Productivity Growth in the Global Agricultural Economy

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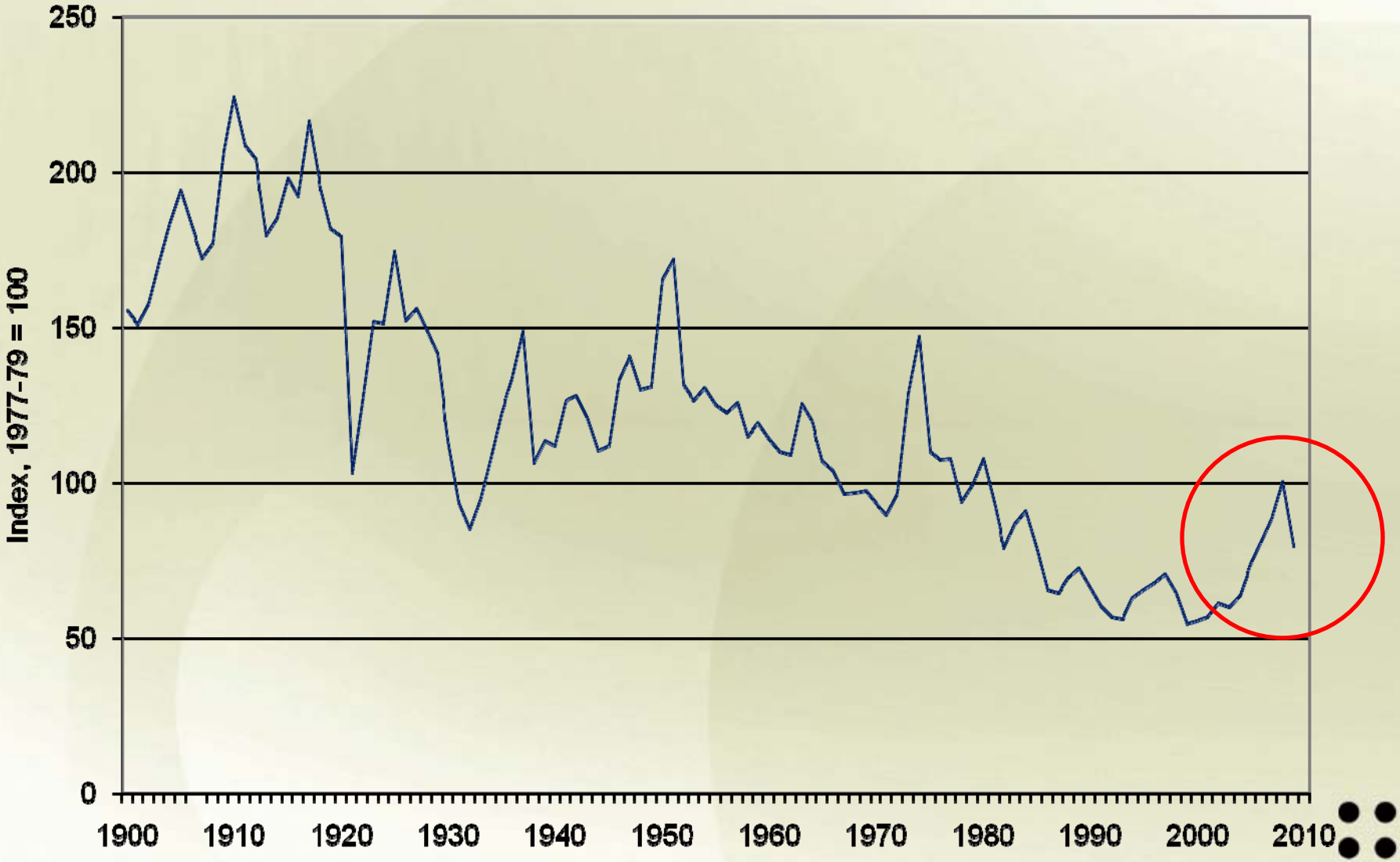
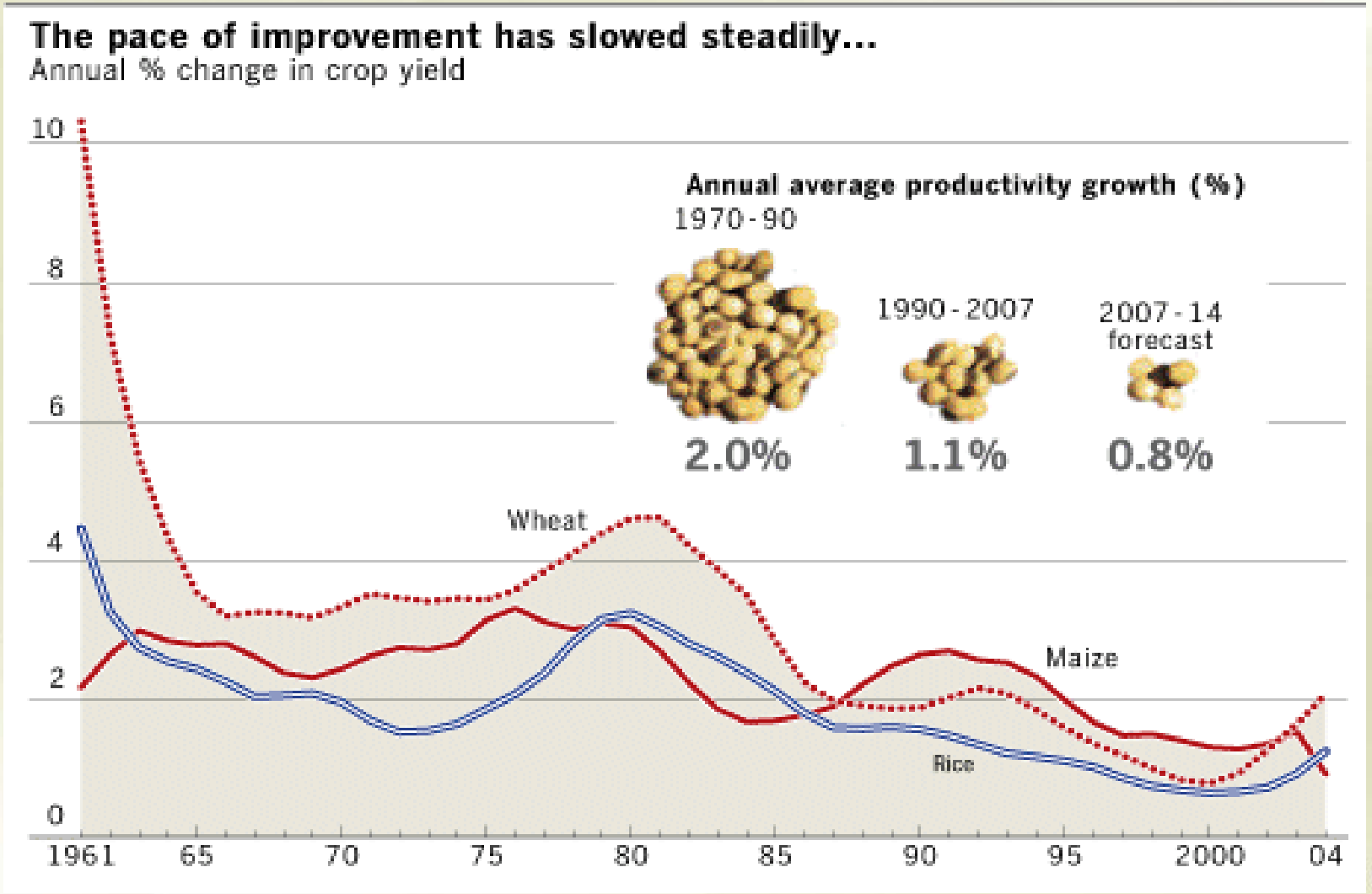
*The views expressed in this presentation are the author's own and not necessarily those of the Economic Research Service.

