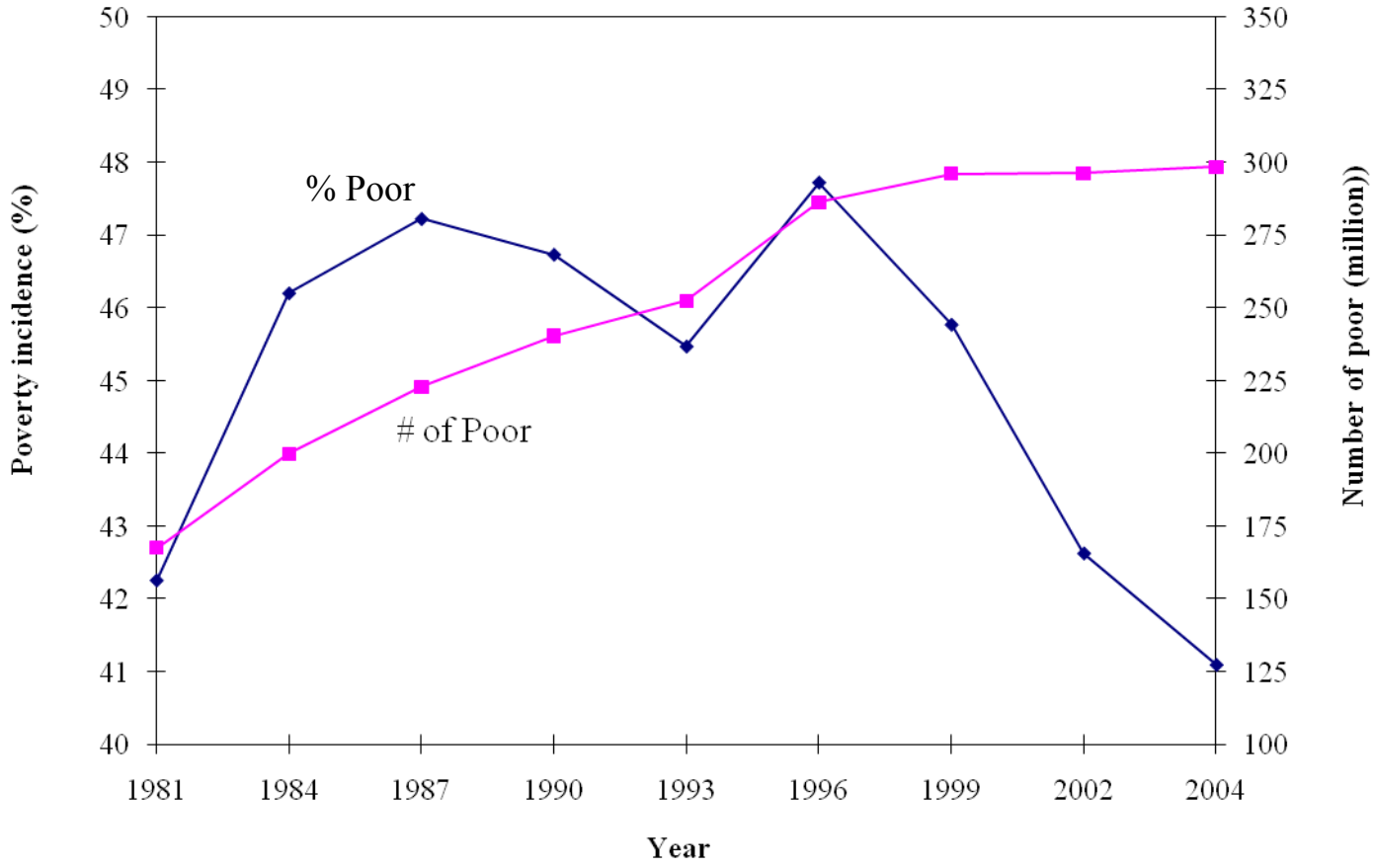
Cereal Yields in African Agriculture

(tons/ha), 1961-2007



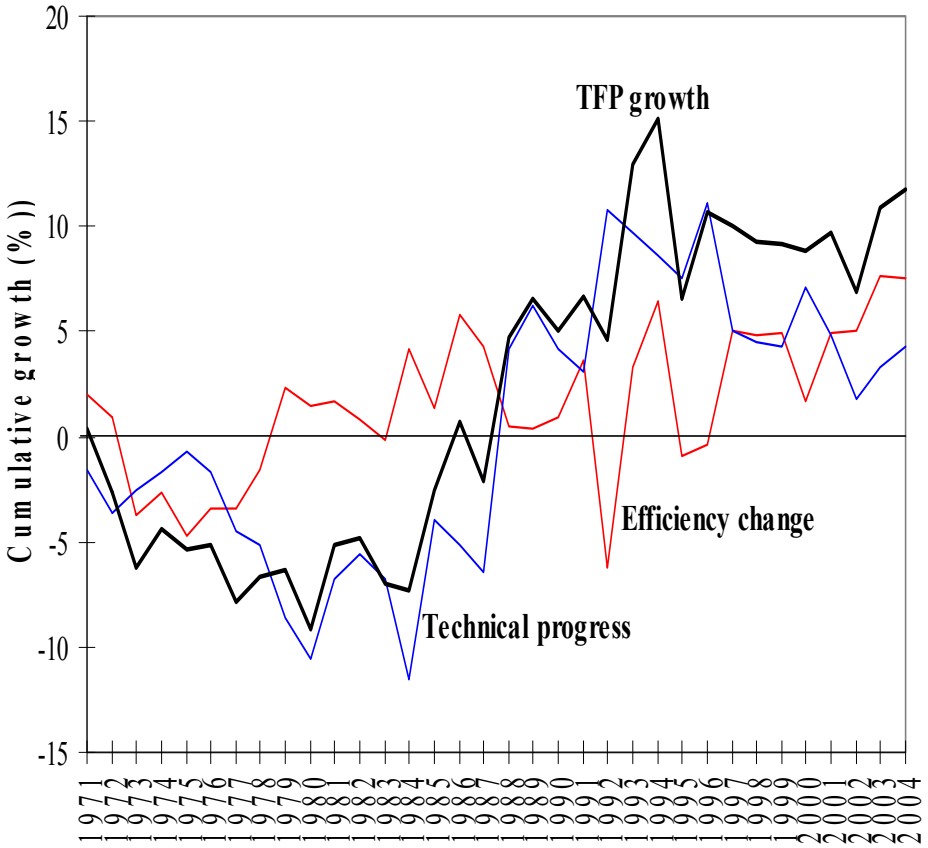
Poverty trends in SSA

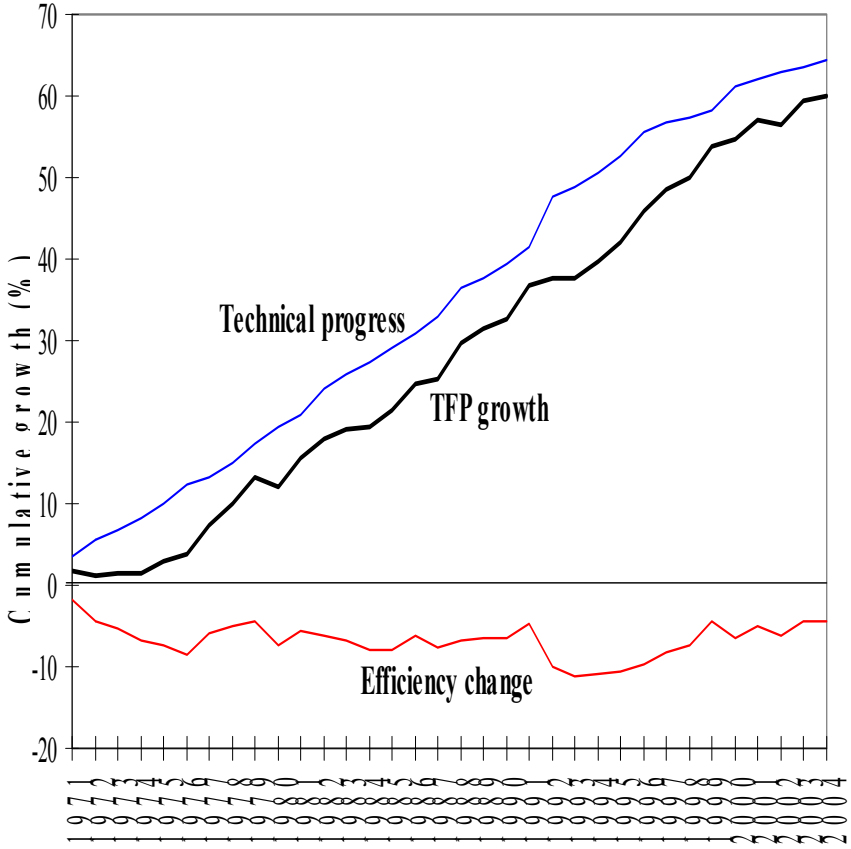


Source: Chen and Ravallion (2007).

Productivity Growth in African Agriculture

Conventional vs. Improved estimates





Conventional estimates 0.3% per year

New estimates **Africa:** 1.8% per year
SSA: 1.6% per year

Stronger recovery of agric. productivity than conventional measures would suggest

Aggregate Performance (%/year)

Study	Method	1981–1990	1991–2004
This Study	C. Malmquist	1.4	0.5
	S. Malmquist	**1.7**	**2.1**
		2.00 (1985–2004)	
Nkamleu (2004) *N*=16	C. Malmquist	**0.10** (1970–2001)	
Lusigi and Thirtle (1997) *N*=47	C. Malmquist	**1.27** (1961–1991)	
Fulginiti et al. (2004) *N*=41	Production function	**1.90** (1985–1999)	
Fuglie (2008)	Growth accounting	**1.20** (1990–2006)	
Nin-Pratt and Yu (2008) *N*=31 (adj.)	C. Malmquist	**1.74** (1984–2003)	
Avila and Evenson (2010) *N*=37	Growth accounting	**1.68** (1981–2001)	
Block (1994,1995) *N*=39	Production function	**1.60** (1983–1988)	

Explaining Agricultural Productivity (*N*=15)

Alternative R&D lag specifications (Fixed Effects: Hausman rejects RE)

