Livestock Productivity and the Global Performance Gap

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Plenary session: Findings on livestock productivity gaps and trends, and their implications for natural resource use efficiency

Global Agenda of Action in Support of Sustainable Livestock Development

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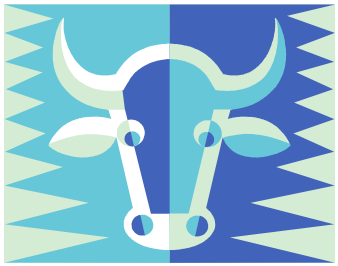
IDB

Outline of Presentation

- Productivity gap. Is there one?
- Looking at species and countries
- What data tells us: PFP vs TFP
- Methodology – Malmquist Index
- Input/output allocation
- Productivity Growth
- Technical change and efficiency
- Convergence in Livestock Productivity



The global performance gap

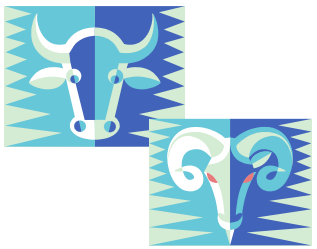
- Where are the largest gaps
  - Animal species and commodity
  - Production systems (grazing, mixed, industrial)
  - Countries/regions
- In this presentation, evidence for:
  - Animal species
  - Countries and regions

Productivity Gap: is there any evidence?

- Evidence regardless of use of productivity measurement
  - Partial Factor Productivity (PFP)
  - Total Factor Productivity (TFP)
- However, TFP offers a more complete picture of resource use (although limited to present discussion)
  - Land, water, nutrients, fossil energy, air
  - Gas emissions

PFP and TFP Measures

- PFP (yield) is the one mostly used
- TFP estimation very recent:
  - Problem in estimation: Input/output allocation
  - Product specific Malmquist Index (Nin-Pratt et al., 2003)): Crops and Livestock
  - Ludena et al. 2007: Crops, Ruminants (beef, dairy, sheep, and goats) and Non-Ruminants (pigs and poultry)

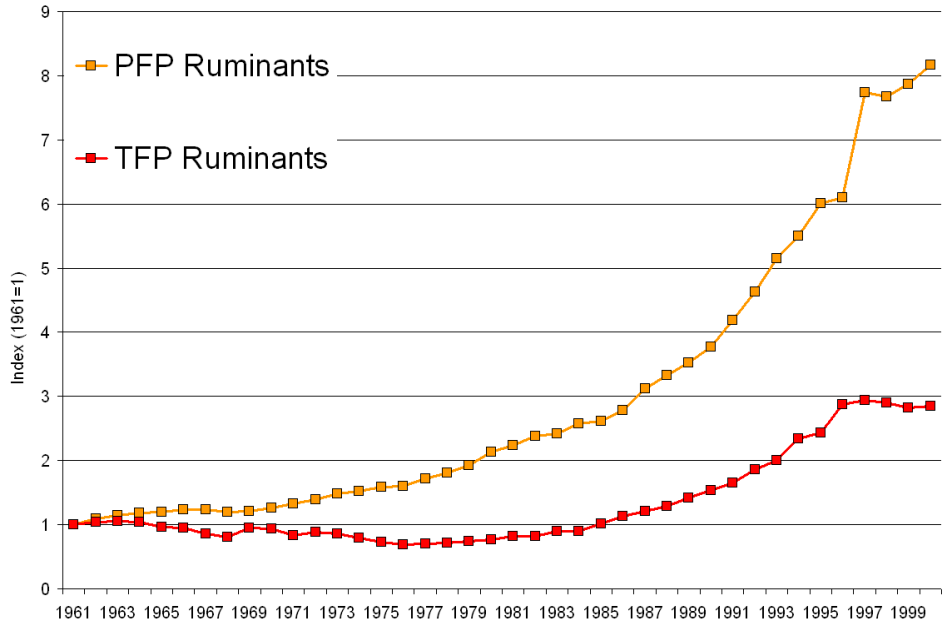


Difference between ruminants and non-ruminants

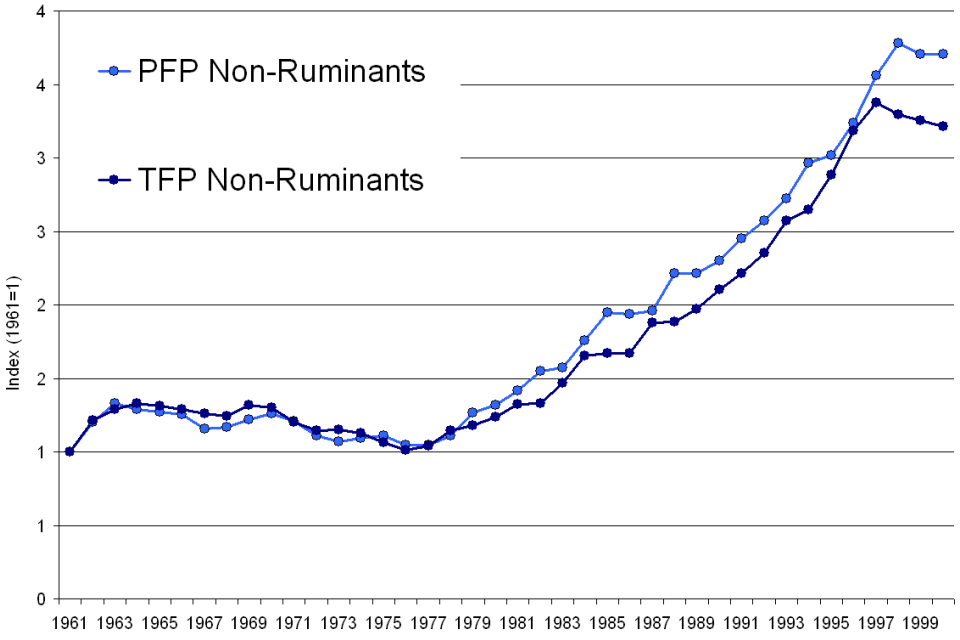
- PFP Evidence:
  - Difference between ruminants (beef, dairy, sheep, goats, horses), and non-ruminants (pigs, poultry)
  - Delgado et al. (1999): Between 1982-1994 average growth per year for beef grew was 0.5%, milk 0.2%, pork 0.6%, and poultry 0.7%
  - Rae and Hertel (2000) show that in Asia the rate of growth for non-ruminants is higher than ruminants