Long-run decline in real agricultural prices reflects rising productivity relative to demand



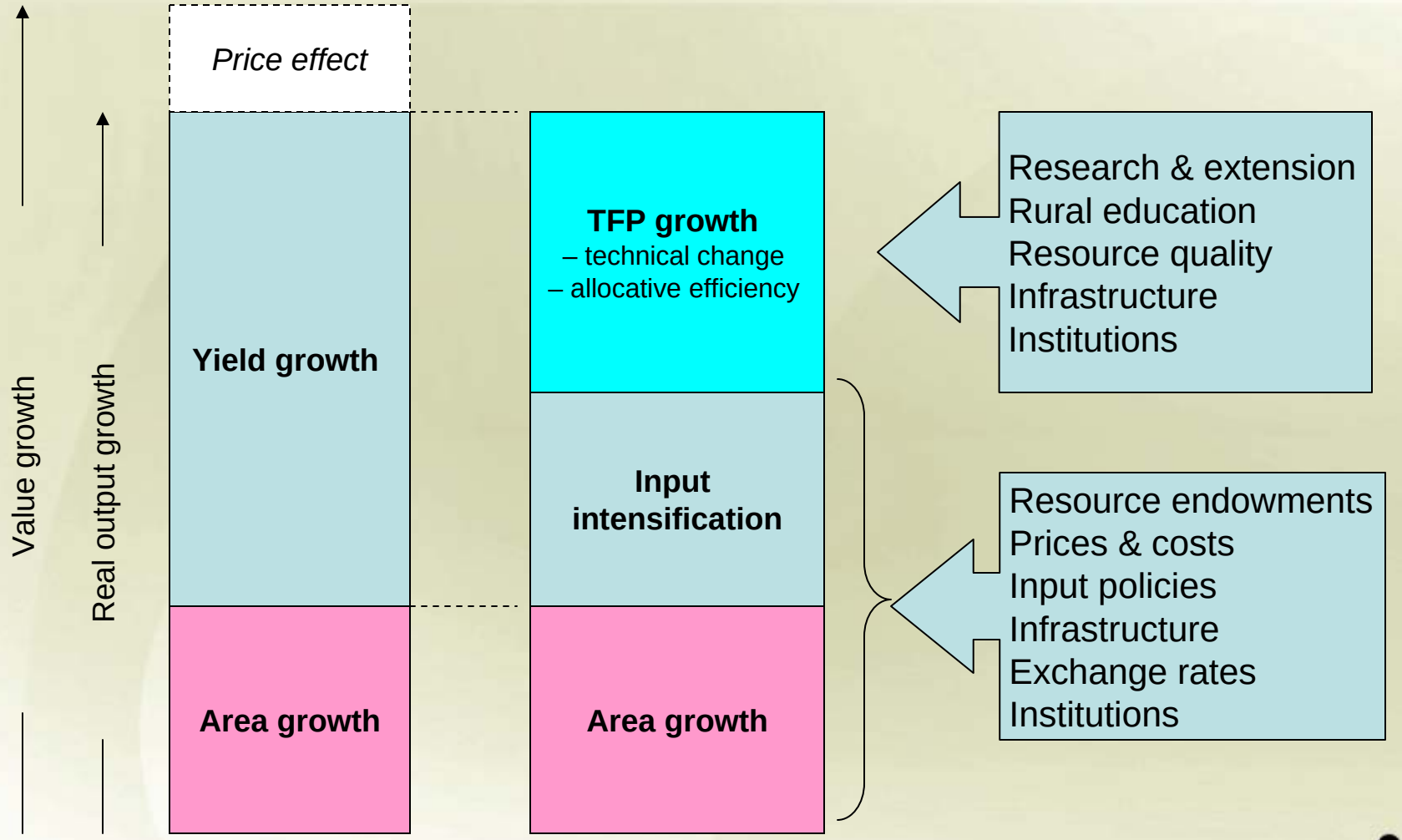
Source: Pfaffenzeller, Newbold & Rayner(2007) updated from International Monetary Fund

Is the recent agricultural price rise because productivity growth has been slowing down?



Source: World Bank Development Report 2008 (figure refers to developing countries only)

Measuring and decomposing growth



Measuring TFP growth

- Previous studies: Malmquist Distance function
  - Arnade (1998), Coelli et al. (2005), Ludena et al. (2007)
  - Uses only Input-Output quantity data
  - Results sensitive to data quality & dimensionality issue

- This study: use Solow-type growth accounting method
  - TFP growth is difference between output growth and input growth

