Technology adaptation, TFP growth, and convergence in agriculture: A global perspective using conditional regression quantiles

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Background

Background

- Do low-productivity countries utilise the same technology as high-productivity countries?
- What are the sources of productivity growth for high or low productivity countries?
- Is there convergence in productivity in an absolute or conditional sense?

Background

- A wide-ranging study using USDA global agricultural productivity data and conditional quantile regressions to provide a response to all three of these answers.
- Estimates of technical change, scale efficiency change, technical efficiency change and total factor productivity change are provided for most countries over the period 1973-2012.
- Initial considerations of convergence are presented

Background

- Non-homogenous differences in technologies between low and high productivity countries are considered using an input-bias measure
- Analysis is undertaken for four agricultural exporting countries: Australia, India, Zimbabwe and the United States.

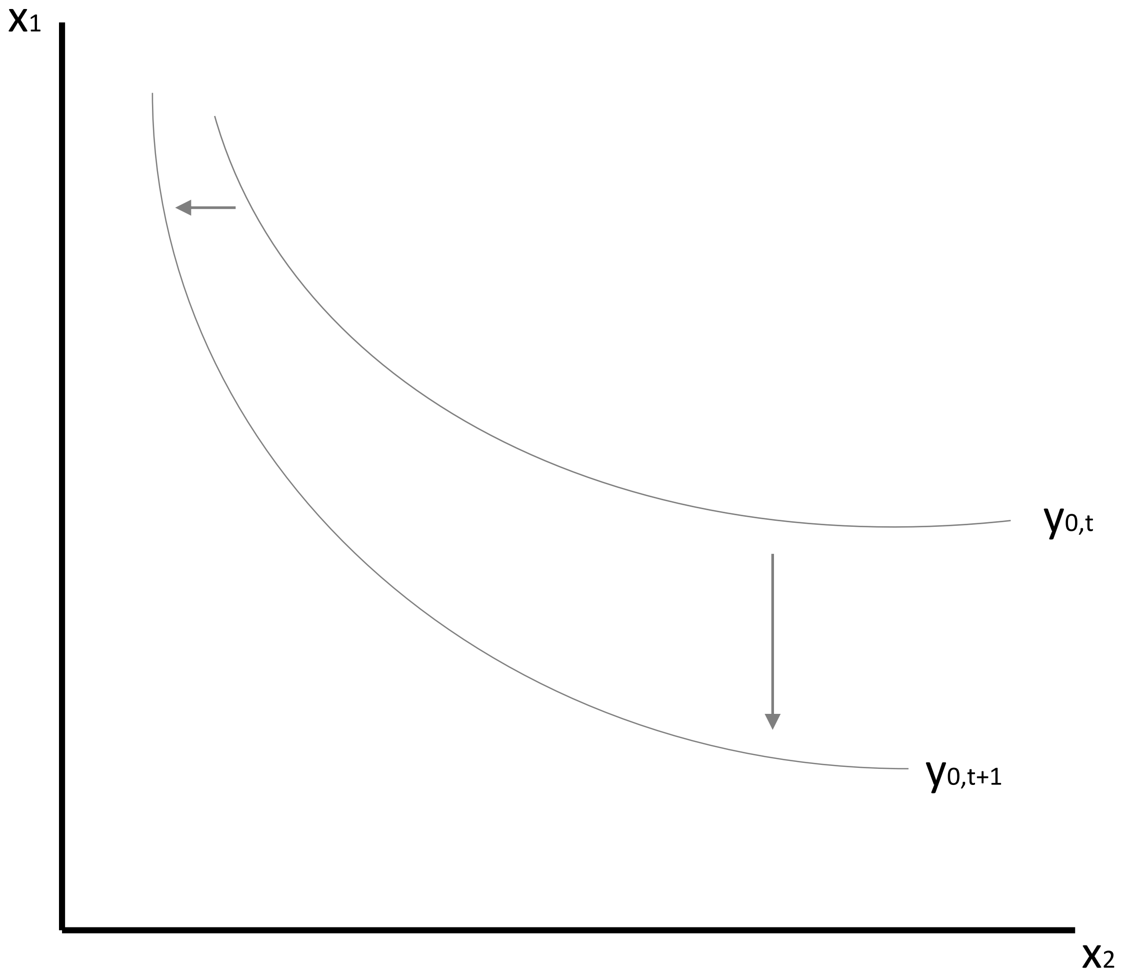
Input bias

Input bias

It is quite widely accepted now that neutral technical change rarely holds at the economy-wide level let alone at industry or enterprise scales of analysis (Färe *et al*. 2004; Managi and Karemera 2004).

Over time, particular inputs are being ‘saved’ in production relative to other inputs which are being ‘used’ more intensively.

Input bias

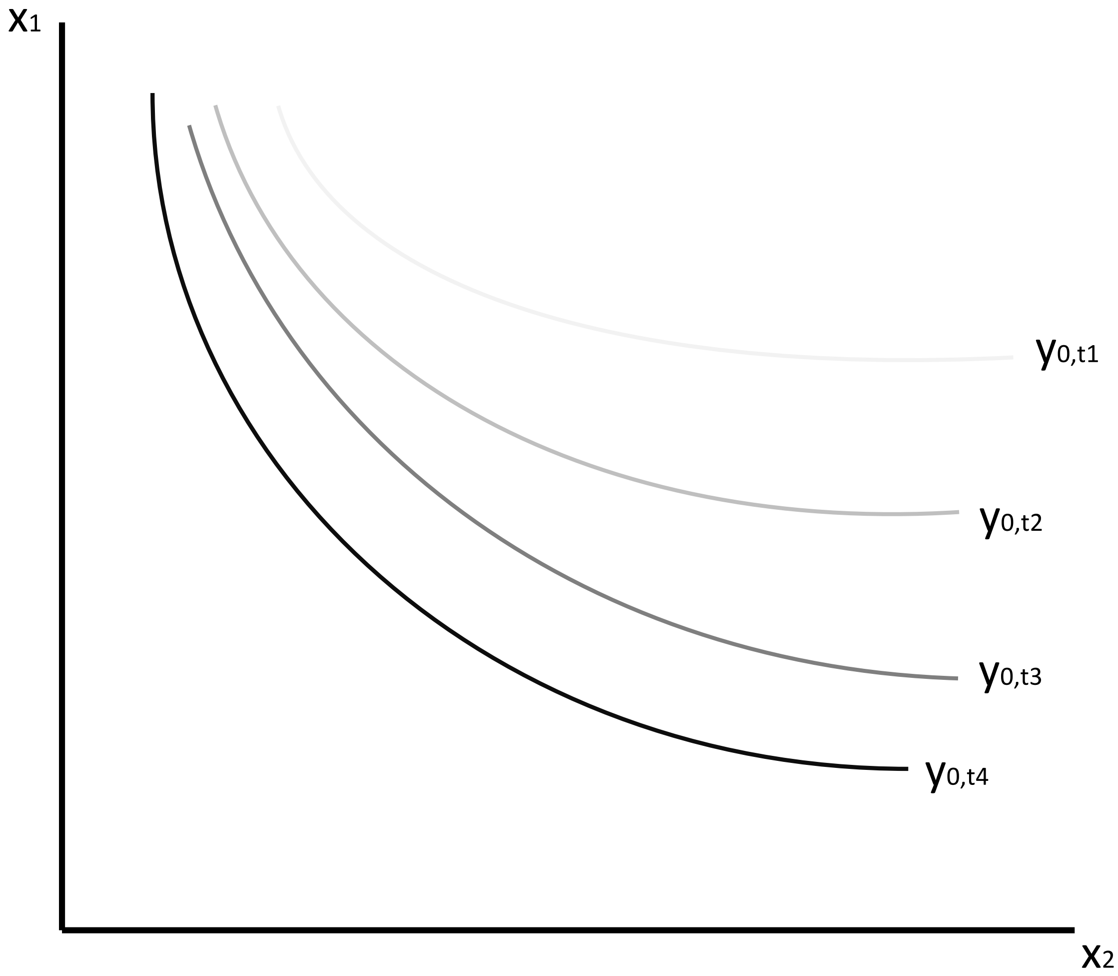


Input bias

As time progresses, some firms may fail to move to the higher frontier. Likewise, some firms may improve slowly in general and thus only slowly adapt to the frontier technology.