TFP vs PFP: Case of China

Ruminants

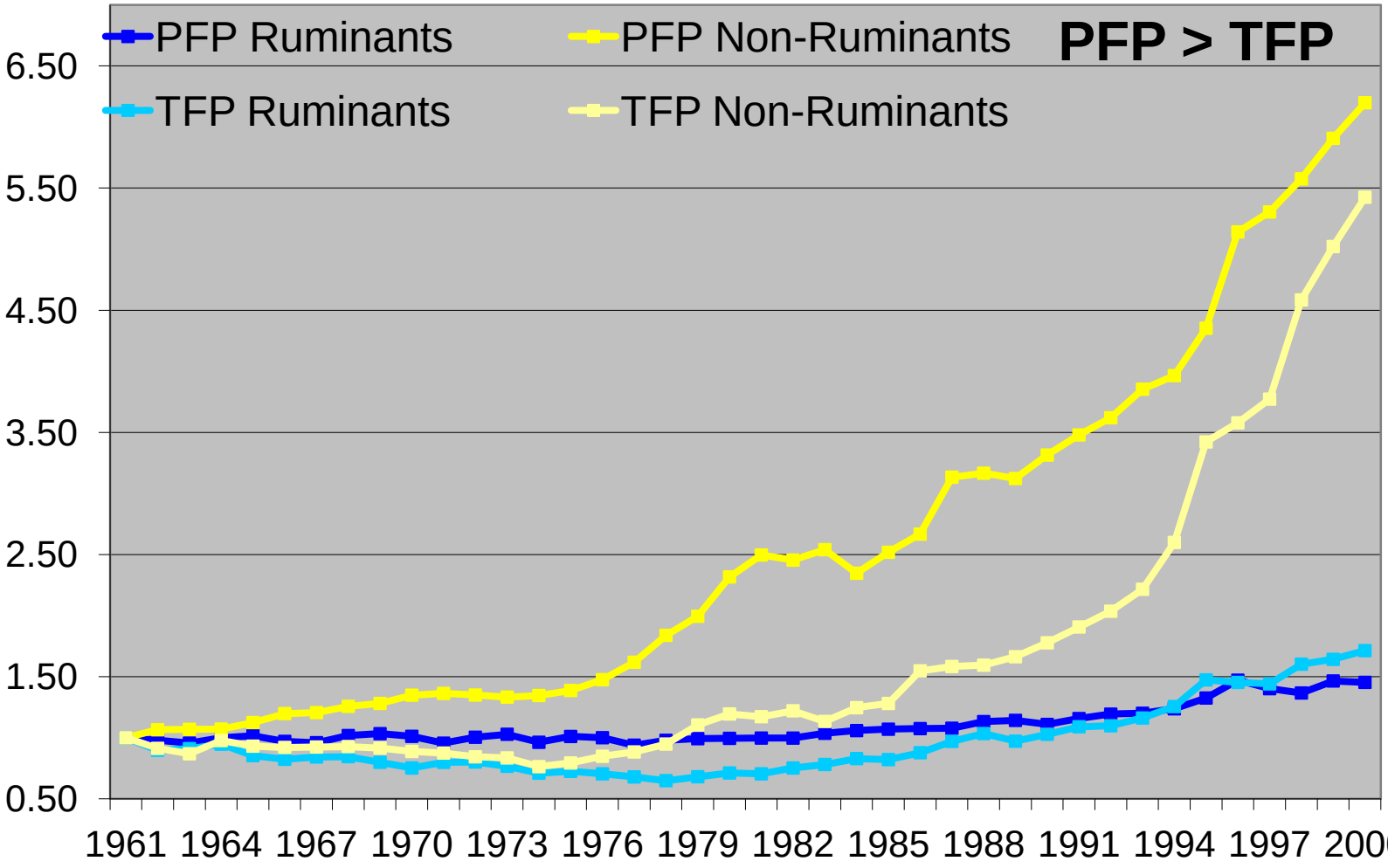


Non-Ruminants



PFP > TFP = farmers in China have substituted other inputs for animal stock. Improved feed efficiency and reduced labor usage.

TFP vs PFP: Case of Brazil



TFP Productivity Measurement - Methodology

- Product-specific directional Malmquist index (Nin-Pratt et al., 2003)

$$DM(t,t+1) = \left[\frac{\left(+\vec{D}_0^t\left(\right.\right.^t, y_i^t, y_{-i}^t; y_i^t, \mathbf{0}\right)}{\left(+\vec{D}_0^t\left(\right.\right.^{t+1}, y_i^{t+1}, y_{-i}^{t+1}; y_i^{t+1}, \mathbf{0}\right)} \cdot \frac{\left(+\vec{D}_0^{t+1}\left(\right.\right.^t, y_i^t, y_{-i}^t; y_i^t, \mathbf{0}\right)}{\left(+\vec{D}_0^t\left(\right.\right.^{t+1}, y_i^{t+1}, y_{-i}^{t+1}; y_i^{t+1}, \mathbf{0}\right)} \right]^{0.5}$$