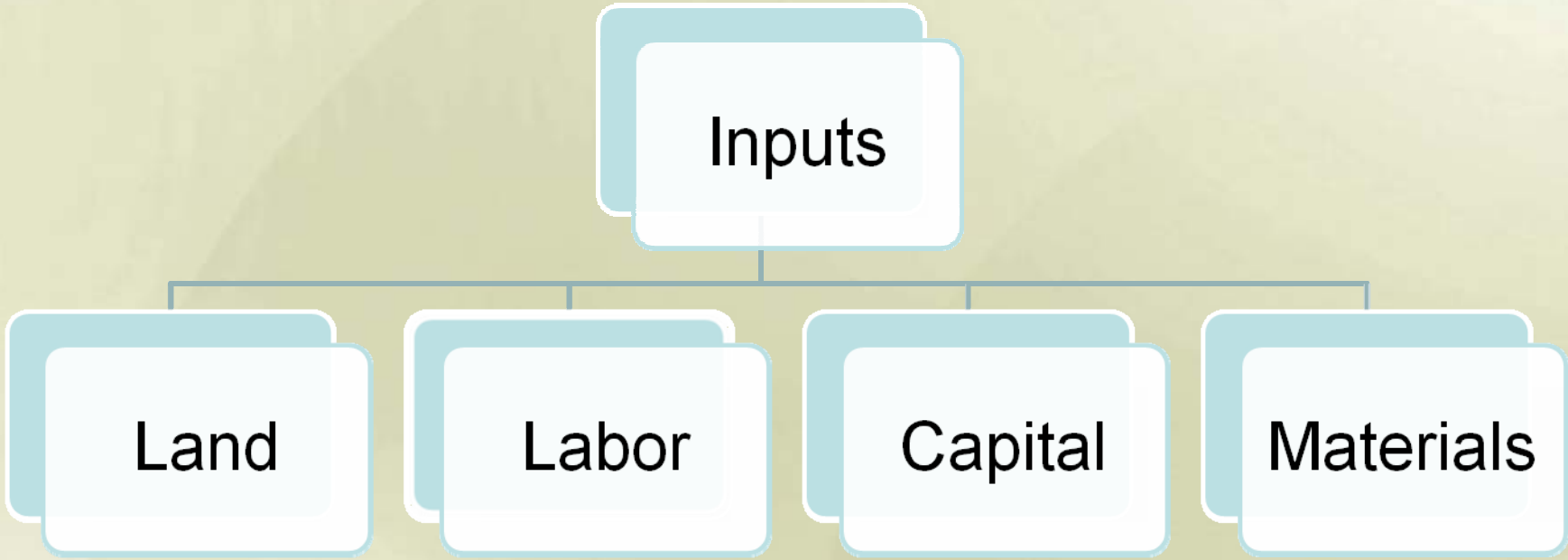
$$\dot{TFP}_{tc} = \sum_i R_{ic} \dot{Y}_{itc} - \sum_j S_{jc} \dot{X}_{jtc}$$

  - Only compare TFP growth, not TFP levels, among countries

Empirical approach

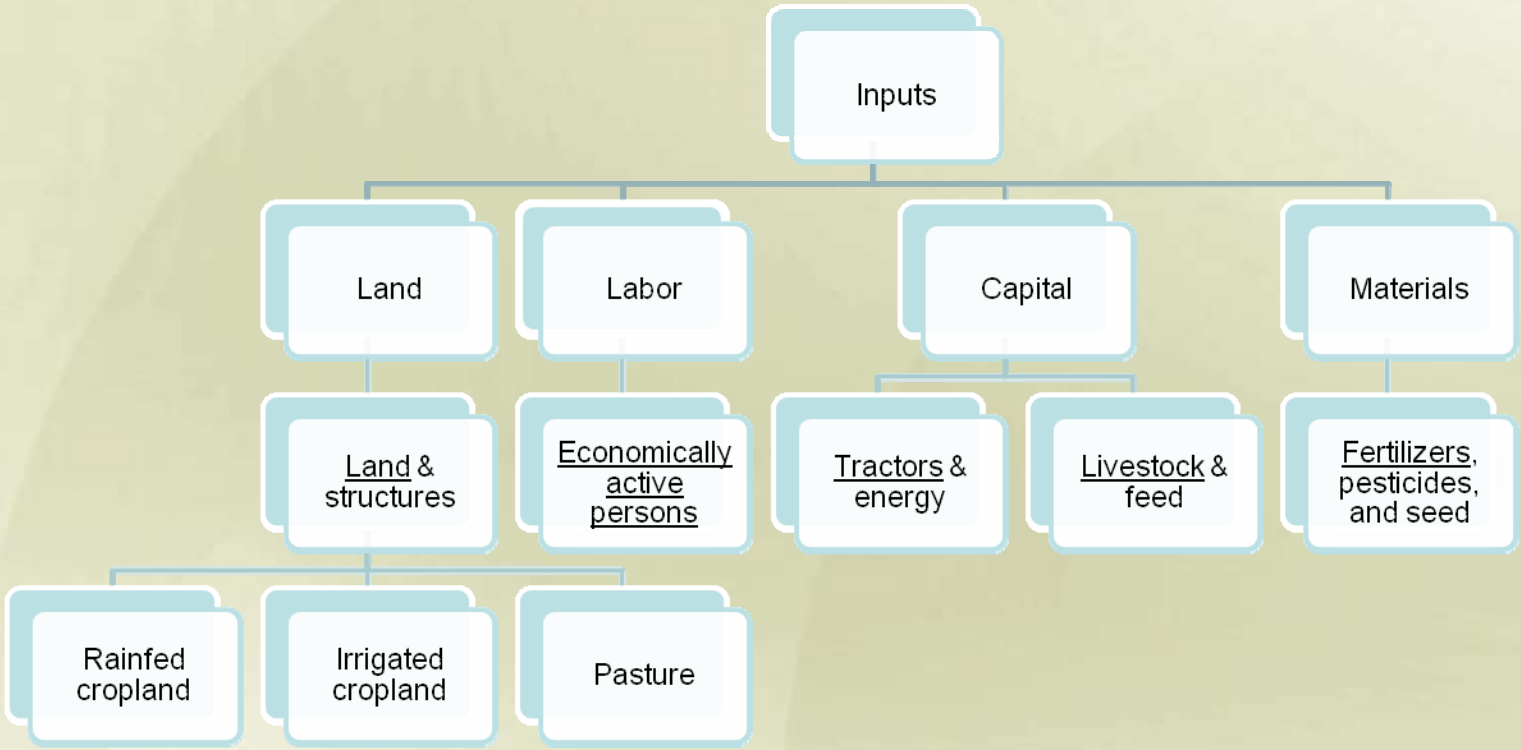
- Output: use FAO real output series
  - Aggregates crop and livestock outputs using fixed global prices measured in constant 2000 US$
- Input: Aggregate FAO input quantity data using cost shares or production elasticities published from previous studies
  - Where not available, assign cost share from “similar” country

