



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

# **Spatial Analysis of Dairy Yield Response to Intensive Farming in New Zealand**

**Wei Yang**

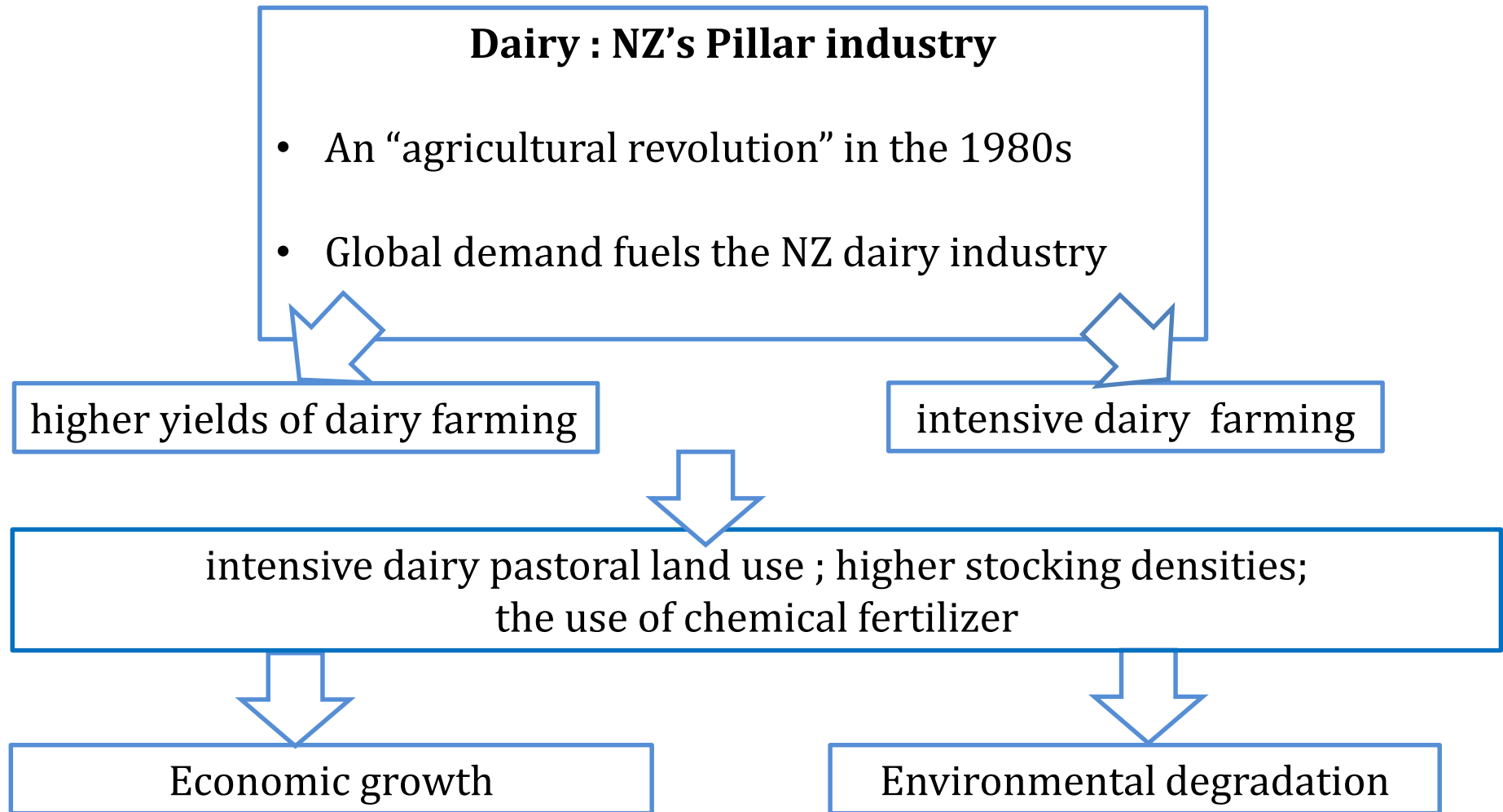
**(Ph.D. Candidate)**

**Economics Department**

**Business School University of Auckland**

**Presented in the 58<sup>th</sup> AARES Conference  
4<sup>th</sup> – 7<sup>th</sup> Feb 2014, Port Macquarie, Australia**

# Background



# Motivation

- Various programs have been launched to control nutrient pollution, but both the government and dairy farmers are still facing tremendous environmental pressure.
- To maintain the international competitiveness and regulate the negative environmental impact, it is important to explore the relationship between dairy yield and intensive farming.
- Considering various characteristics of different regions, the relationship between dairy yield and intensive farming might be partially estimated if spatial effects are excluded.

# Research Objectives

- Apply spatial panel data models, examining the spatial relevance of territorial dairy yield with regard to intensive farming in New Zealand.
- Take into account the traditional intensive inputs but also includes the areas of effluent sprayed over farms.
- Allow for spatially modeling the different dairy yields between South Island and North Island with respect to intensive farming.

# Methods and Data

## Spatial Panel Data Models

- Spatial panel data are expressed as specific point locations and aggregated data over geographic areas.
- The relationships between the spatial units are exogenously specified by using the spatial weights matrix.
- Account for fixed or random effects in the setting of both a spatial autoregressive variable and a spatial autocorrelated error process (Debarys & Ertur, 2010).

