Agricultural Productivity in New Zealand: Estimating Production Functions Using the Longitudinal Business Database

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Motu Economic & Public Policy Research

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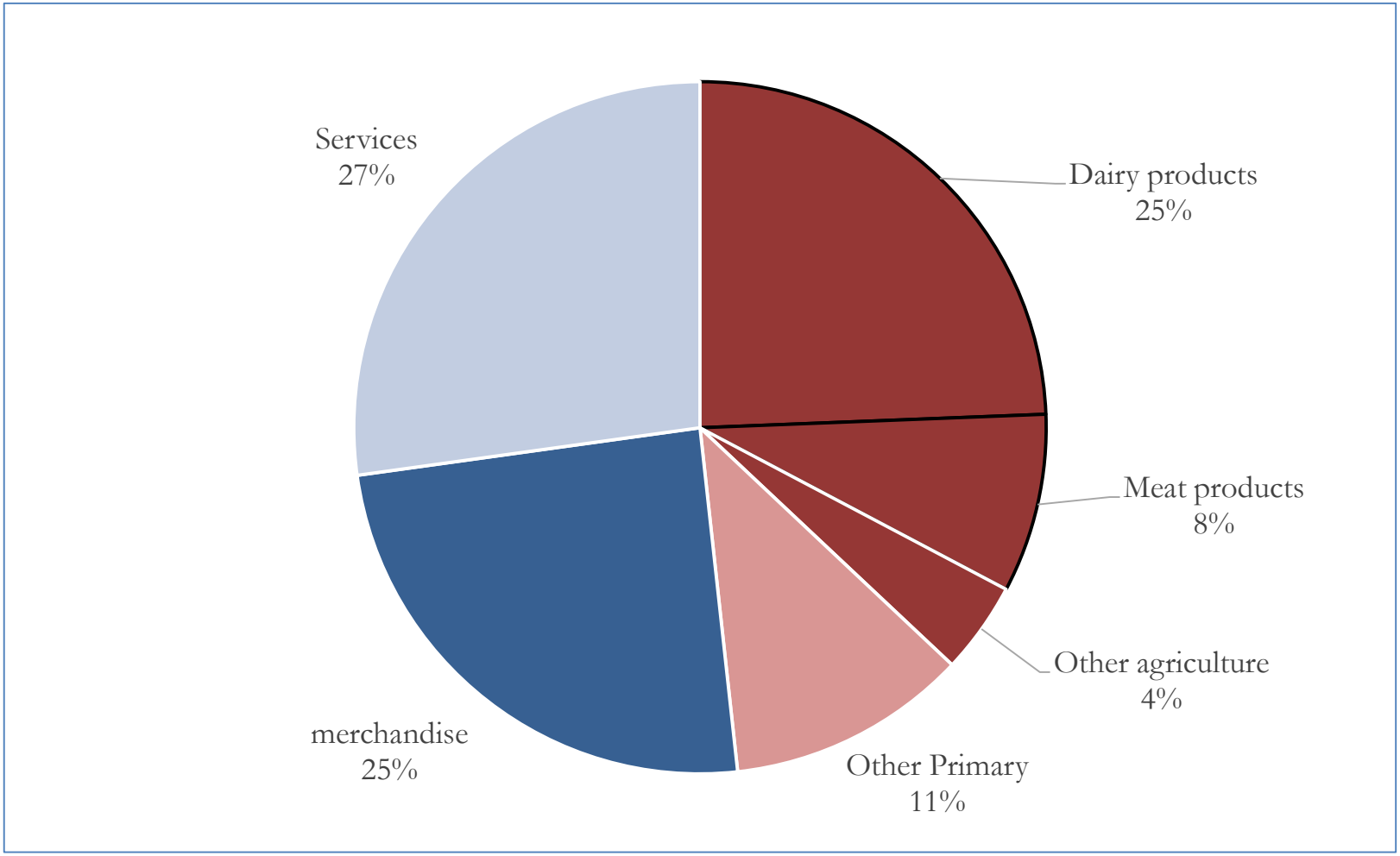
Rotorua, New Zealand

Agricultural Productivity in New Zealand - *motivation*

New Zealand Exports, 2014



Source: Statistics New Zealand (2015)

Agricultural Productivity in New Zealand - *motivation*

Main information sources:

- **Statistics New Zealand -**
  - Agricultural production survey/census
  - Business Demography Statistics
  - LEED tables
  - National accounts
  - International Trade Statistics
  - Productivity Statistics

- **DairyNZ, Beef and Lamb New Zealand, Meat Industry Association (MIA), DCANZ, etc.**

Agricultural Productivity in New Zealand – *Key questions*

- What can firm level data tell us about the relationship between inputs (financial and agricultural) and output in the dairy and sheep/beef industries

- To what extent is this relationship is sensitive to firm size size and employment structure?

- What can the data tell us about industry level productivity (i.e. *MFP*) at a national level, as well as by region?

Agricultural Productivity in New Zealand - *Model*

- Second order Translog:

$$Gross\ Output_{i,t} = f(K, L, M, PL) + \sum_j \beta_j X_{i,t} + A_{i,t}$$

  - $A_{i,t} = \beta_0 + \phi_{i,t} + \varepsilon_{i,t}$
  - $\phi_{i,t} = \zeta_i + \psi_t,$
  - $\epsilon_{i,t} \sim N(0, \sigma_t^2), t = 2002, \ldots, 2012$

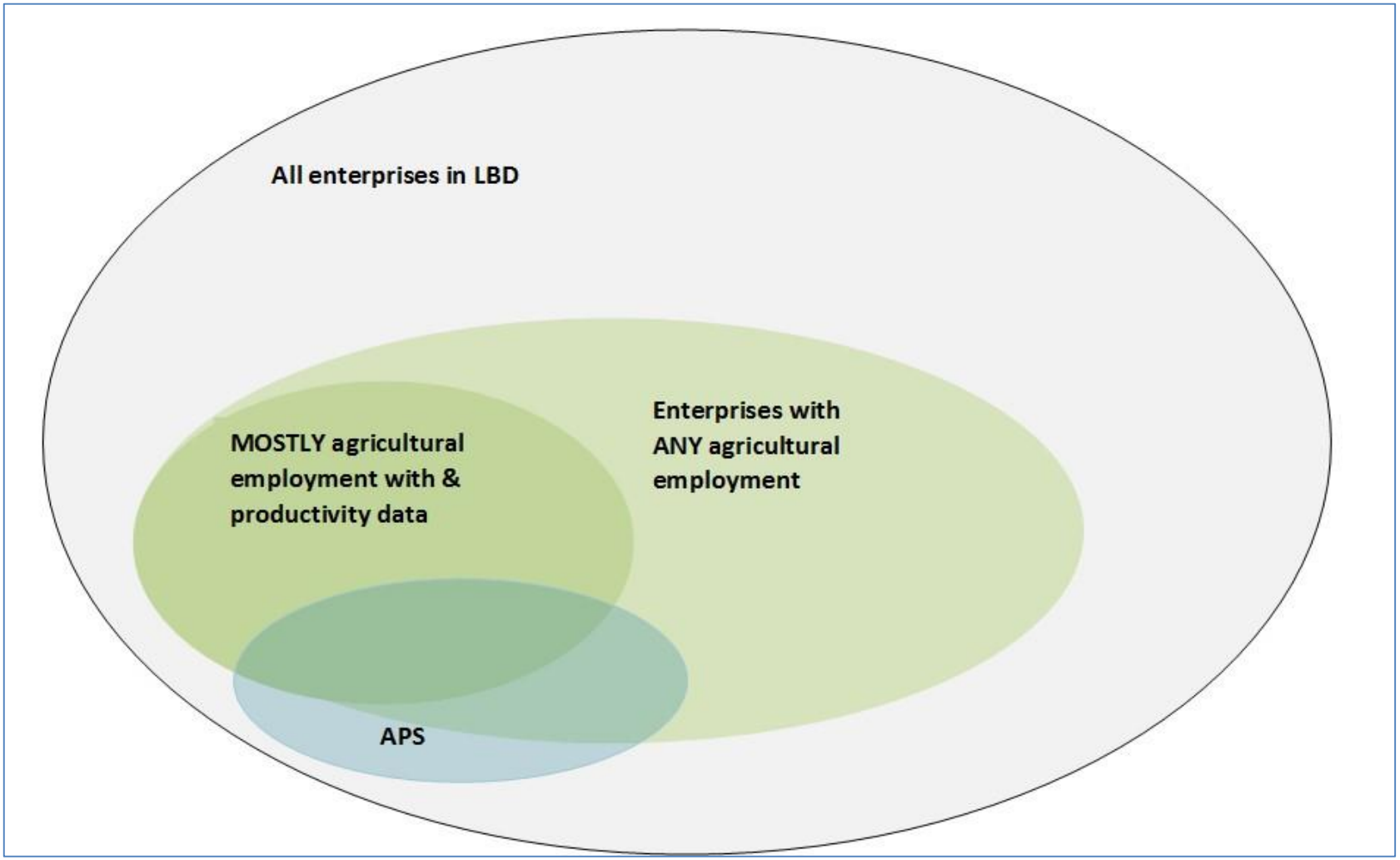
- Variables:
  - ***Output*** – *Gross output (Y)*
  - ***Inputs*** – *Capital (K), Labour (L), Intermediate Expenditure (M), Productive land (PL)*
  - ***Controls*** – *Primary & secondary production, farm management*
  - ***Fixed effect*** – *firm, year, regional council, regional council * year*