Constructing an input index

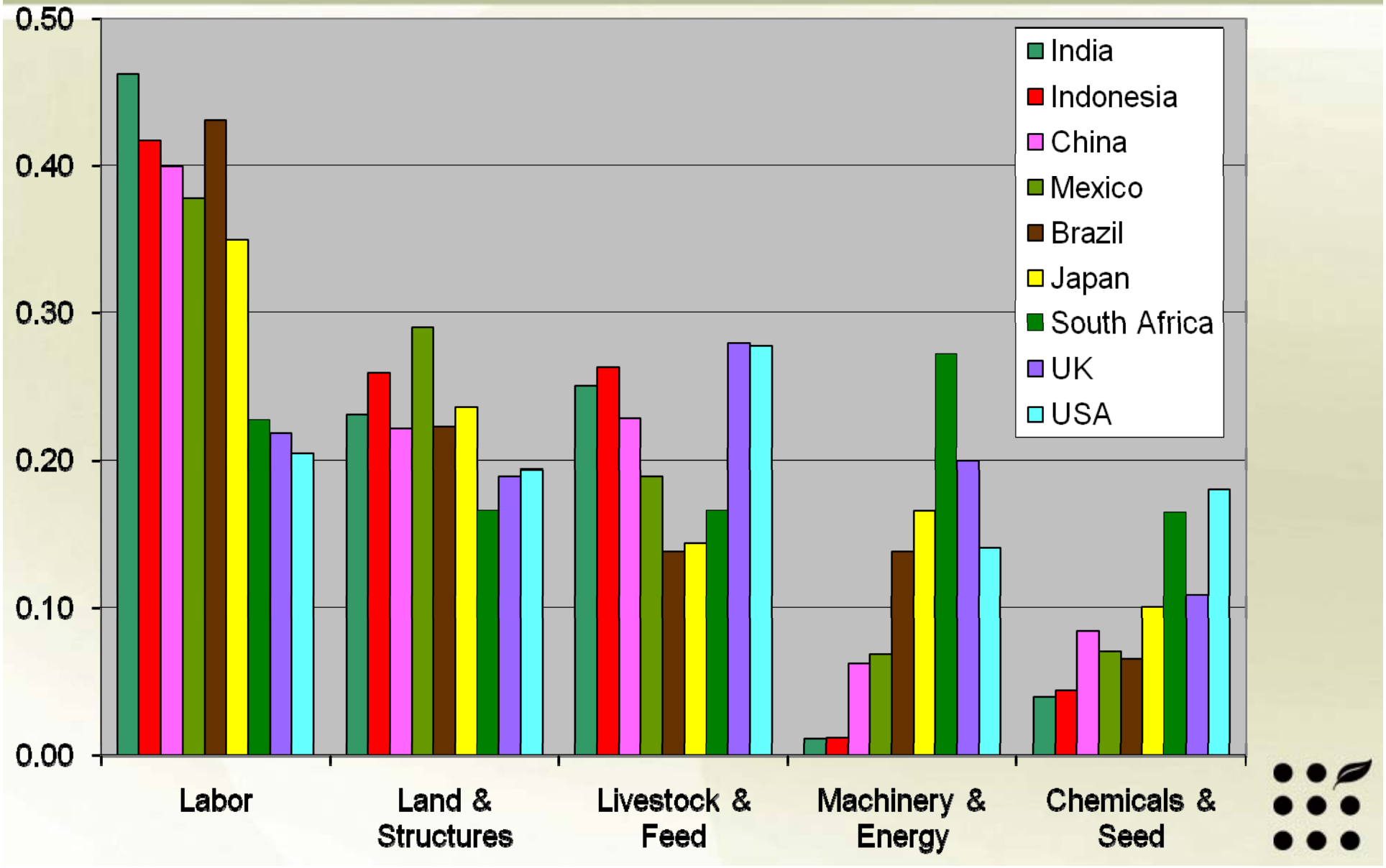


Growth rate aggregate input is weighted average of growth in Land, Labor, Capital and Materials, where weights are their (fixed or varying) cost shares.

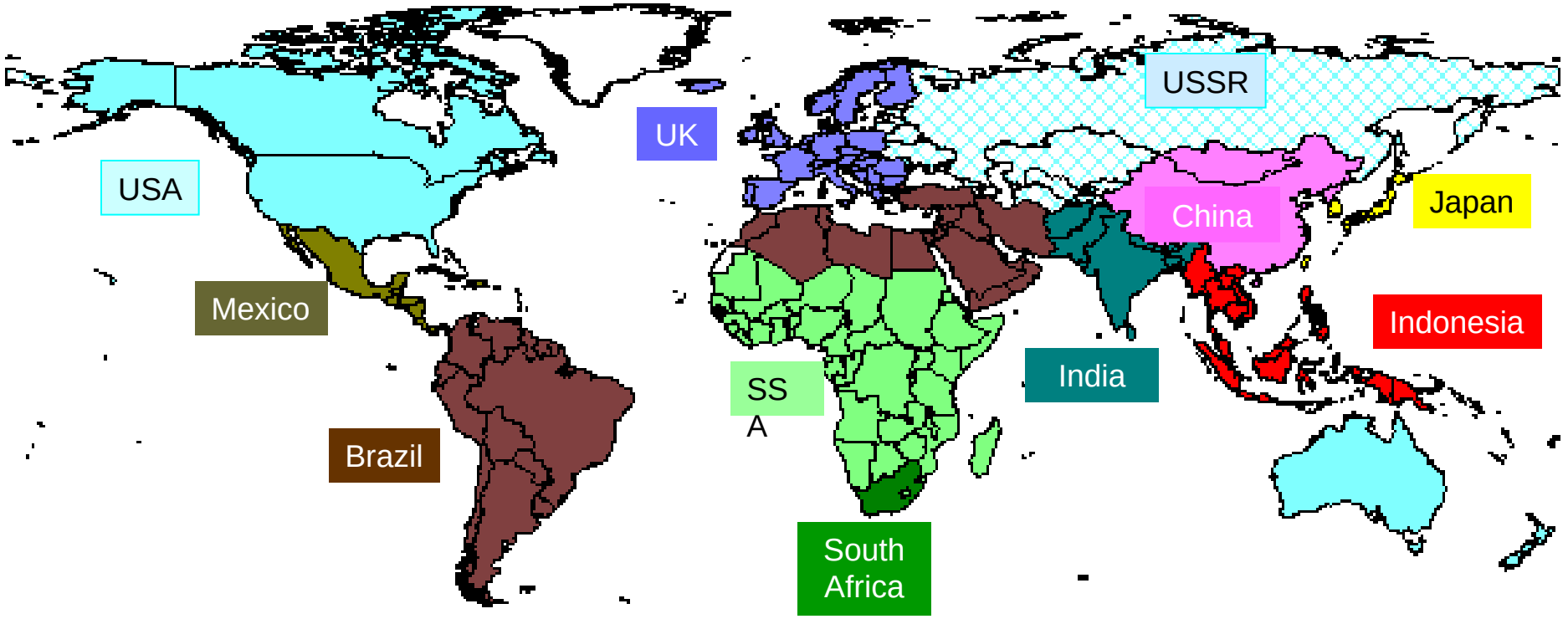
Constructing an input index



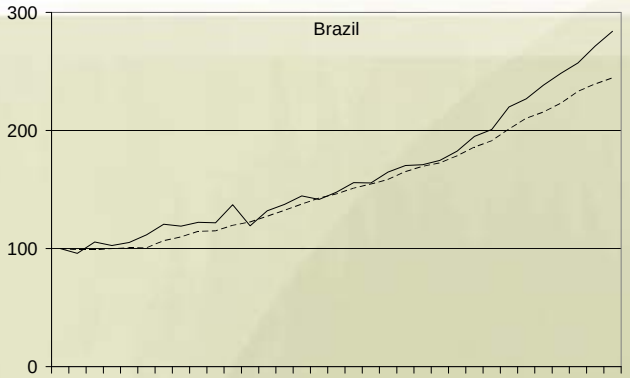
Average input cost shares for 9 countries

