Does Agriculture Lead the Economy's Growth?

A Quantitative Analysis of Asian Countries after the Green Revolution

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Today's Presentation

- Motivation and Questions
- The Model
- Results
- Conclusion

Motivation and Questions (Object)

The object

- To analyze the effect of a change in agri production on the whole economy with a model
- To test it using simulation
- Asian Countries, after the Green Revolution
  —Thailand and India, 1960–2000

  The Green Revolution
  - Modern varieties of primary crops
  - Use of capital input
  - after 1960s, in Asia and America

Motivation and Questions (Fact)

A well-known observation –Asia after 1950s

Similar events

Agricultural Revolution –Green Revolution

$\downarrow$

Industrial Revolution –Asian Miracle

Agri production change $\rightarrow$ Manuf growth

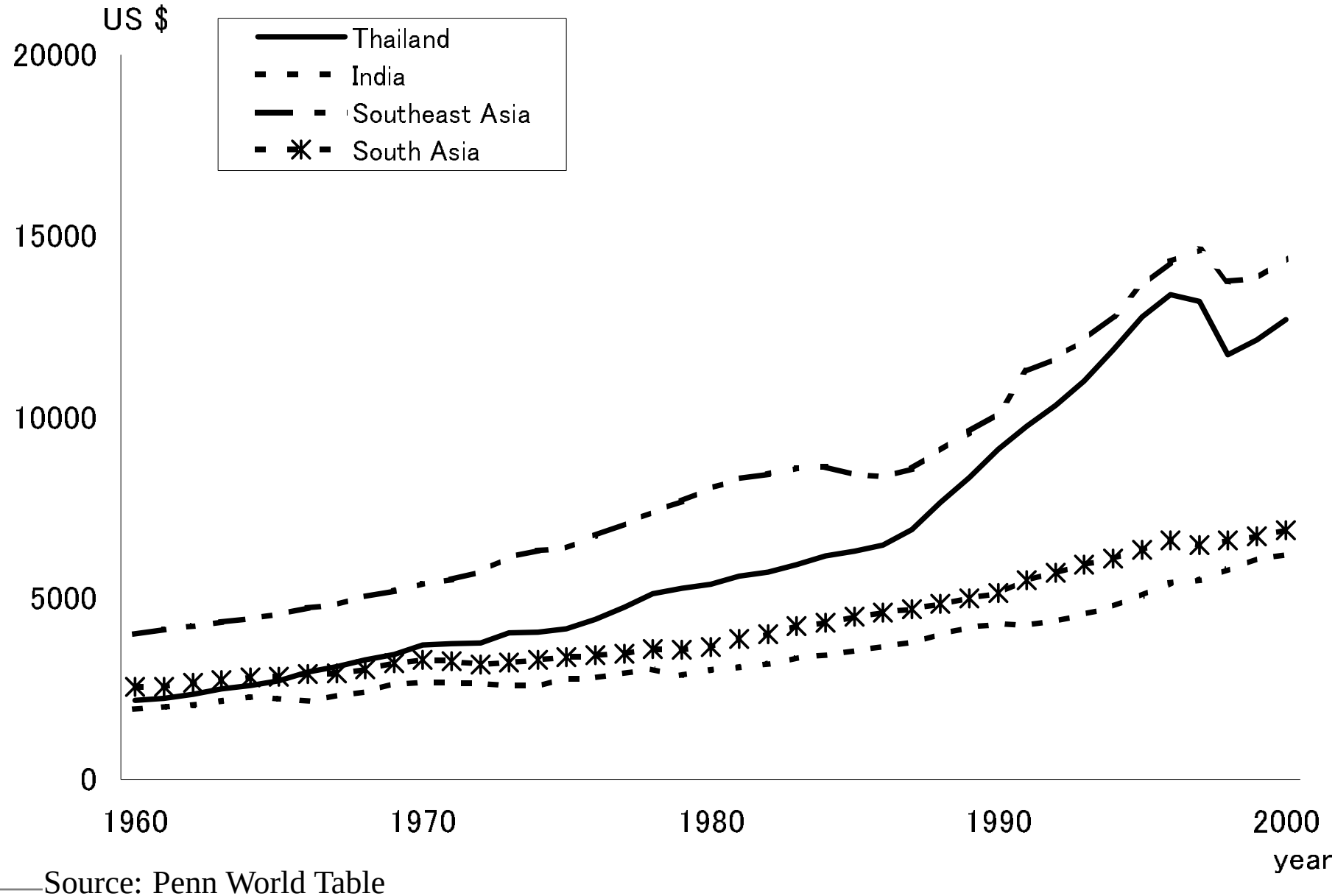
$\rightarrow$ Ratio of Agri$\downarrow$

Is this causaility?