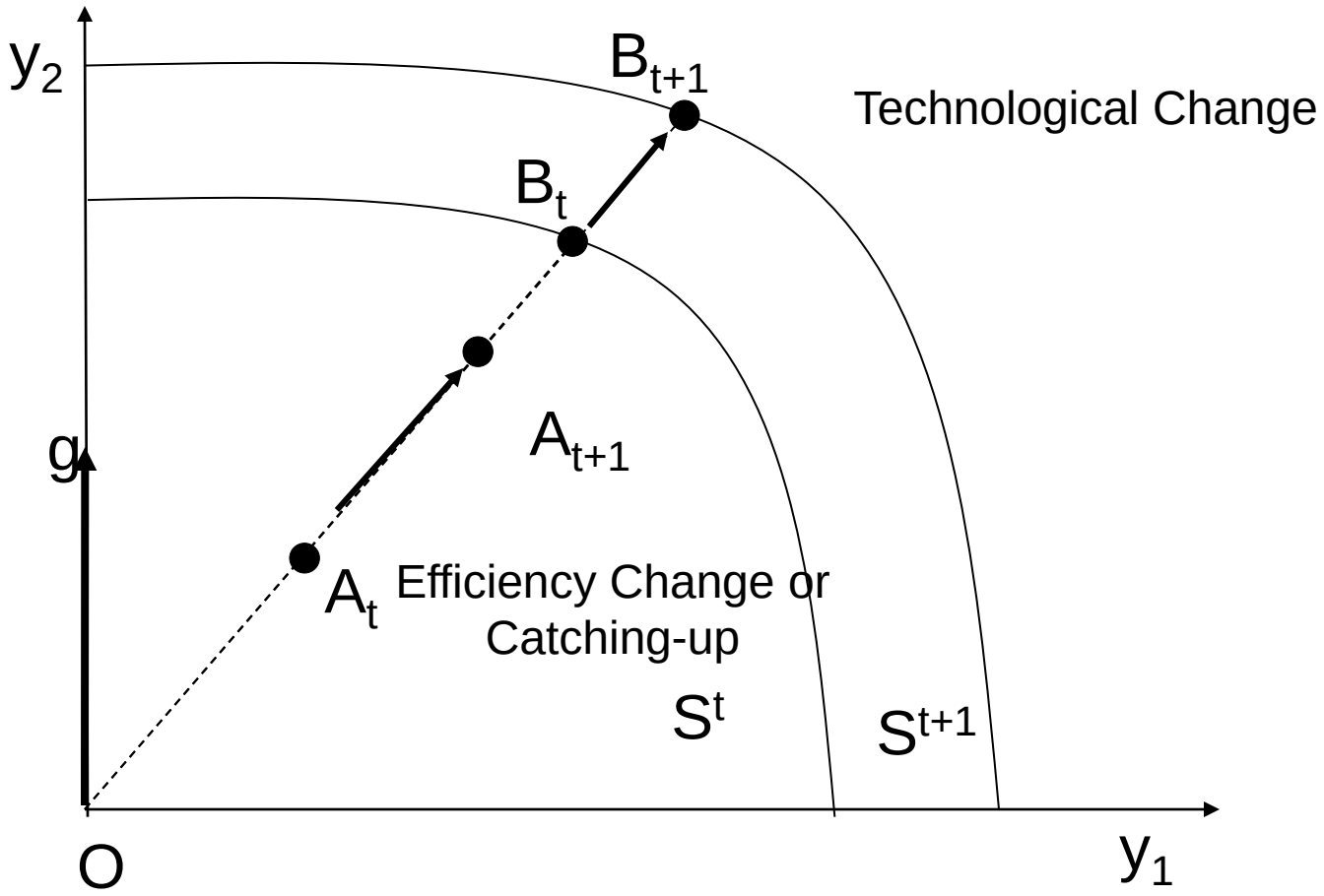
TFP Productivity Measurement - Methodology

- Malmquist index efficiency and technical change components:

$$DEFF(t,t+1) = \frac{\left(+\vec{D}_0^t\left(x^t, y_i^t, y_{-i}^t; y_i^t, \mathbf{0}\right)\right)}{\left(+\vec{D}_0^t\left(x^{t+1}, y_i^{t+1}, y_{-i}^{t+1}; y_i^{t+1}, \mathbf{0}\right)\right)}$$

$$DTECH(t,t+1) = \left[\frac{\left(+\vec{D}_0^{t+1}\left(x^t, y_i^t, y_{-i}^t; y_i^t, \mathbf{0}\right)\right)}{\left(+\vec{D}_0^t\left(x^t, y_i^t, y_{-i}^t; y_i^t, \mathbf{0}\right)\right)} \cdot \frac{\left(+\vec{D}_0^{t+1}\left(x^{t+1}, y_i^{t+1}, y_{-i}^{t+1}; y_i^{t+1}, \mathbf{0}\right)\right)}{\left(+\vec{D}_0^t\left(x^{t+1}, y_i^{t+1}, y_{-i}^{t+1}; y_i^{t+1}, \mathbf{0}\right)\right)}\right]^{0.5}$$

Technological and Efficiency Changes Compared



TFP Productivity Measurement - Data

- FAOSTAT: 116 countries, 1961-2001
- Output – Crops and Livestock (Ruminants and Non-Ruminants)
- Inputs
  - Land (Pasture, Arable and Permanent Crops)
  - Machinery (tractors, milking machines)
  - Animal stock
  - Feed
  - Fertilizers
  - Labor