If technological progress is consistently input-biased in a particular direction, these inefficient firms will be consistently input-biased, in efficiency terms, relative to the frontier

Input bias



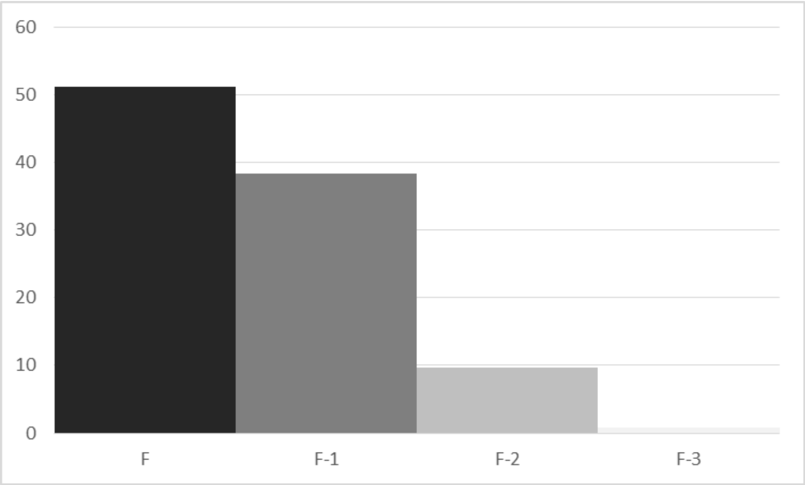
Adoption aspect

Observations of input bias over non-frontier technologies may be linked to adoption by considering if bias is monotonic or can be linked to innovation events.

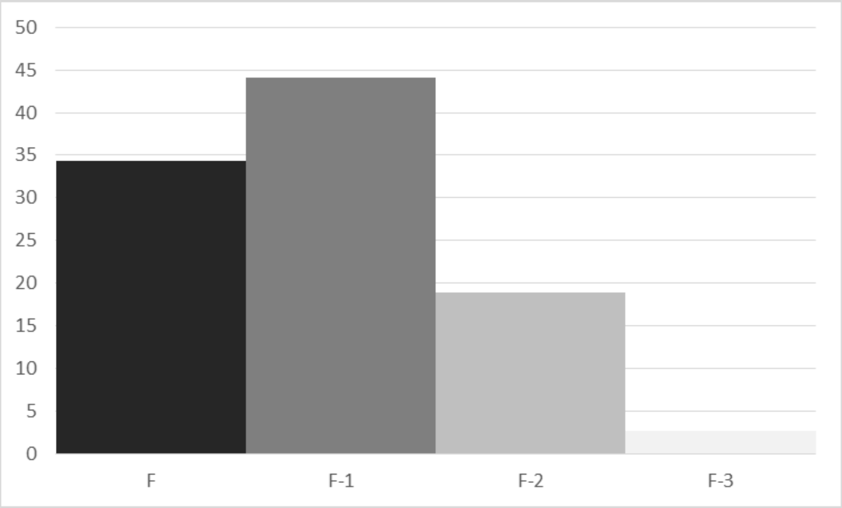
Familiar-looking distributions of efficiencies can be obtained simply from an adoption process whereby X% of firms move to the next ‘better’ technology in each period:

Conceptual aspects

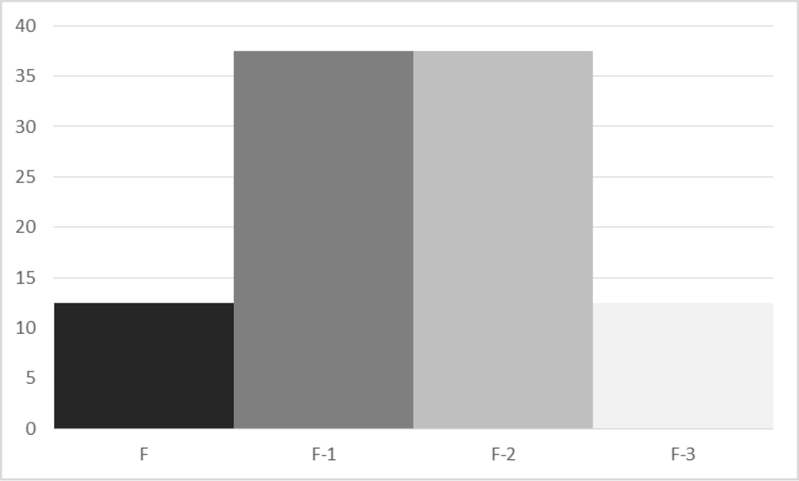
Rate = 80%



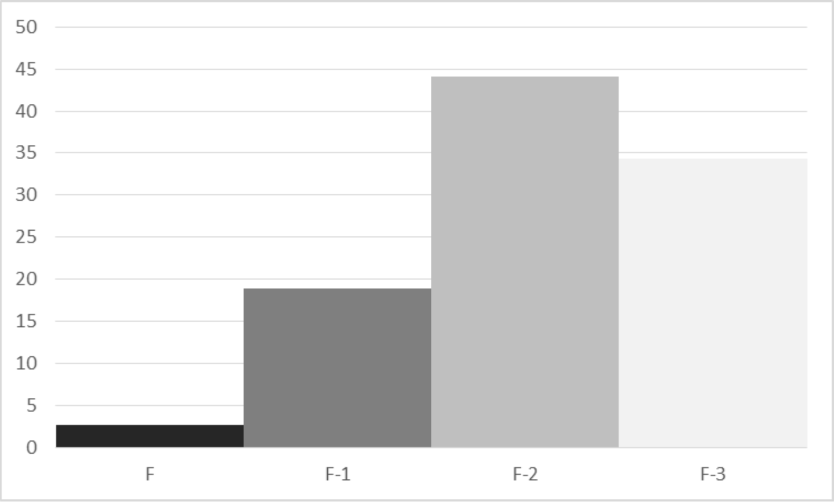
Rate = 70%



Rate = 50%



Rate = 30%



Adoption aspect

May also be able to consider adoption of technologies by testing for homogeneity.

Non-homogenous differences will show up in efficiency rankings derived from different technologies – should provide a relatively simple test of homogeneity.

Measures of Bias

No measures of input biased inefficiency currently exist (that I'm aware of) that do not rely on an underlying homogenous translation of the frontier (i.e. studies on labour efficiency)

However a good deal of work has been done on considering bias in technological progress.

Measures of Bias

Färe *et al*. (1997) outline a measure of the extent in input biases in technological progress using a decomposition approach based on distance measures

Their measure only provides a measure of input-specific bias in the case of two inputs however.

In the case of many inputs it may be of interest to consider the directions of bias (input-using, saving or neutral) for all substantive inputs.

Measures of Bias

Binswanger (1974) ran into this issue in considering many input biases in technological change. As a result he developed a simple measure based on the ratio of elasticities to scale elasticity (Antle 1984):

$$B_i = \frac{\partial \ln \frac{\epsilon_i}{\epsilon}}{\partial \ln t}$$

$Where$:
$\epsilon_i = Output\ elasticity\ for\ input\ i$
$\epsilon = scale\ elasticity$
$t = time$

Regression and efficiency quantiles

Conditional quantile regression methods are increasingly being used for consideration of the measurement of productive efficiency.

These provide a measure of technologies at internal locations of the production set – needed to consider input bias associated with inefficiency.