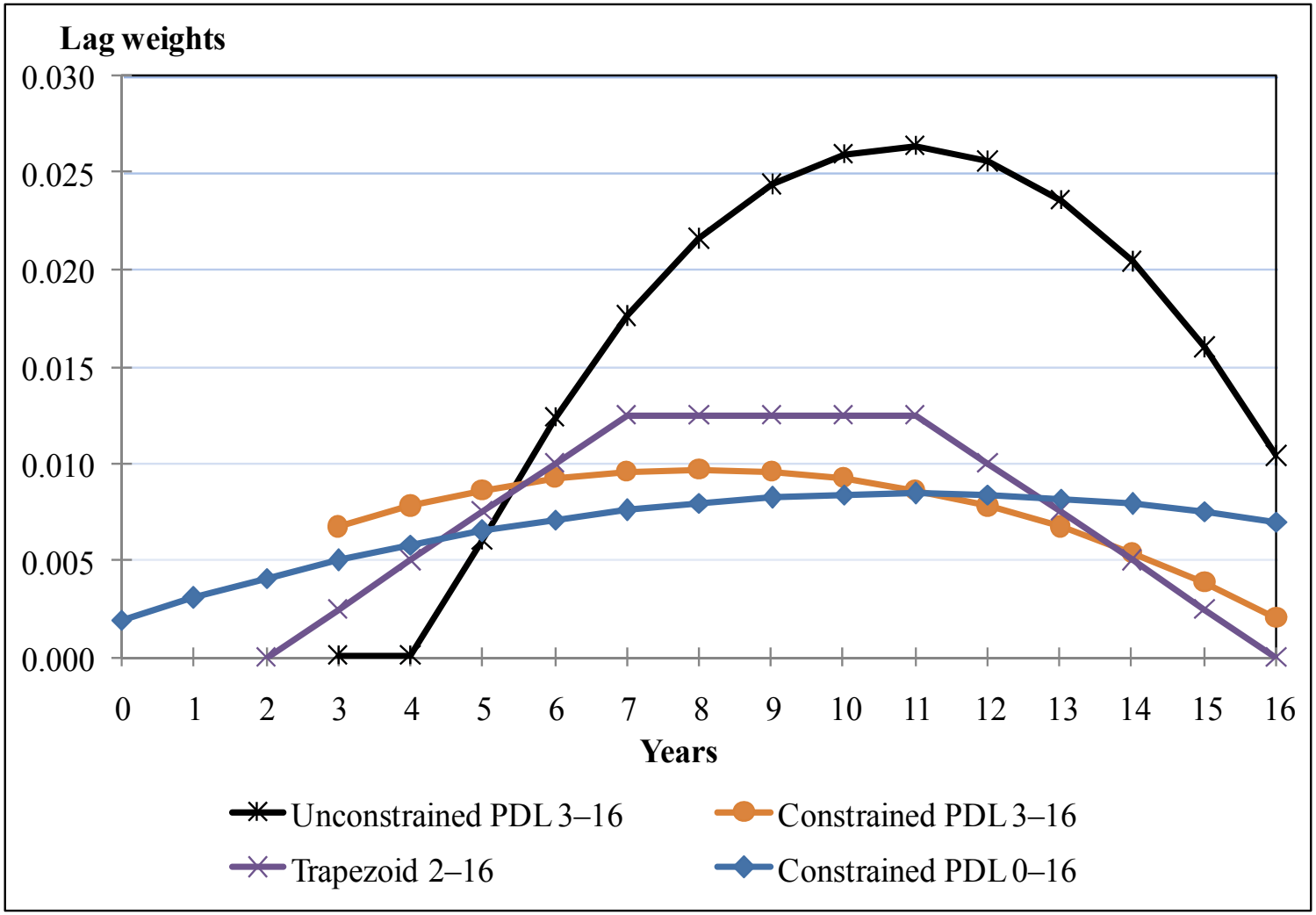
Variable	Trapezoid (2—16)		Constrained PDL (0—16)		Unconstrained PDL (3—16)	
	Coefficient	*t*-value	Coefficient	*t*-value	Coefficient	*t*-value
$R\&D_t$			0.0019	1.65*		
$R\&D_{t-1}$			0.0030	1.65*		
$R\&D_{t-2}$	0		0.0041	1.65*		
$R\&D_{t-3}$	0.0025	1.83*	0.0050	1.65*	–0.0104	–1.09
$R\&D_{t-4}$	0.0050	1.83*	0.0058	1.65*	–0.0016	–0.39
$R\&D_{t-5}$	0.0075	1.83*	0.0065	1.65*	0.0060	0.61
$R\&D_{t-6}$	0.0100	1.83*	0.0071	1.65*	0.0124	1.52
$R\&D_{t-7}$	0.0125	1.83*	0.0076	1.65*	0.0176	2.05**
$R\&D_{t-8}$	0.0125	1.83*	0.0080	1.65*	0.0216	2.33**
$R\&D_{t-9}$	0.0125	1.83*	0.0082	1.65*	0.0244	2.48**
$R\&D_{t-10}$	0.0125	1.83*	0.0084	1.65*	0.0260	2.58**
$R\&D_{t-11}$	0.0125	1.83*	0.0084	1.65*	0.0264	2.64**