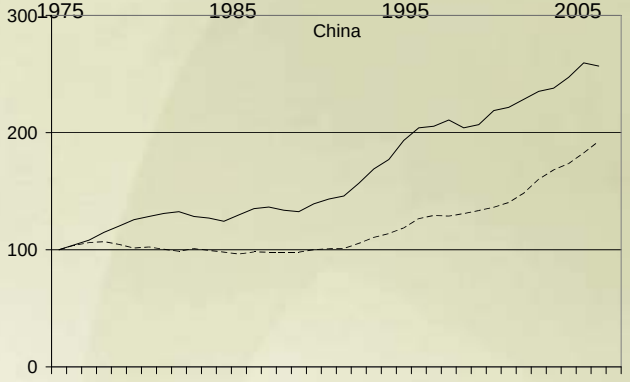


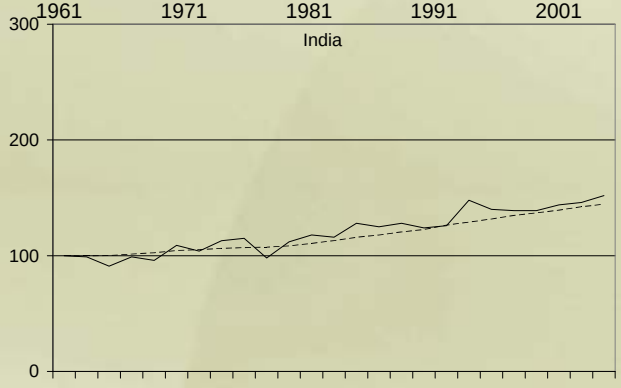
Application of cost shares to regions

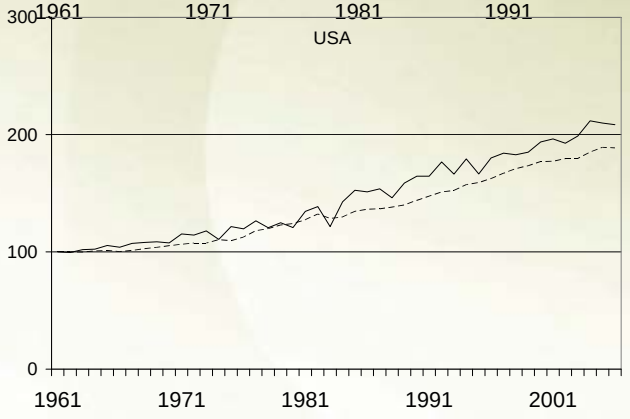


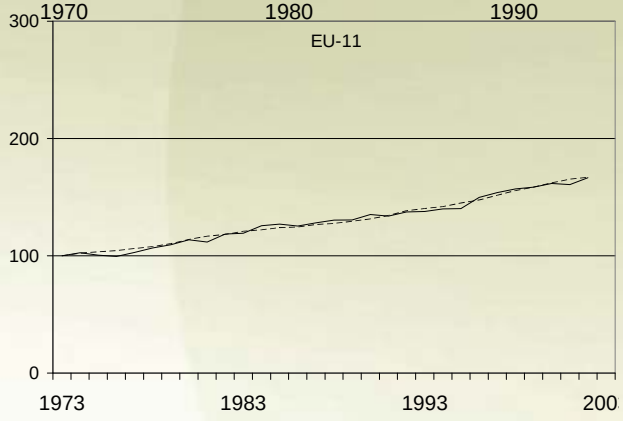
TFP growth indexes compared with Tornqvist indexes from country studies