Regression and efficiency quantiles

A quantile regression function provides a measure of the technology:

$$Q(Y|\tau) = \{y\ is\ in\ \mathbb{R}^N\colon\ y\ is\ the\ \tau^{th}\ quantile\ of\ Y(y,x)\}$$

From which an efficiency measure can be calculated using:

$$\mathrm{Q}(Y_i|\tau) = \frac{y_i}{\delta_{i|\tau}}$$

$$\delta_{i|\tau} = \frac{y_i}{\mathrm{Q}(Y_i|\tau)}$$

Regression and efficiency quantiles

Process:

1. Estimate production functions for 5-year epochs between 1973 to 2012 allowing for dummy variables for each year (TC not constrained by functional form), and an interactions functional form for inputs. Inputs and Outputs logged and means subtracted.
2. Calculate a range factors contributing to TFP change and consider possibility of convergence
3. Calculate input-bias effects between efficiency quantiles for each epoch and within efficiency quantiles over time.

Results

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I am not presenting regression tables as there are too many of them (9 epochs and 17 percentiles = 153 separate regressions)

NB: These results are possibly under-ripe and require some refining and testing.

Results – efficiency quantiles

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Compare actuals versus expected for each quantile regression in each time period to allocate countries to efficiency quantiles:

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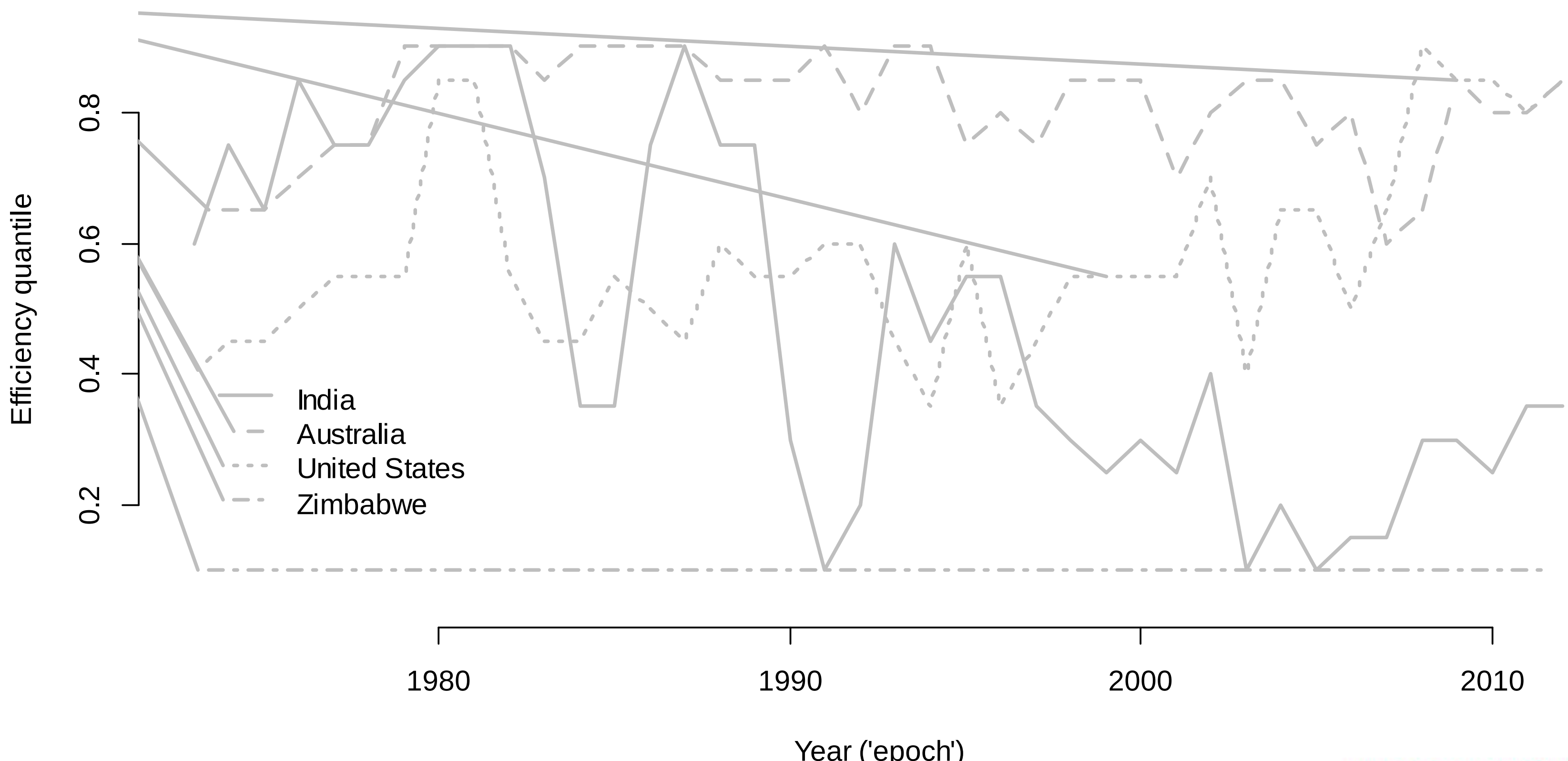

Results – Technical change

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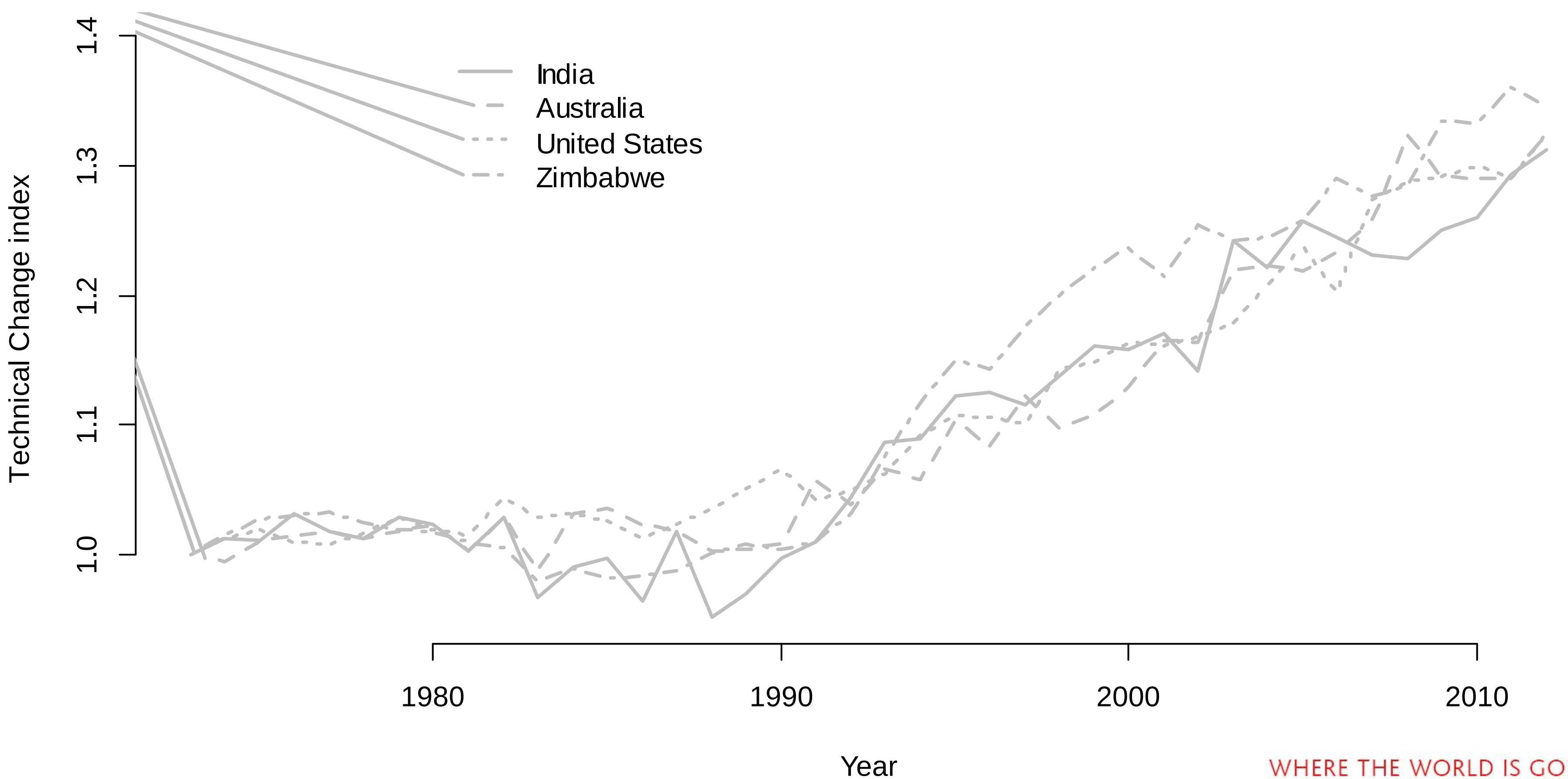
Technical Change index (1973=base)