$R\&D_{t-12}$	0.0100	1.83*	0.0084	1.65*	0.0256	2.63**
$R\&D_{t-13}$	0.0075	1.83*	0.0082	1.65*	0.0236	2.43**
$R\&D_{t-14}$	0.0050	1.83*	0.0079	1.65*	0.0204	1.79*
$R\&D_{t-15}$	0.0025	1.83*	0.0075	1.65*	0.0160	0.78
$R\&D_{t-16}$	0		0.0070	1.65*	0.0104	0.01
$\sum_j R\&D_{t-j}$	0.11		0.10		0.20	
Weather	0.166	2.82***	0.161	2.74***	0.167	2.82***
Labor/ha	0.319	1.15	0.290	1.05	0.389	1.39
$(\text{Labor/ha})^2$	0.035	0.71	0.036	0.72	0.044	0.87
Literacy	0.016	0.18	0.014	0.16	0.022	0.25
Trade	0.188	3.31***	0.192	3.37***	0.176	3.08***
Time trend	–0.003	–0.11	–0.003	–0.12	–0.002	–0.07
$(\text{Time trend})^2$	–0.001	–0.18	–0.001	–0.14	–0.001	–0.29
Constant	–1.854	–2.31**	–1.856	–2.31**	–1.745	–2.18**
R^2	0.80		0.80		0.88	
Log likelihood	168		168		170	
AIC	–318		–317		–318	
SBIC	–288		–288		–282	