Agricultural Productivity in New Zealand - *Disclaimer*

- The results in this study are not official statistics, they have been created for research purposes from the Integrated Data Infrastructure (IDI), managed by Statistics New Zealand.
- The opinions, findings, recommendations, and conclusions expressed in this paper are those of the author(s), not Statistics NZ.
- Access to the anonymised data used in this study was provided by Statistics NZ in accordance with security and confidentiality provisions of the Statistics Act 1975. Only people authorised by the Statistics Act 1975 are allowed to see data about a particular person, household, business, or organisation, and the results in this paper have been confidentialised to protect these groups from identification.
- Careful consideration has been given to the privacy, security, and confidentiality issues associated with using administrative and survey data in the IDI. Further detail can be found in the Privacy impact assessment for the Integrated Data Infrastructure available from www.stats.govt.nz.
- The results are based in part on tax data supplied by Inland Revenue to Statistics NZ under the Tax Administration Act 1994. This tax data must be used only for statistical purposes, and no individual information may be published or disclosed in any other form, or provided to Inland Revenue for administrative or regulatory purposes.
- Any person who has had access to the unit record data has certified that they have been shown, have read, and have understood section 81 of the Tax Administration Act 1994, which relates to secrecy. Any discussion of data limitations or weaknesses is in the context of using the IDI for statistical purposes, and is not related to the data's ability to support Inland Revenue's core operational requirements

Agricultural Productivity in New Zealand – *Data*

Graphical representation of the sample and sources



Agricultural Productivity in New Zealand – *Key questions*

- **What can firm level data tell us about the relationship between financial agricultural and financial inputs with output in the dairy and sheep/beef industries**

- To what extent this relationship is sensitive the firm's size and employment structure?

- What can the data tell us about industry level productivity (i.e. *MFP*) at a national level, as well as by region?

Agricultural Productivity in New Zealand – *Benchmark results*

Change in gross output when input increases by 10%, by industry

	Dairy	Sheep/beef
Capital	**1.1%**	
Labour	**1.2%**	
Expenditure	**5.3%**	
Land	**1%**	
Stockrates	**0.47%**	
1(dairy cows > 0)	**-**	
1(dairy rising > 0)	**-**	
1(forest harvesting > 0)	**-**	
Lime application rates	**-**	
Non-lime application rates	**-**	
Effluent application rates	**-0.3%**	
1(Lime fertilizer > 0)	**-**	
1(Non-Lime fertilizer > 0)	**-2.9%**	
1(Effluent > 0)	**-6%**	
New firm	**-6.90%**	
Exiting firm	**-5.40%**	
Observations	22,674	
Adjusted R^2	94.9%	

Agricultural Productivity in New Zealand – *Benchmark results*

Change in gross output when input increases by 10%, by industry

	Dairy	**Sheep/beef**
Capital	1.1%	**1.3%**
Labour	1.2%	**0.5%**
Expenditure	5.3%	**6.9%**
Land	1%	**1.6%**
Stockrates	0.47%	**1.2%**
1(dairy cows > 0)	-	**3.5%**
1(dairy rising > 0)	-	**4.5%**
1(forest harvesting > 0)	-	**6%**
Lime application rates	-	**-0.1%**
Non-lime application rates	-	**0.2%**
Effluent application rates	-0.3%	**-**
1(Lime fertilizer > 0)	-	**-**
1(Non-Lime fertilizer > 0)	-2.9%	**1.8%**
1(Effluent > 0)	-6%	**-**
New firm	-6.90%	**-11.9%**
Exiting firm	-5.40%	**-5.8%**
Observations	22,674	61,224
Adjusted R^2	94.9%	95.3%

Agricultural Productivity in New Zealand – *Key questions*

- What can firm level data tell us about the relationship between financial agricultural and financial inputs with output in the dairy and sheep/beef industries

- **To what extent this relationship is sensitive the firm's size and employment structure?**

- What can the data tell us about industry level productivity (i.e. MFP) at a national level, as well as by region?

Agricultural Productivity in New Zealand – *Results*

Change in gross output when input increases by 10%, by industry and employment status

	Dairy		Sheep/beef	
	Working proprietors	**Employing**	Working proprietors	Employing
Capital	**1.1%**	**0.9%**		
Labour	**0.8%**	**1.2%**		
Expenditure	**5.6%**	**5%**		
Land	**1.2%**	**0.7%**		
Observations	8,448	14,226		
Adjusted R2	95%	95.6%		

Note: Statistically different coefficients for each pair of sub-industries are highlighted in red

Agricultural Productivity in New Zealand – *Results*

Change in gross output when input increases by 10%, by industry and employment status

	Dairy		**Sheep/beef**	
	Working proprietors	Employing	**Working proprietors**	**Employing**
Capital	1.1%	0.9%	**1.4%**	**1.2%**
Labour	0.8%	1.2%	**-0.5%**	**0.9%**
Expenditure	5.6%	5%	**7.5%**	**5.8%**
Land	1.2%	0.7%	**1.6%**	**1.2%**
Observations	8,448	14,226	**34,869**	**26,355**
Adjusted R2	95%	95.6%	**90.8%**	**95.4%**

Note: Statistically different coefficients for each pair of sub-industries are highlighted in red

Agricultural Productivity in New Zealand - *Results*

- Second order Translog:

$$Y_{i,t} = \beta_k K_{i,t} + \beta_l L_{i,t} + \beta_m M_{i,t} + \beta_p PL_{i,t} + \beta_{kk} K_{i,t}^2 + \beta_{ll} L_{i,t}^2 + \beta_{mm} M_{i,t}^2 + \beta_{pp} PL_{i,t}^2 + \beta_{kl} K_{i,t} L_{i,t} + \beta_{km} K_{i,t} M_{i,t} + \beta_{kp} K_{i,t} PL_{i,t} + \beta_{lm} L_{i,t} M_{i,t} + \beta_{mp} M_{i,t} PL_{i,t} + \sum_j \beta_j X_{i,t} + A_{i,t}$$

- Elasticity depends on a number of factors. For example, capital elasticity:

$$\frac{\partial Y}{\partial K} = \boldsymbol{\beta_k + \beta_{kk} K + \beta_{kl} L + \beta_{km} M + \beta_p PL}$$

Agricultural Productivity in New Zealand – Results by firm size

Output elasticity by firm size and industry

	Dairy				Sheep/beef			
	<25p	25p-50p	50p-75p	>75p	<25p	25p-50p	50p-75p	>75p
Capital	**1.11%**	**0.63%**	**0.74%**	**0.89%**				
	[0.8%]	[0.3%]	[0.3%]	[0.2%]				
Labour	**0.53%**	**0.12%**	**0.14%**	**0.14%**				
	[0.7%]	[0.2%]	[0.2%]	[0.1%]				
Expenditure	**5.83%**	**5.13%**	**5.21%**	**4.97%**				
	[0.6%]	[0.3%]	[0.2%]	[0.2%]				
Land	**2.42%**	**1.89%**	**0.13%**	**0.71%**				
	[1.8%]	[1.1%]	[0.8%]	[0.3%]				