Results – RTS

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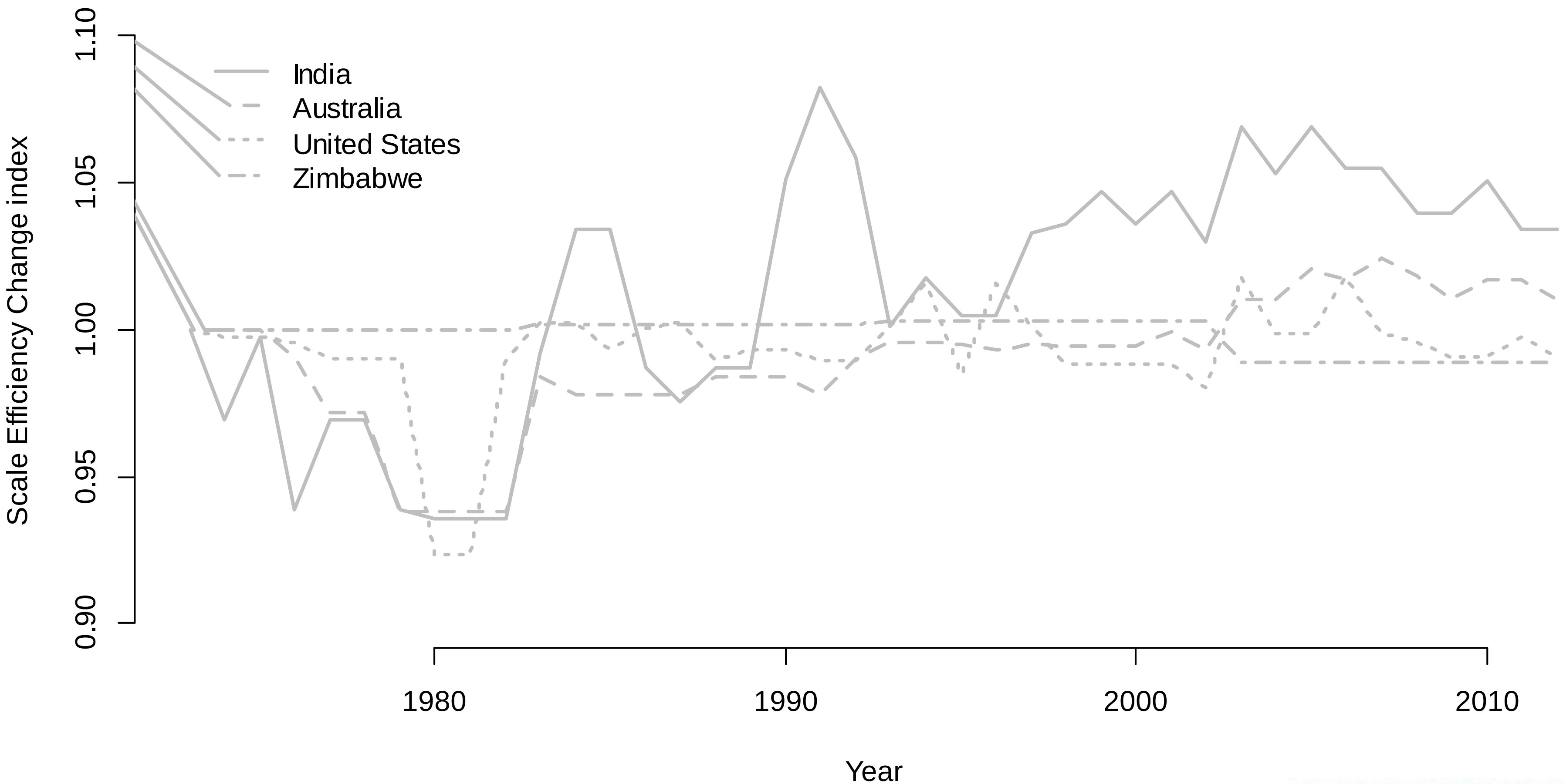
Returns To Scale index (1973=base)



Results – Efficiency

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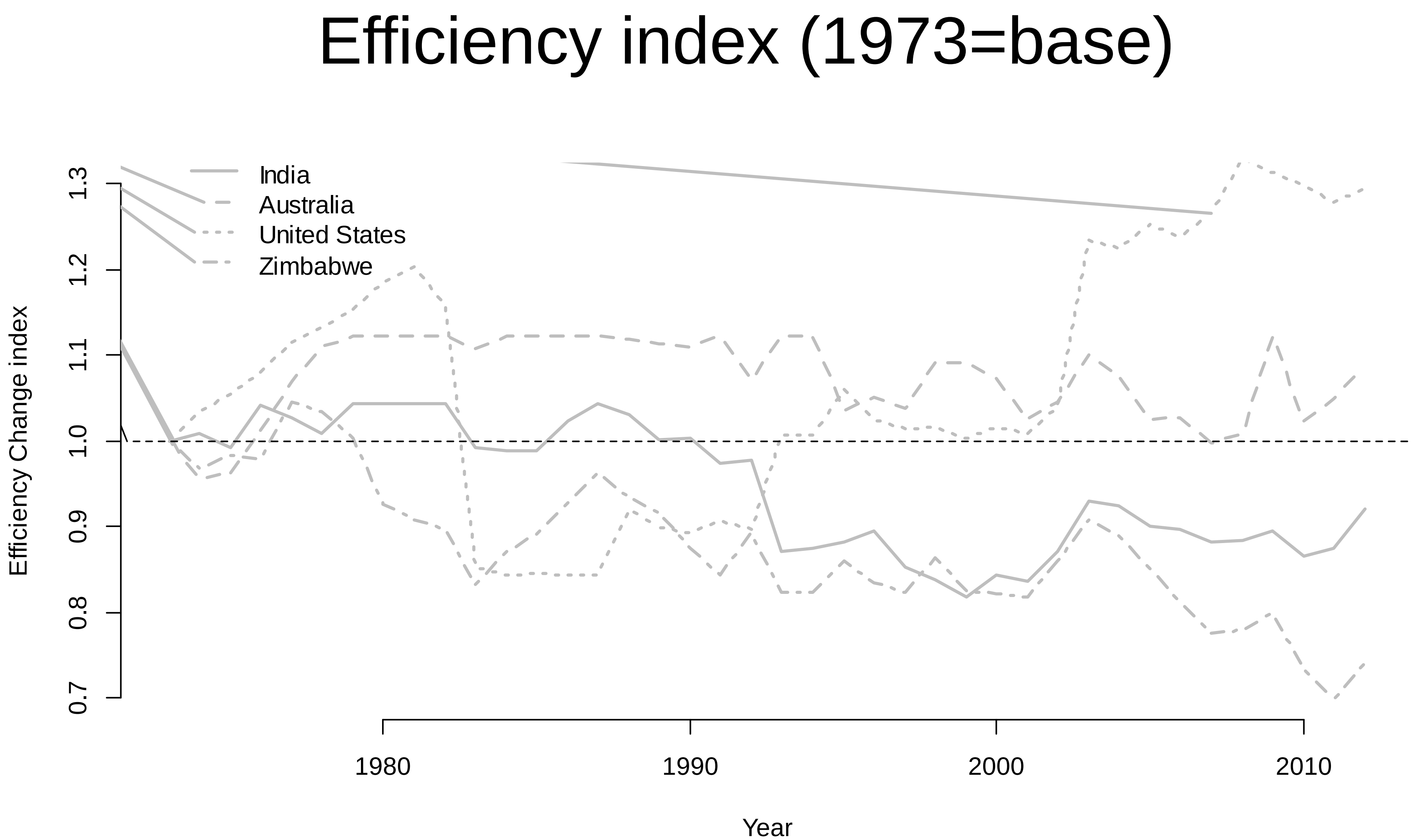

