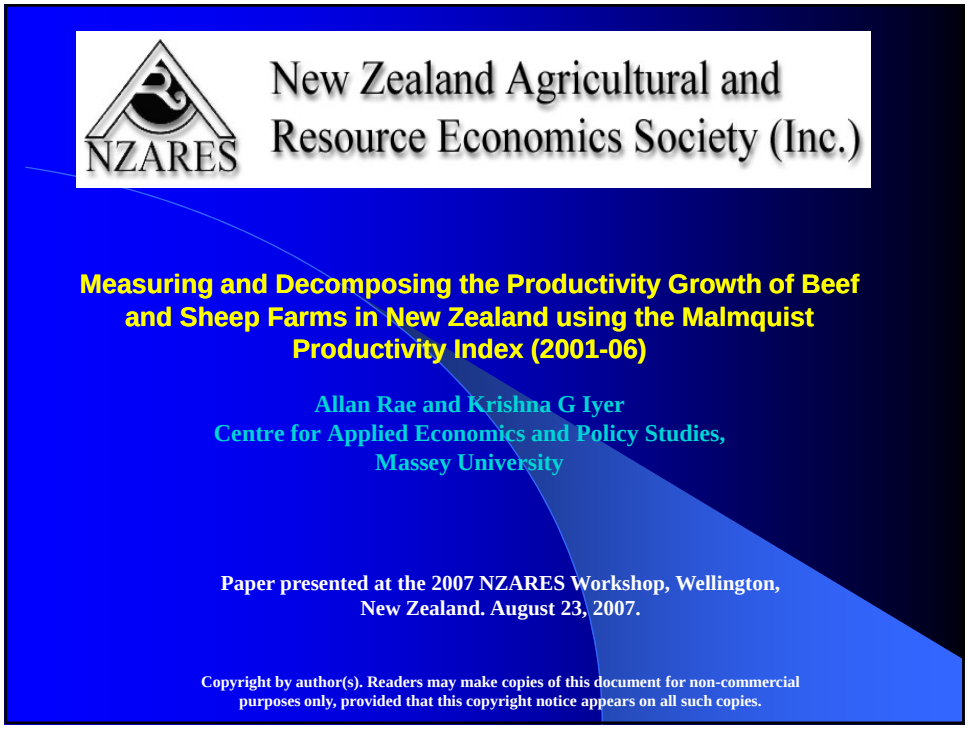
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Measuring and Decomposing the Productivity Growth of Beef and Sheep Farms in New Zealand using the Malmquist Productivity Index (2001-06)
Allan Rae and Krishna G Iyer
Centre for Applied Economics and Policy Studies,
Massey University
Paper presented at the 2007 NZARES Workshop, Wellington, New Zealand. August 23, 2007.
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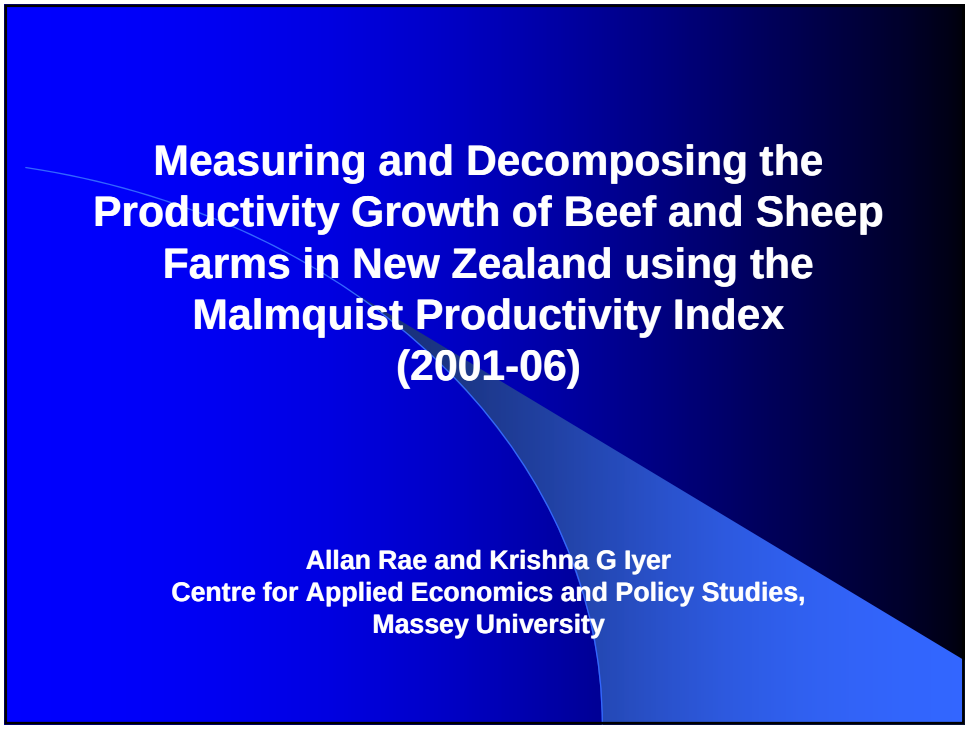
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Format of the Presentation