Note: Standard errors in brackets

Agricultural Productivity in New Zealand – *Results by firm size*

Output elasticity by firm size and industry

	Dairy				**Sheep/beef**			
	<25p	25p-50p	50p-75p	>75p	<25p	25p-50p	50p-75p	>75p
Capital	1.11%	0.63%	0.74%	0.89%	**1.64%**	**1.11%**	**0.94%**	**1.30%**
	[0.8%]	[0.3%]	[0.3%]	[0.2%]	[0.4%]	[0.2%]	[0.1%]	[0.1%]
Labour	0.53%	0.12%	0.14%	0.14%	**-0.26%**	**0.54%**	**0.53%**	**0.84%**
	[0.7%]	[0.2%]	[0.2%]	[0.1%]	[0.7%]	[0.3%]	[0.1%]	[0.1%]
Expenditure	5.83%	5.13%	5.21%	4.97%	**8.33%**	**7.12%**	**5.86%**	**5.47%**
	[0.6%]	[0.3%]	[0.2%]	[0.2%]	[0.3%]	[0.2%]	[0.1%]	[0.1%]
Land	2.42%	1.89%	0.13%	0.71%	**1.88%**	**1.09%**	**1.43%**	**1.56%**
	[1.8%]	[1.1%]	[0.8%]	[0.3%]	[0.6%]	[0.4%]	[0.3%]	[0.2%]

Note: Standard errors in brackets

Agricultural Productivity in New Zealand – *Key questions*

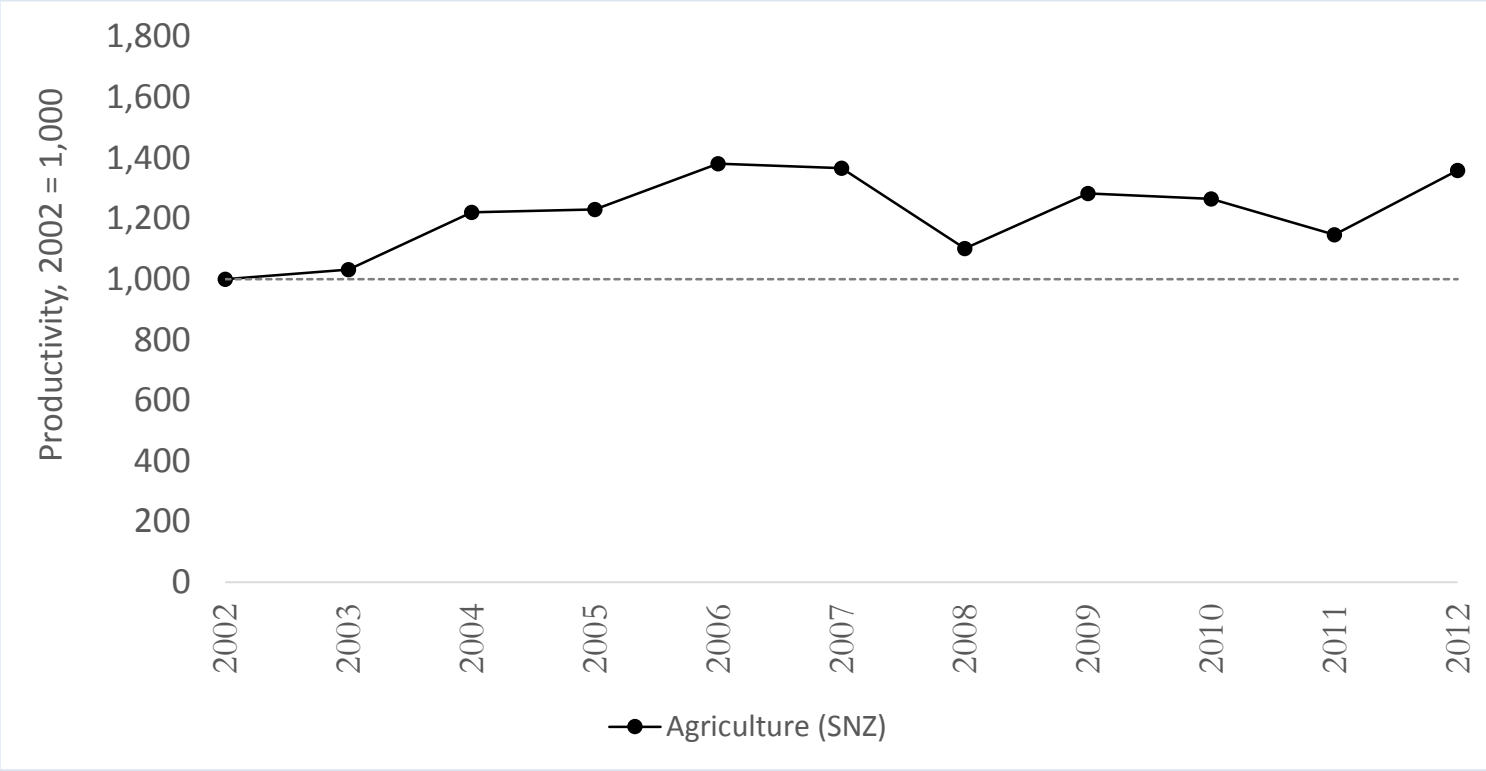
- What can firm level data tell us about the relationship between financial agricultural and financial inputs with output in the dairy and sheep/beef industries

- To what extent this relationship is sensitive the firm's size and employment structure?

- **What can the data tell us about industry level productivity (i.e. MFP) at a national level, as well as by region?**

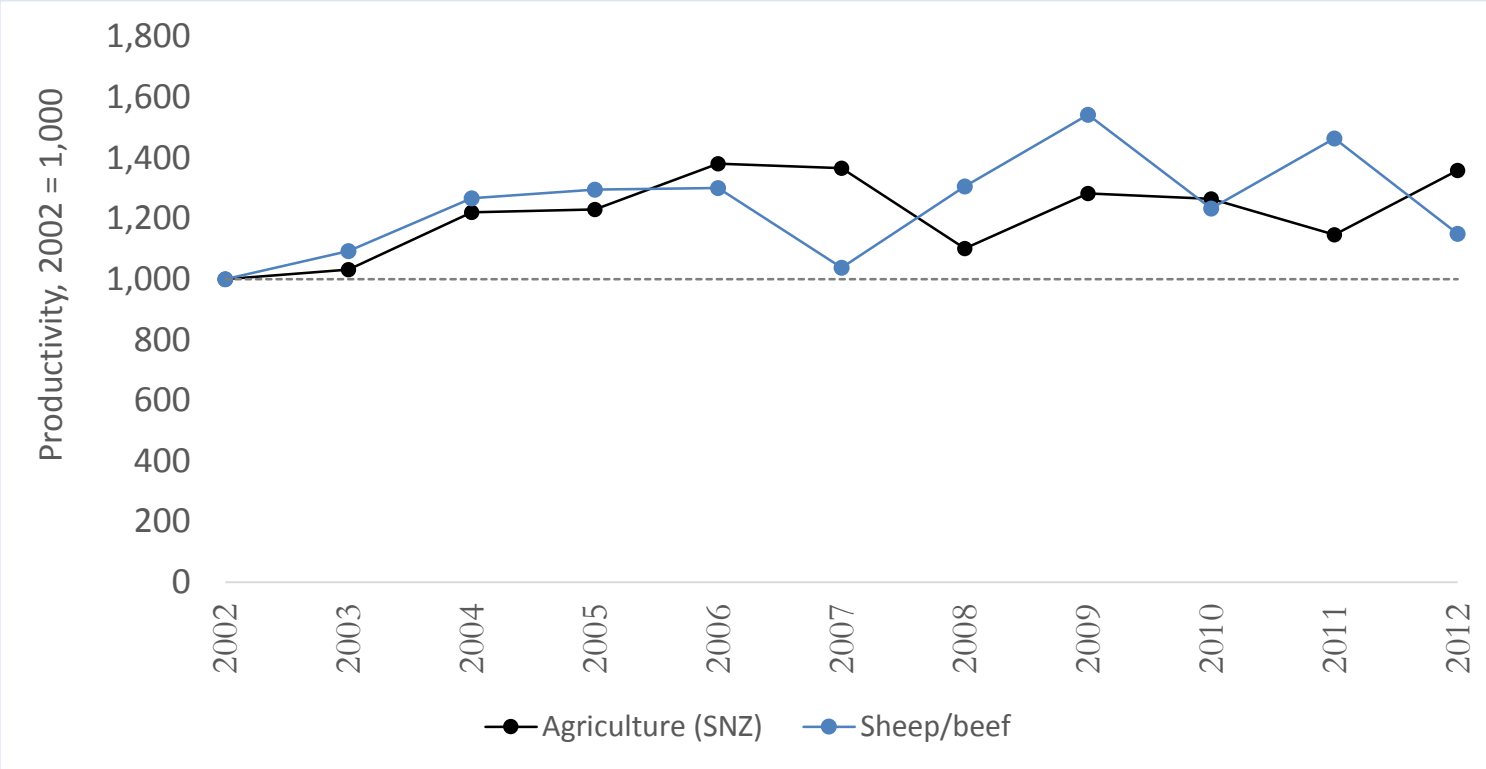
Agricultural Productivity in New Zealand – *Productivity trends*