—— *Yes*, in

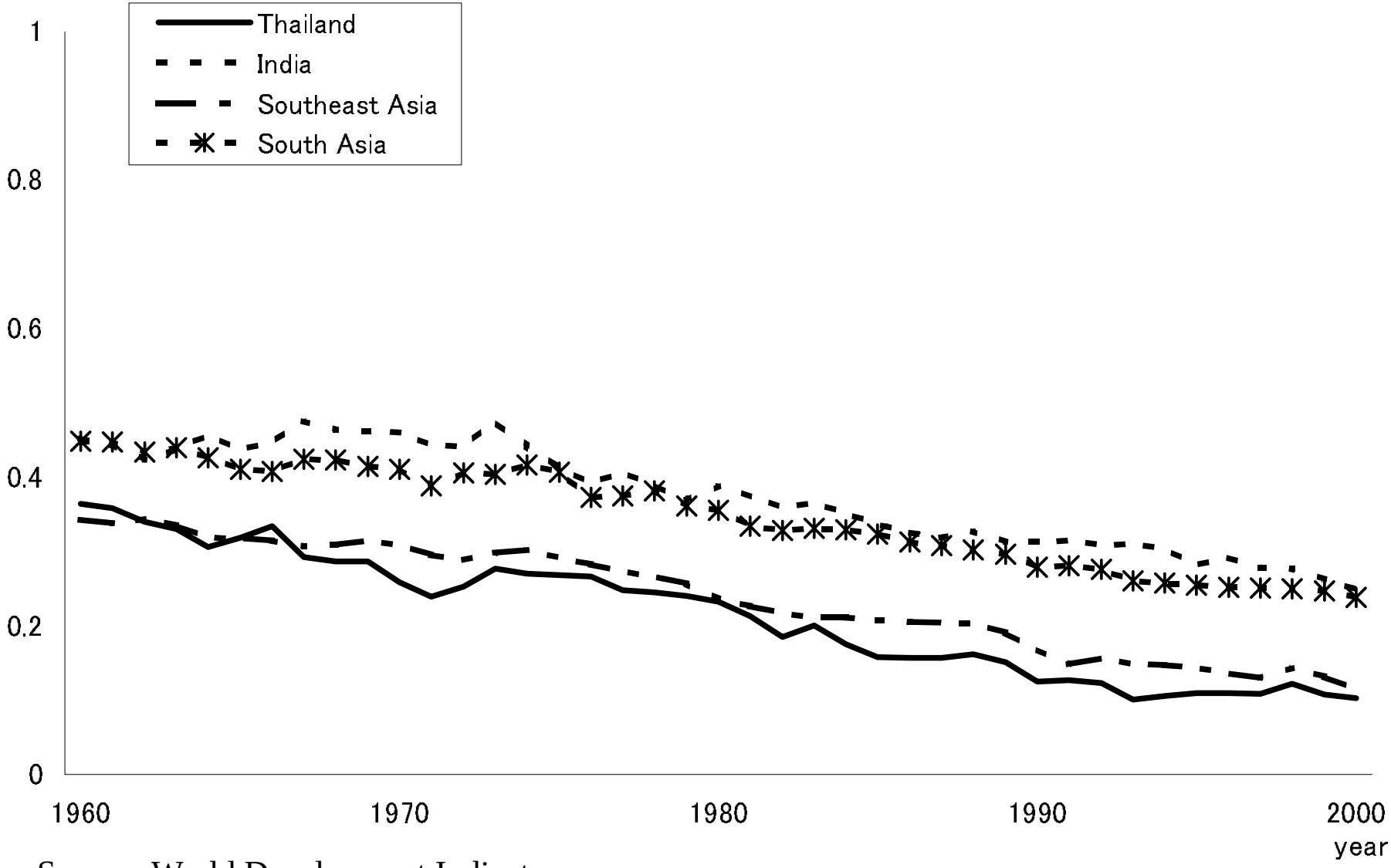
Johnson (2000), Gollin et al.(2002), etc...

Motivation and Questions (GDP per worker)



Source: Penn World Table

Motivation and Questions (Ratio of Agri)



Source: World Development Indicators

Motivation and Questions (Literature)

- Theory
  Lewis (1954), Johnston and Mellor (1961), Jorgenson (1961), Matsuyama (1992)
- Simulation
  Echevarria (1995, 1997), Murata (2002), Tamura (2002), Hansen and Prescott (2002)
- Green Revolution and Income Difference
  Gollin et al.(2001), Restuccia et al.(2004)
- My research
  analyzes growth facts of Asia quantitatively.

Motivation and Questions (Hypothesis)

Questions

- Why did some Asian countries suddenly start rapid growth from low income and growth?
- What is the role of the agriculture for the growth?

Hypothesis

- A change in agri technology (Green Revolution) $\rightarrow$ overcome subsistence food consumption, capital accumulation $\rightarrow$ increase manuf production.

Model (Environment)

- Infinite horizon
- Homogenous Representative agent
- Exogenous Population growth
- Perfect Foresight with no uncertainty
- Closed economy
- 2 production technologies (Agri, manuf)
- 2 goods (explicit treatment of agri and manuf)
- Embodied the Engel's law in HH preference

Model (HH)

The HH maximizes

$$\sum_{t=0}^{\infty} \beta^t N_t(\sigma \ln(c_{at} - \alpha) + (1-\sigma)\ln c_{mt})$$

s.t. $$p_t C_{at} + C_{mt} + K_{t+1} \leq p_t Y_{at} + w_t N_{mt} + r_t K_{mt} + (1-\delta)K_t$$

$$N_{at} + N_{mt} \leq N_t$$

$$K_{at} + K_{mt} = K_t$$

$$Y_{at} = A_{at} K_{at}^{\phi} N_{at}^{\psi} (Land)^{1-\phi-\psi}$$

with $A_{at+1}/A_{at} = \chi.$

Model (Firm and RC)

The firm maximizes

$$
\begin{aligned}
& Y_{mt} - w_t N_{mt} - r_t K_{mt} \\
\text{s.t.} \qquad & Y_{mt} = A_{mt} K_{mt}^{\theta} N_{mt}^{1-\theta} \\
& \text{with} \quad A_{mt+1}/A_{mt} = \gamma_t^{1-\theta}.
\end{aligned}
$$

Resource Constraints are:

$$
\begin{aligned}
C_{at} &= Y_{at} \\
C_{mt} + K_{t+1} &= Y_{mt} + (1-\delta) K_t.
\end{aligned}
$$

Model (Competitive Equilibrium)

Definition: A *Competitive Equilibrium* of the economy is a sequence of prices $\{p_t, w_t, r_t\}_{t=0}^{\infty}$ and associated quantities $\{C_{at}, C_{mt}, N_{at}, N_{mt}, Y_{at}, Y_{mt}, K_{at}, K_{mt}, K_{t+1}\}_{t=0}^{\infty}$ given exogenous values $\{A_{mt}, A_{at}, N_t\}_{t=0}^{\infty}$ and initial value K_0 such that, for all t,

i) the household maximizes the utility as prices given;

ii) the firm maximizes the profit as prices given;

iii) resource constraints are satisfied.