1) The theory underlying the Malmquist Productivity Index (MPI).
2) Common empirical tools to compute and decompose MPI.
3) Examining the data.
4) Empirical model and discussion of the results.
5) Conclusion.

3

1) The Theory Underlying the MPI

4

Measuring Total Factor Productivity (TFP)

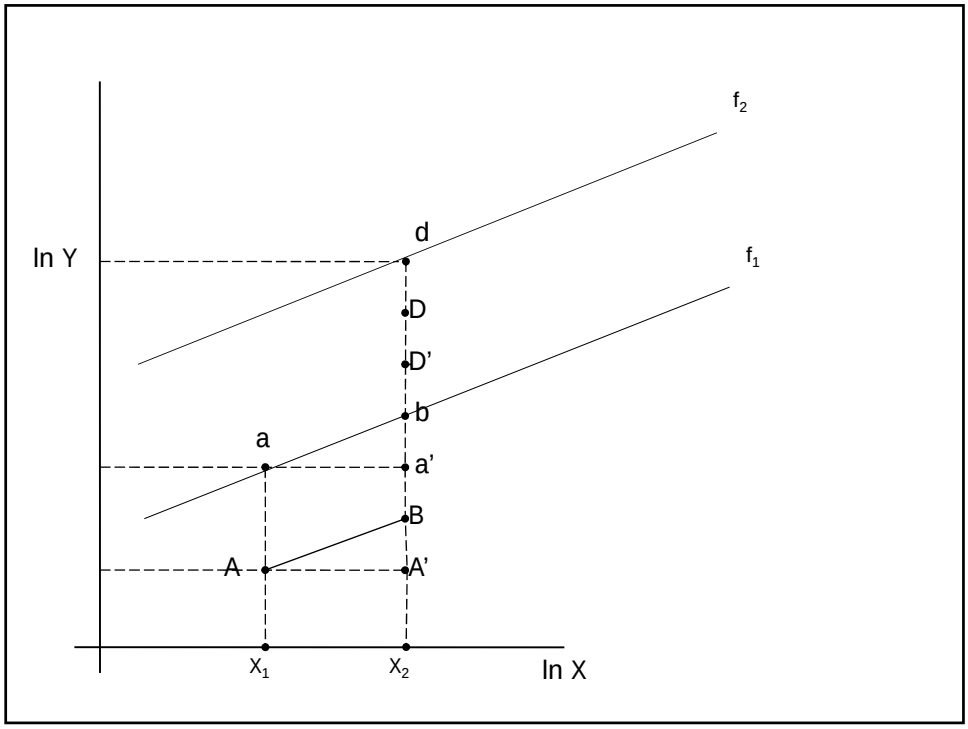
- Traditionally, TFP growth has been considered synonymous with technical change – e.g., Growth Accounting, Tornqvist Index, Fisher Index etc.
- An implicit assumption:100 percent efficiency in the utilization of factor inputs, given a level of technology.
- In reality, TFP growth includes not only technological progress but also efficiency changes (technical, scale and allocative) and random disturbances.

5

The MPI

- Based on the concept of distance functions.
- MPI allows decomposing productivity growth into technical change and efficiency change components.
- Consider, a production possibilities frontier (PPF) which is constructed using output and input data from production entities.

6



The MPI (contd…)

- Movements of the PPF is measured as technical change.
- A farm on the PPF is fully efficient (in other index number methods, all farms would necessarily lie on the PPF).
- Movement of a farm towards the PPF is measured as efficiency (pure technical, scale and resource allocation).