Capital Productivity, 2002 - 2012



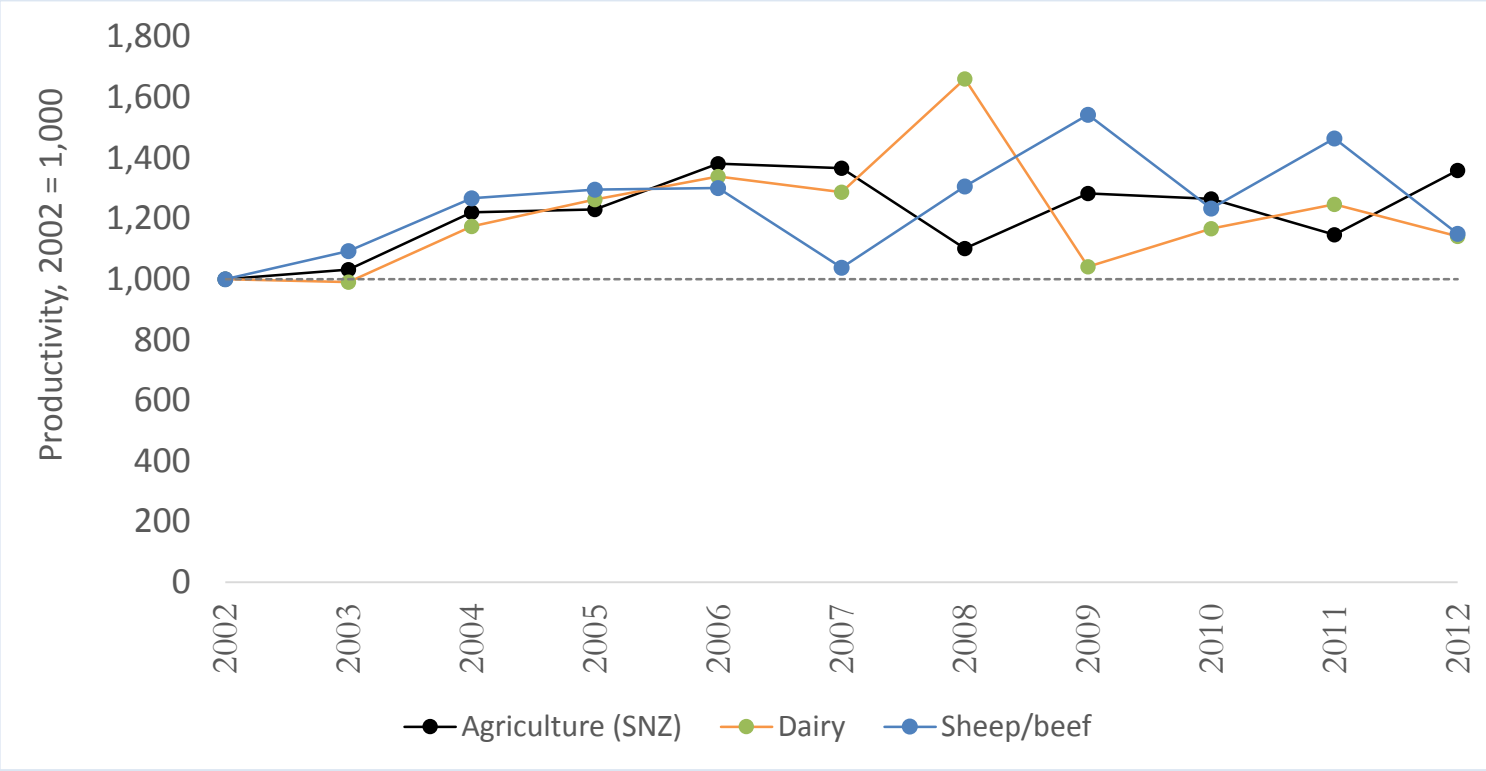
Agricultural Productivity in New Zealand – *Productivity trends*

Capital Productivity, 2002 - 2012



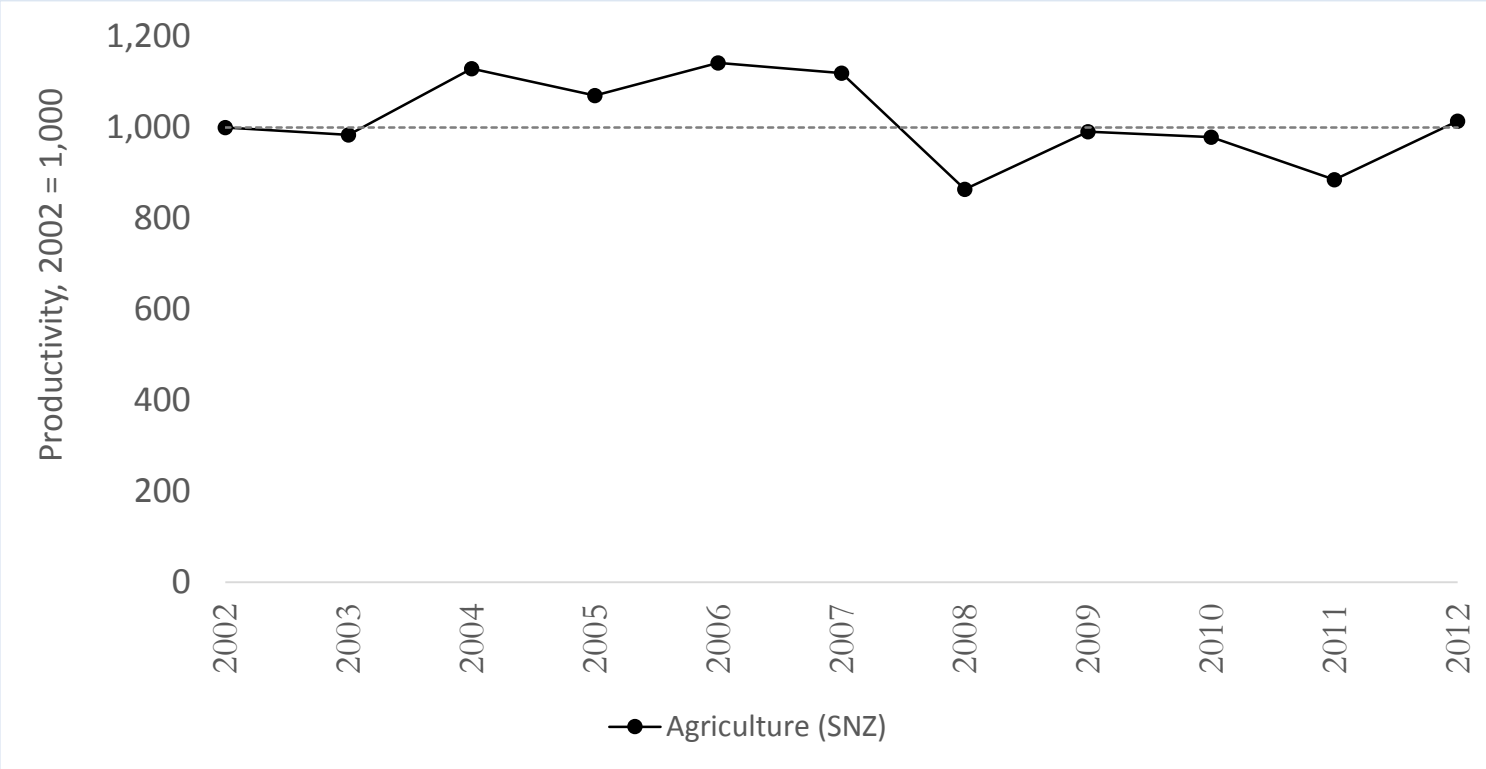
Agricultural Productivity in New Zealand – *Productivity trends*