Model (Transformation)

To calculate SS values, values are detrended:

$$\tilde{z}_t = \frac{Z_t}{A_{mt}^{1/(1-\theta)} N_t}$$

where $Z_t = C_{mt}, C_{at}, K_t, K_{mt}, K_{at}$ and

$$\tilde{c}_{at} = \frac{C_{at}}{A_{at} A_{mt}^{(\phi/(1-\theta)} N_t^{\phi+\psi}}.$$

Define $x_t = \tilde{k}_{mt}/n_{mt}$.

Model (Eqb conditions)

$$\tilde{c}_{mt} + \tilde{k}_{t+1} n_t \gamma_t = \tilde{k}_{mt} x_t^{\theta-1} + (1-\delta)\tilde{k}_t$$

$$\tilde{c}_{at} = \tilde{k}_{at}^{\phi} n_{at}^{\psi}$$

$$\frac{\gamma_t}{\beta} \frac{\tilde{c}_{mt+1}}{\tilde{c}_{mt}} = \theta x_{t+1}^{\theta-1} + 1 - \delta$$

$$\theta x_t^{\theta-1} = \frac{\sigma\phi}{1-\sigma} \frac{\tilde{c}_{mt}}{\tilde{c}_{at} - \alpha_t} \frac{\tilde{c}_{at}}{\tilde{k}_{at}}$$

$$(1-\theta) x_t^{\theta} = \frac{\sigma\psi}{1-\sigma} \frac{\tilde{c}_{mt}}{\tilde{c}_{at} - \alpha_t} \frac{\tilde{c}_{at}}{n_{at}}$$

$$1 = n_{at} + n_{mt}$$

$$\tilde{k}_t = \tilde{k}_{at} + \tilde{k}_{mt}$$

$$x_t = \tilde{k}_{mt} / n_{mt}$$

Model (Difference eq)

The conditions can be reduced to

$$(\tilde{c}_{at+1}, \tilde{k}_{at+1}) = F(\tilde{c}_{at}, \tilde{k}_{at}, \Theta_t)$$

where Θ_t is set of exogenous variables.

Shooting Algorithm:

Given $\tilde{k}_{a0}$, we guess $\tilde{c}_{a0}$ iteratively.
Find appropriate $\tilde{c}_{a0}$ converging to SS.

$\Rightarrow$ All values are calculated.

Results (Prameters)

		Thailand	India
n	1+pop g.	1.010	1.019
$(\gamma-1)^{1-\theta}$	manuf TFP g.	1.041	1.046
θ	manuf K share	$1/3$	
δ	dep. rate	0.050	0.046
χ	1+agri TFP g.	1.00	
ϕ	agri K share	0.40	
ψ	agri N share	0.50	
β	disc. factor	0.95	
σ	food share	0.20	0.40
α	subsist. food	$c_{a1960} \times 0.45$	

n and γ are long-run values. Actual values are used before 2000.

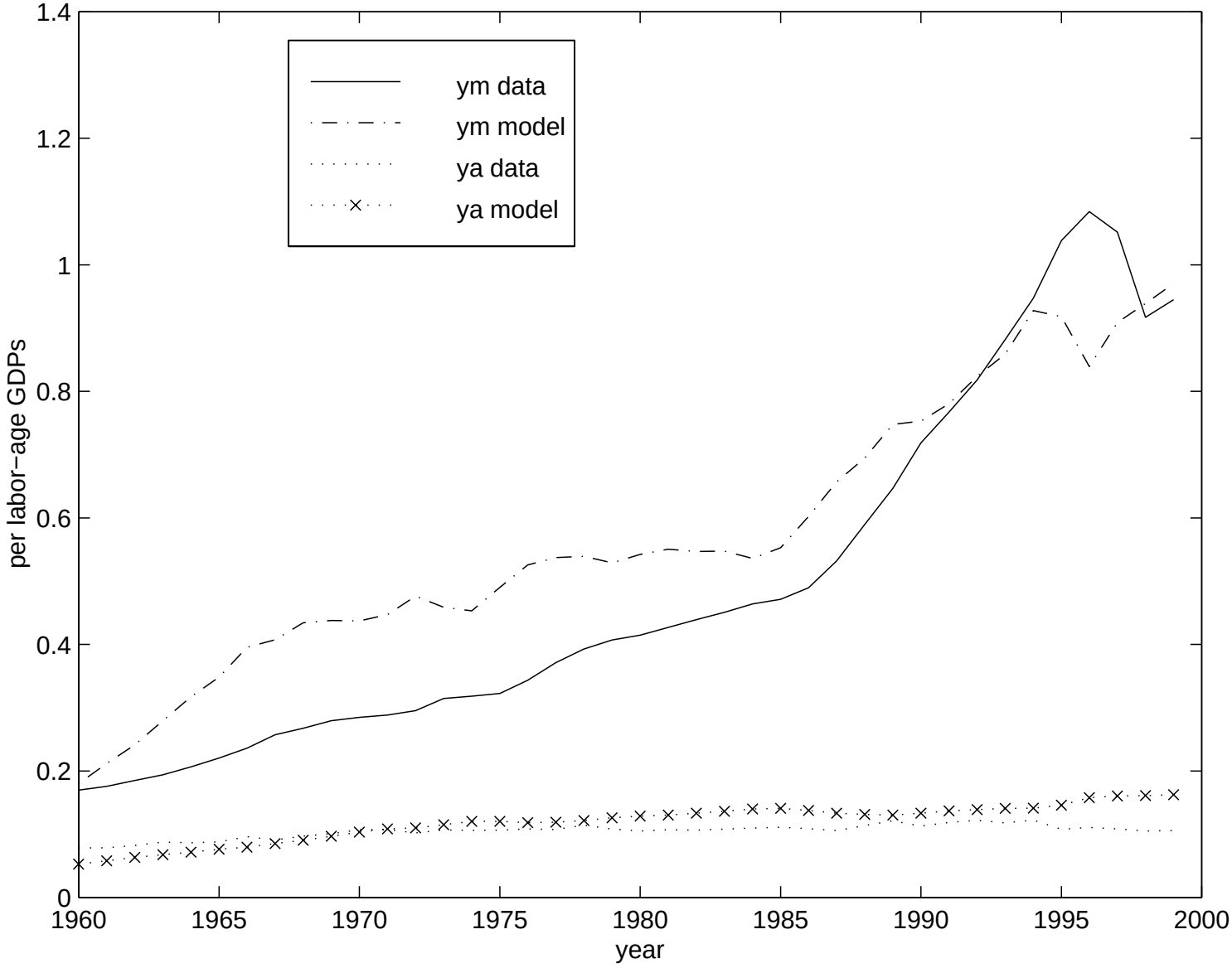
(Actual γ is up to 1996 for Thailand.)