R&D
ε = 0.20

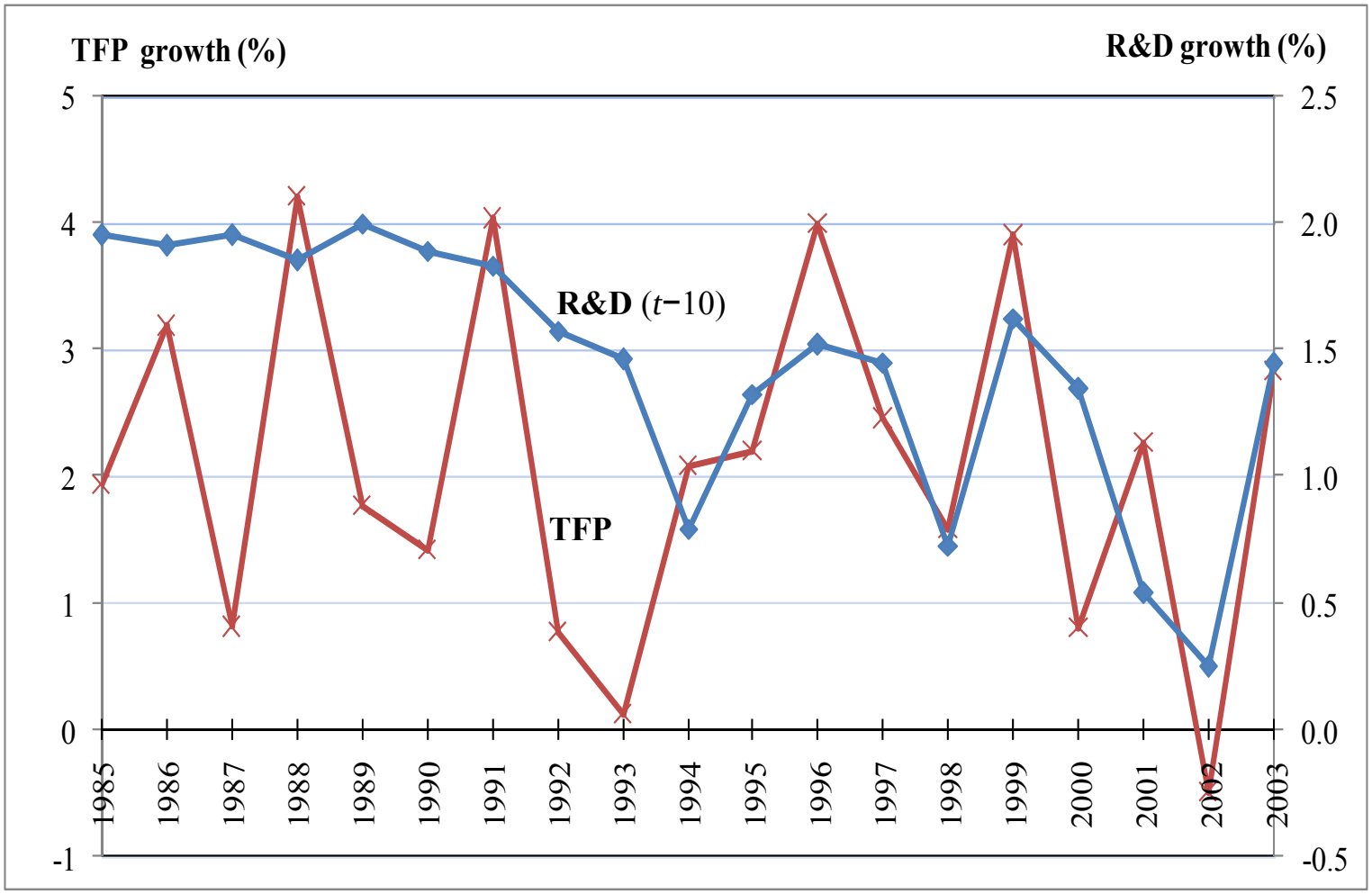
Weather
ε = 0.17

Reforms
ε = 0.18

Alternative R&D lag structures

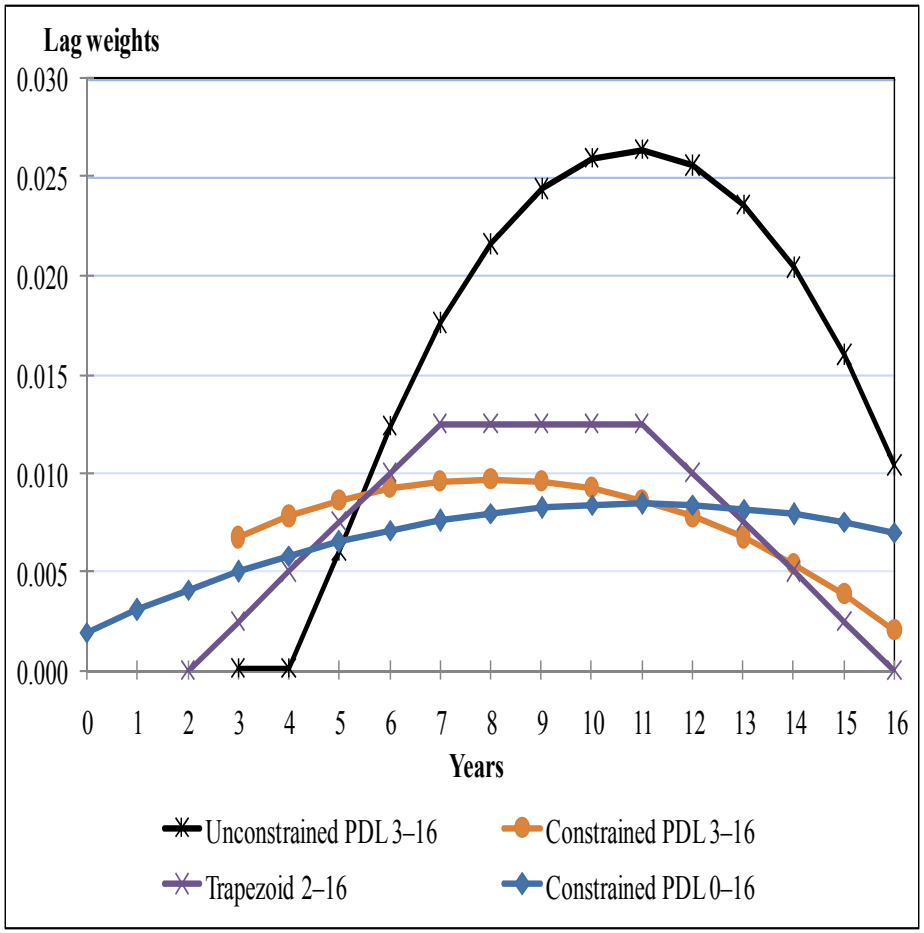


R&D and Agricultural Productivity



Aggregate Rate of Return

$$\sum_{j=0}^{L}\left[\frac{\beta_{1j}\times\frac{\overline{TFP_t}}{\overline{(R\&D)_{t-j}}}\times\frac{\Delta VA_t}{\Delta TFP_t}}{(1+r)^j}\right]-1=0$$