Capital Productivity, 2002 - 2012



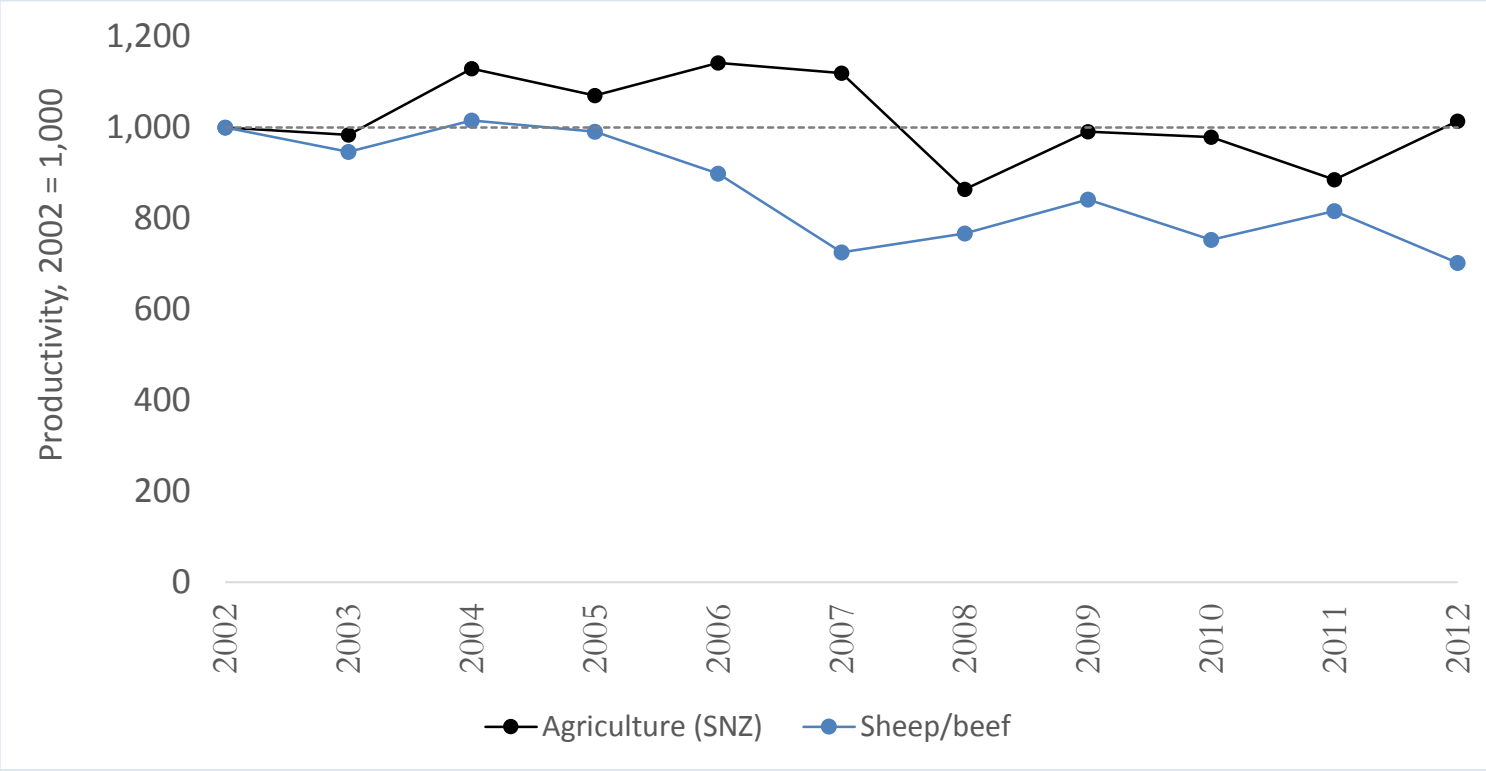
Agricultural Productivity in New Zealand – *Productivity trends*

Labour Productivity, 2002 - 2012



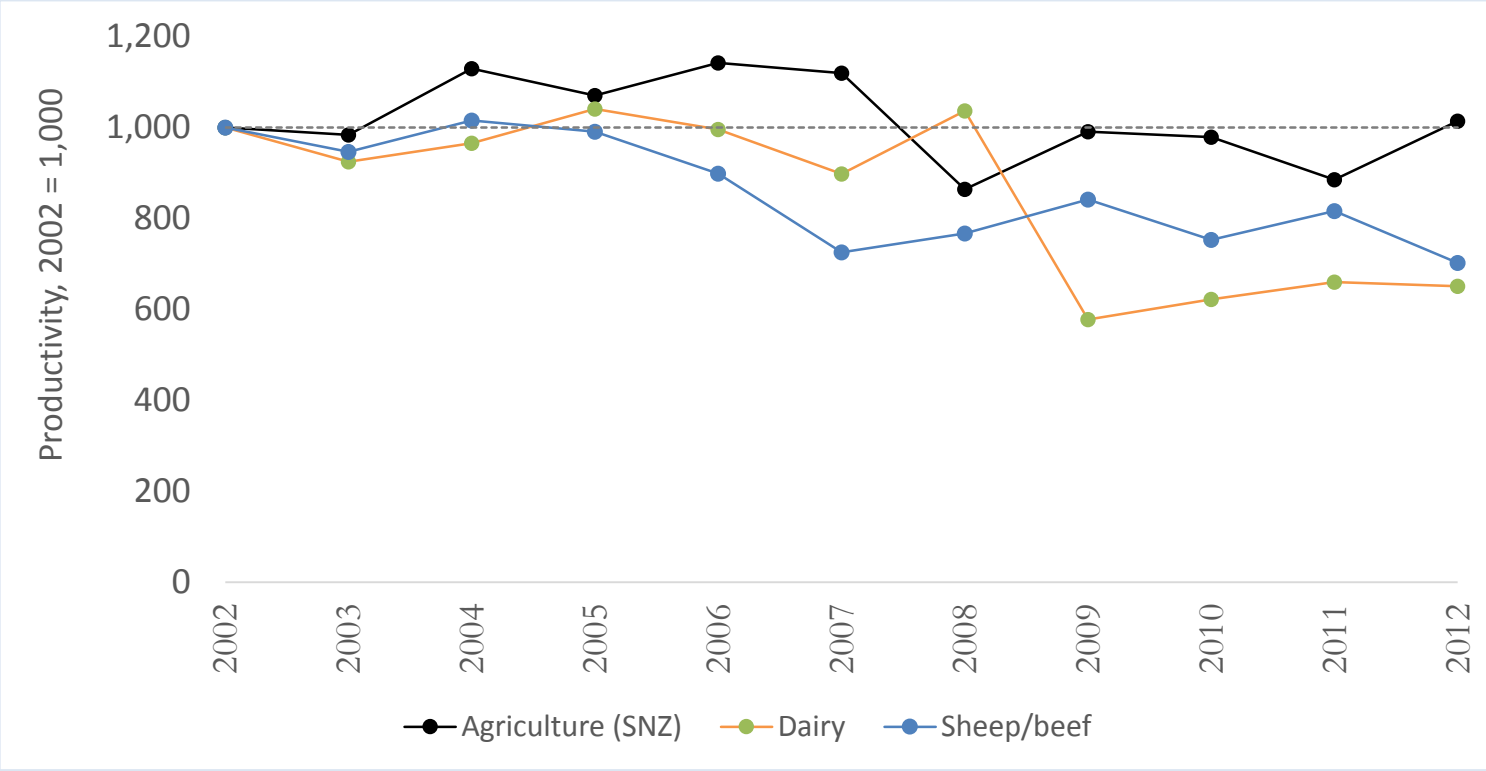
Agricultural Productivity in New Zealand – *Productivity trends*

