THE DRIVERS OF PRODUCTIVITY CHANGE IN THE MARKET SECTORS OF THE AUSTRALIAN ECONOMY: 1995-2008

presented by

Chris O'Donnell
Centre for Efficiency and Productivity Analysis
School of Economics, University of Queensland

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Overview

- Profitability change (a measure of value change) can be decomposed into the product of a terms-of-trade index (price change) and a multiplicatively-complete TFP index (quantity change): dPROF = dTT x dTFP

- Any multiplicatively-complete index can be decomposed into measures of technical change and efficiency change: dTFP = dTech x dEff

- Among the efficiency change components are measures of technical, scale and mix efficiency change: dEff = dOTE x dOSE x dRME = dOTE x dOSME. Many other decompositions are available.

- There is no need for restrictive assumptions about the technology (e.g., constant returns to scale), the optimising behaviour of firms (e.g., cost minimisation) or market structure (e.g., perfect competition).

- Policies designed to improve productivity may be misdirected if we fail to understand and properly identify the drivers of productivity change.

Outline

- TFP Change and Profitability Change
- Data
- The ABS Approach to Measuring TFP Change
- An Alternative Approach
- Estimating The Components of TFP Change
- Efficiency Levels
- Conclusions

TFP Change and Profitability Change

TFP is defined as the ratio of an aggregate output to an aggregate input:

$$TFP_t = \frac{Q_t}{X_t}$$

where $Q_t \equiv Q(q_t)$ is an aggregate output and $X_t \equiv X(x_t)$ is an aggregate input. Then

(1) $$TFP_{st} \equiv \frac{TFP_t}{TFP_s} = \frac{Q_t / X_t}{Q_s / X_s} = \frac{Q_t / Q_s}{X_t / X_s} = \frac{Q_{st}}{X_{st}}$$

TFP indexes that can be expressed as in (1) are said to be multiplicatively complete (O'Donnell, 2008).

TFP Change and Profitability Change cont.

Profitability is defined as the ratio of revenue to cost:

$$PROF_t = \frac{P_t Q_t}{W_t X_t}$$

where $P_t \equiv p_t' q_t / Q_t$ and $W_t \equiv w_t' x_t / X_t$ are aggregate output and input prices. Then

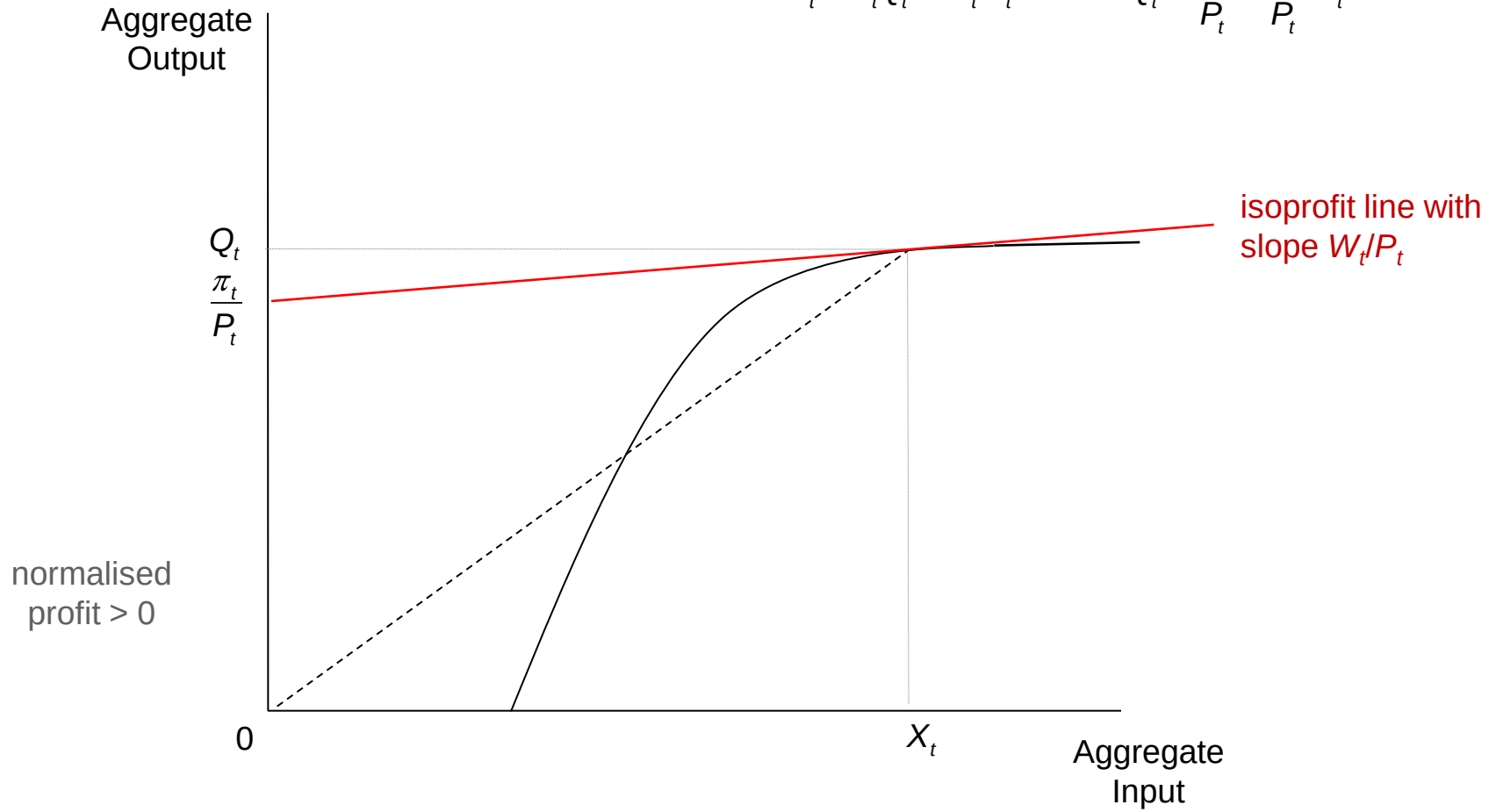
$$PROF_{st} = \frac{PROF_t}{PROF_s} = \left(\frac{P_t / P_s}{W_t / W_s} \right) \left(\frac{Q_t / Q_s}{X_t / X_s} \right) = \left(\frac{P_{st}}{W_{st}} \right) \left(\frac{Q_{st}}{X_{st}} \right)$$