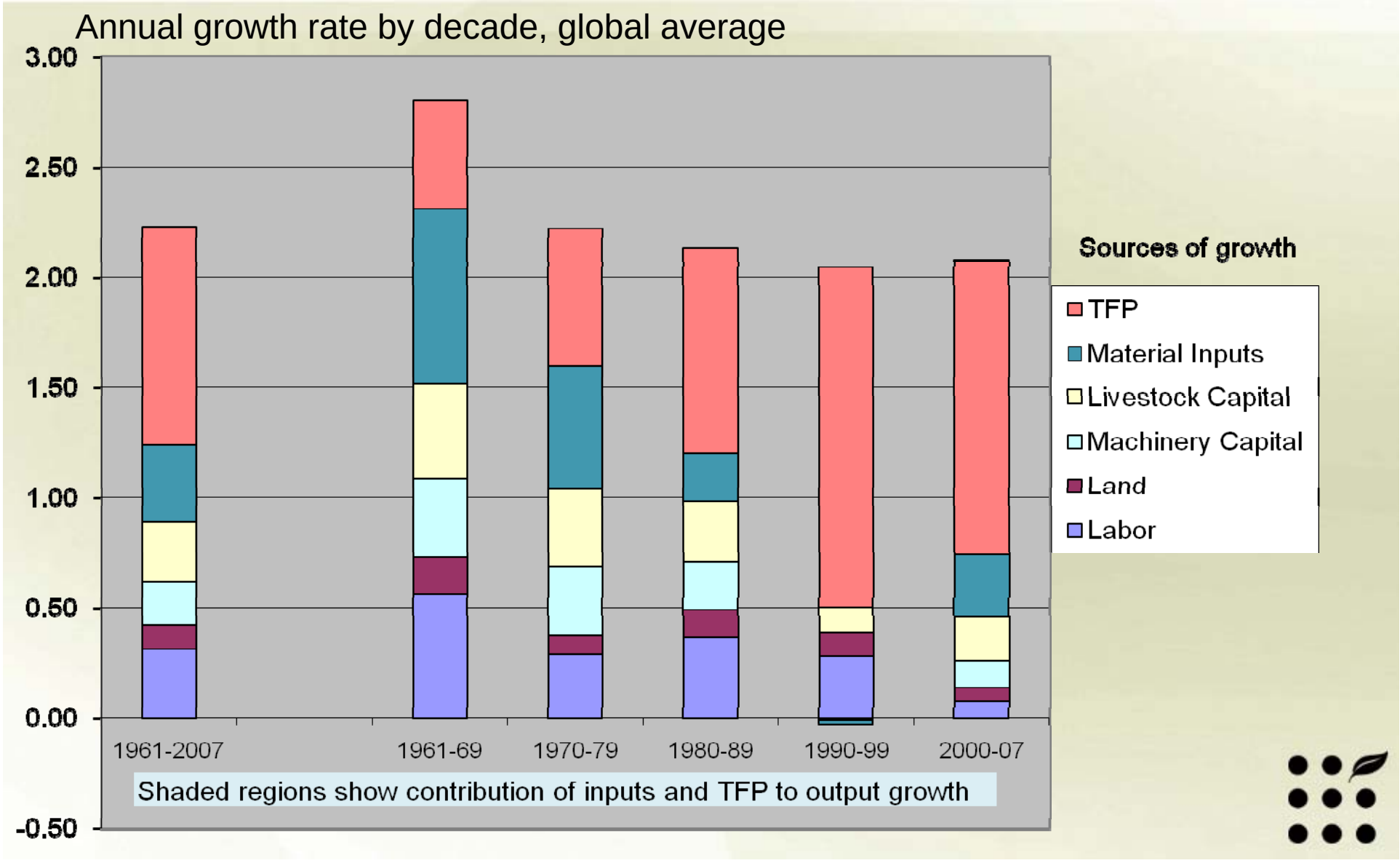


TFP indexes

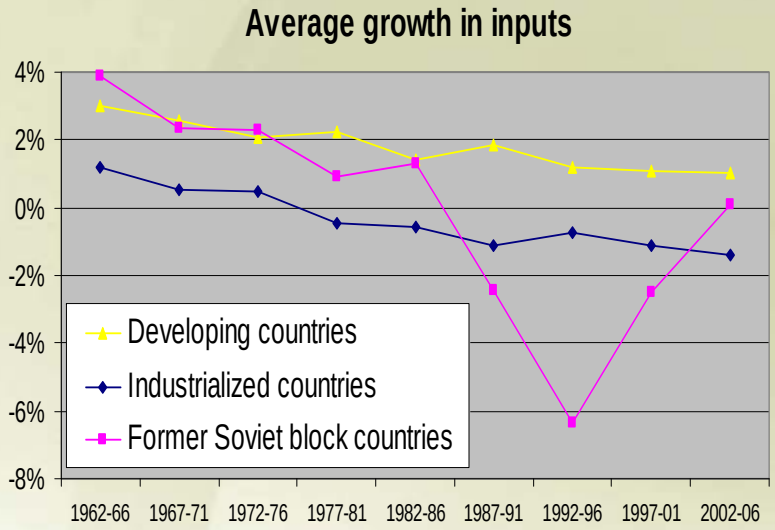
country studies

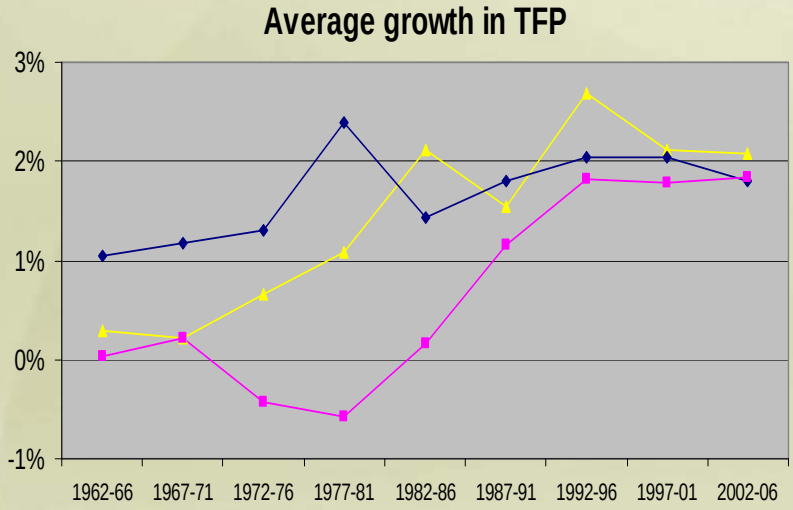
this study

Agricultural growth decomposition shows declining input intensification and rising TFP

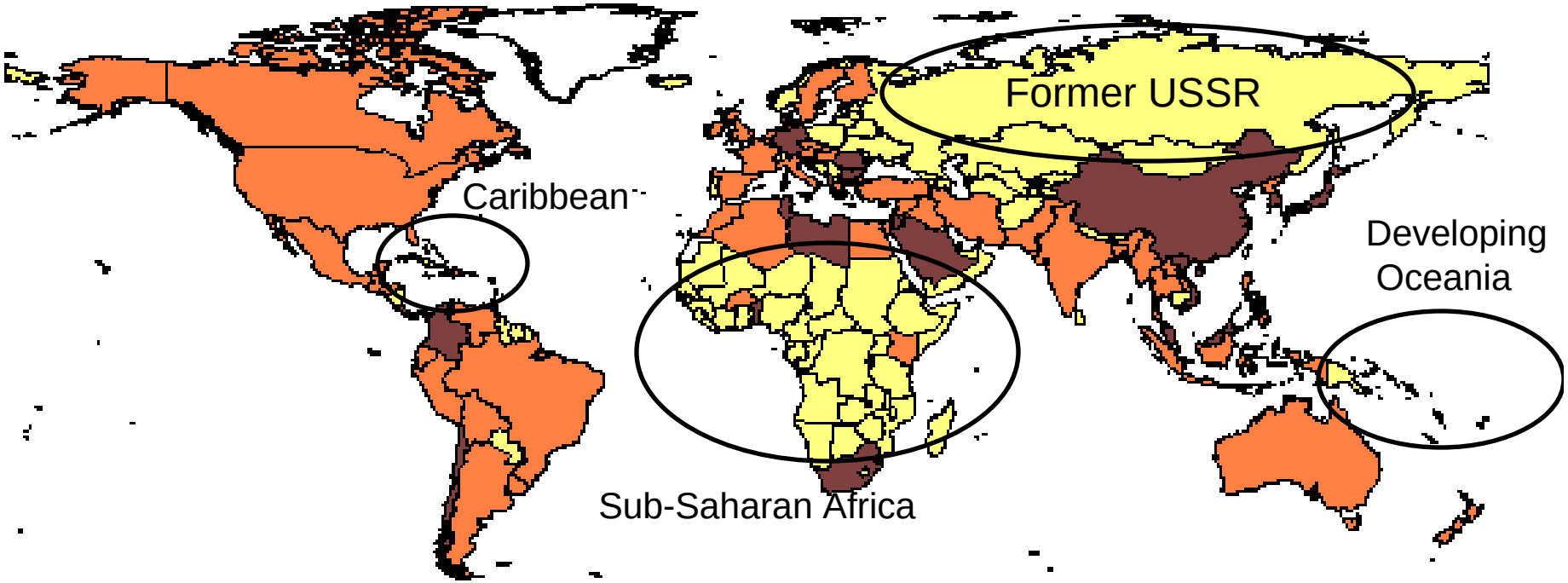


Agricultural TFP growth rates converging among major global regions





Average ag TFP growth, 1970-2006
(% per year)