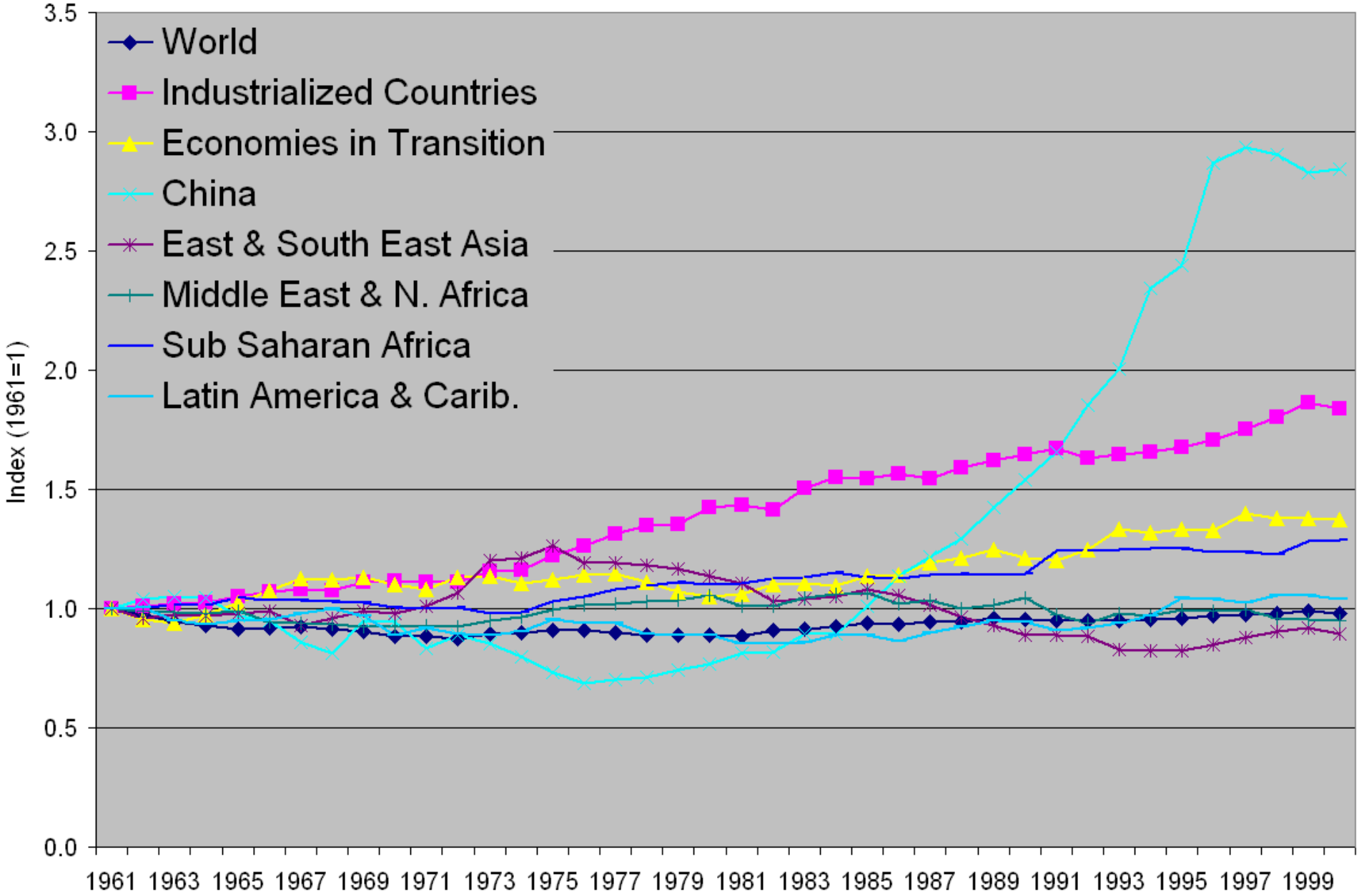
Input-Output Allocation

Input	Output
Arable land and permanent crops	Crops
Land in pasture	Ruminants
Tractors and harvesters	Crops
Milking Machines	Ruminants
Ruminant Stock	Ruminants
Non-Ruminant Stock	Non-ruminants
Feed	Livestock
Fertilizer	Crops
Labor	All

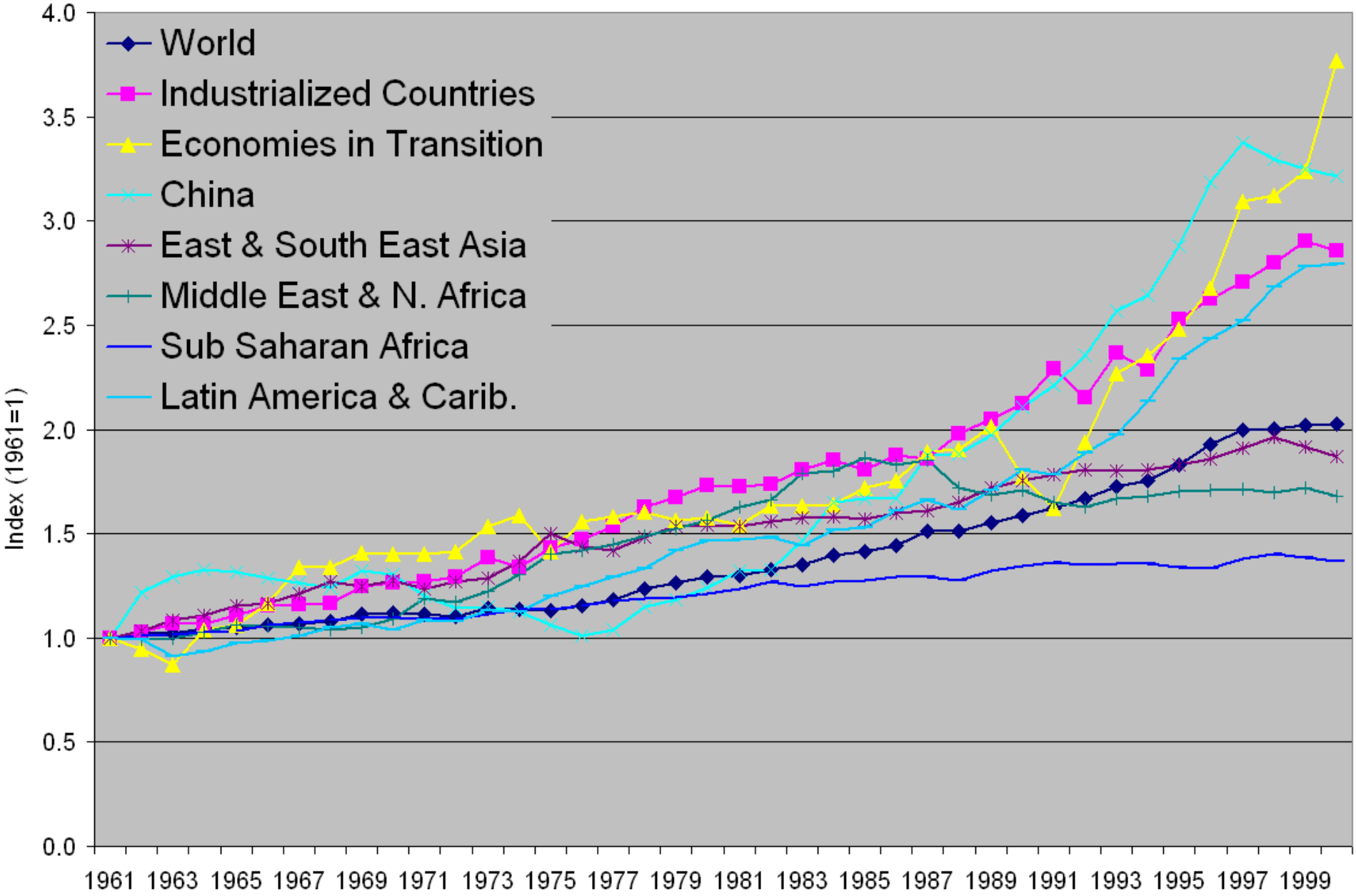
Annual TFP Growth Rates (%) (1961-2001)

Country/Region	Ruminants			Non-Ruminants		
	TFP	EFF	TCH	TFP	EFF	TCH
World	0.62	-0.03	0.65	2.10	-1.08	3.23
Developed Countries	0.93	-0.27	1.20	2.11	-1.36	3.52
Developing Countries	0.38	-0.27	0.65	2.38	-0.90	3.31
Economies in Transition	0.76	-0.50	1.27	3.24	-1.84	5.17
East and South East Asia	-0.27	-1.14	0.87	1.65	-1.91	3.56
China	2.87	1.88	0.97	3.39	-1.90	5.39
Middle East/North Africa	-0.03	-1.28	1.25	1.54	-0.53	2.07
Sub-Saharan Africa	0.59	-0.05	0.64	0.80	-0.40	1.21
Latin America and Carib.	0.12	-1.01	1.13	2.64	-1.12	3.76
Brazil	1.20	-0.31	1.51	4.33	0.55	3.76

Cumulative Ruminant Productivitv Growth



Cumulative Non-Ruminant Productivitv Growth



Taking a closer look to meat, dairy, poultry and pig production

Region	Ruminants		Non-Ruminants	
	Meat	Dairy	Poultry	Pigs
Ruminants				
Developed	6.16	4.95	7.40	
Developing	1.39	1.60	3.37	
Non-Ruminants				
Developed	4.98		10.88	3.20
Developing	1.72		2.93	3.33
Ruminants & Non-Ruminants				
Developed	5.45	5.51	10.66	3.61
Developing	1.05	1.71	3.28	3.96

World Productivity Growth by decade (annual TFP growth rates, %)