dTT dTFP

This has important implications for policy …

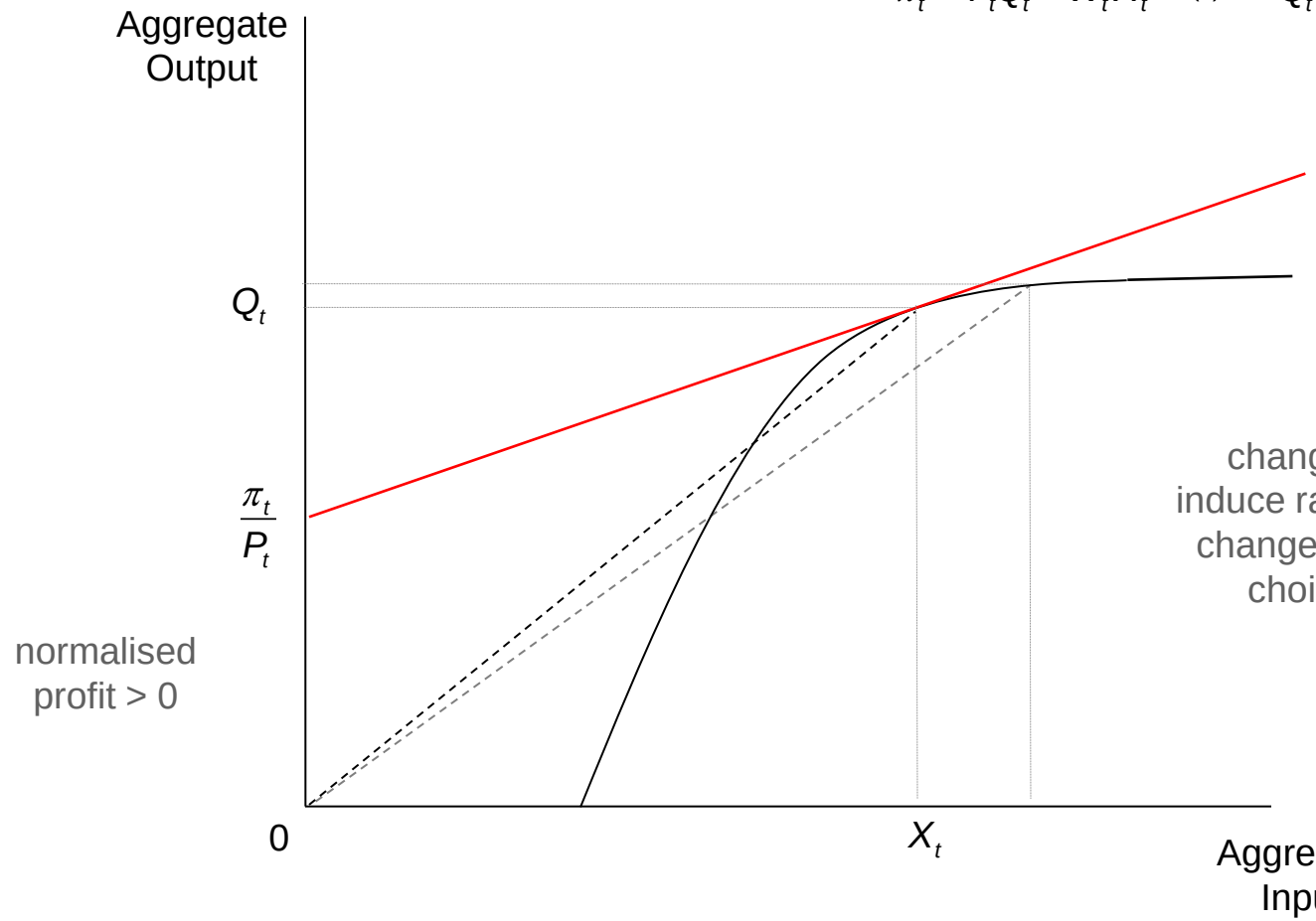
TFP Change and Profitability Change cont.

$$\pi_t = P_t Q_t - W_t X_t \quad \Leftrightarrow \quad Q_t = \frac{\pi_t}{P_t} + \frac{W_t}{P_t} X_t$$



TFP Change and Profitability Change cont.

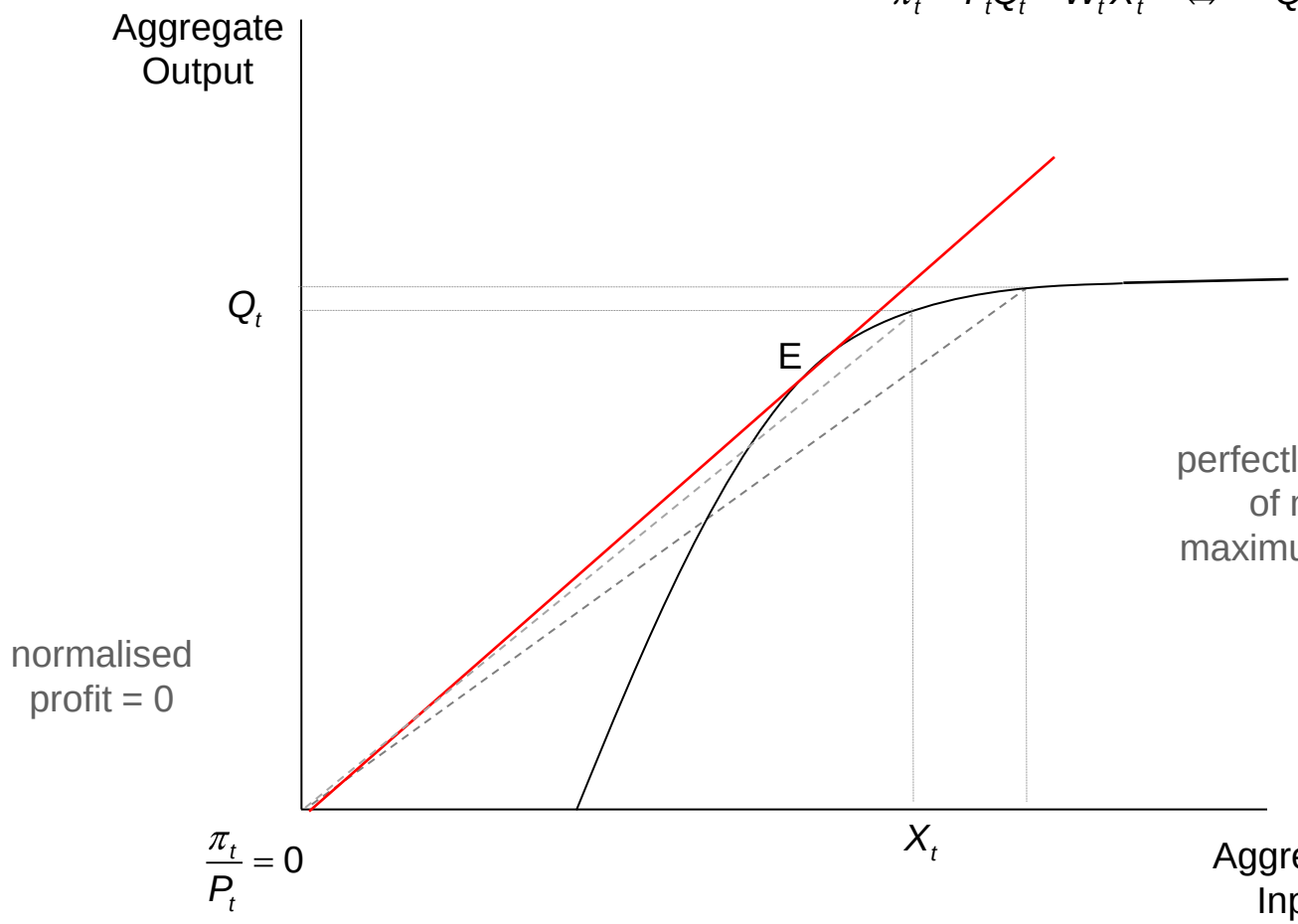
$$\pi_t = P_t Q_t - W_t X_t \quad \Leftrightarrow \quad Q_t = \frac{\pi_t}{P_t} + \frac{W_t}{P_t} X_t$$



changes in relative prices induce rational efficient firms to change their input and output choices and, therefore, productivity.