8

Distinguishing Technical and Efficiency Changes

- The determinants of technical change and efficiency may be different.
- For example, exposure to trade may drive farmers to upgrade technology: technical change.
- Productivity may also result from other factors such as enhanced competition or increased returns to scale: these are captured in efficiency.
- Decomposing productivity is important to better identify its determinants.

9

2) Empirical tools for computing the MPI

10

Methodologies

- Popular Techniques: Data Envelopment Analysis (DEA) - mathematical and Stochastic Frontier Approach (SFA) – econometric.
- Differences, merits and demerits of each well documented.

11

Main Differences (DEA and SFA)

- DEA assumes all deviations from PPF as inefficiency (no random errors). SFA distinguishes between random error and inefficiency.
- SFA requires specification of a production function; DEA does not. Relatively flexible production function forms such as Translog alleviate the seriousness of the assumption sometimes (but not always).

12

3) Examining the Data

13

About the Data

- MAF provided data from their sheep and beef, farm monitoring program.
- Each year MAF monitors the production and financial status of farms to create models of specific farm types.
- This paper uses the raw data from the actual farms and not the data from the constructed model farm.

14

About the Data (contd..)

- It should be noted that the data were collected for purposes other than the estimation of productivity.
- Hence, they have some shortcomings in terms of how well they measure the physical output and input data that are required to estimate productivity growth.

15

NZ Sheep and Beef Farms
9 Regions 20 farms each
6 years (2001-06)

1. Northland (NTHLND)
2. Gisborne Hill Country (GLHC)
3. Waikato-Bay of Plenty Intensive Framing (WIF)
4. Manawatu-Rangitikei Intensive Farming (MRIF)
5. Marlborough-Canterbury Hill Country (MCHC)
6. South Island Merino (SIMER)
7. Otago Dry Hill (ODH)
8. Southland/South Otago Hill Country (SOHC)
9. Southland/South Otago Intensive Farming (SOIF)

16

Output

- A larger number of outputs are typically produced on the sheep and beef farms.
- Output comprised the aggregation of:
  - sheep and deer sales (deflated by the livestock price index),
  - cattle sales (deflated by the cattle price index) and
  - sales of wool, forestry products, crops and grazing (all deflated by the CPI).

17

Inputs

- Livestock, deflated by livestock price index.
- Plant and Machinery, deflated by farm equipment price index.
- Labour (wages paid), deflated by farm wage index.
- Material Inputs (e.g. fertilizers), deflated by farm expenses price index.
- Purchased services, deflated by CPI.
- Farm buildings (includes land), deflated by farm buildings price index.

18

Output and Inputs (in 000's of NZ Dollars)

	Sales	Farm Bldg	P&M	Live Stock	Labor	Mater-ials	Servi-ces
GLHC	817	3571	112	1401	121	91	260
MCHC	427	2558	100	549	27	60	119
MRIF	800	3650	124	374	38	68	133
NTHLND	313	1475	71	392	9	47	71
ODH	399	2002	137	508	20	64	127
SIMER	524	3752	187	742	45	82	182
SOHC	477	2758	142	527	25	73	145
SOIF	231	1490	88	201	6	30	70
WIF	345	1737	58	371	17	59	78
NZ	481	2555	113	563	34	64	132

19

4) Empirical model and discussion of results

20

Stochastic Frontier Production Function (Translog Specification)

$$\ln Y_{it} = \beta_0 + \sum_{j=1}^{6} \beta_j \ln X_{jit} + \frac{1}{2}\sum_{j=1}^{6}\sum_{k=1}^{6} \beta_{jk} \ln X_{jit} \ln X_{kit}$$
$$+ \beta_t t + \frac{1}{2}\beta_{tt} t^2 + \sum_{j=1}^{6} \beta_{jt} t \ln X_{jit} - u_{it} + v_{it}$$

Decomposition of Total Factor Productivity

$$\frac{\dot{TFP}_{it}}{TFP_{it}} = \frac{\partial \ln Y^d}{\partial t} + \frac{\dot{Te}_{it}}{Te_{it}} + (RTS - 1)\sum_k \lambda_k \frac{\dot{X}_{it}}{X_{it}} + \sum_k (\lambda_k - s_k)\frac{\dot{X}_{it}}{X_{it}}$$