Results – Efficiency

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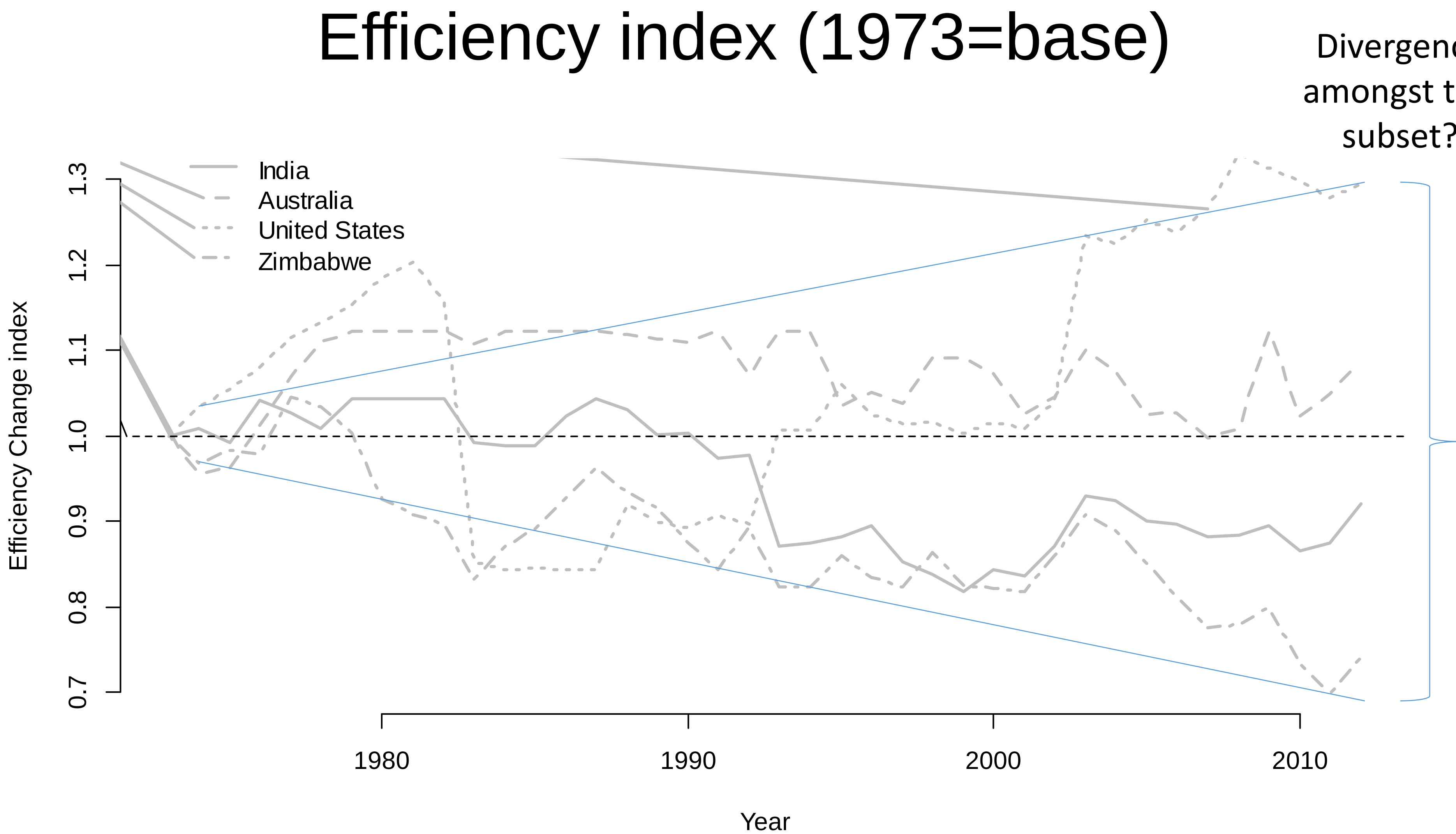
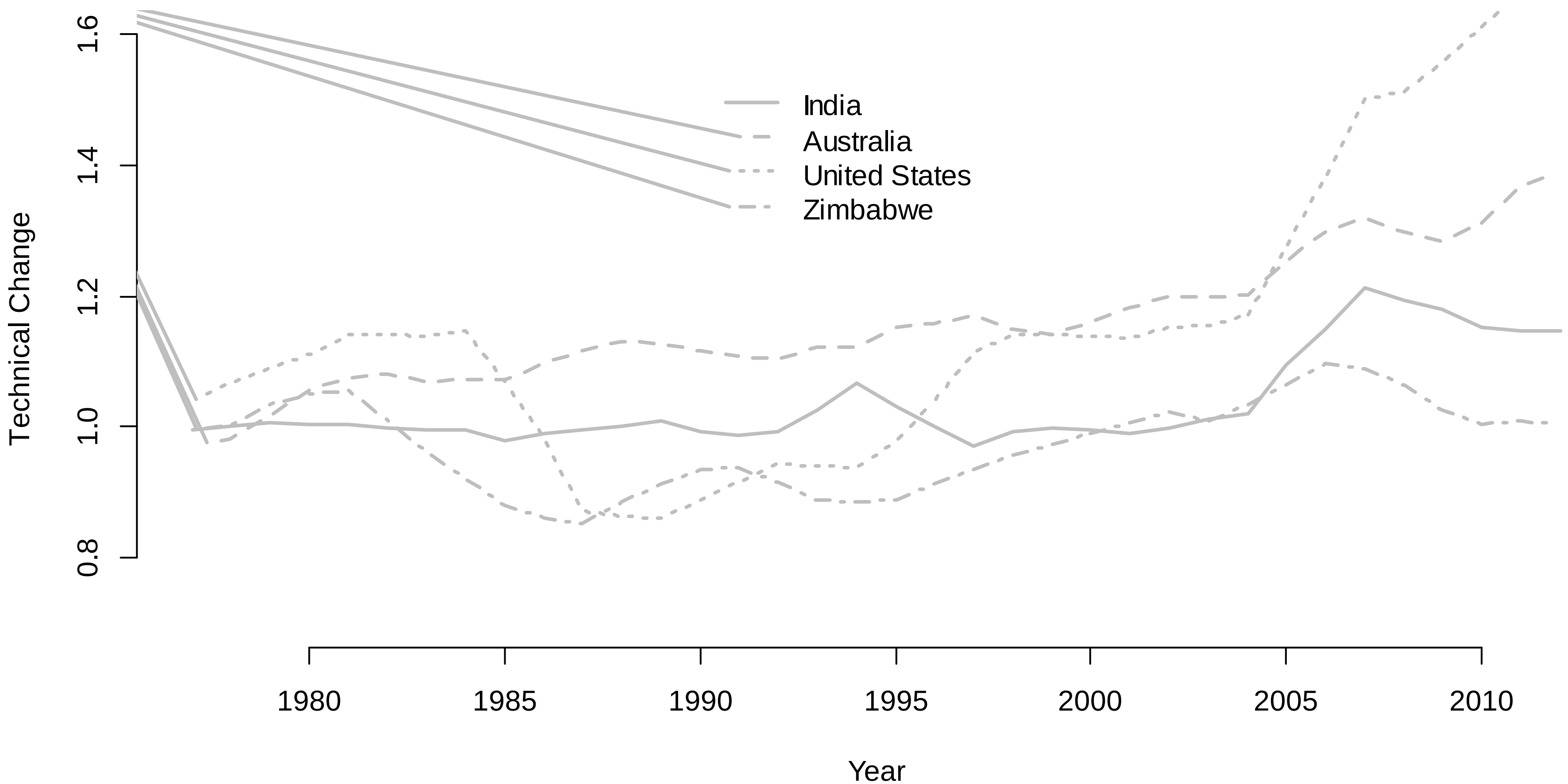


Divergence amongst this subset?