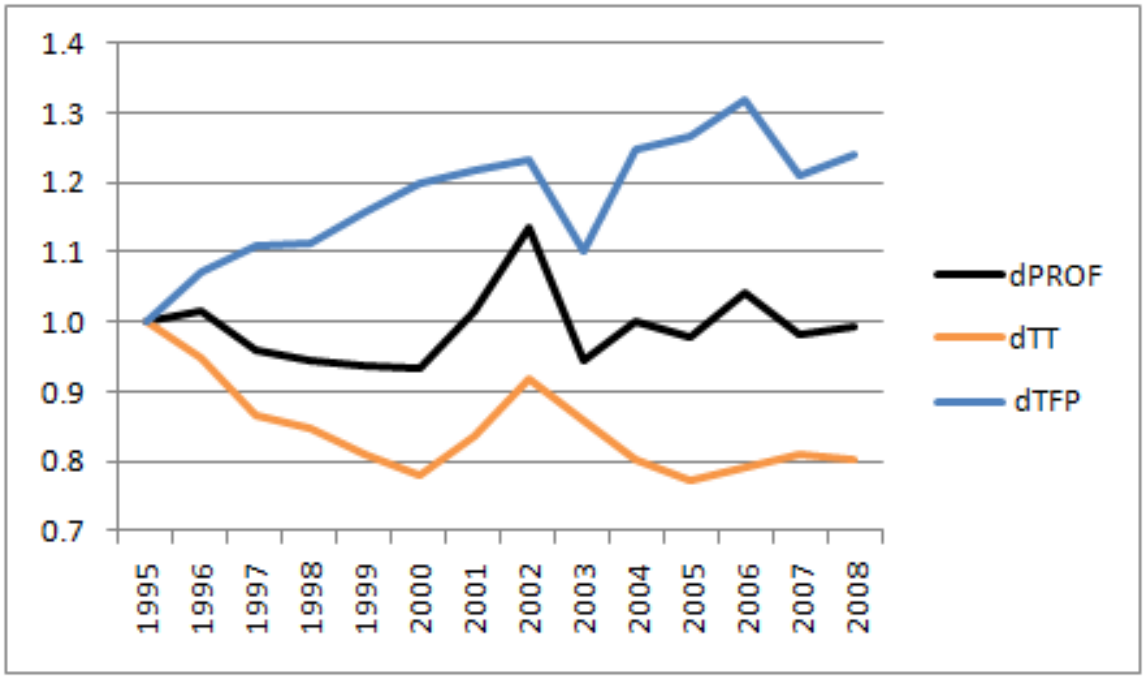
TFP Change and Profitability Change cont.

$$\pi_t = P_t Q_t - W_t X_t \quad \Leftrightarrow \quad Q_t = \frac{\pi_t}{P_t} + \frac{W_t}{P_t} X_t$$



perfectly competition $\Rightarrow$ points of maximum profit and maximum productivity coincide

Agriculture



Data

ABS Cat. No. 5260.0.55.002 Experimental Estimates of Industry Multifactor Productivity, Australia: Detailed Productivity Estimates

Q = Gross Output Index

L = Hours Worked Index

K = Capital Services Index

X = Intermediate Inputs Index

A: Agriculture, Forestry and Fishing

B: Mining

C: Manufacturing

D: Electricity, Gas, Water and Waste Services

: : : : :

R = Arts and Recreation Services

16 = Market Sector Industries

The ABS Approach to Measuring TFP Change

ABS measures TFP change in a growth accounting framework. This involves the following assumptions:

A.1 there is no technical inefficiency

A.2 the technology is input homothetic and technical change is Hicks-neutral

A.3 the technology exhibits constant returns to scale

A.4 marginal revenue products equal factor prices (perfect competition)

(assumption A.4 can be avoided using an econometric approach and by making assumptions about parameter variation and the properties of error terms)

An Alternative Approach

This paper measures TFP change using an index number approach. This involves choosing output and input quantity index formulas (equivalently, choosing output and input aggregator functions).

Laspeyres

Laspeyres output quantity index:

$$Q(q) = p_s' q \qquad \Rightarrow \qquad Q_{st}^L = \frac{Q(q_t)}{Q(q_s)} = \frac{p_s' q_t}{p_s' q_s}$$

Laspeyres input quantity index:

$$X(x) = w_s' x \qquad \Rightarrow \qquad X_{st}^L = \frac{X(x_t)}{X(x_s)} = \frac{w_s' x_t}{w_s' x_s}$$

Laspeyres TFP index:

$$TFP_{st}^L = \frac{Q_{st}^L}{X_{st}^L} = \frac{p_s' q_t}{p_s' q_s} \frac{w_s' x_s}{w_s' x_t}$$

To compute this index we must have price data.

Hicks-Moorsteen

Malmquist output quantity index:

$$Q(q) = D_O^t(x_t,q)D_O^s(x_s,q)^{1/2} \quad \Rightarrow Q_{st}^M = \frac{Q(q_t)}{Q(q_s)} = \left(\frac{D_O^t(x_t,q_t)}{D_O^t(x_t,q_s)}\frac{D_O^s(x_s,q_t)}{D_O^s(x_s,q_s)}\right)^{1/2}$$

Malmquist input quantity index:

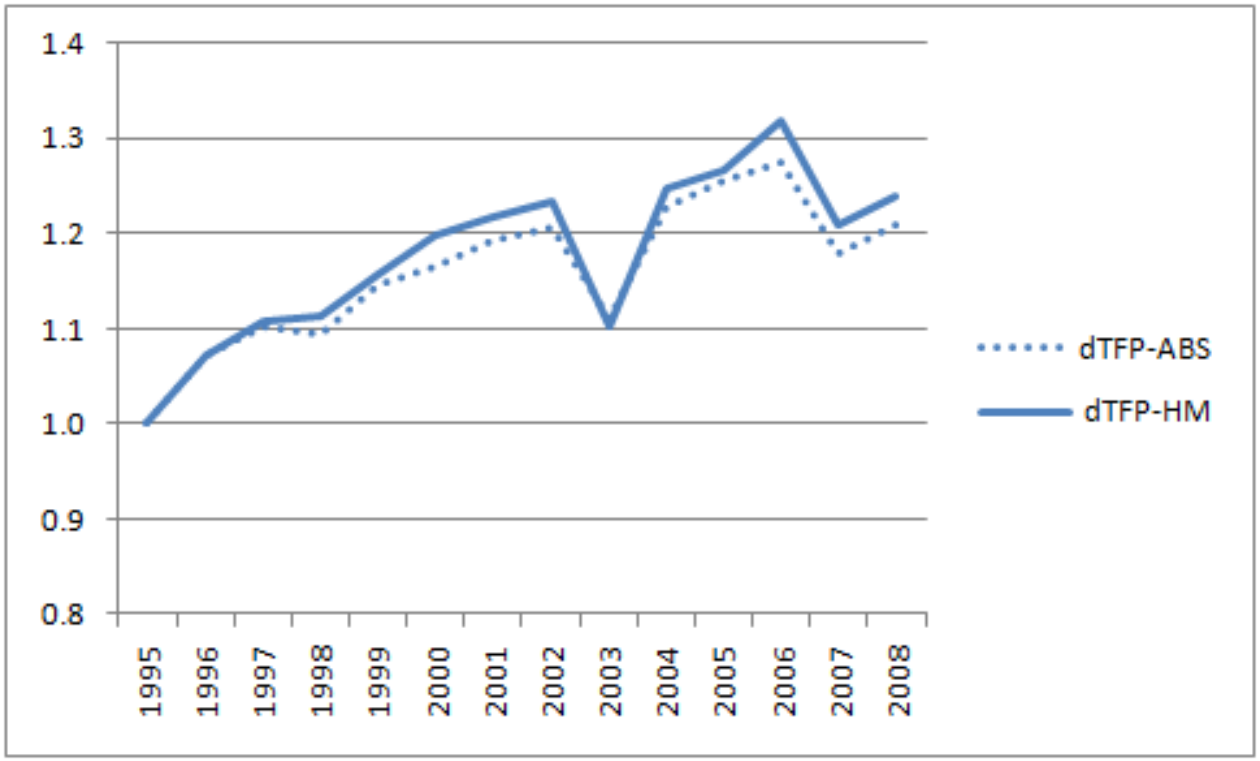
$$X(x) = D_I^t(x,q_t)D_I^s(x,q_s)^{1/2} \quad \Rightarrow \quad X_{st}^M = \frac{X(x_t)}{X(x_s)} = \left(\frac{D_I^t(x_t,q_t)}{D_I^t(x_s,q_t)}\frac{D_I^s(x_t,q_s)}{D_I^s(x_s,q_s)}\right)^{1/2}$$