Results (Summary)

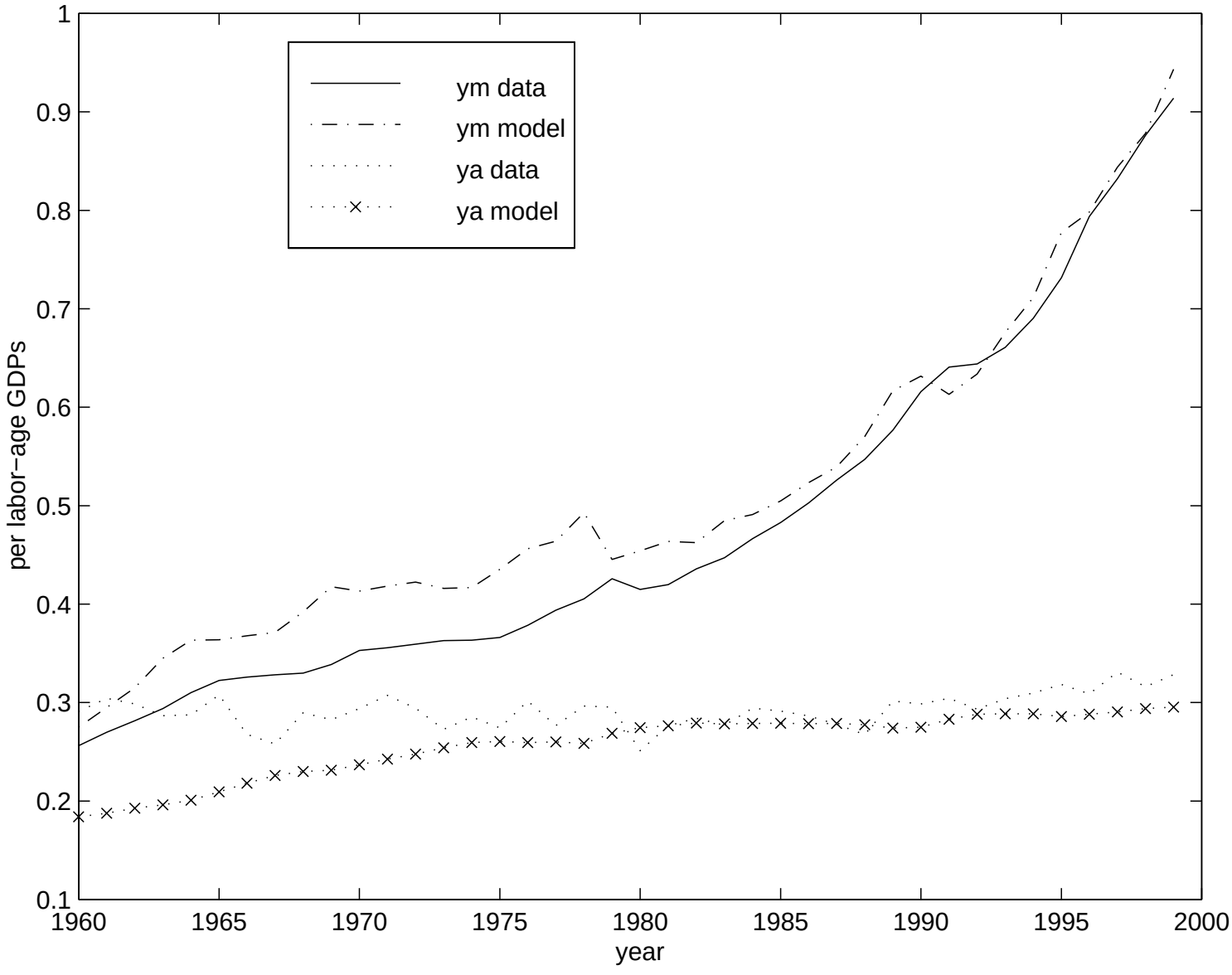
- Baseline
  - The model can trace growth paths
  - and GDP ratio
- Counterfactual Experiment
  (if GR didn't realize.)
  - Set $\phi = 0.25$
    low capital share, high land share
    (Hayami and Ruttan (1985)).
  - Ratio of Agri: High

This may be because of reduction of returns to scale.