Results – TFP

TFP index (1973=base, 3 year moving average)



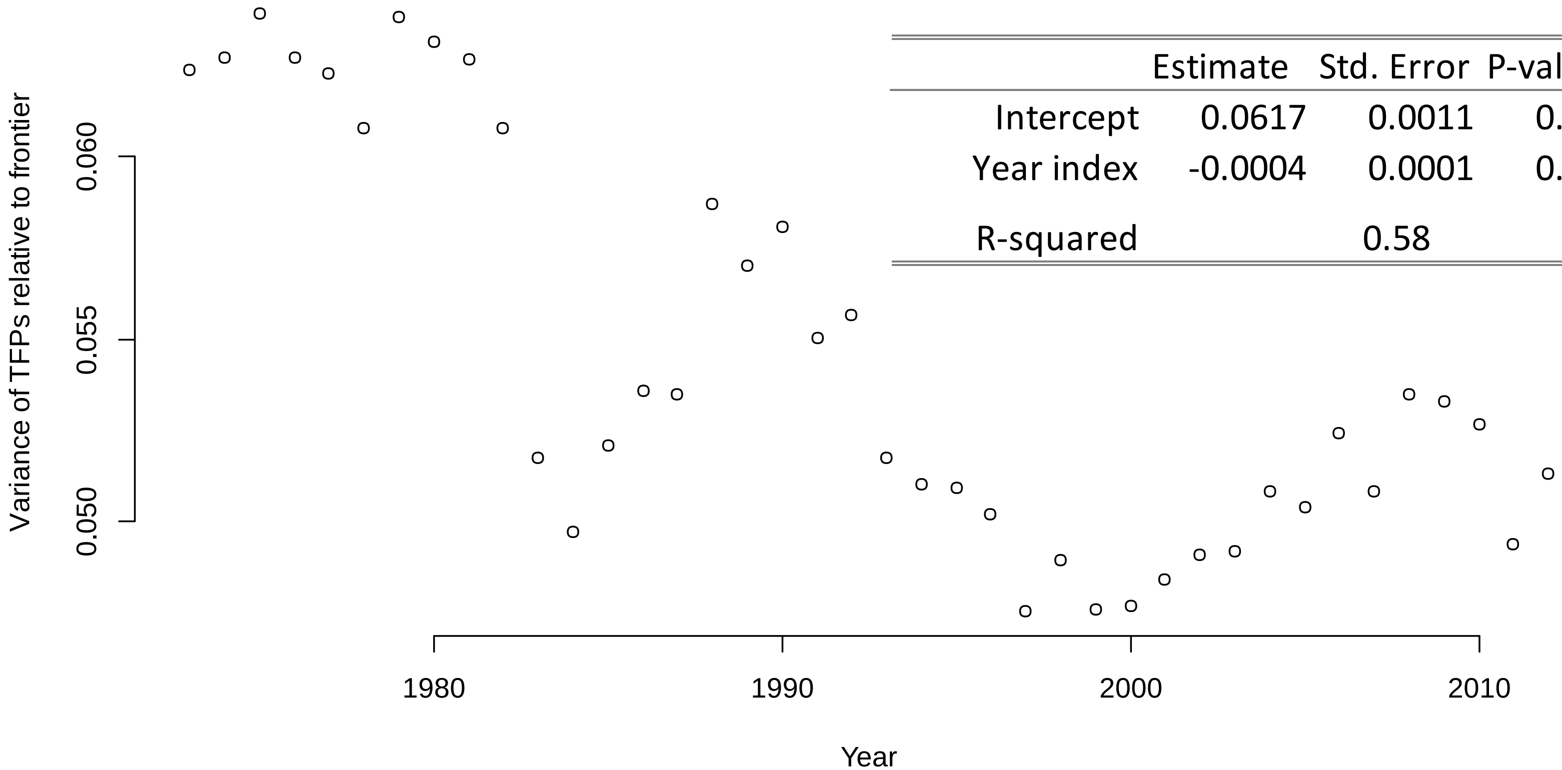
Results – Convergence (initial)

Calculate Q/Q90 for each year and each country (get an efficiency distribution for each year). Use the variance test of McCunn and Huffman (2000):

$$VAR(e) = \beta_0 + \beta_t t$$

Results – Convergence (initial)

Sufficient condition for convergence is variance of TFPs is declining over time



	Estimate	Std. Error	P-value
Intercept	0.0617	0.0011	0.0000
Year index	-0.0004	0.0001	0.0000
R-squared	0.58		

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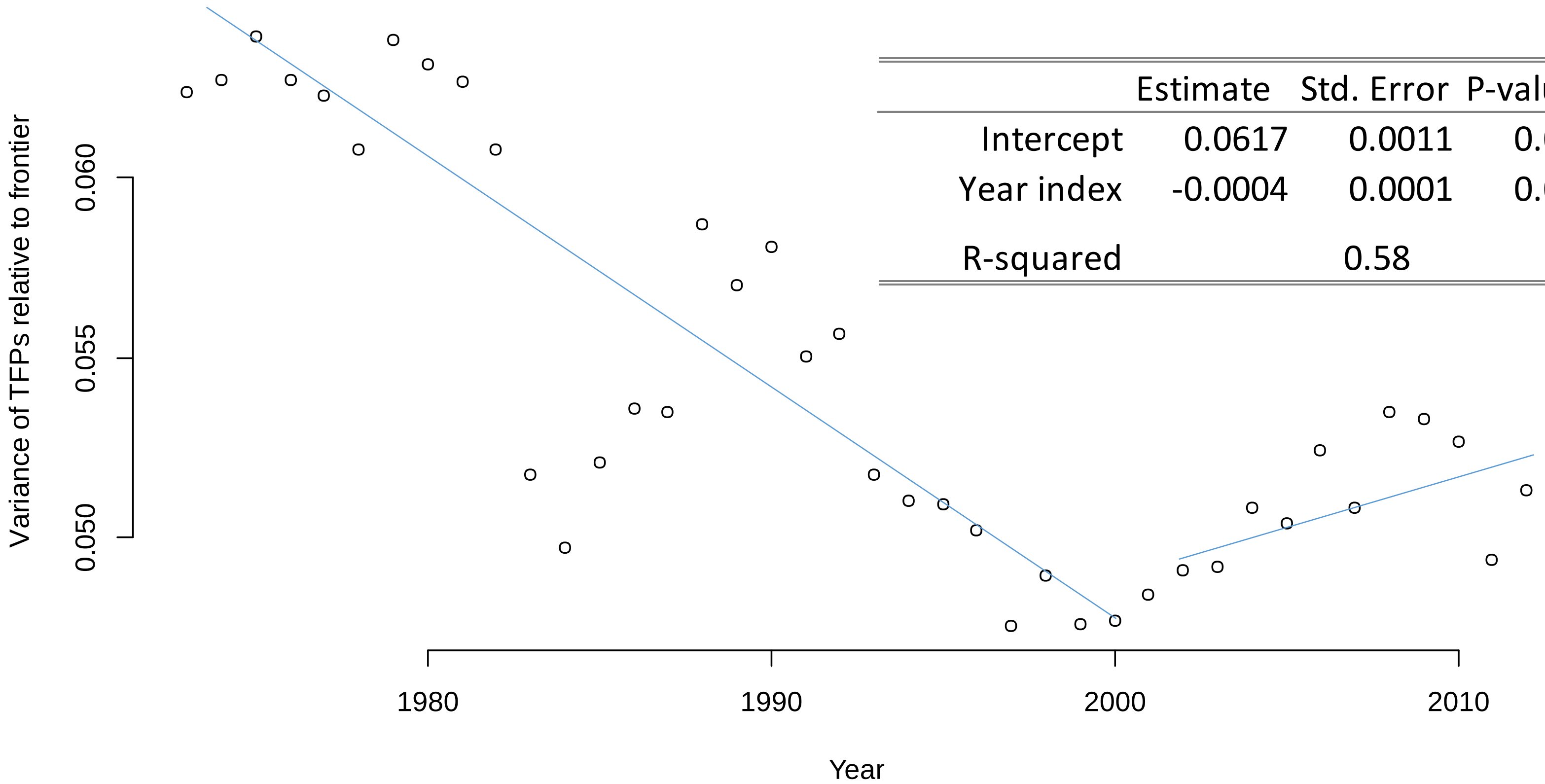