Labour Productivity, 2002 - 2012



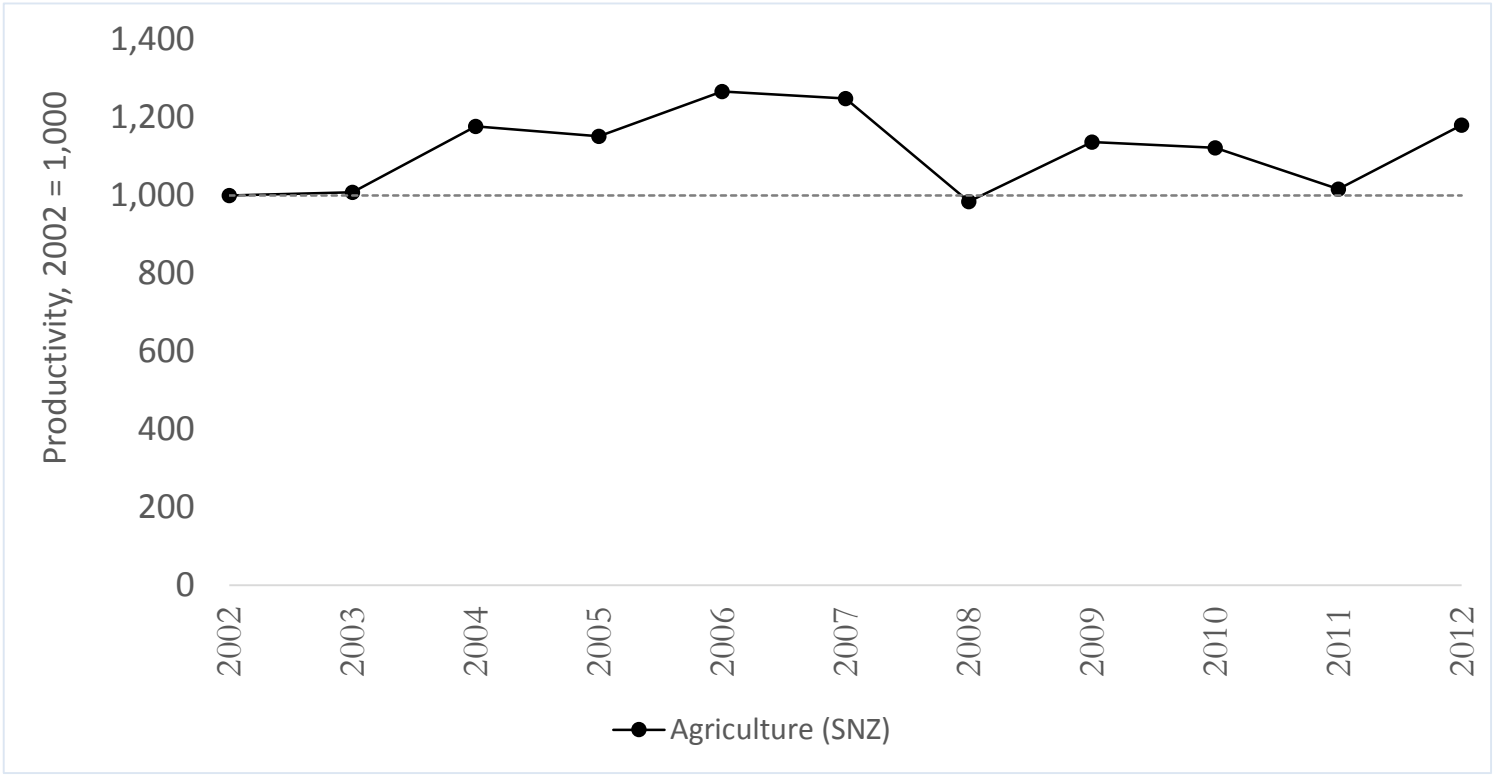
Agricultural Productivity in New Zealand – *Productivity trends*

Labour Productivity, 2002 - 2012



Agricultural Productivity in New Zealand – *Productivity trends*

Multi-Factor (*MFP*) Productivity, 2002 - 2012



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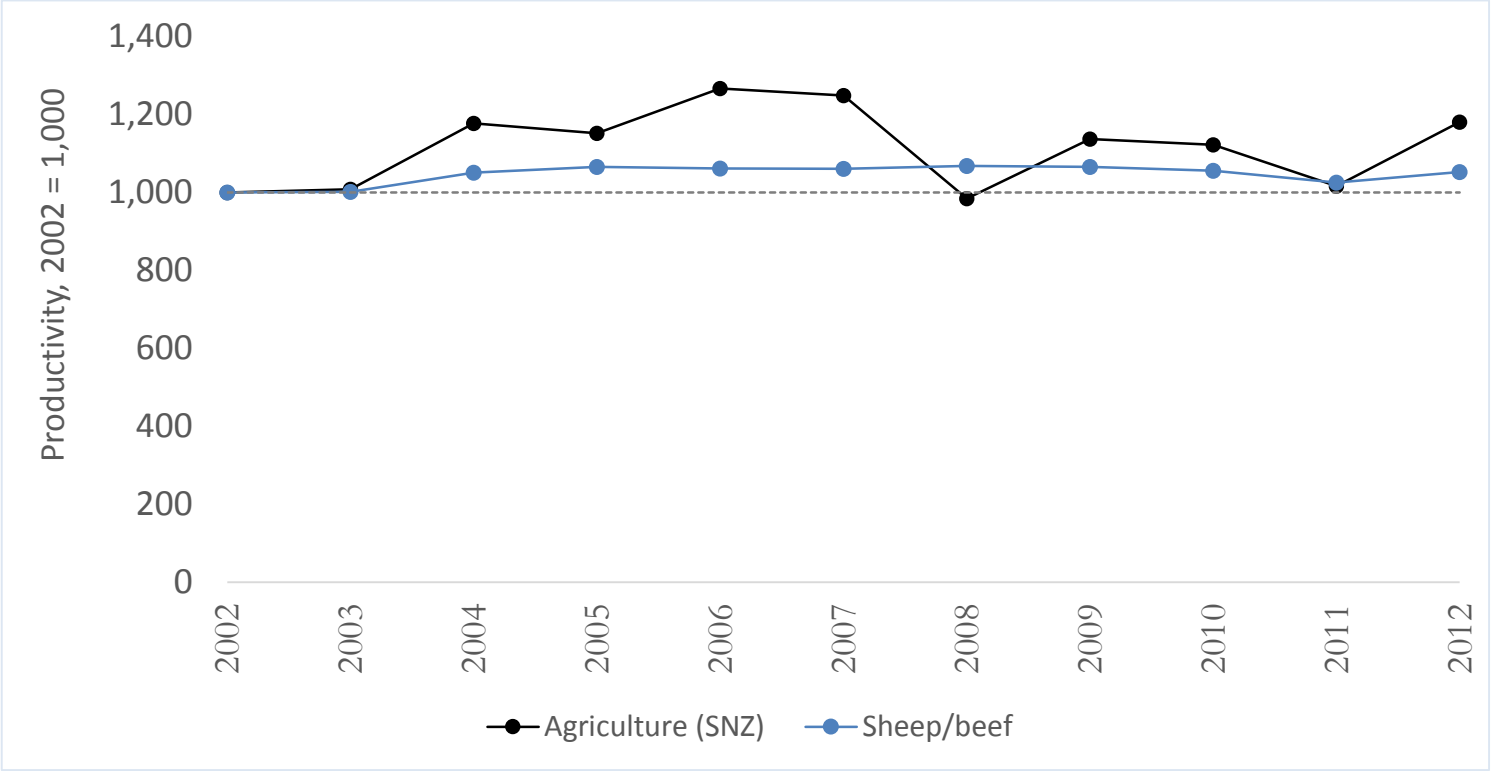