Hicks-Moorsteen TFP index:

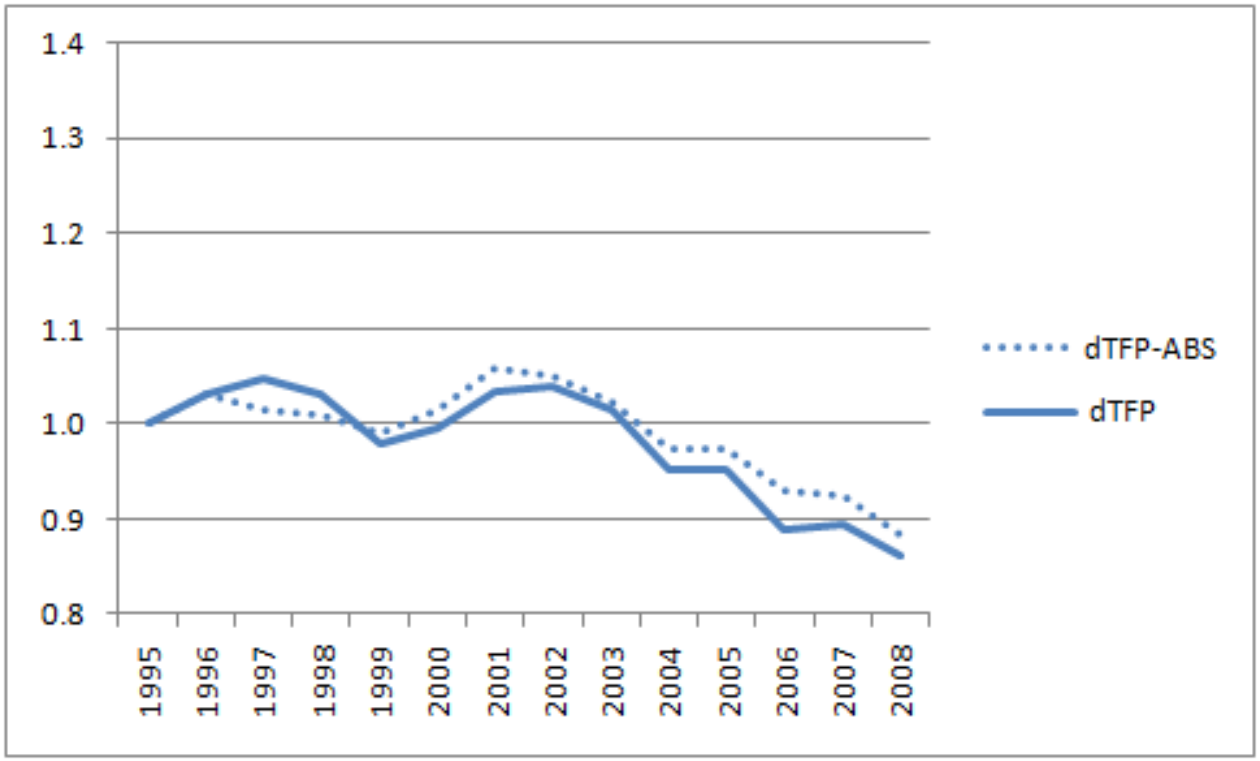
$$TFP_{st}^{HM} = \frac{Q_{st}^M}{X_{st}^M} = \left(\frac{D_O^t(x_t,q_t)D_O^s(x_s,q_t)}{D_O^t(x_t,q_s)D_O^s(x_s,q_s)}\frac{D_I^t(x_s,q_t)D_I^s(x_s,q_s)}{D_I^t(x_t,q_t)D_I^s(x_t,q_s)}\right)^{1/2}$$

To compute this index we must estimate the production technology.

Agriculture, Forestry and Fishing



Mining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Estimating The Components of TFP Change

Any multiplicatively-complete TFP index can be exhaustively decomposed into measures of

- technical change (movements in the frontier)
- technical efficiency change (movements towards the frontier)
- scale and mix efficiency change (movements around the frontier surface to capture economies of scale and scope)

This has important implications for policy, because different policies can be directed at different components:

- R&D policies affect the technical change component
- education, training and extension policies affect the technical efficiency change component
- policies that change relative prices (e.g., competition policy, interest rate policy, tariff policy) affect the scale and mix efficiency change components.

Estimating the Components of TFP Change cont.

Decomposing productivity index numbers involves estimating the production frontier. In principle, any parametric or nonparametric methodology could be used . DEA linear programs can be found in O'Donnell (2010).

The DPIN software package:

- uses DEA methodology
- can be used to compute and decompose Paasche, Laspeyres, Hicks-Moorsteen, Fisher and Lowe indexes under different assumptions about technical change and returns to scale

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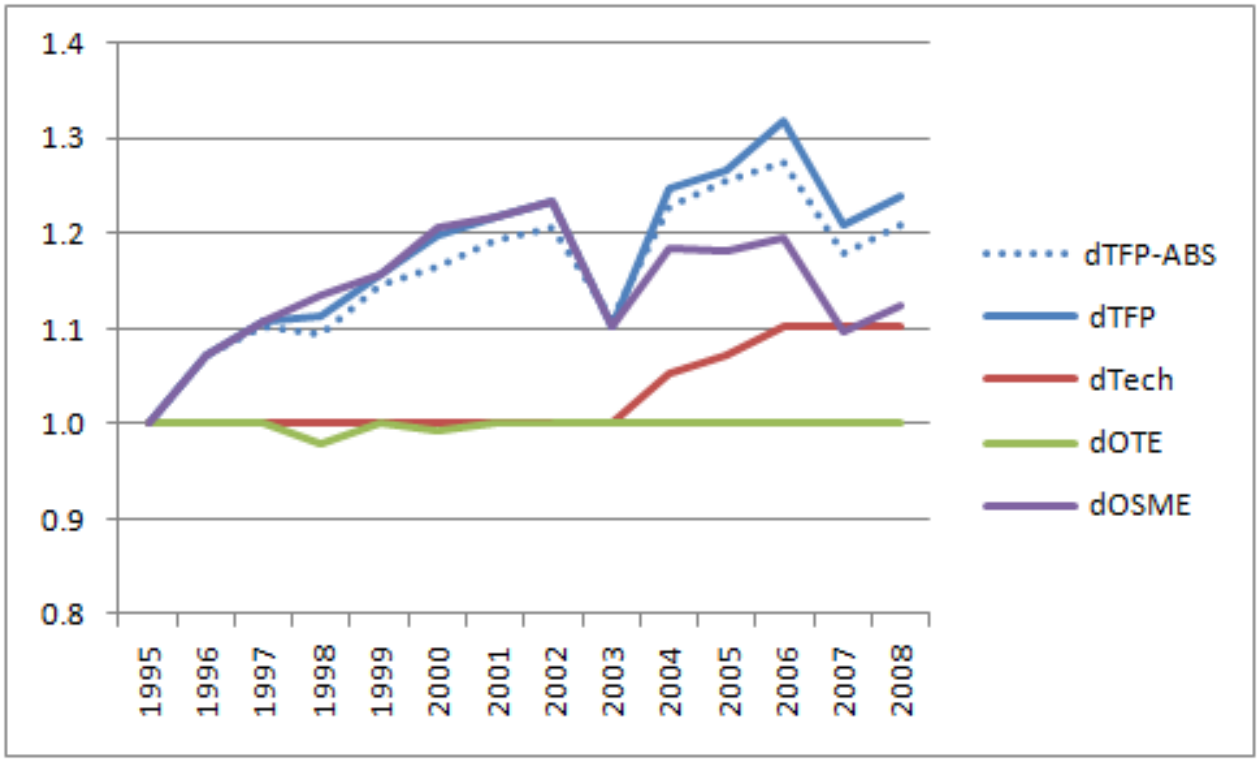
Agriculture, Forestry and Fishing