Period	Ruminants			Non-Ruminants		
	TFP	EFF	TCH	TFP	EFF	TCH
1961-00	***0.62***	***-0.03***	***0.65***	***2.10***	***-1.08***	***3.23***
1961-70	0.00	-0.88	0.89	2.31	-0.04	2.35
1971-80	0.31	-0.39	0.70	0.72	-1.39	2.16
1981-90	1.13	0.70	0.43	2.71	-3.09	6.08
1991-00	1.06	0.50	0.57	2.72	0.27	2.43

Productivity Growth by Decade (annual TFP growth rates, %)

Period	Developed			Developing		
	TFP	TCH	EFF	TFP	TCH	EFF
Ruminants						
1961-2001	0.93	1.20	-0.27	0.38	-0.27	0.65
1961-1971	0.84	0.94	-0.10	-0.61	0.85	-1.46
1971-1981	0.73	0.73	0.00	0.17	0.17	0.00
1981-1991	1.37	1.37	0.00	0.70	0.70	0.00
1991-2001	0.79	0.79	0.00	1.28	3.02	-1.80
Non-Ruminants						
1961-2001	2.11	3.52	-1.36	2.38	3.31	-0.90
1961-1971	1.98	1.95	0.03	2.39	1.35	1.04
1971-1981	1.83	1.83	0.00	1.08	1.08	0.00
1981-1991	1.57	1.57	0.00	3.38	3.38	0.00
1991-2001	3.07	4.87	-1.80	2.68	3.99	-1.31

Productivity Growth Convergence

- Is there a common trend for livestock (ruminant and non-ruminant) factor productivities across countries?
- Use of efficiency time series (Bernard and Durlauf; Johansen, 1988; Cornwell and Watcher, 1999)
- Test for unit roots (non-stationary series) and then cointegration (Johansen, 1991)
  - Linear combination of non-stationary series is stationary => series move together in the long run.

Convergence in Non Ruminants

- Ruminants
  - Divergence between developed and developing countries (DC's)
- Non-Ruminants
  - Evidence of catching-up
  - Convergence of EIT and Latin America to developed countries
  - Convergence of Sub-Saharan Africa to Europe, Asia and Latin America

Conclusions

- Productivity growth in livestock
  - Different productivity growth rates among species
  - Non-Ruminants > Ruminants
  - Poultry seems to have highest growth rate in developed countries
  - Beef vs Milk → inconclusive
- Developing vs Developed
  - Developed – Ruminants
  - Developing – Non-Ruminants
- Convergence
  - Catching-up in non-ruminants