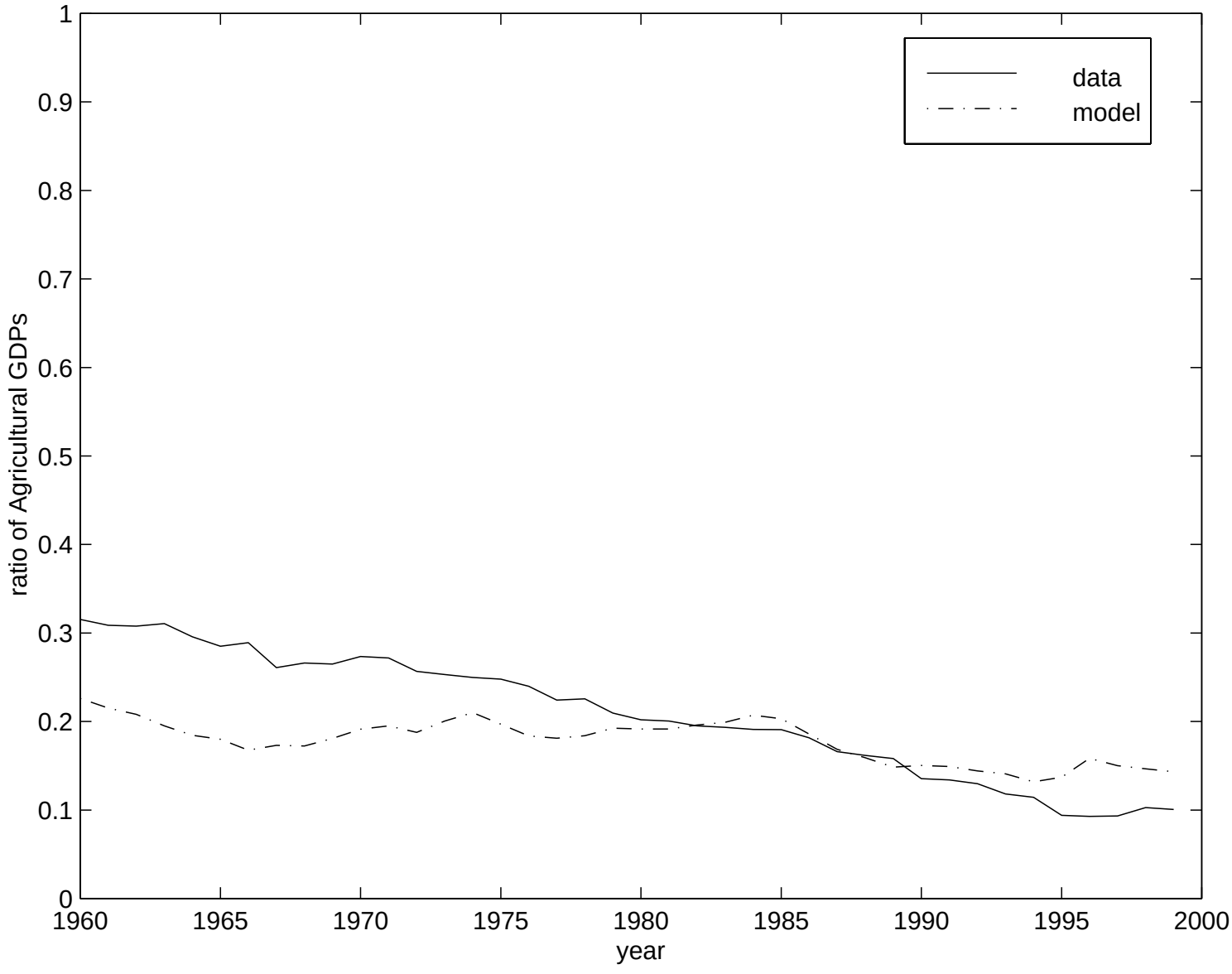
Results (GDPs, Thailand)



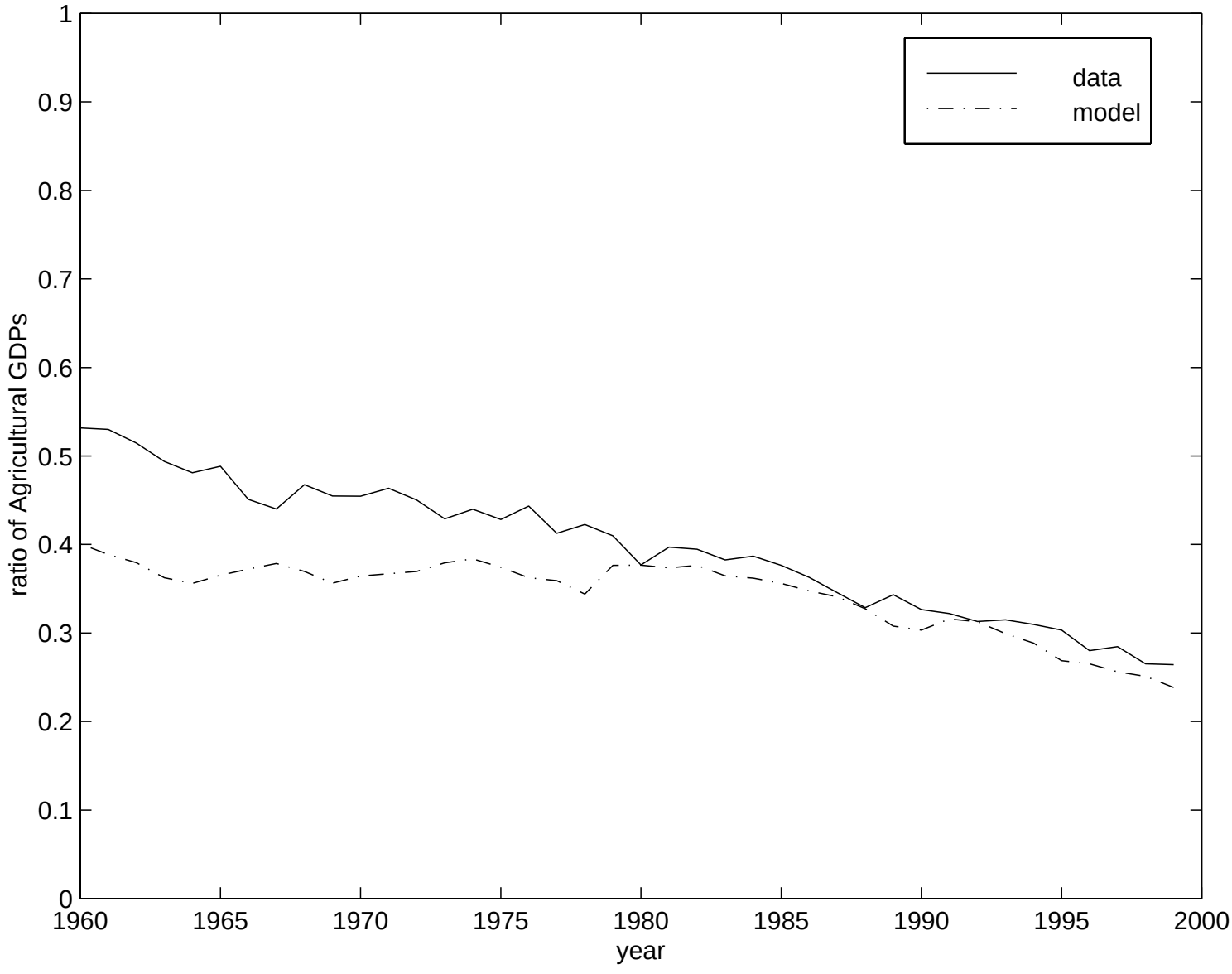
Results (GDPs, India)



