Decomposing Efficiency Indices of Wheat Production Systems in Western Australia

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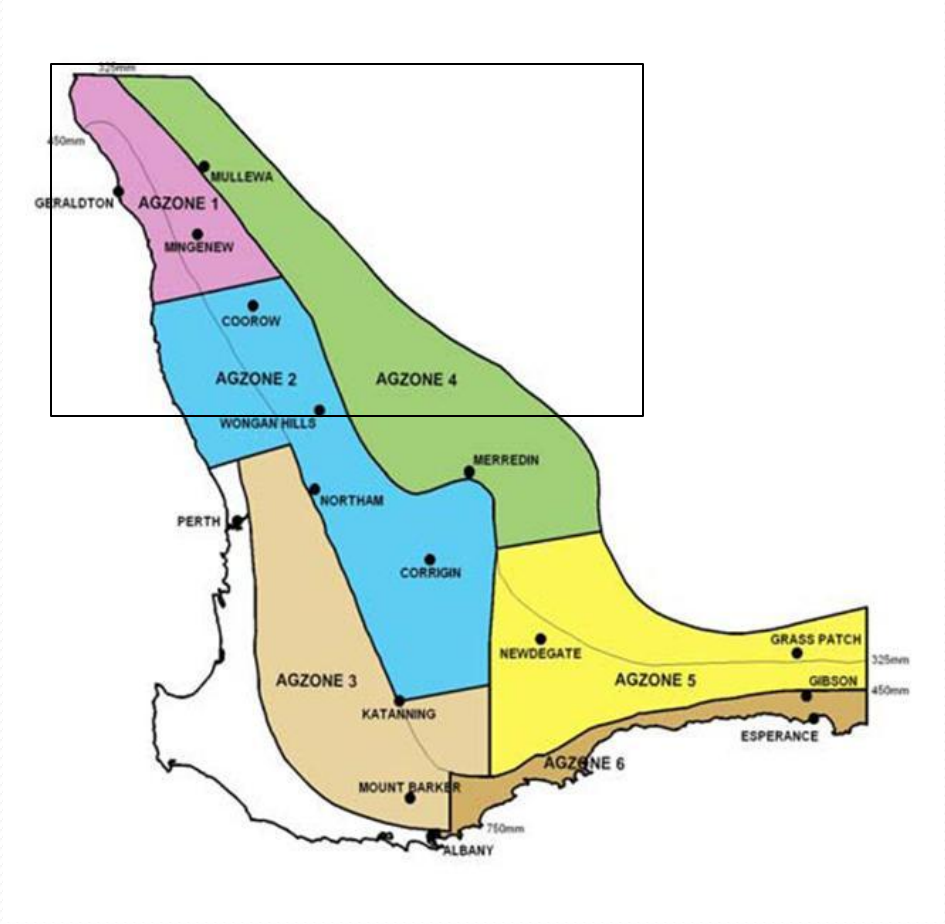
Background

- GRDC project - Increasing Water Use Efficiency in the northern sandplain region of WA.
- Focus on farm level factors affecting WUE.
- Including profitability measures, not technical efficiency

Background – Northern Agricultural Region.



Background

- Water use efficiency (WUE)
  - kg of grain per mm of effective rainfall
- Target (cereals) – 20 to 25 kg /ha/mm of effective rainfall
- Effective rainfall = .3*SRF + (GSR -50mm)
- Other efficiency - nitrogen use efficiency (NUE)

Decomposing Productivity Index Numbers

- O'Donnell (2008, 2010) defined a set of total factor productivity (TFP) index numbers that were *multiplicatively complete*.

- These indexes can be expressed as the ratio of an output quantity index to an input quantity index.

Mix Efficiency

- Output Mix Efficiency – increase in productivity due to change in output mix holding input mix constant.
- Input mix efficiency – increase in productivity due to change in input mix holding output mix constant.
- Mix efficiency is a measure of gains in efficiency from change in scope.