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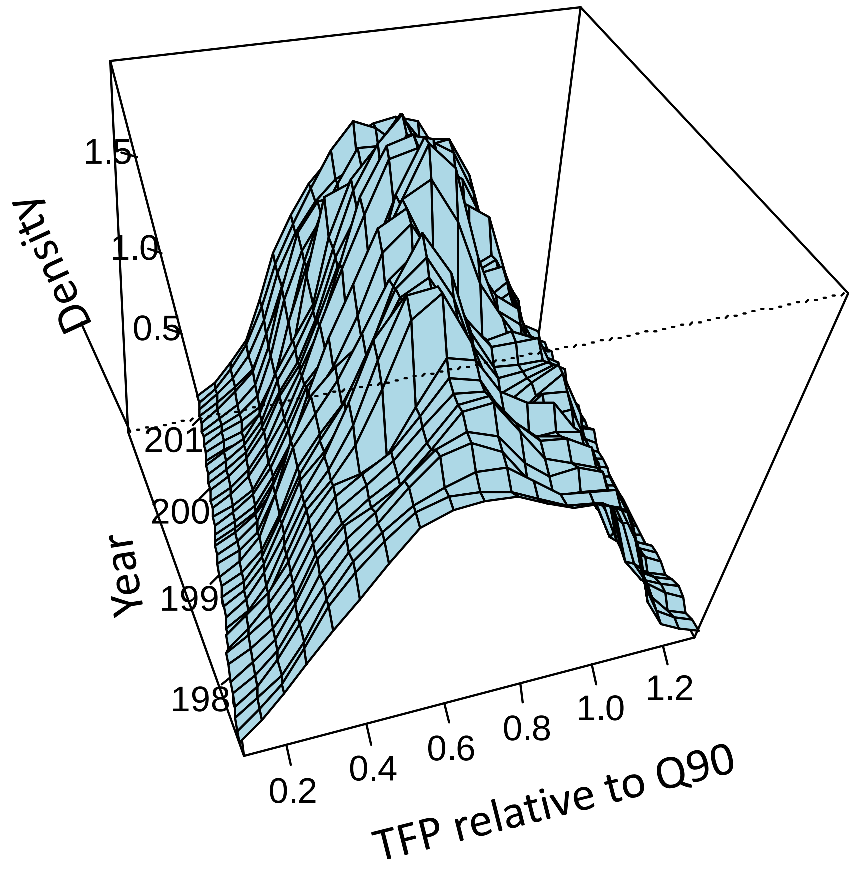

Results – input bias effects

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Use Binswanger (1974) measure to consider if there is input bias effects from low efficiency (Q10) to high efficiency (Q90) technologies.

An increasing trend indicates that factor has an increasing income share in production and a relatively higher elasticity than non-increasing trend factors

Results – input bias effects

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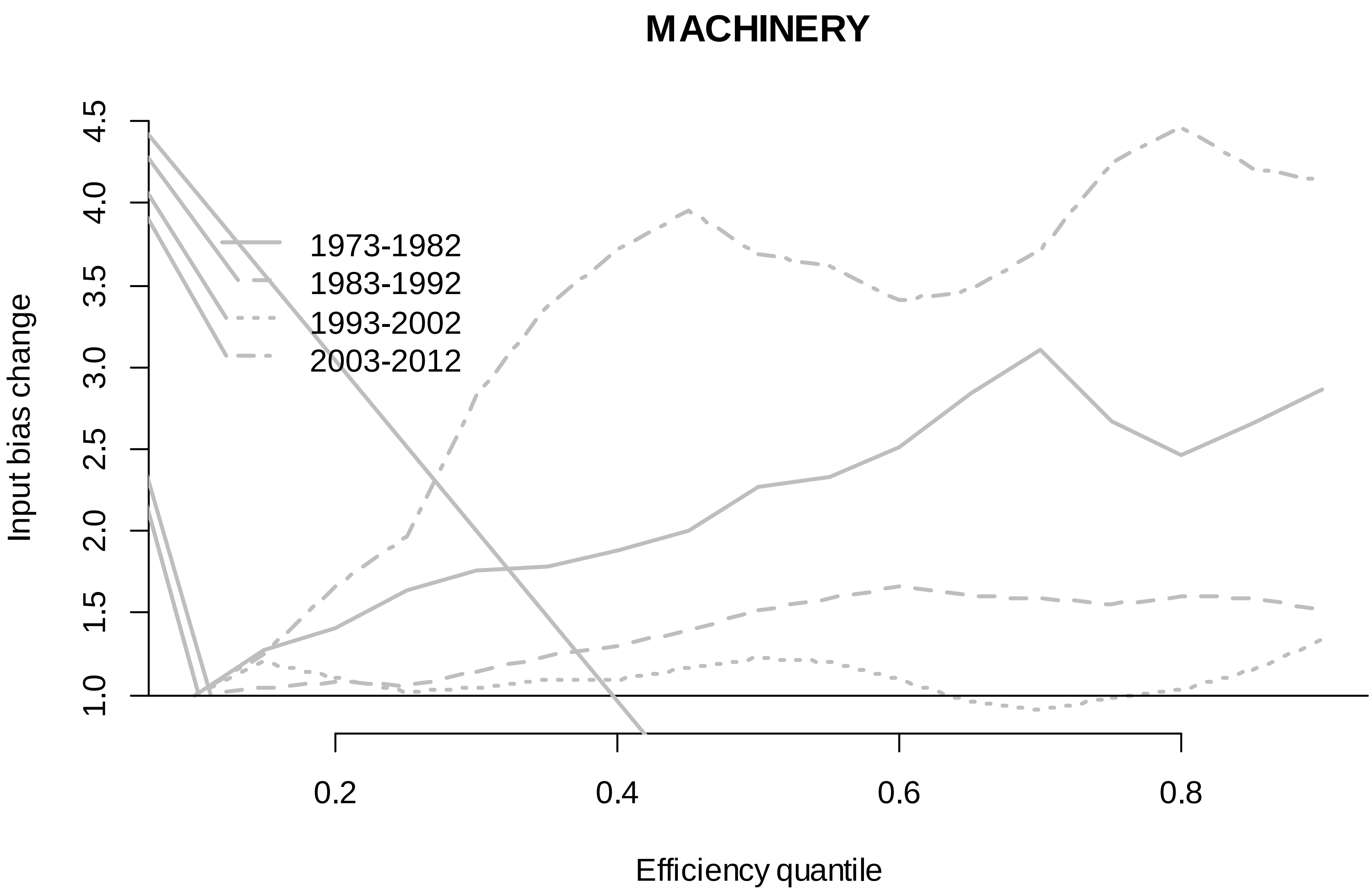
Results – input bias effects