22

Further on the TFP Decomposition

• Technical Change or Technological Progress	$TP_{it} = \frac{\partial \ln Y_t}{\partial T}$
• Improved Efficiency in use of resources and technology	$TE_{it} = -\frac{\partial U_{it}}{\partial T}$
• Economies-of-scale effects	$SE_{it} = (RTS - 1)\sum_k \lambda_k \frac{\dot{X}_{it}}{X_{it}}$
• Resource allocation effects	$AE_{it} = \sum_k (\lambda_k - s_k)\frac{\dot{X}_{it}}{X_{it}}$
• Random Errors (i.e., measurement errors, omitted variables, aggregation bias, and model misspecification)	$Errors = -\frac{\partial V_{it}}{\partial T}$

Hypothesis Tests

Null Hypothesis (H_0)	LR-Test Statistic	Decision
No inefficiency effects	94.98*	Reject H_0
A Cobb- Douglas function is adequate	259.78*	Reject H_0
There is no technical change	34.38*	Reject H_0
Technical change is Hicks Neutral	24.50*	Reject H_0

* significant at 1 percent.

24

Elasticity of Factor Inputs

Factor Input	Elasticity
Farm Buildings	0.194*
Plant & Machinery	0.015
Live Stock	0.217*
Labour	0.035*
Materials	0.135*
Services	0.336*

* significant at 1 percent

25

New Zealand Average

	TC	EC	SEC	AEC	TFPC
2001-02	-1.22	-1.17	-1.00	2.12	-1.26
2002-03	1.01	-1.22	-2.02	-2.69	-4.92
2003-04	2.97	-1.27	-2.18	-6.65	-7.12
2004-05	5.01	-1.33	-2.48	-2.95	-1.75
2005-06	6.65	-1.39	-1.39	-14.90	-11.03

26

Regional Averages

Region	TC	EC	SEC	AEC	TFPC
GLHC	4.78	-1.28	-2.10	-3.41	-2.01
MCHC	2.64	-1.41	-1.81	-6.97	-7.55
MRIF	0.38	-0.59	-0.43	8.54	7.89
NTHLND	5.58	-1.24	-3.10	-25.19	-23.95
ODH	3.67	-1.49	-2.91	-3.49	-4.22
SIMER	2.38	-1.85	-2.72	-0.32	-2.51
SOHC	2.81	-1.34	-1.34	-4.16	-4.03
SOIF	0.68	-1.28	-0.03	-5.59	-6.22
WIF	3.25	-0.96	-1.92	-4.33	-3.96

Rankings

Ranking	TC	EC	SEC
1	NTHLND	MRIF	SOIF
2	GLHC	WIF	MRIF
3	ODH	NTHLND	SOHC
4	WIF	GLHC	MCHC
5	SOHC	SOIF	WIF
6	MCHC	SOHC	GLHC
7	SIMER	MCHC	SIMER
8	SOIF	ODH	ODH
9	MRIF	SIMER	NTHLND

DEA Results
New Zealand Average

year	TC	EC	PEC	SEC	TFPC
2001-02	0.09	-1.29	-1.17	-0.11	-1.20
2002-03	2.27	-1.90	-1.24	-0.65	0.33
2003-04	-0.55	0.25	-0.21	0.50	-0.30
2004-05	-1.15	1.22	0.76	0.47	0.05
2005-06	-1.65	0.45	0.65	-0.18	-1.10

29

Regional Averages

Region	TC	EC	PEC	SEC	TFPC
GLHC	0.43	-0.60	-0.04	-0.54	-0.18
MCHC	-0.09	-0.37	-0.39	0.03	-0.47
MRIF	-0.20	-0.04	-0.11	0.07	-0.24
NTHLND	-0.14	0.51	0.36	0.16	0.37
ODH	-0.83	-0.12	-0.17	0.07	-0.94
SIMER	-0.59	-0.81	-0.75	-0.05	-1.29
SOHC	0.09	-0.56	-0.55	-0.01	-0.49
SOIF	0.00	-0.37	-0.51	0.18	-0.38
WIF	-0.41	0.06	-0.02	0.08	-0.35

30

Rankings

Ranking	TC	PEC	SEC
1	GLHC	NTHLND	SOIF
2	SOHC	WIF	NTHLND
3	SOIF	GLHC	WIF
4	MCHC	MRIF	MRIF
5	NTHLND	ODH	ODH
6	MRIF	MCHC	MCHC
7	WIF	SOIF	SOHC
8	SIMER	SOHC	SIMER
9	ODH	SIMER	GLHC

31

5) Conclusion

32

To Sum up..