Decomposition and TFP

- Output-orientated

$$TFPE_{nt} = \left(\frac{\mathrm{TFP_{nt}}}{TFP^{*}_{nt}}\right)$$
$$= OTE_{nt} \times OME_{nt} \times ROSE_{nt}$$
$$= OTE_{nt} \times OSE_{nt} \times RME_{nt}$$

- Input-orientated

$$TFPE_{nt} = ITE_{nt} \times IME_{nt} \times RISE_{nt}$$
$$= ITE_{nt} \times ISE_{nt} \times RME_{nt}$$

Data

- Farm consultant data set 1995 -2008.
- Approximately 250 – 350 observations each year.
- Participation not compulsory.
- Six rainfall zones (High, medium, low, North and South)

Input Data Summary

Year	Nitrogen	Phosphorus	Effective Rainfall	Fuel	Sheep expenses	Operating Costs	Wages and Salaries
Unit	kg/ha	kg/ha	mm	$/ha	$/hd	$/ha	$
2004	47.74	10.20	193	26.48	15.77	101.65	105,254
2005	48.38	9.74	249	31.33	15.84	175.29	105,149
2006	28.26	8.00	128	33.80	22.67	141.52	103,220
2007	34.01	8.59	164	33.20	19.46	156.71	105,753

Output Data Summary

Year	Wheat	Lupins	Barley	Canola	Wool
Unit	t/ha	t/ha	t/ha	t/ha	kg/hd
2004	1.98	0.86	1.76	0.41	4.08
2005	2.22	1.27	1.77	0.51	3.79
2006	1.33	0.49	1.08	0.16	4.61
2007	1.83	0.86	1.78	0.37	4.32