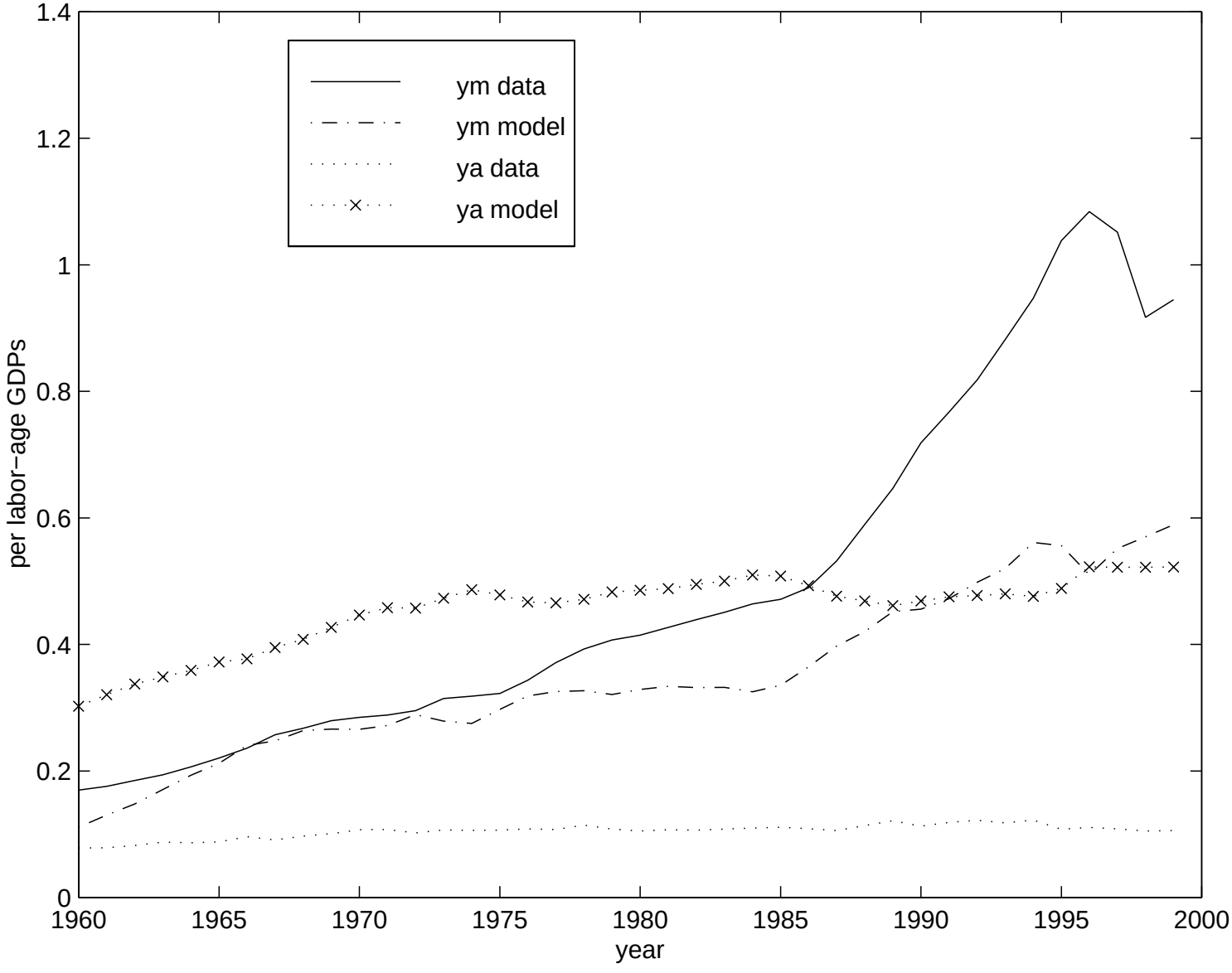
Results (Ratio, Thailand)