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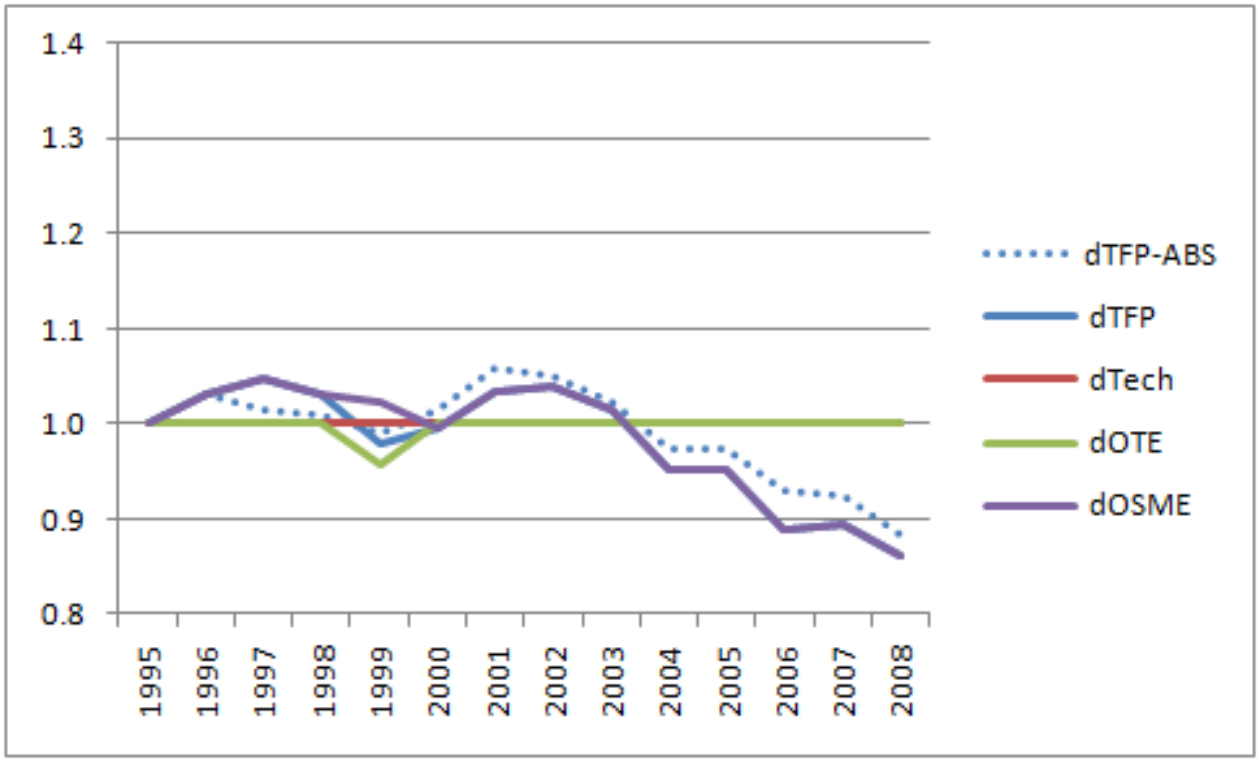
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