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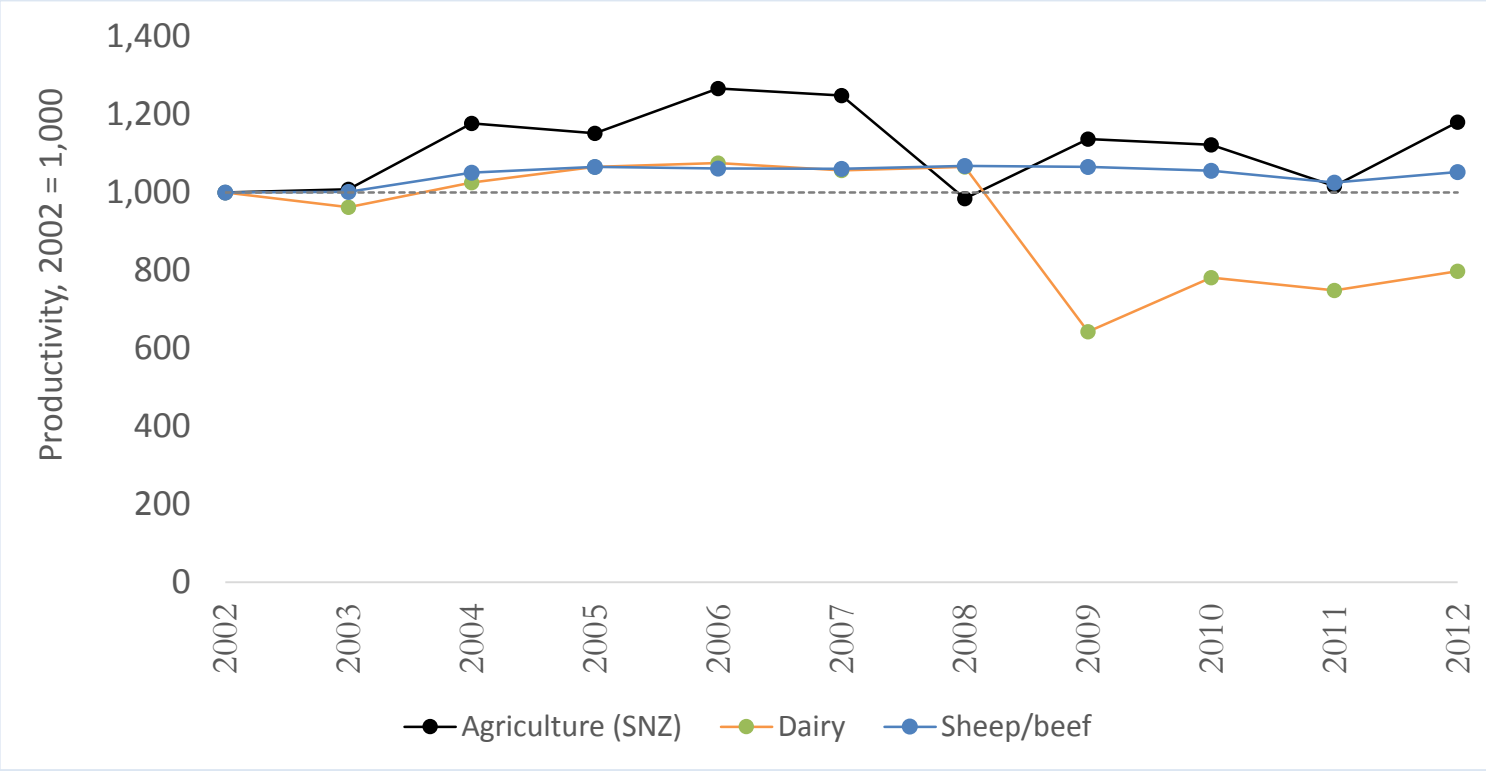
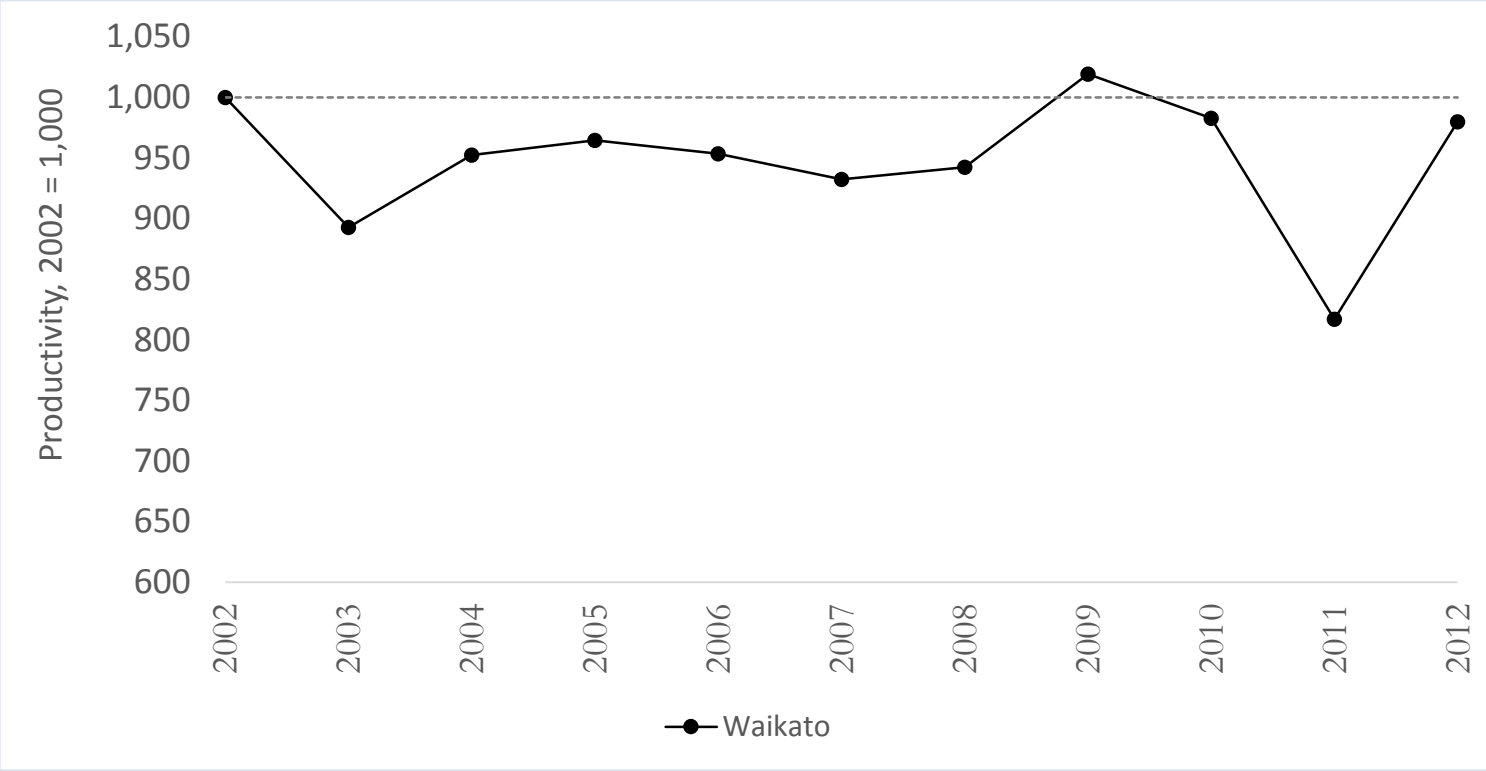