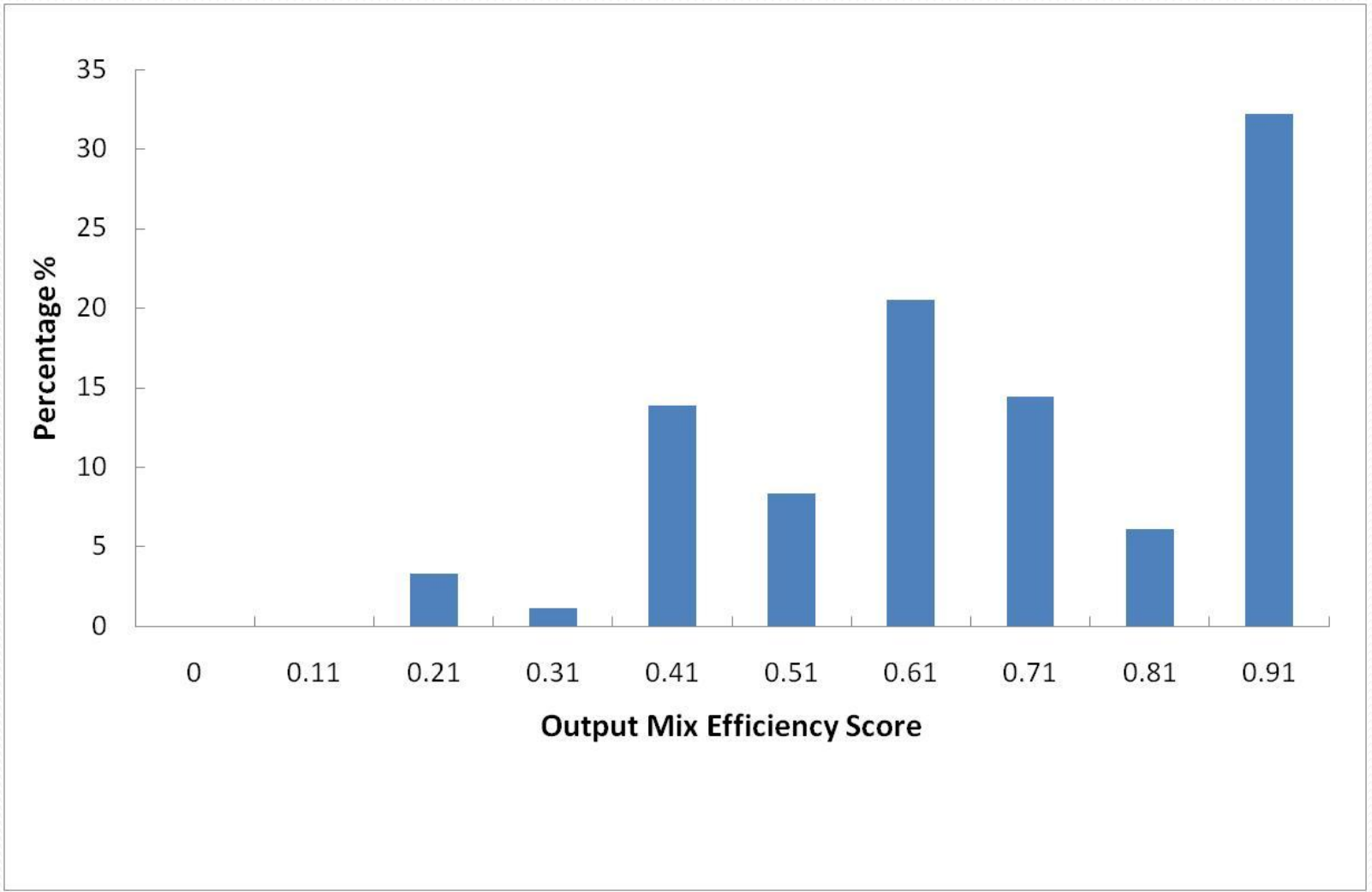
Results

- For each efficiency measure we get 180 (4x45) values between 0 and 1.
- Summary tables and graphs
- Discussion of interesting outcomes.