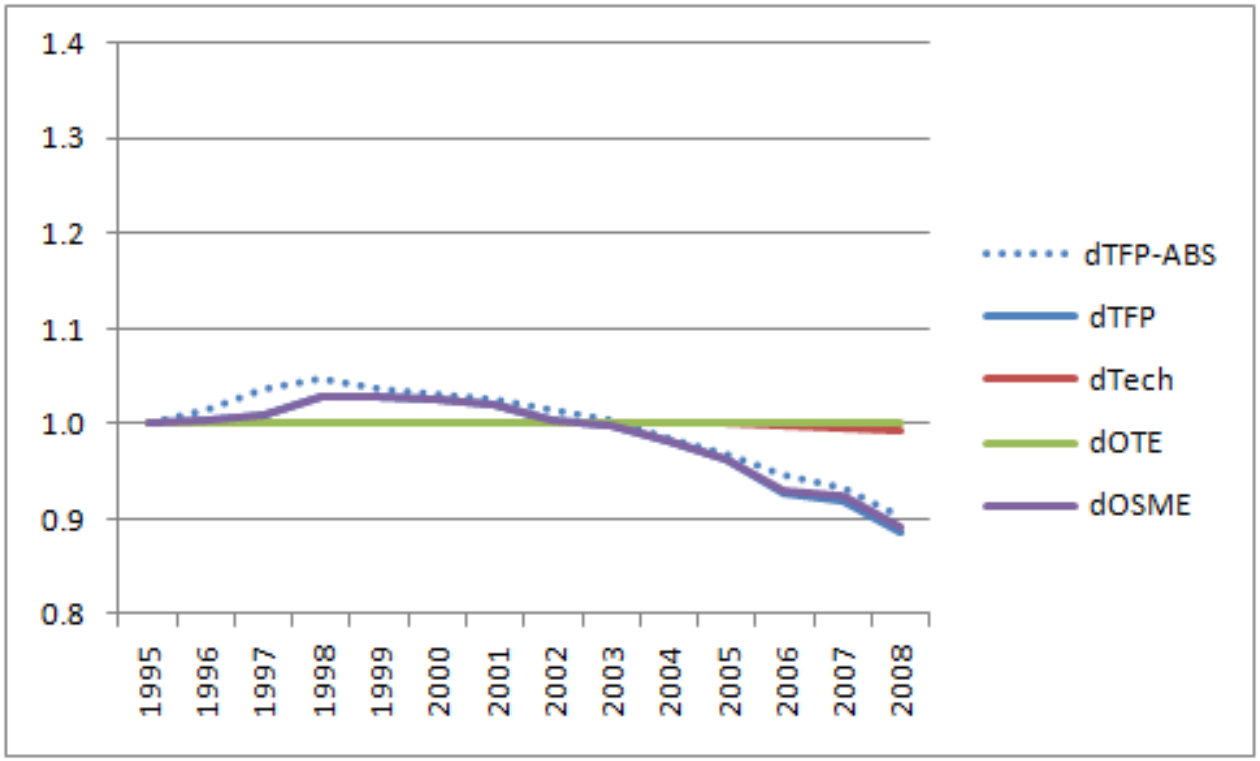
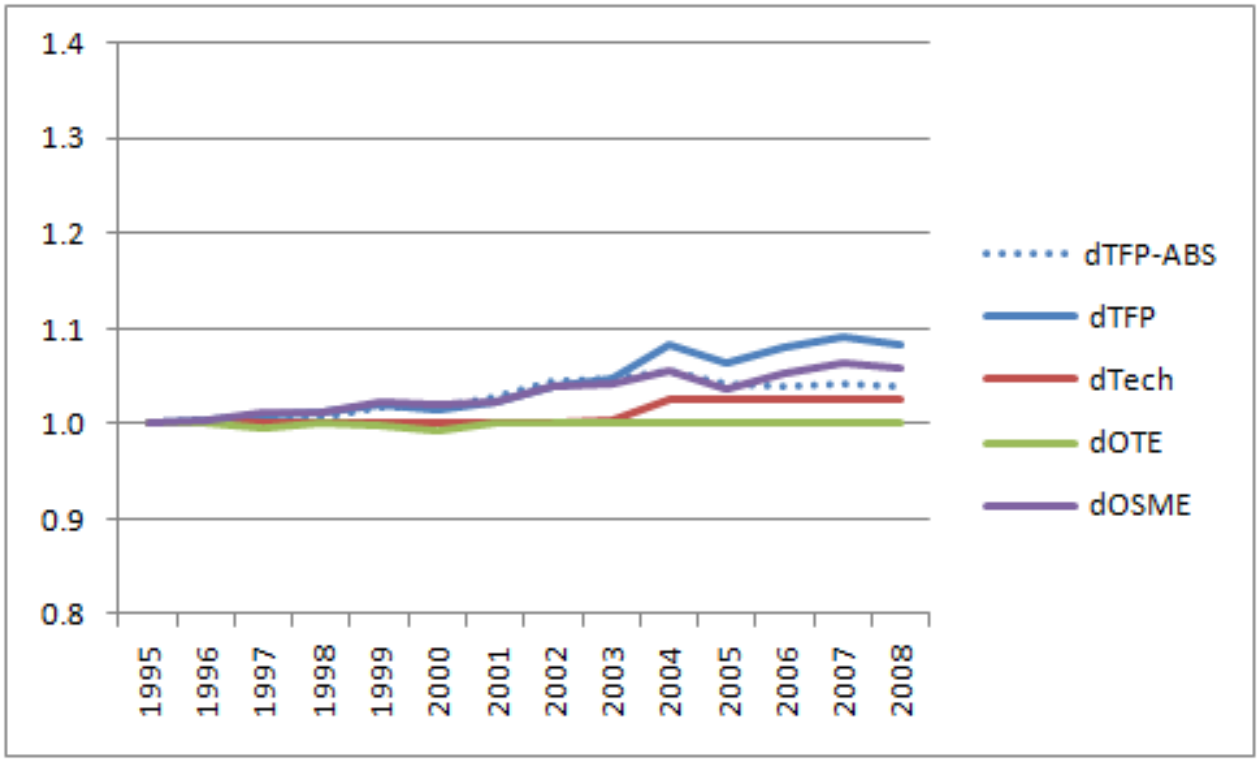
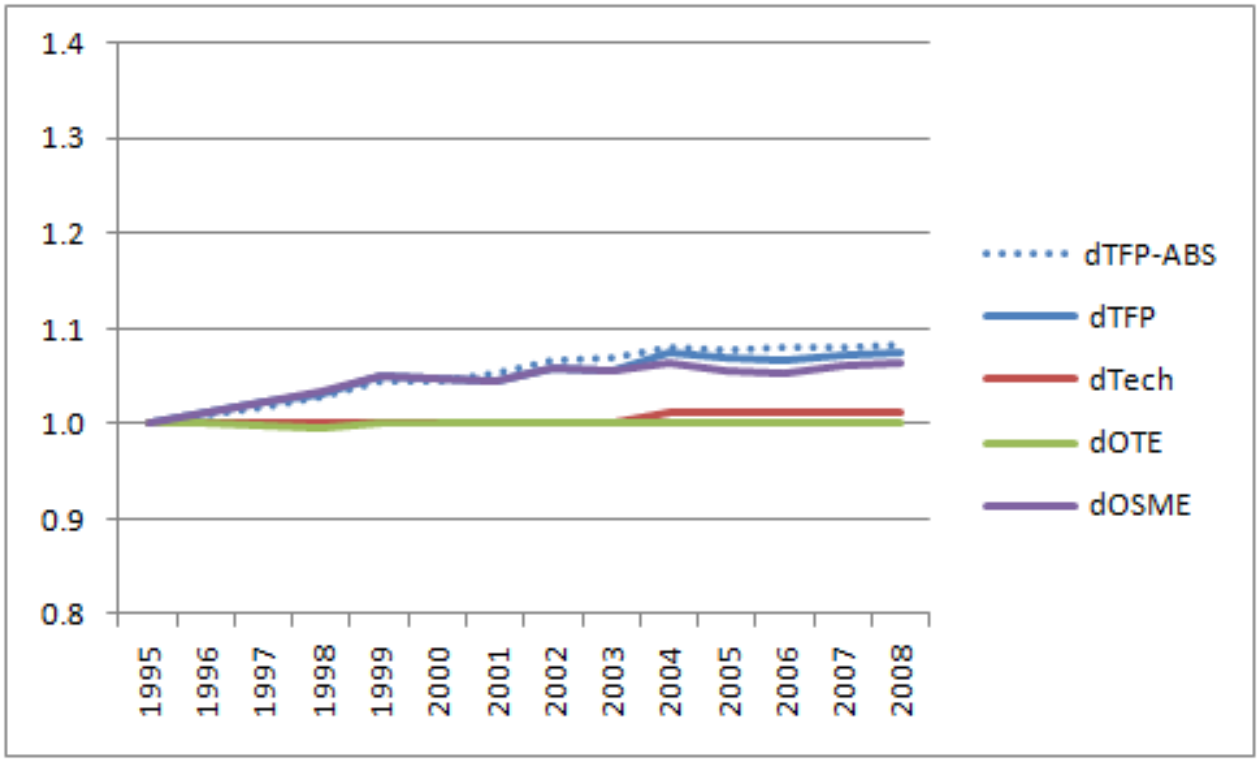
Electricity, Gas, Water and Waste Services