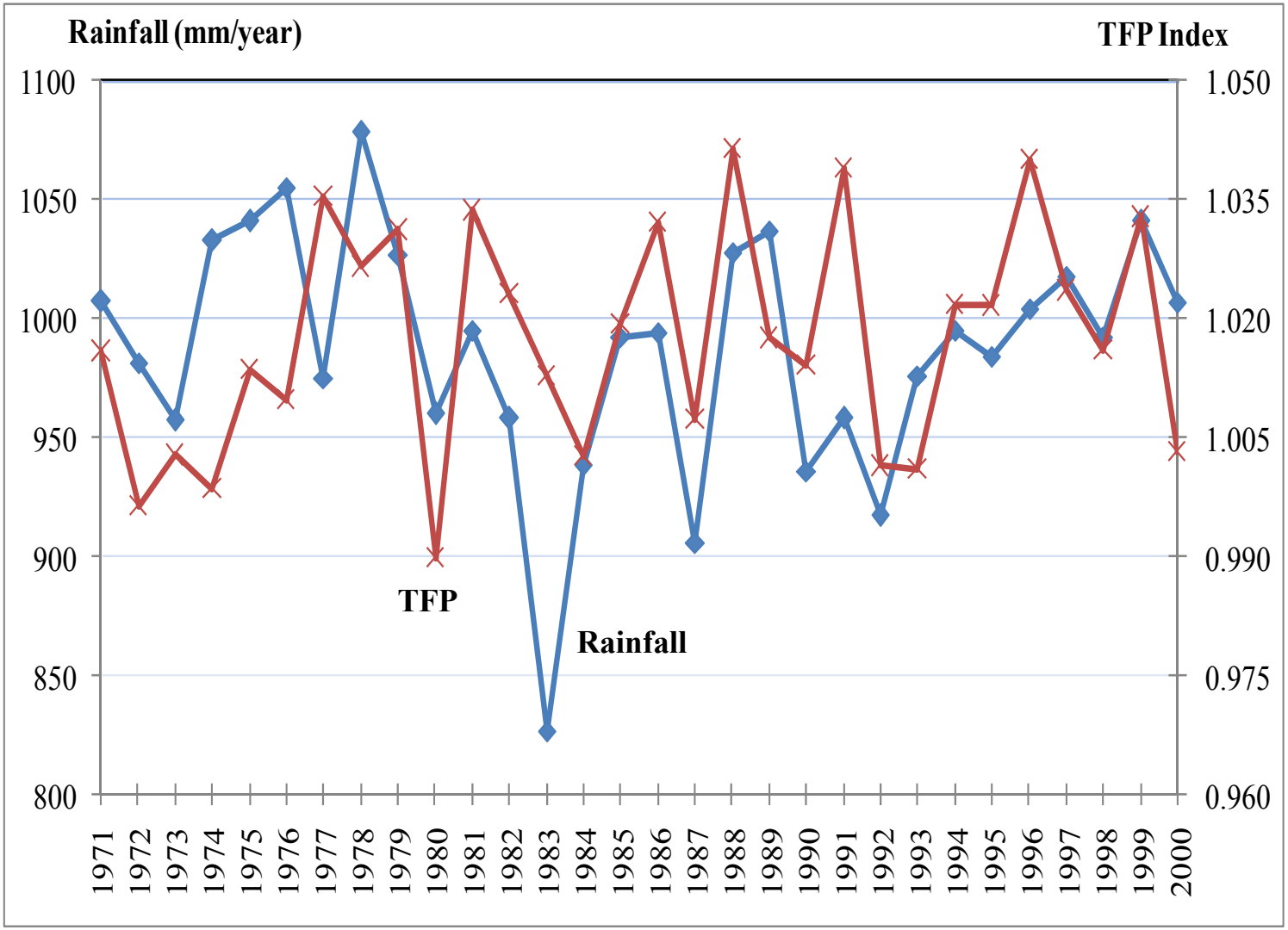


Model	G. lag (years)	Elasticity	ROR (%)
Trapezoid	3	0.11	**27**
	1	0.10	34
C. PDL	3	0.10	31
	0	0.10	44
UC. PDL	3	0.20	**33**
	0	0.10	39