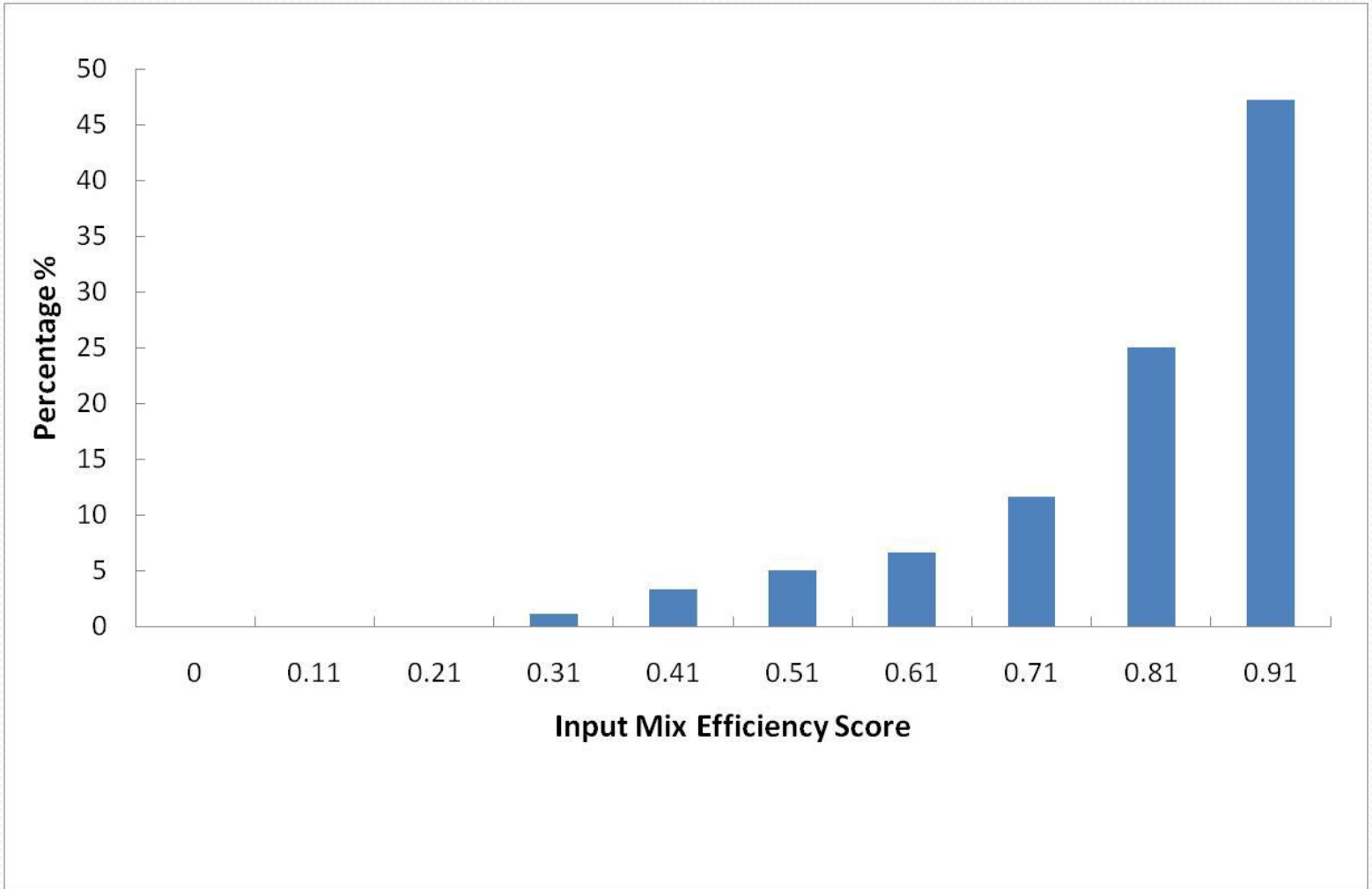
Results – Efficiency scores

Year	Average OTE	Average OME	Average ITE	Average IME
1.00	0.99	0.74	0.99	0.94
2.00	0.99	0.71	0.99	0.92
3.00	0.94	0.71	0.94	0.75
4.00	0.95	0.77	0.95	0.81
All Data	**0.97**	**0.73**	**0.97**	**0.85**

Distribution of Output Mix Efficiency



Distribution of Input Mix Efficiency



Input and Output Mix Efficiency

- Output mix efficiency was positively correlated to number of enterprises and canola cropping.

- Input mix efficiency was not correlated to any enterprise variable, i.e., number or crop type.

Input and Output Mix Efficiency

- Only one producer was both input and output efficient, 2 more were very close, i.e. Average scores > 0.95.

- Efficient producer grew only cereals in bad year with reduced N and kept sheep, but kept costs down.