Manufacturing



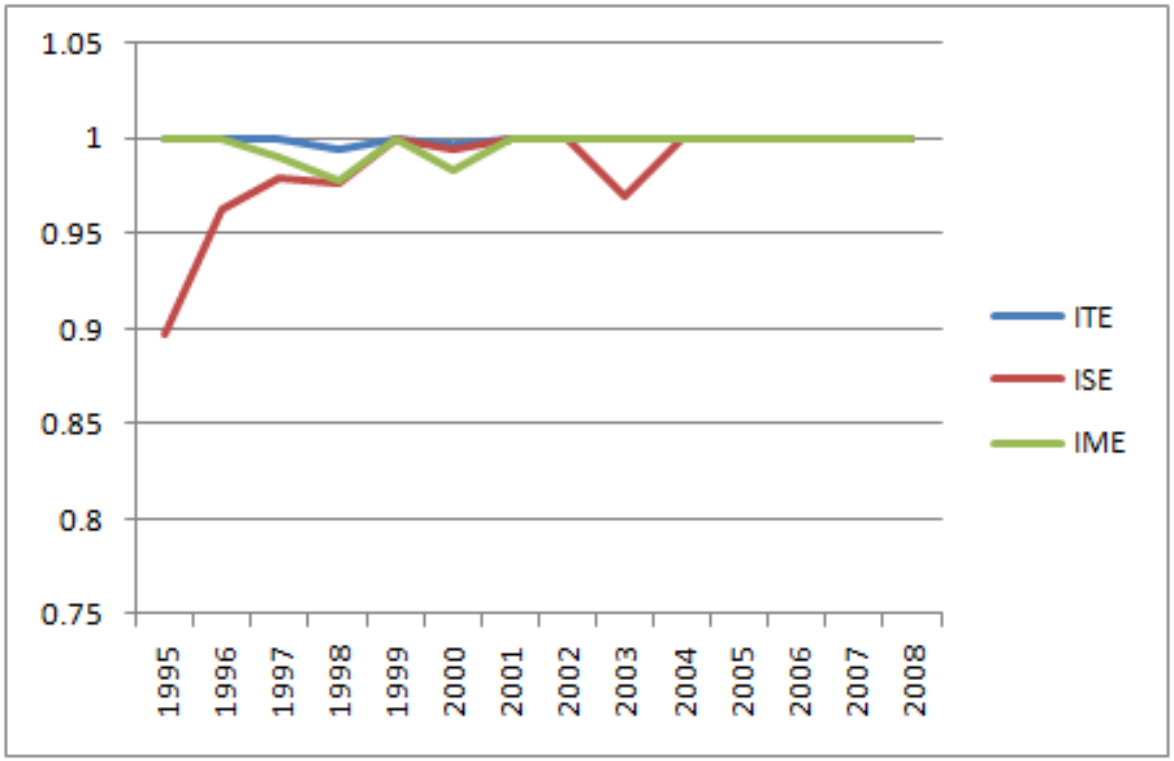
Market Sector



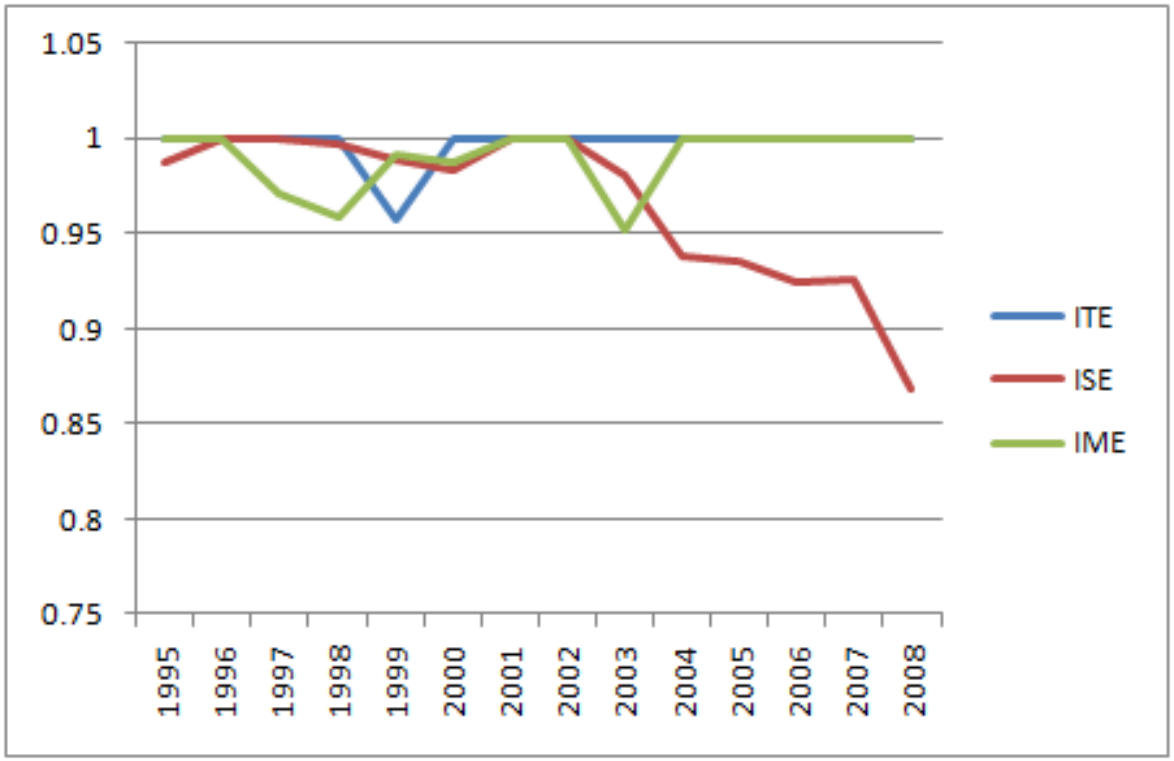
Efficiency Levels

The DPIN software package can also be used to compute levels of technical, scale and mix efficiency ...