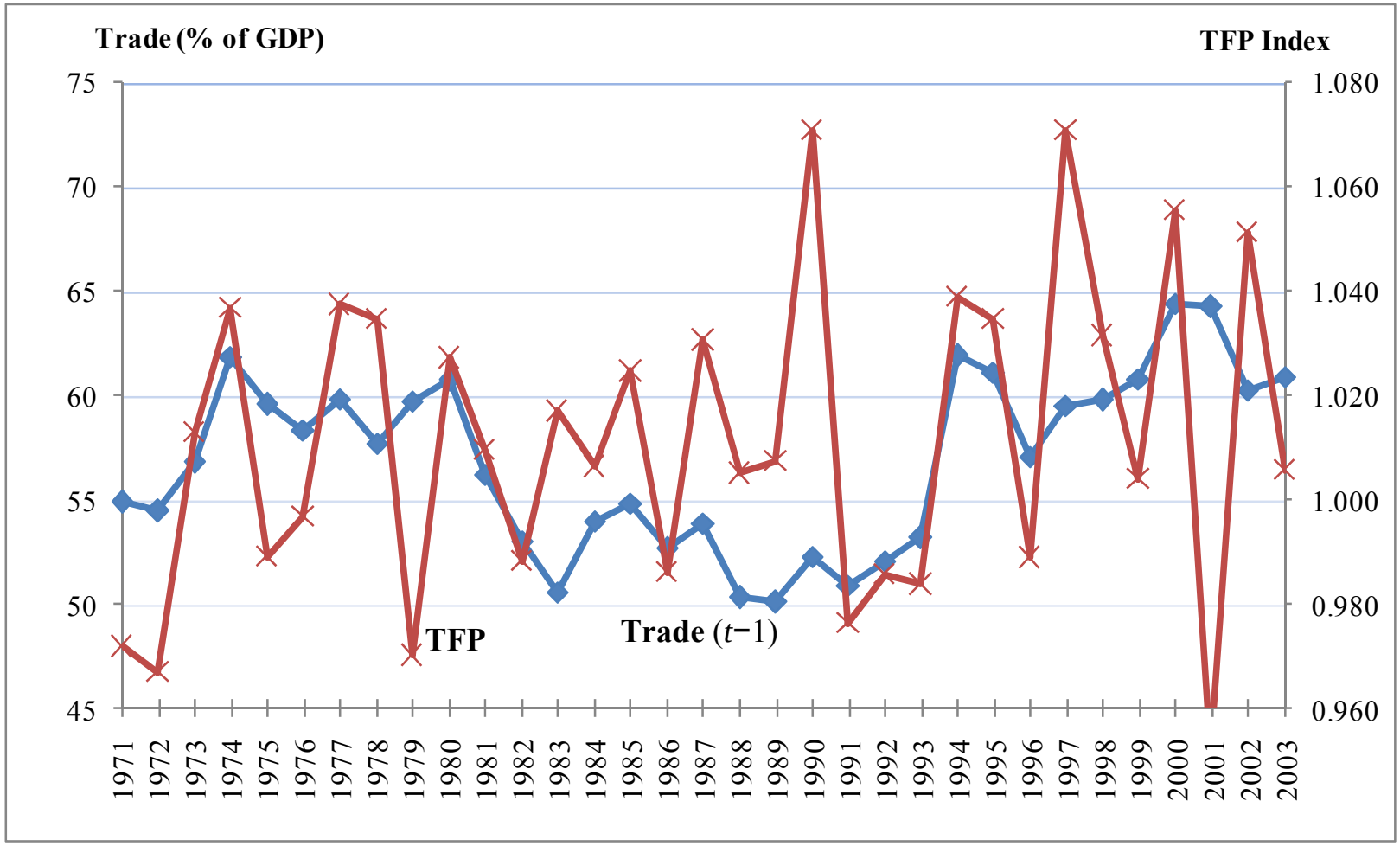
Effects of weather and trade policy reforms

Model	**Gestation lag** (years)	**Elasticity**	
		Weather	Trade
Trapezoid	3	0.17***	0.19***
	1	0.16***	0.19***
Constrained PDL	3	0.16***	0.19***
	0	0.16***	0.19***
Unconstrained PDL	3	0.17***	0.18***
	0	0.16***	0.19***

Weather and agricultural productivity



Trade reforms and agricultural productivity



Conclusion

- Stronger recovery of TFP than conventional analyses would suggest
- Results confirm the key roles of R&D, weather, and reforms
- Vulnerability of the gains to climate change
- Scope for achieving greater impacts through:
  - greater liberalization and full implementation of reform programs
  - Increased R&D investments (ROR > 30%)

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Thank You