Individual Results – Some Examples

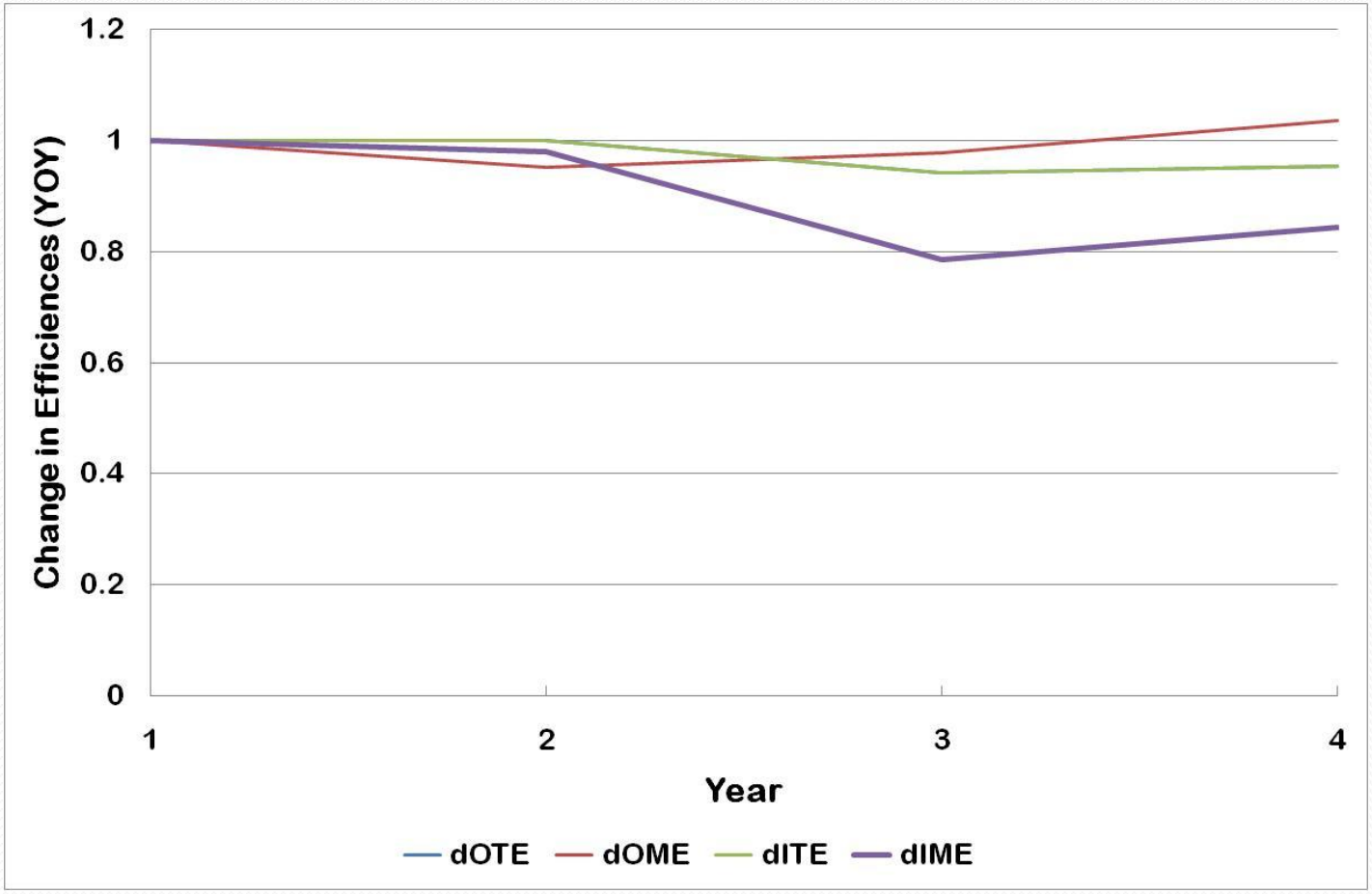
Firm ID	Average OTE	Average OME	Average ITE	Average IME
5	1.00	1.00	1.00	0.99
7	1.00	1.00	1.00	0.93
8	0.67	0.43	0.67	0.83
13	1.00	0.52	1.00	0.87
25	0.79	0.62	0.79	0.67
37	1.00	0.66	1.00	0.95

Input and Output Mix Efficiency

- Several producers started off well, but several bad "decisions" caused efficiency to fall over the study period, i.e. keeping sheep, dropping/keeping "wrong" crop .

- Hard to define one single element in changes in mix efficiency, but rainfall seems to be the trigger. (No data on timing of rainfall).

Changes in Efficiency over Time



Changes in Efficiency over Time

- Changes in input mix efficiency seem to be related to year, with the major effects occurring in 2006.
- Input mix efficiency dropped in that year then increased in 2007 as producers adapted to low rainfall events.
- Also, probably due to keeping sheep in high cost years.

Concluding Remarks

- In this research we have attempted to utilize a relatively new technique to decompose factor productivity into various measures of efficiency at a micro level.

- These are technical and mix, due to assumption about CRS scale efficiency is not estimated, but can be estimated with technique.

Concluding Remarks

- Results are mixed with respect to input and output mix efficiency.
  - Input mix efficiency more consistent
- Mix efficiency affected by year to year variations.
  - Also, appears to be some rigidity in output mix choice (rotations, crop preferences) and therefore lower output mix efficiency.

THANK YOU

QUESTIONS

Today's Presentation

- Background to region/project
- Method, Data, Results, Interpretation
- Some concluding remarks