QUESTIONS

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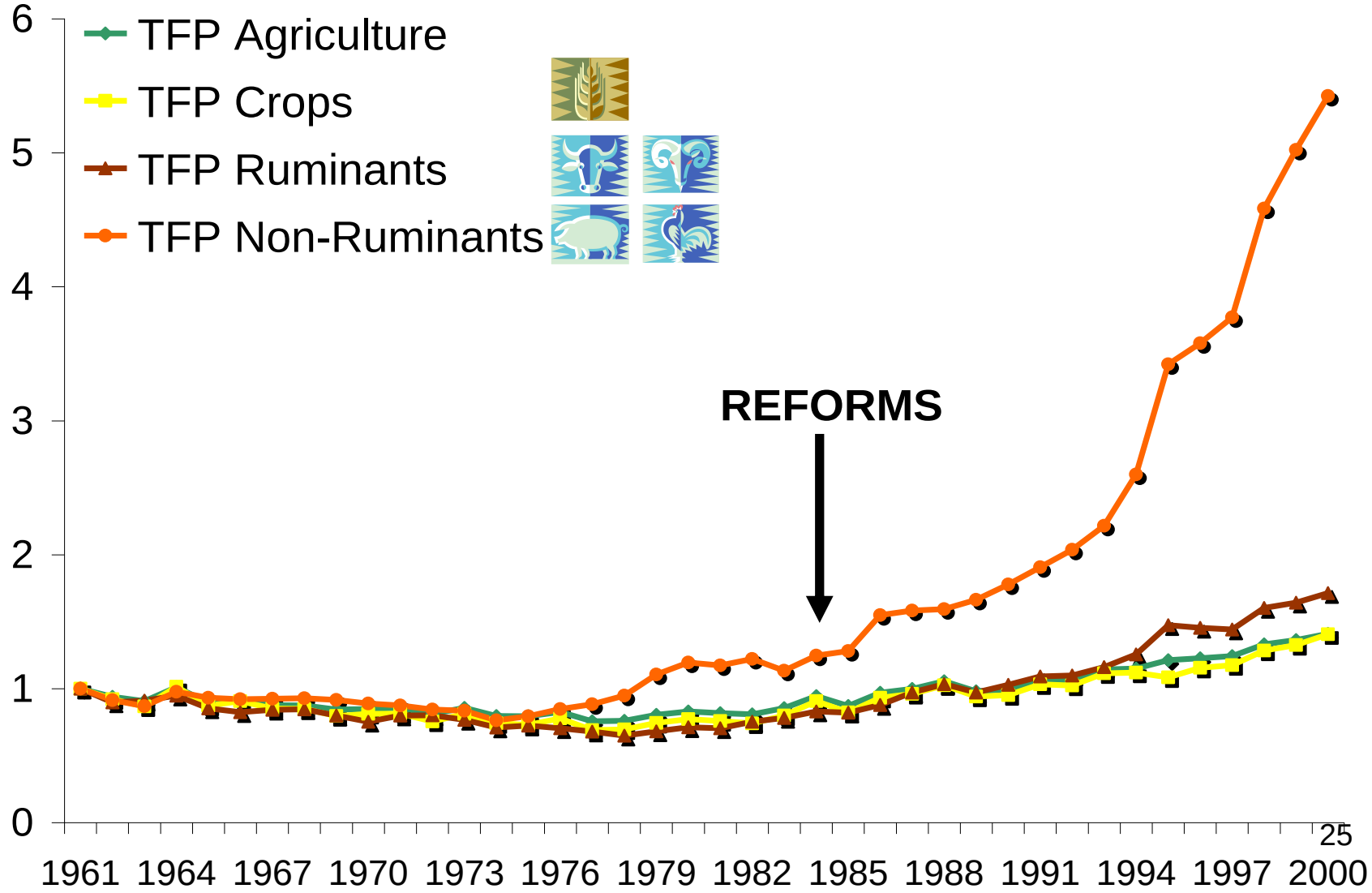
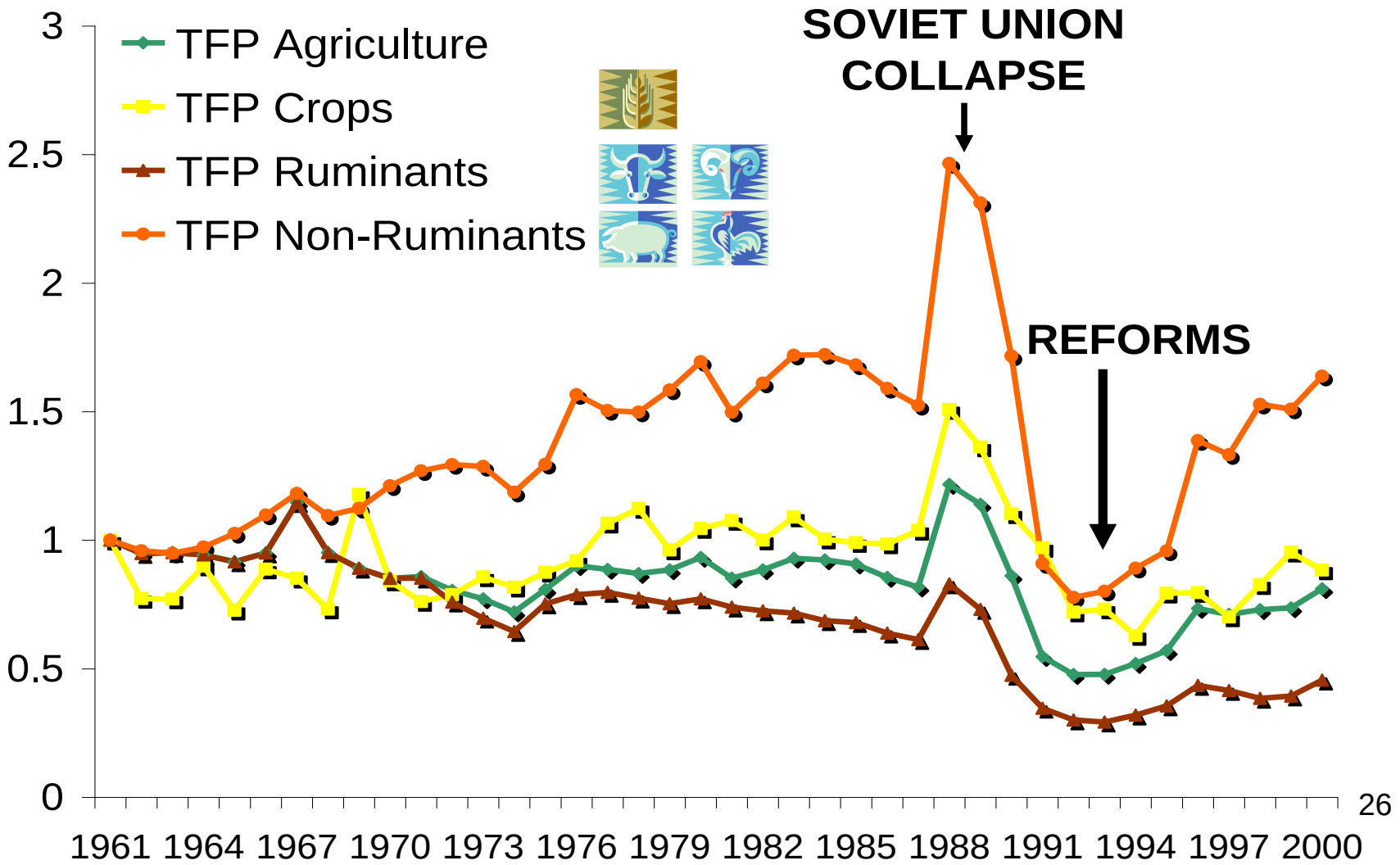
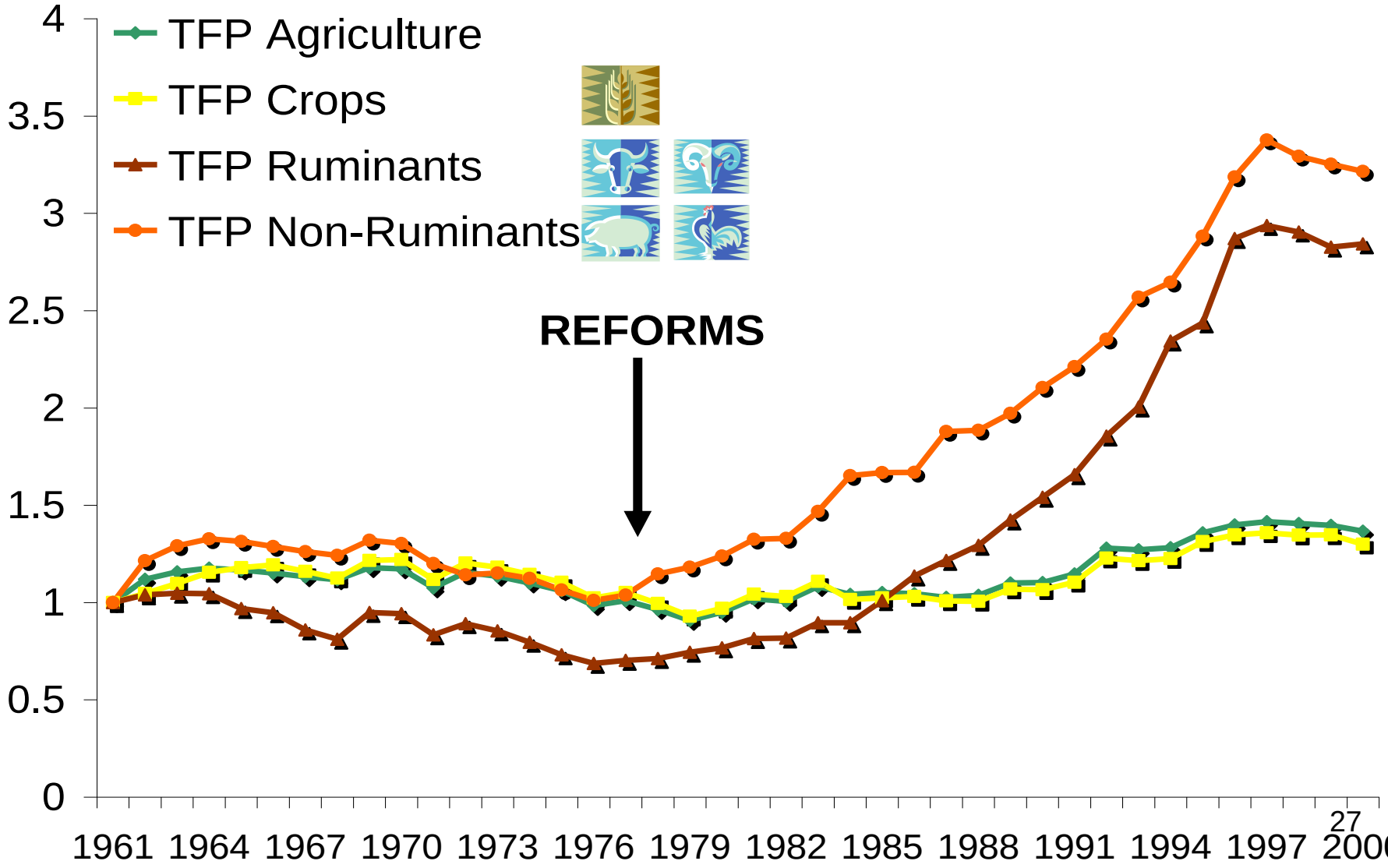
Cumulated Productivity Growth in Brazil (%), 1961-2000