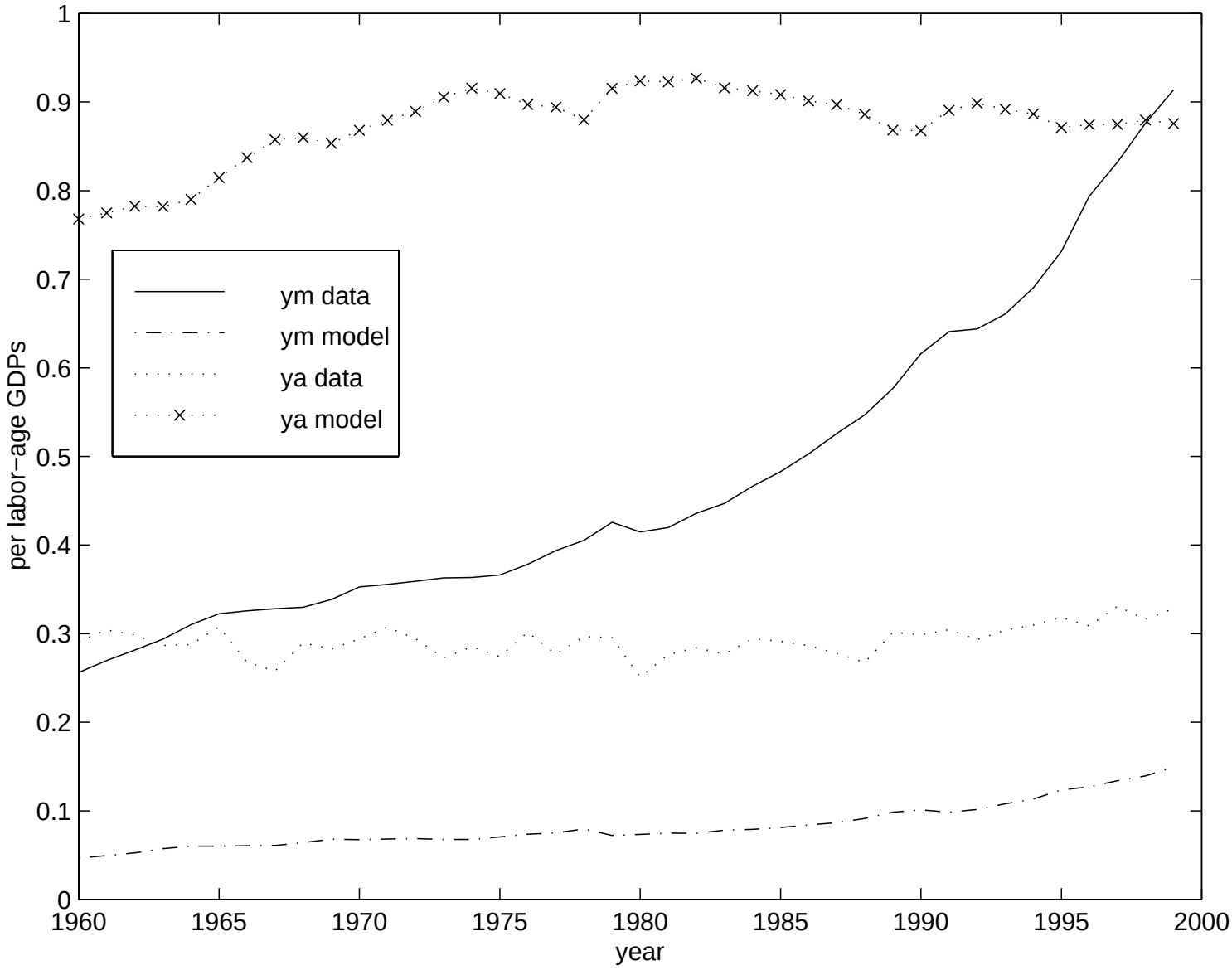
Results (Ratio, India)



Results (CF, GDPs, Thailand)



Results (CF, GDPs, India)



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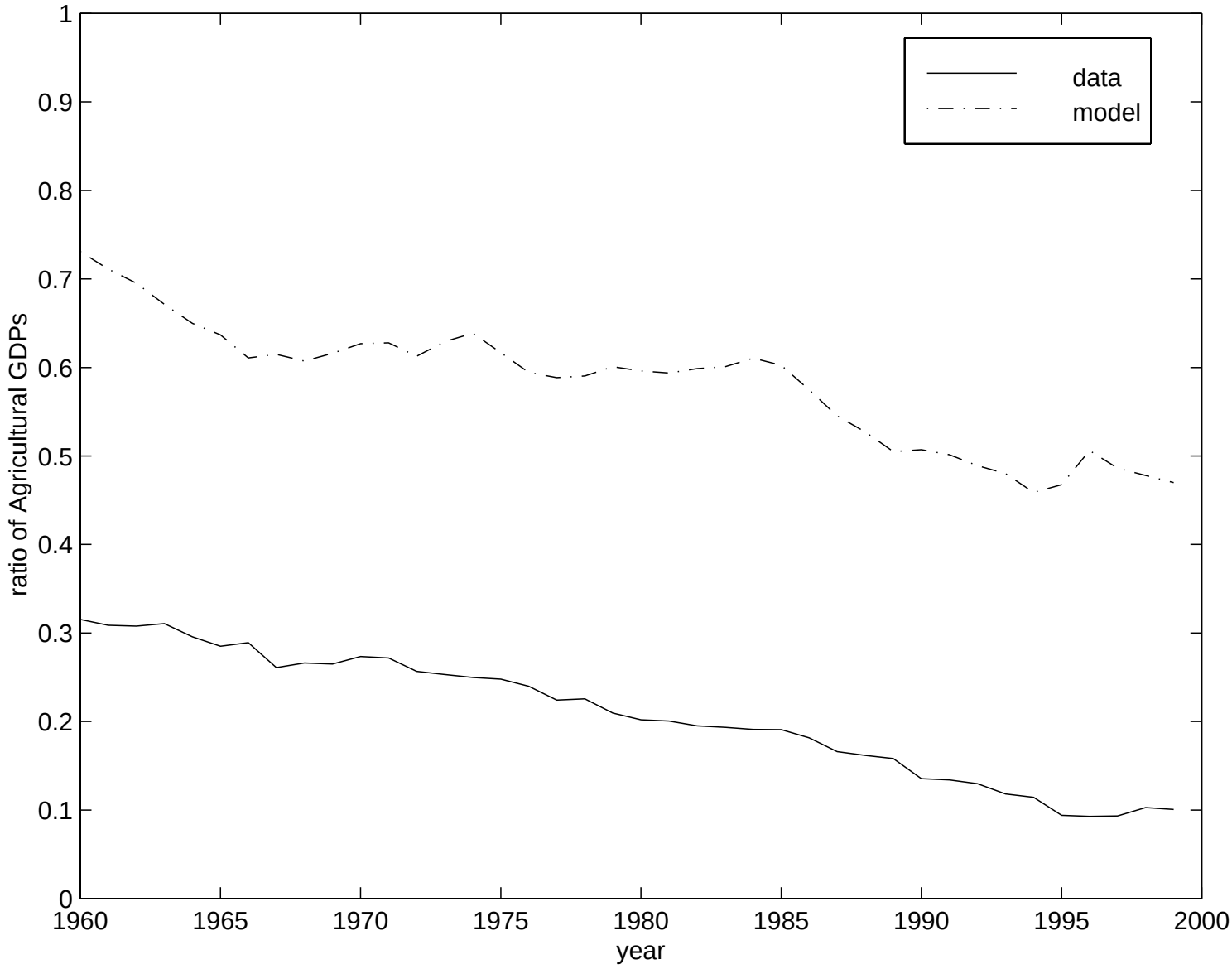