Agricultural Productivity in New Zealand – *Productivity trends*

Dairy Multi-Factor (*MFP*) Productivity by regional council, 2002 - 2012



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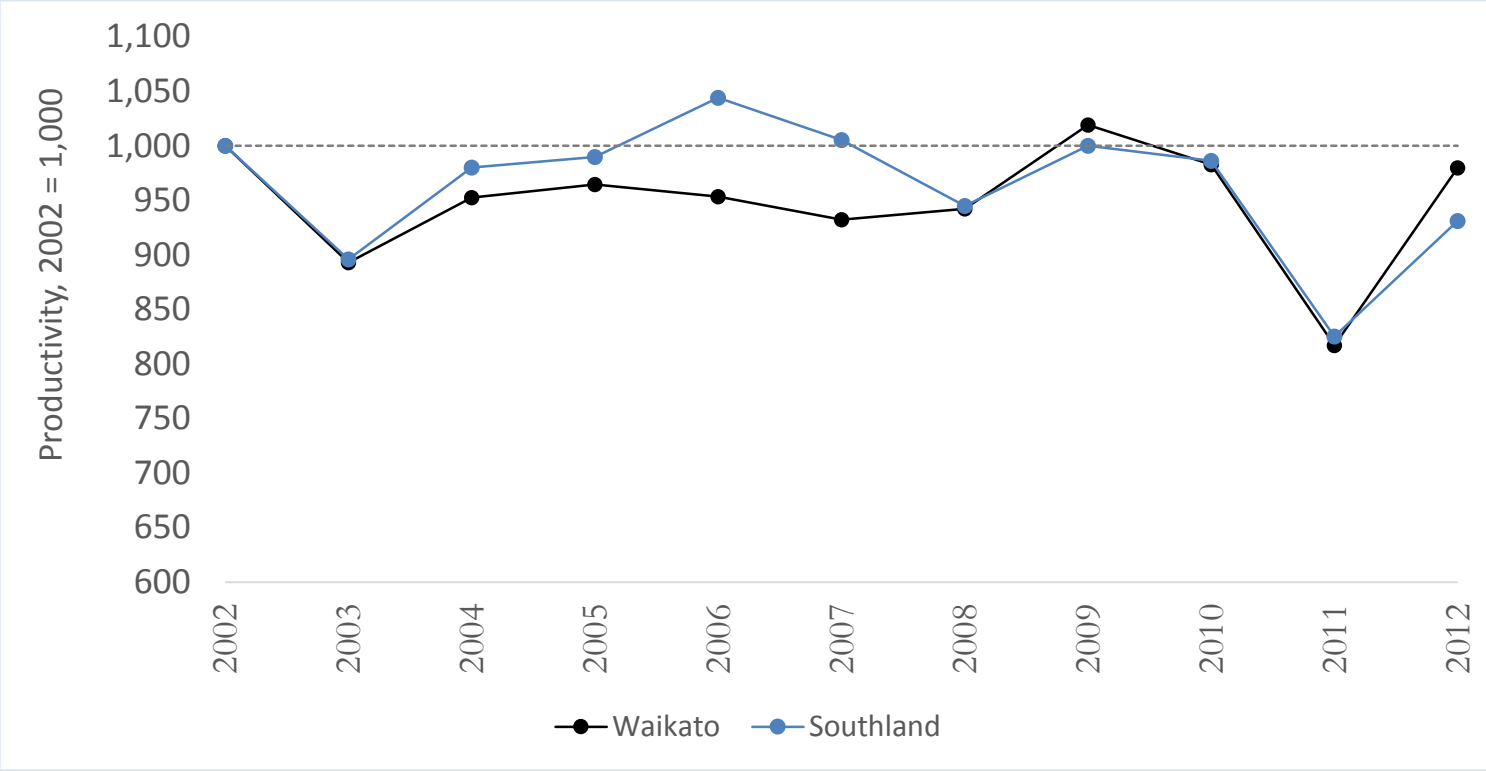

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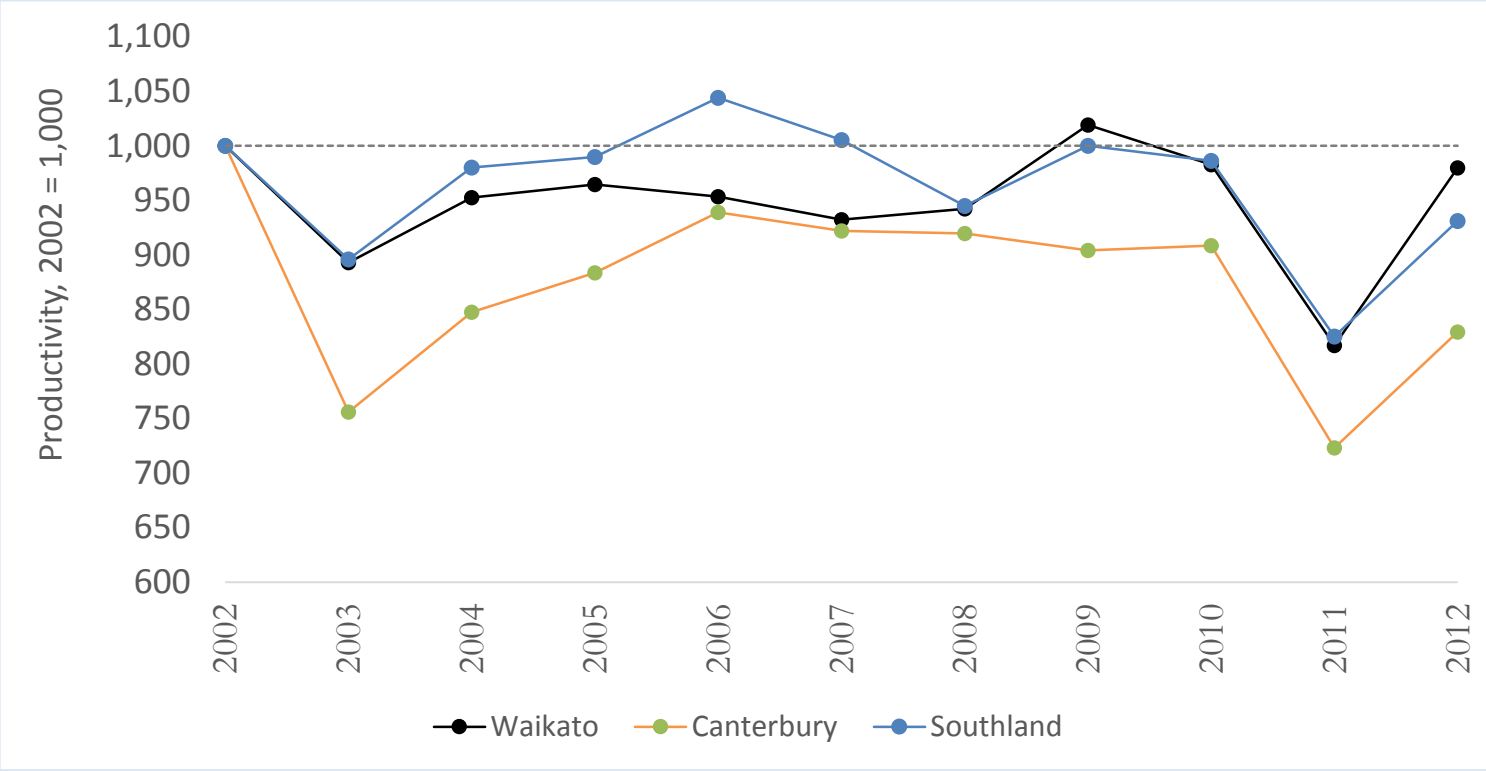

Agricultural Productivity in New Zealand – *Conclusions & Next steps*

- **Conclusions:**
  - We can explain a large proportion of variation in output using firm level input data
  - We find significant differences in these relationships between industries, and within (e.g. by land area)
  - Our estimates of *Multifactor Productivity* differ across industries and regions.
  - Our estimates suggest only a marginal increase in sheep/beef productivity (i.e. *MFP*), and a fall in the dairy industry
- **Possible next steps:**
  - Integrate behavioural/structural elements
  - Explore reasons for heterogeneity
  - Incorporate other variables (e.g. management practices from the Business Operation Survey, labour characteristics from the Integrated Data Infrastructure).