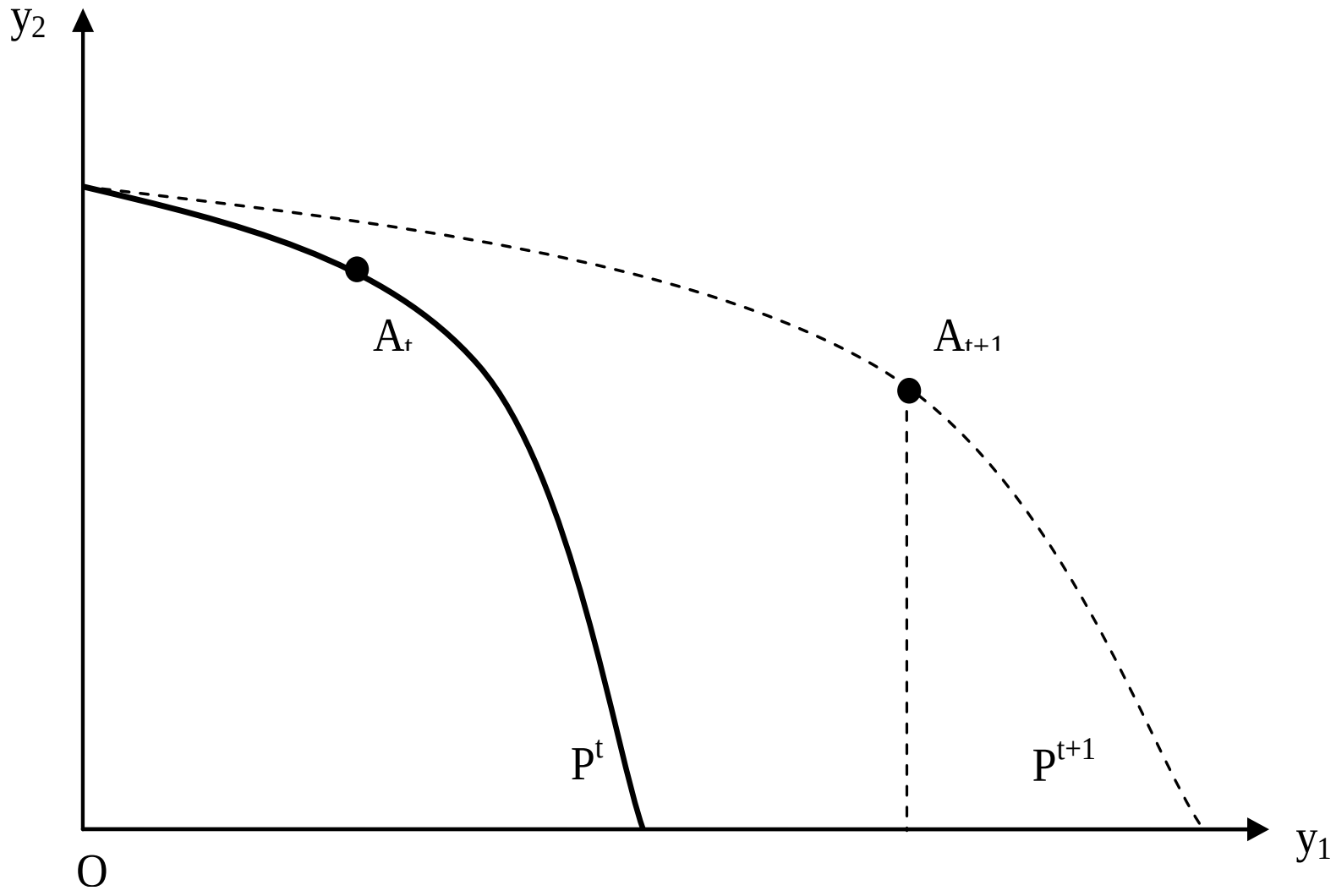
Cumulated Productivity Growth in Cuba (%), 1961-2000