Circled regions show persistently low TFP growth

Further work to improve global TFP index

- Cost share data from more countries
- Allow cost shares to vary over time
- More complete data on capital stocks
  - Treestocks
  - Machinery and structures
- Include natural resource stocks
  - Water (irrigation withdrawals)
  - Land (soil) quality

“Technology capital” as driver of TFP growth

- Index of Innovation-Invention (*II*) capital
  - Ag scientists / cropland (ASTI)
  - Industrial R&D as % of GDP (UNESCO)
- Index of Technology Mastery (*TM*) capital
  - Ag extension workers / cropland (Judd et al.)
  - Average schooling of male workers (Barro & Lee)
- Index measures for 87 developing countries in two periods: 1970-75 and 1990-95 (panel data)

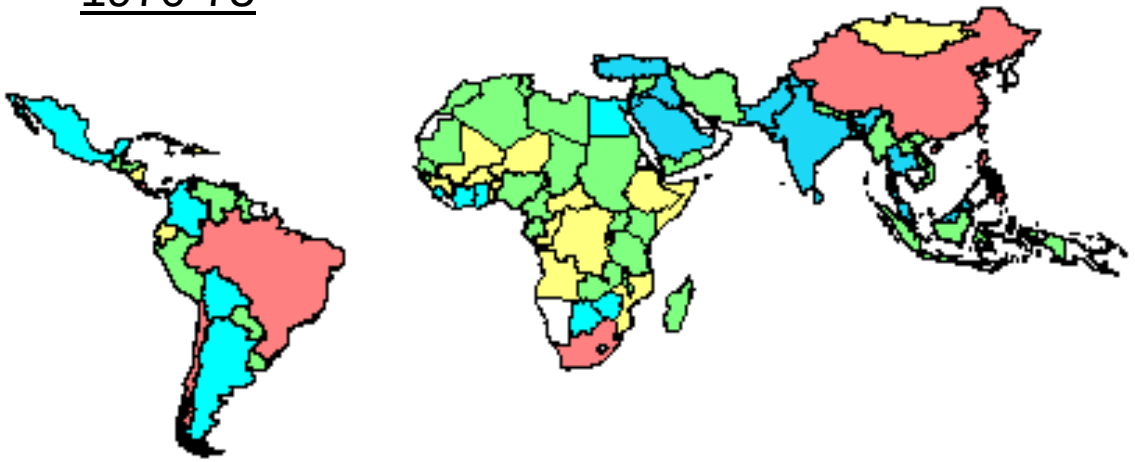
Technology capital in “Invention-Innovation”

Innovation-Invention Score

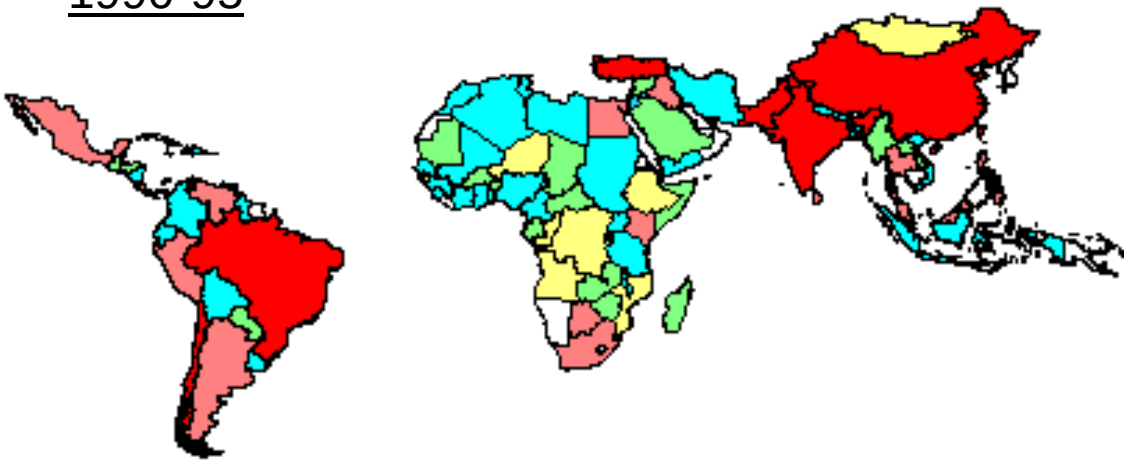
2
3
4
5
6

Score:
(i) Ag Sci/cropland, 1 to 3
(ii) Industrial R&D/GDP, 1 to 3
Invention-innovation = (i) + (ii)

1970-75



1990-95



Model: Technology capital and TFP growth

Model 1: Did technology capital influence subsequent TFP growth?