Agriculture, Forestry and Fishing



Mining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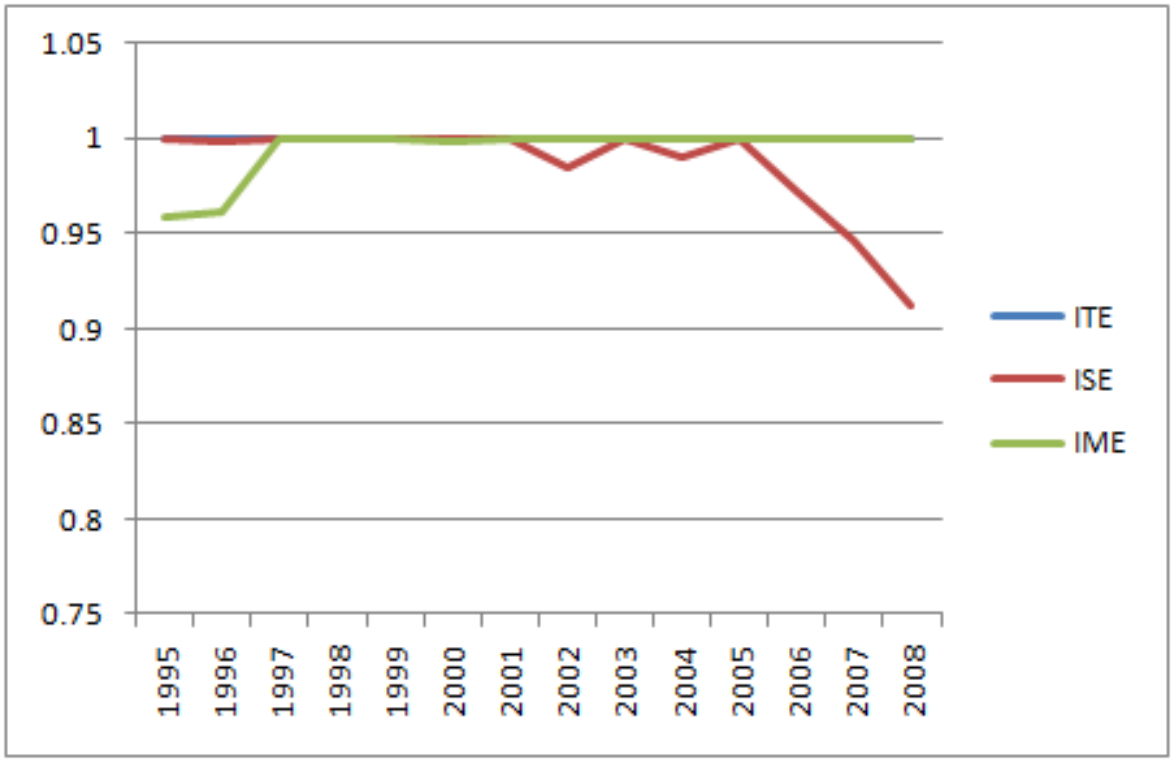
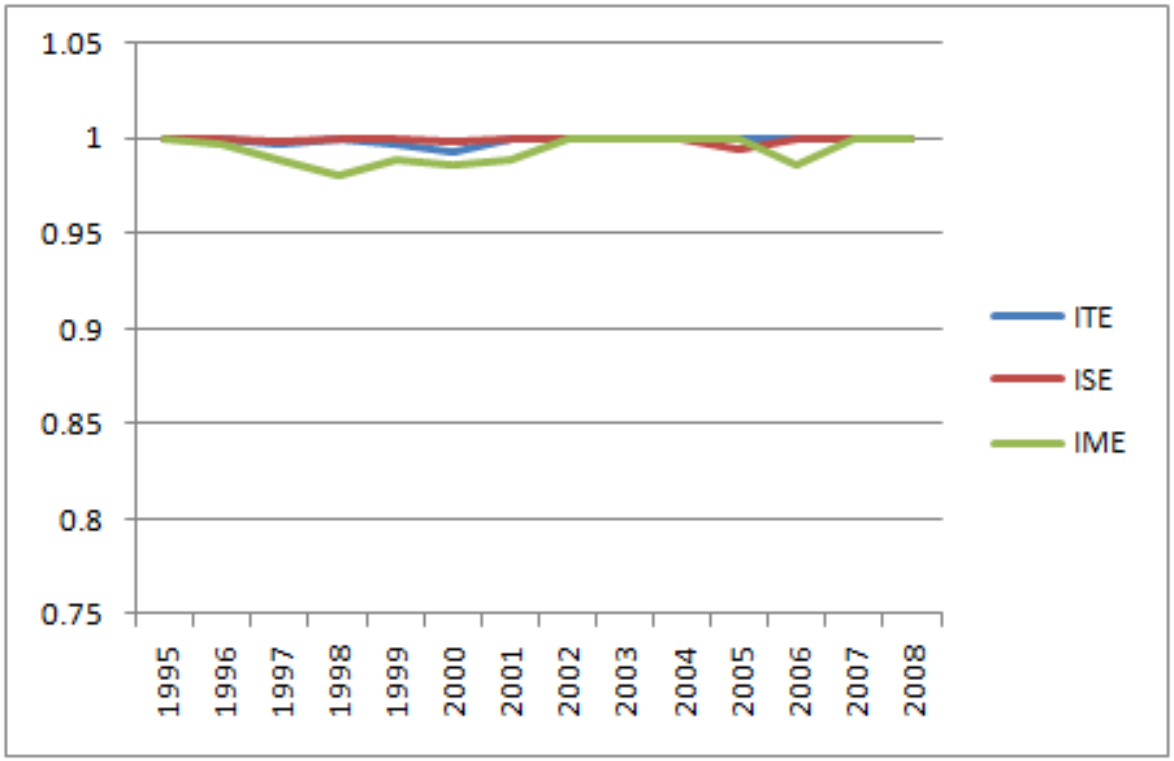
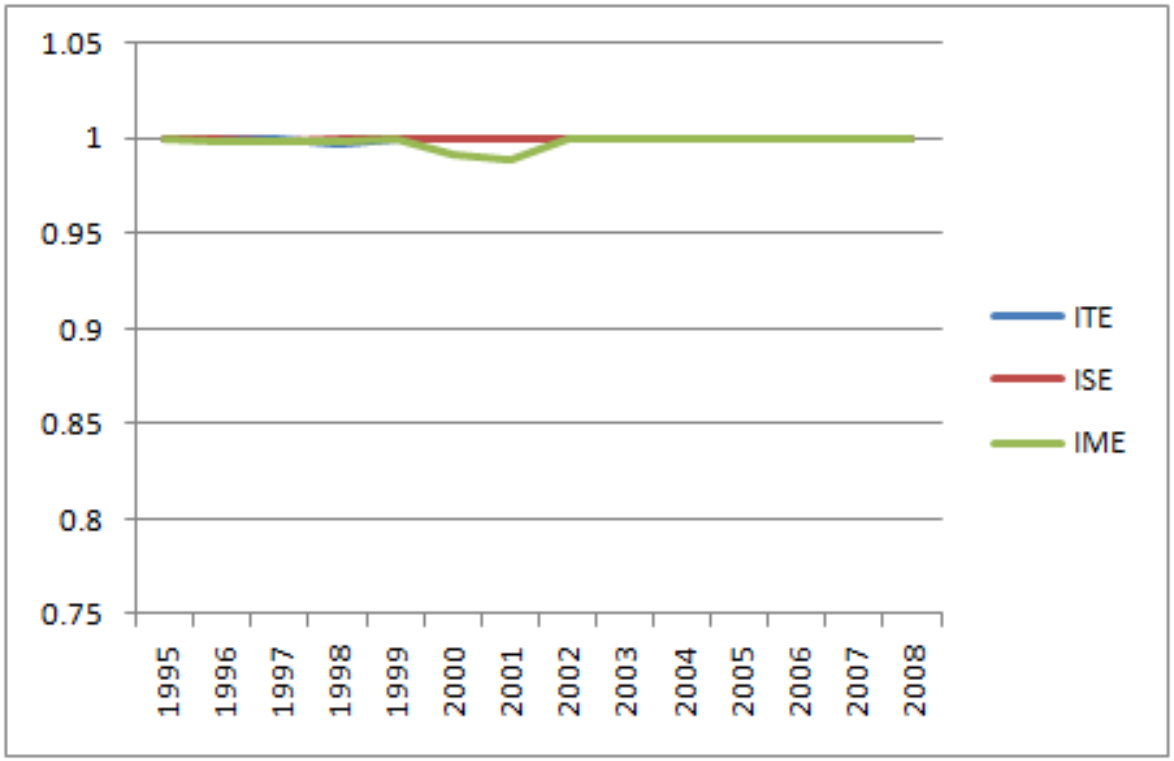
Electricity, Gas, Water and Waste Services



Manufacturing



Market Sector



Conclusions

- Irrespective of whether or not there is any technical change, changes in the terms of trade (i.e., relative prices) can be expected to induce changes in levels of profitability and productivity.

- Except in very special cases (e.g., perfectly competitive markets), the point of maximum productivity does not equal the point of maximum profitability.

- Increasing profits may involve lowering productivity (e.g., mining).

- Policies designed to improve productivity may be misdirected if we fail to understand and properly identify the drivers of productivity change.

References

- O'Donnell, C. J. (2008). "An Aggregate Quantity-Price Framework for Measuring and Decomposing Productivity and Profitability Change." *Centre for Efficiency and Productivity Analysis Working Papers* WP07/2008. University of Queensland. http://www.uq.edu.au/economics/cepa/docs/WP/WP072008.pdf.

- O'Donnell, C. J. (2010). "Measuring and Decomposing Agricultural Productivity and Profitability Change." *Australian Journal of Agricultural and Resource Economics 54(4): 527-560.*