- The MPI is a less well known index which can be gainfully applied to measure productivity.
- An advantage of the MPI is that it allows decomposing productivity growth into technical change and efficiency change components.
- Since technical change and efficiency change may be driven by a different set of factors, such decomposition is very useful in better understanding the determinants of productivity.
- Common empirical tools applied to compute the MPI include DEA and SFA.

33

Contd..

- Both DEA and SFA have their merits and demerits.
- The DEA does not provide for random disturbances and the SFA imposes a functional form on the production function – which at times determines the estimate of technical change.

34

Contd..

- Using data from 177 farms across 9 regions of NZ over the period 2001-06, this report measured the productivity of sheep and beef farms.
- The data was not completely suitable, given that they were not collected for this purpose.
- Nonetheless, the estimates of productivity arrived at, specially using the DEA, were found plausible.

35

Contd..

- In the initial years of analysis 2001-03, technical change was driving productivity while negative efficiency change was pulling productivity down.
- An introduction of new (or foreign) technology does push up the frontier – but can all farms appropriate this technology? At least, not immediately. This explains negative efficiency.

36

Contd..

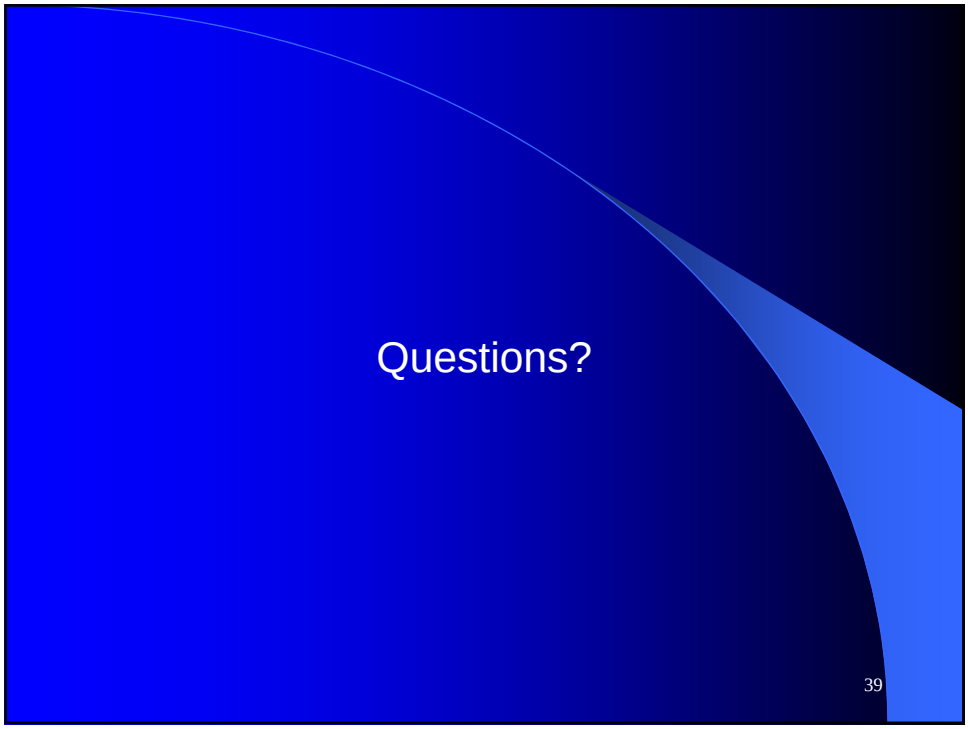
- In the later years (2004-06), farms were observed to catch-up with the frontier – resulting in positive efficiency change.
- But the technical change is found negative. This area needs to be explored further.
- Both DEA and SFA, despite being vastly different methods, find one common ground – north island farms are more efficient than the south island ones. This area also needs a look in.

37

Contd..

- One way to approach this north-south divide will be identifying factors explaining efficiency and examine how they differ across the regions.
- Another way would be to question whether at all the north and south island farms share a common production frontier. MAF and CAPS are working on this topic.
- Other works that CAPS and MAF are involved in includes research on the determinants of productivity.

38


Questions?
39