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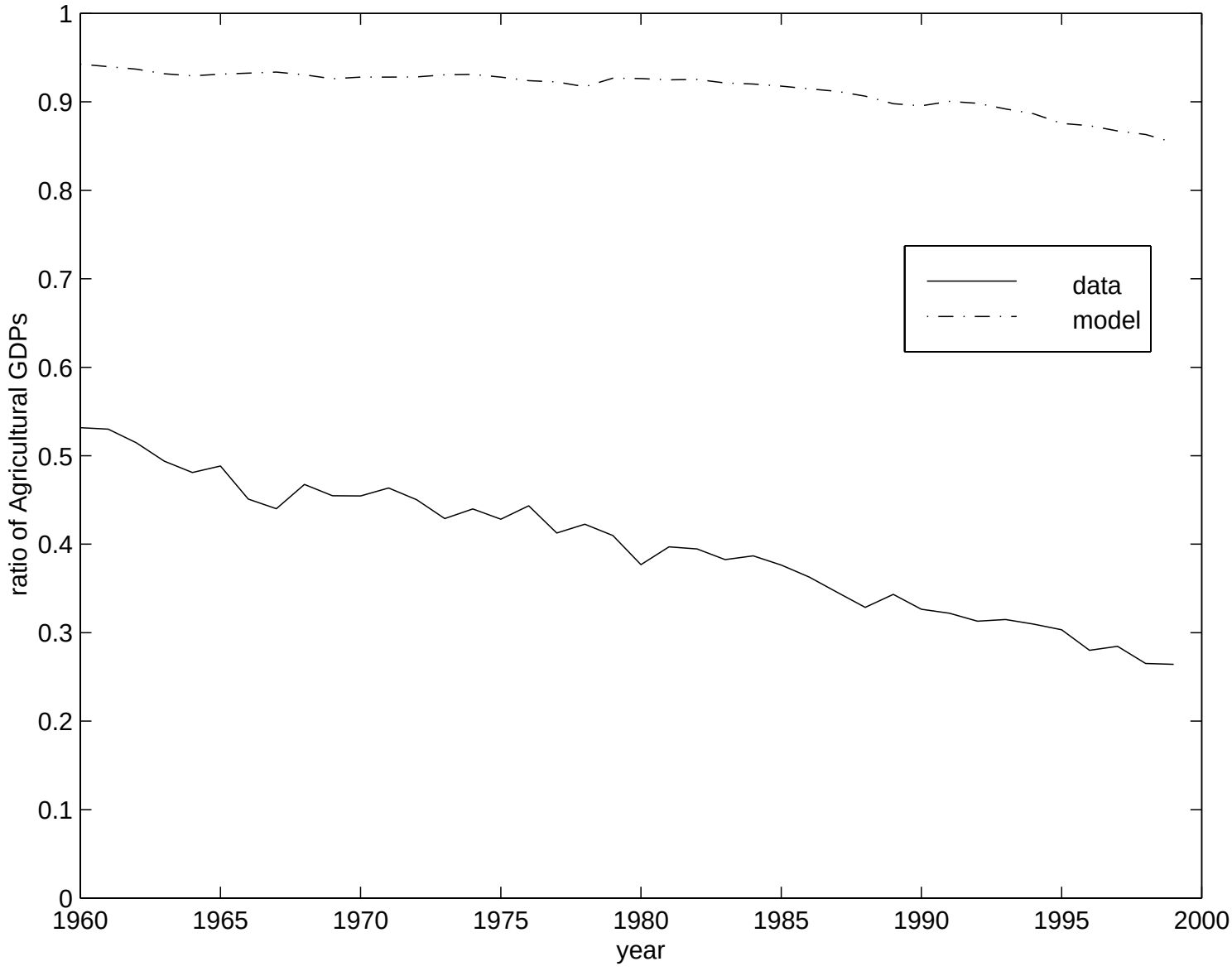

Conclusion

- Agri production technology influences on the whole economy.
- Shortcomings
  - Closed Economy
  - Exogenous tech growth in Manuf