Profit, TFP and Terms of Trade

- Letting P and W represent output and input prices, respectively we have a profit function/ratio for firm n in period t:

$$PROF_{nt} = \frac{P_{nt}Q_{nt}}{W_{nt}X_{nt}}$$

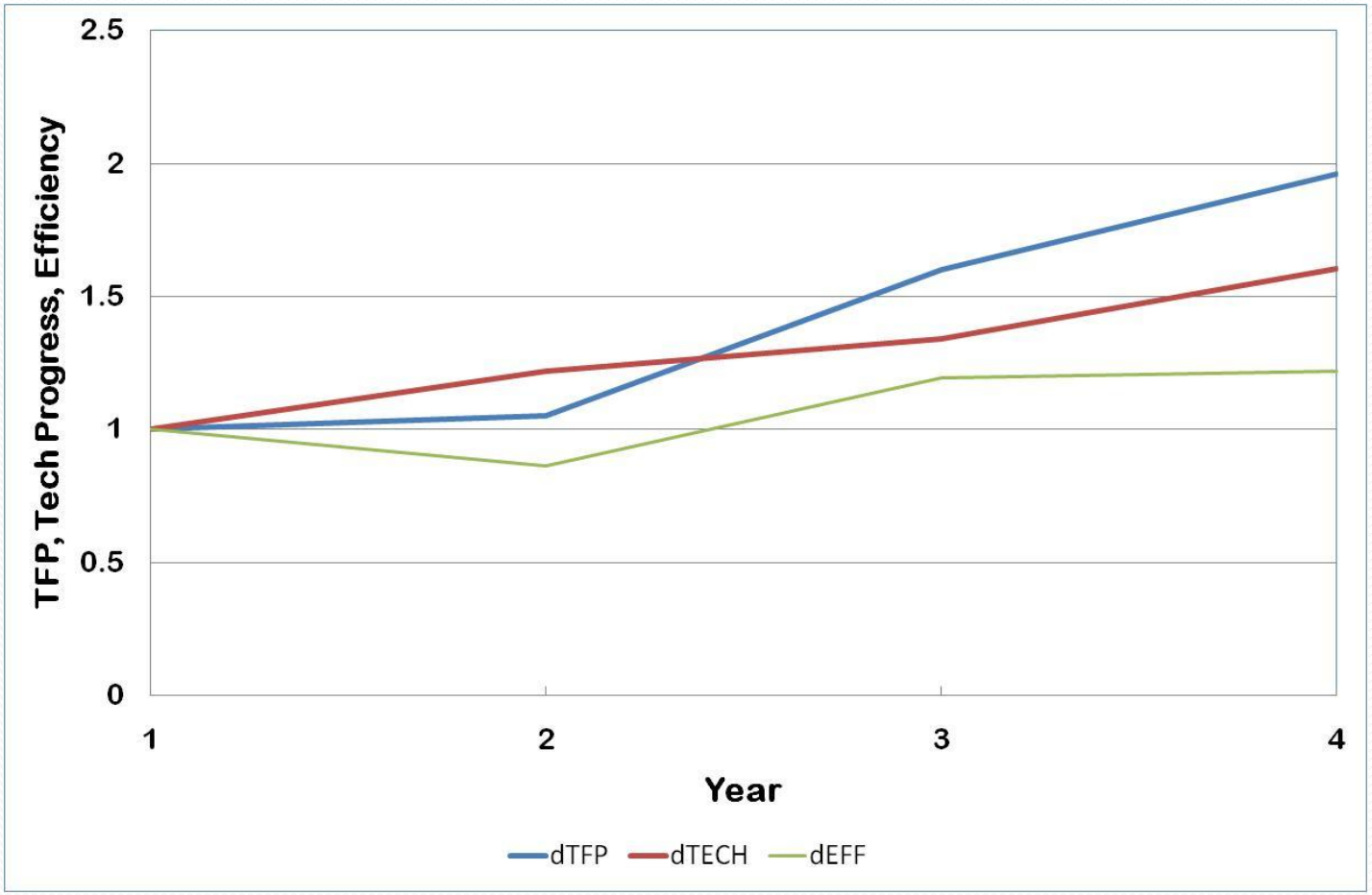
Profit, TFP and Terms of Trade

$$PROF_{nt,ms} = \frac{PROF_{nt}}{PROF_{ms}}$$

$$= \frac{P_{nt,ms} Q_{nt,ms}}{W_{nt,ms} X_{nt,ms}}$$

$$= TT_{nt,ms} \times TFP_{nt,ms}$$

Changes in TFP, Technical Progress, Efficiency



Measures of Efficiency