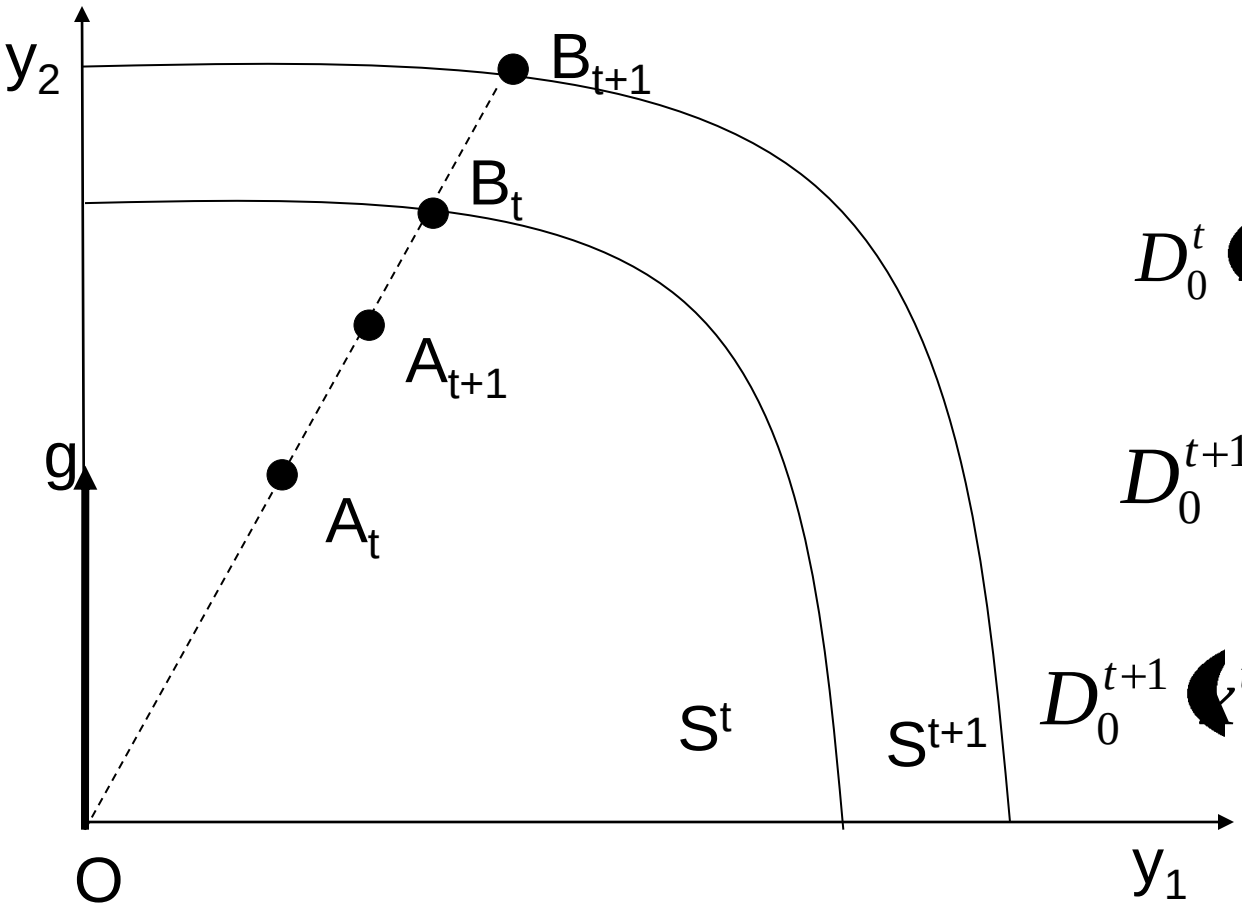
Policy reforms and cumulative productivity growth in China



Efficiency in *y*1's direction of a production point in *t* + 1 with technology in *t* as reference



Distance Functions and Productivity Indices



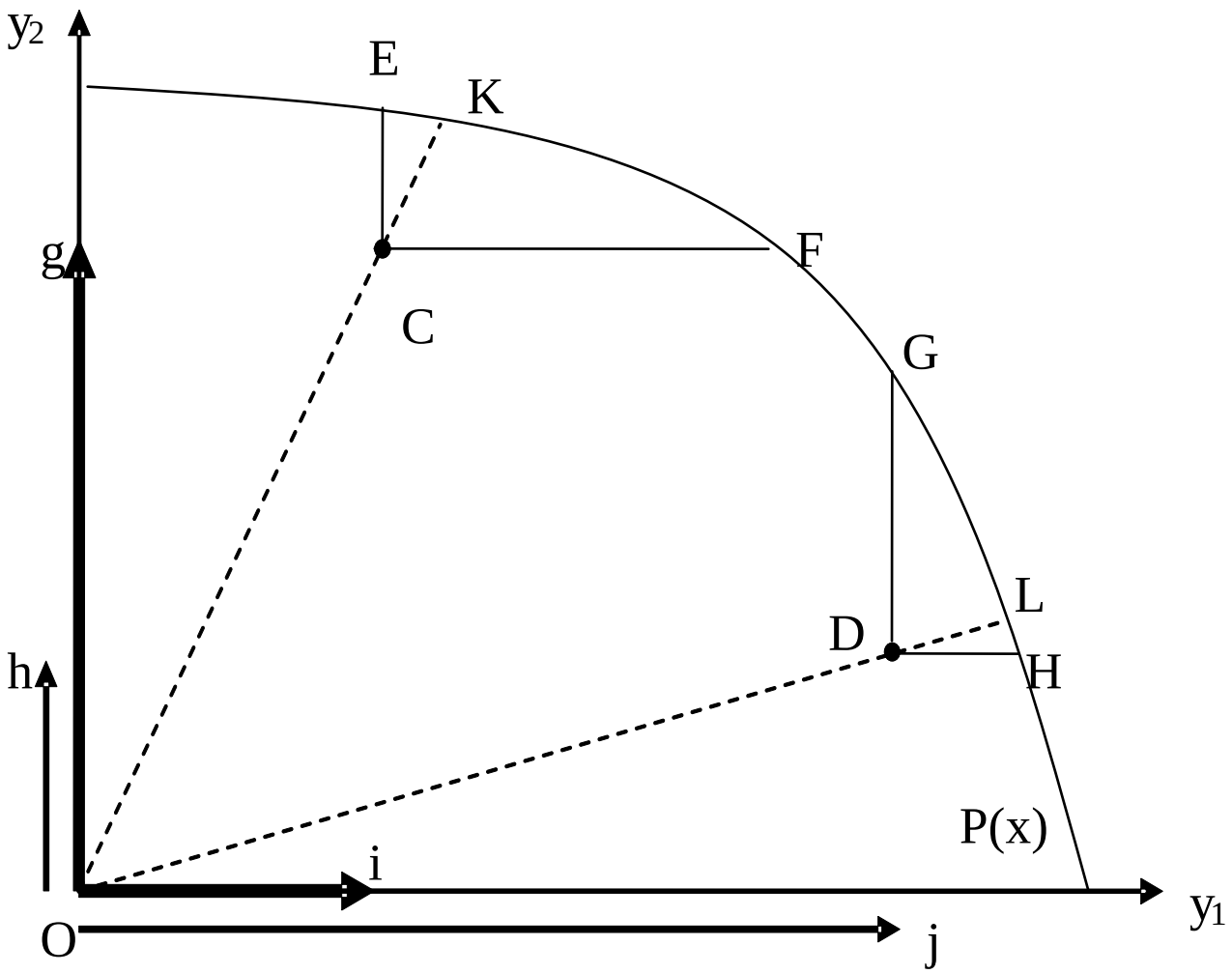
$$D_0^t(x^t, y^t) = \frac{OA_t}{OB_t}$$

$$D_0^t(x^{t+1}, y^{t+1}) = \frac{OA_{t+1}}{OB_t}$$

$$D_0^{t+1}(x^t, y^t) = \frac{OA_t}{OB_{t+1}}$$

$$D_0^{t+1}(x^{t+1}, y^{t+1}) = \frac{OA_{t+1}}{OB_{t+1}}$$

Distance to the frontier measured in different directions



Limitations of the study

- Directional Malmquist Index
  - Not always defined
  - Possible reallocation factor bias in the measure - movement of unallocated inputs
- Data – zero output in pork production for some countries
- Input/Output Aggregation and dissaggregation
  - i.e. feed in livestock
- Regional Aggregation and dissaggregation