Results – input bias effects

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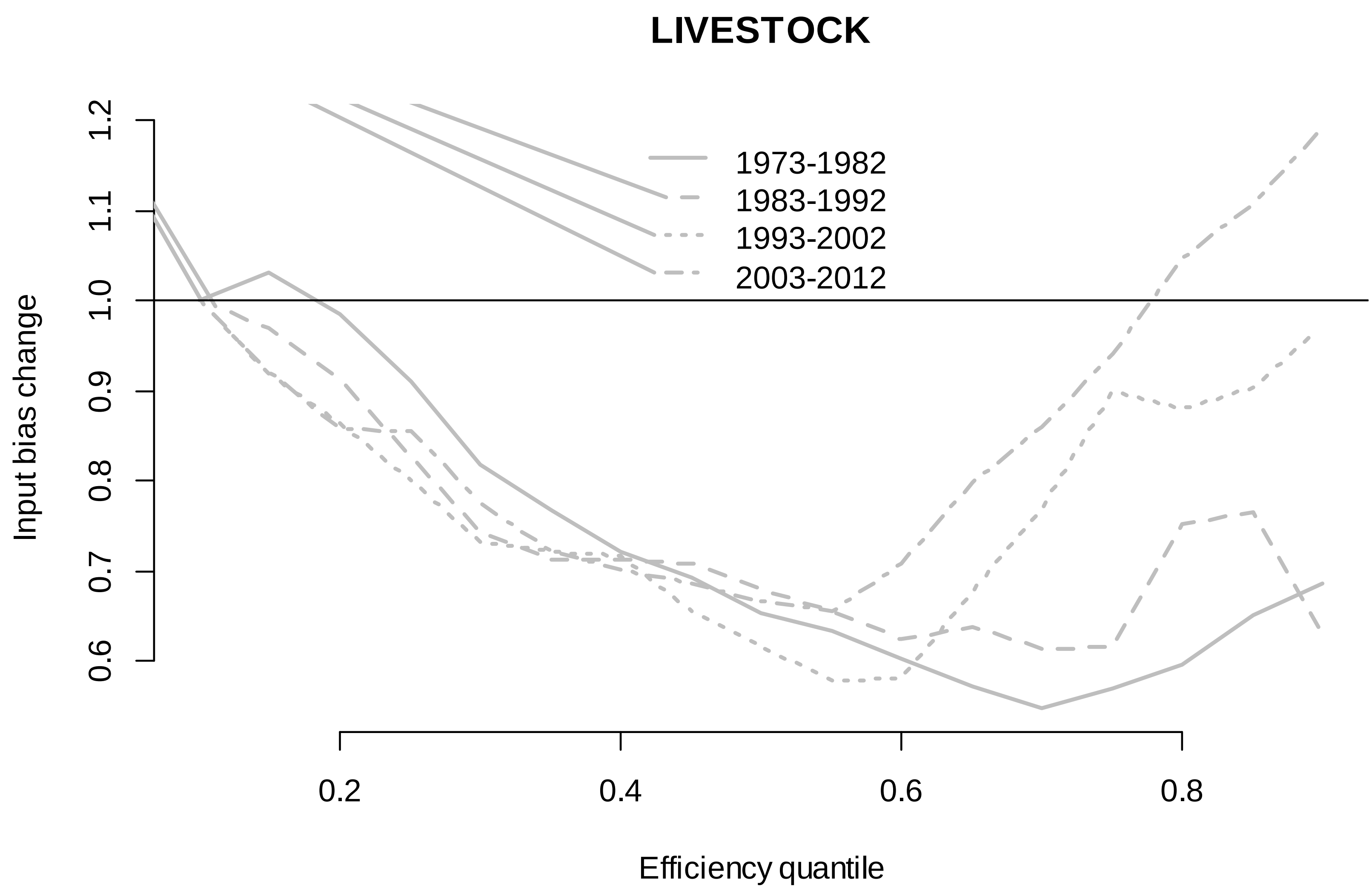

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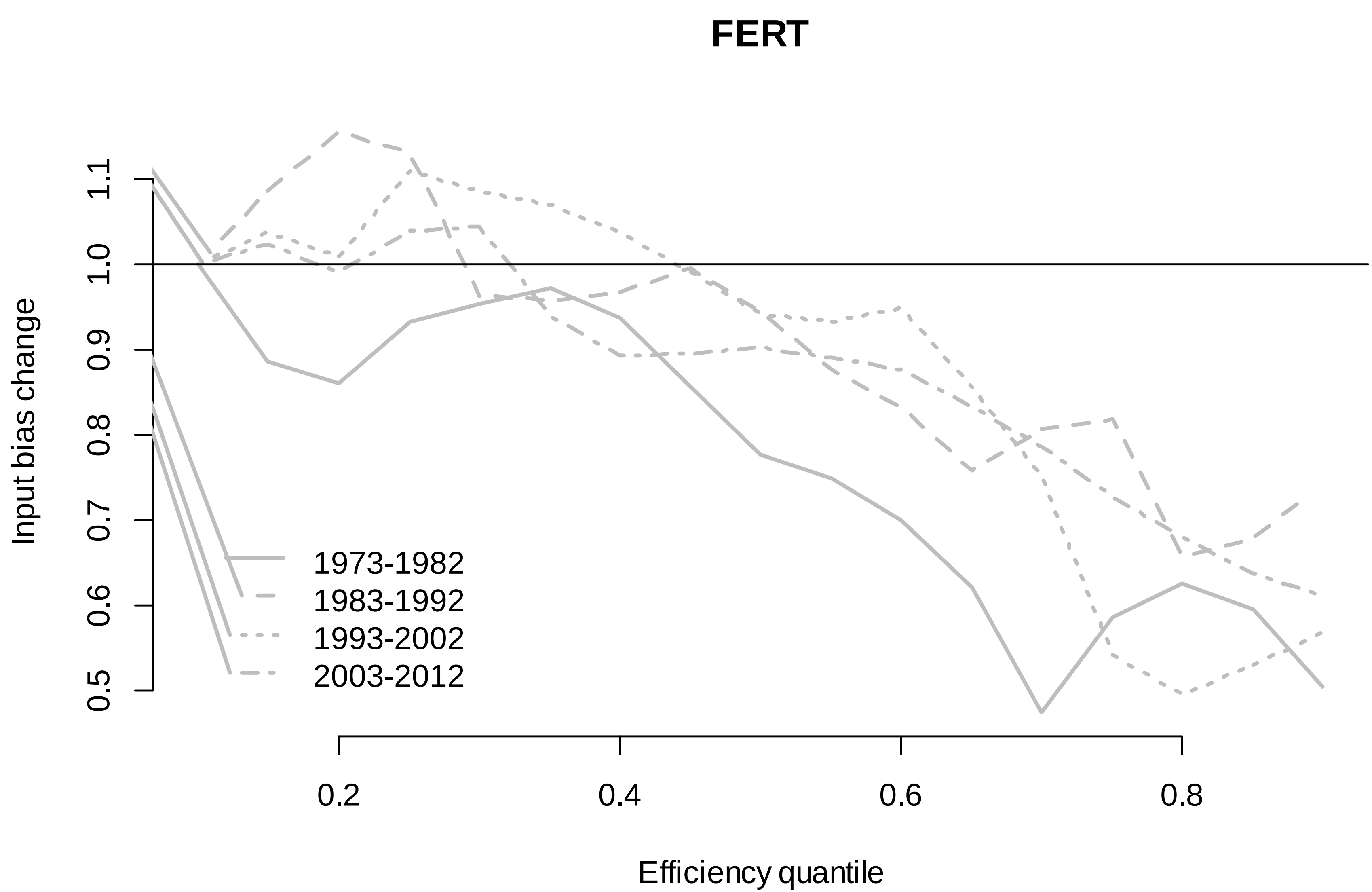

Results – input bias effects

Conclusions

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TFP

TFP change has been increasing across all efficiency quantiles. For the subset of countries considered though TFP change was lowest for Zimbabwe and India and highest for Australia and USA.

TFP changes are due to different factors depending on country: All countries relied largely relied on technical change but most particularly Australia, USA additionally on efficiency change, India additionally on scale change.

Conclusions

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Convergence

There appears to be evidence of absolute convergence both qualitatively (distribution becoming more peaked and with skinnier tails) and based on a simple variance test.

Need to do more work on this aspect and introduce other tests.

More recent data indicates that convergence may have reversed.

Conclusions

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Input bias

High efficiency countries have far higher returns to capital and labour in agriculture. This may be associated with land consolidation.

Fertilisers have considerably higher marginal returns for low efficiency producers – indicates that a pathway to efficiency improvement could be through more intensive agronomic practices.

Conclusions

Any suggestions would be appreciated on this work.

The aim is to do a full global study for all countries decomposing TFP change into the components shown in addition to decomposing efficiency into input-bias effects. A case study of major ag exporting countries will be used to highlight major aspects of outcomes.

Thanks for listening.

Questions?