-- average TFP growth in 1970-89 as function of 1970-75 II & TM capitals

-- average TFP growth in 1990-07 as function of 1990-95 II & TM capitals

$$\dot{TFP}_{c,t} = \sum_{i=2}^{6} \sum_{j=2}^{6} \delta_{i,j} Dij_{c,t}.$$

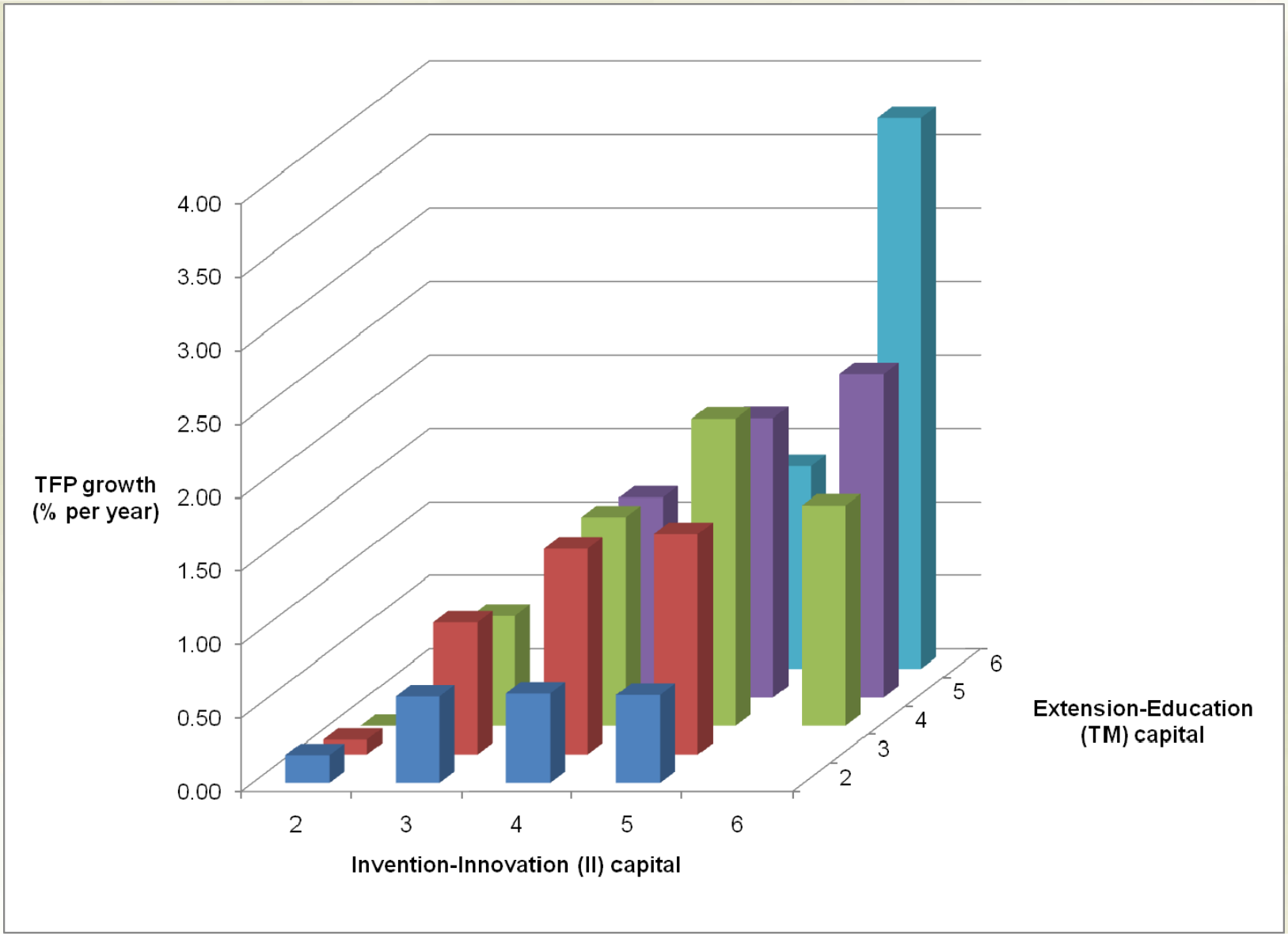
Dij = series of 19 dummy variables representing different combinations of *II* and *TM* technology capital (c=country, t= period)

Model 2: Difference-in-differences model

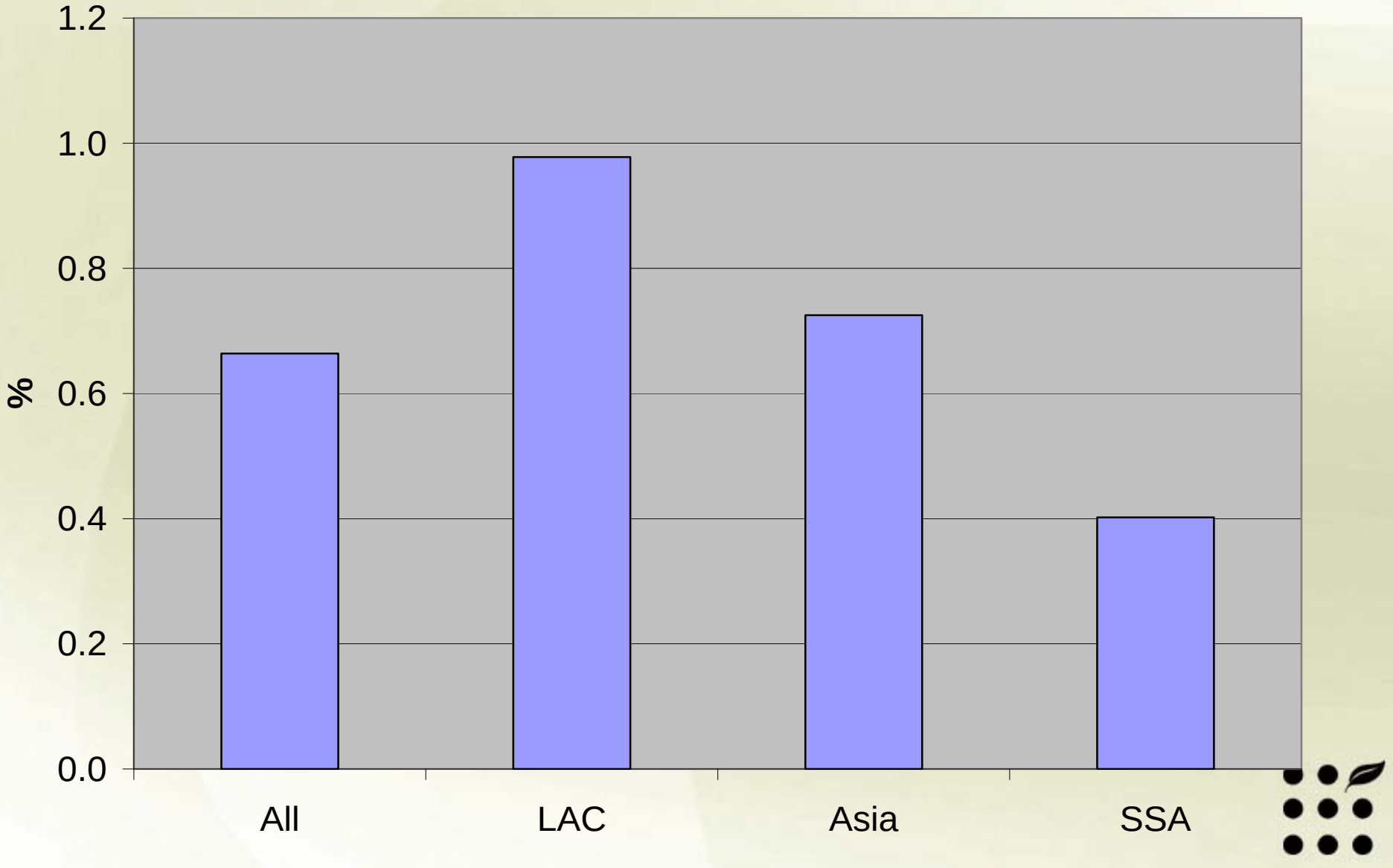
-- did change in II & TM capitals between 1970/75 and 1990/95 affect TFP growth?

$$\Delta\dot{TFP}_{c} = \delta_{II}\left(\Delta II_{c}\right) + \delta_{TM}\left(\Delta TM_{c}\right).$$

Model 1 results: Technology capital strongly associated with subsequent TFP growth



Model 2: Countries that increased their II capital (R&D) increased their rate of TFP growth



Conclusions

- Global agricultural TFP growth accelerating
  - Led by developing countries
  - Offset decline in growth in input intensification
- Long-run TFP growth strongly associated with technology capital
  - Research capacity more important than extension-education
  - Evidence strong except sub-Saharan Africa