# Methods and Data

## Data from Two Database

- The Agricultural Production Census (Statistics NZ): fertilizer application (N nitrogen, P phosphorus, L lime and K potassic fertilizer) and the area of effluent irrigated (EFF).
- Dairy Statistics (DairyNZ): Y (kg MS/ ha) and SR (stock rate, numbers of cow/ efficient areas)

## Panel Data Structure

Years of 2002, 2007 and 2012; fifty-five out of sixty-seven NZ territorial authorities.

# Spatial Diagnosis-Visualized Data

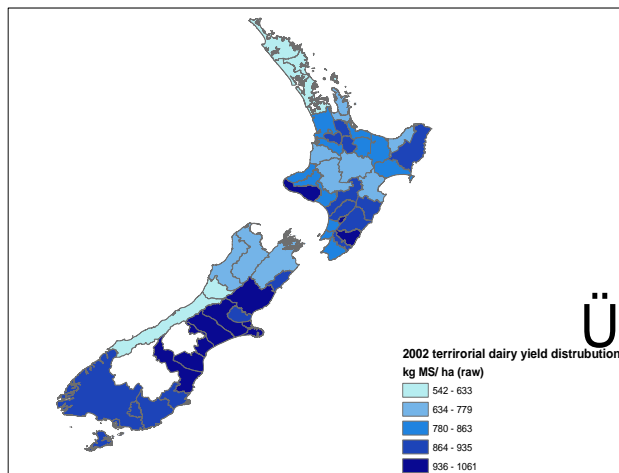


Figure 1a Dairy yield distribution-raw in 2002

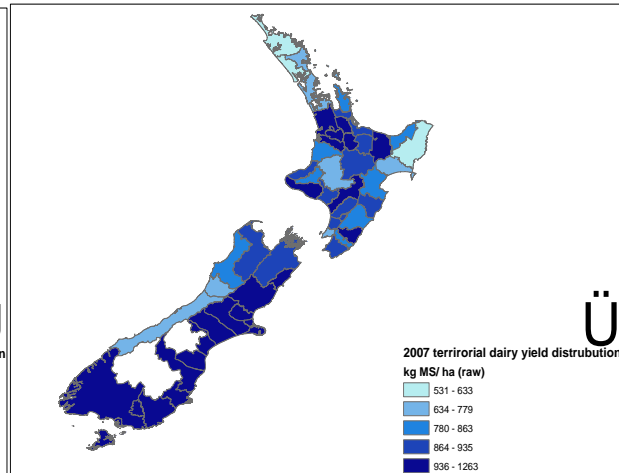


Figure 1b Dairy yield distribution-raw in 2007

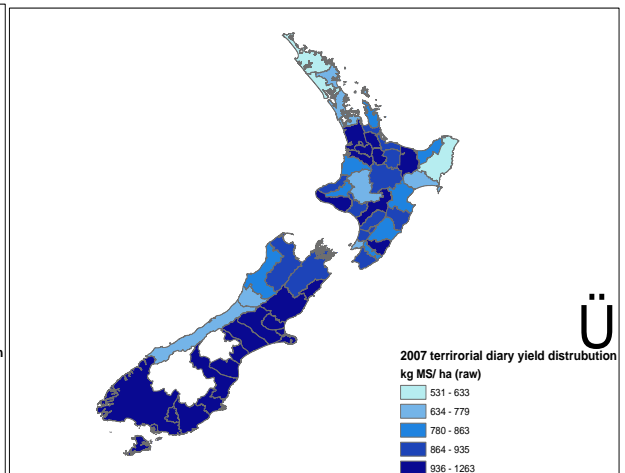


Figure 1c Dairy yield distribution-raw in 2012

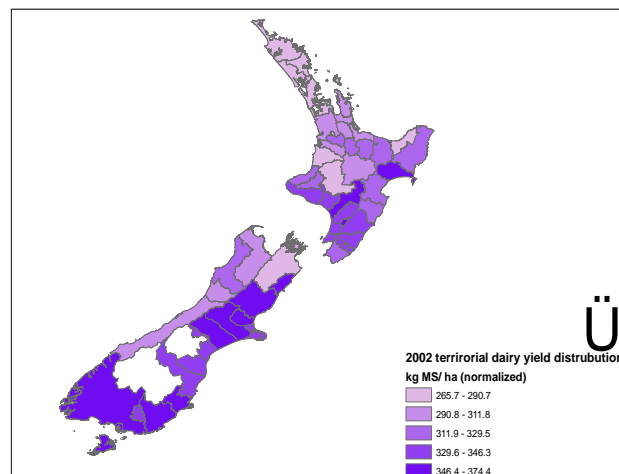


Figure 1d Normalized distribution in 2002

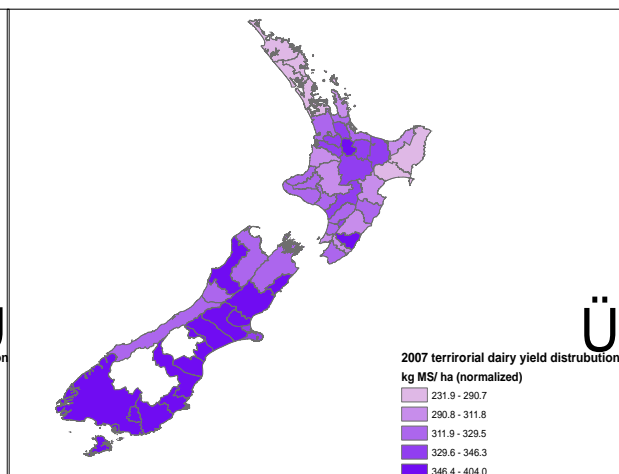


Figure 1e Normalized distribution in 2007

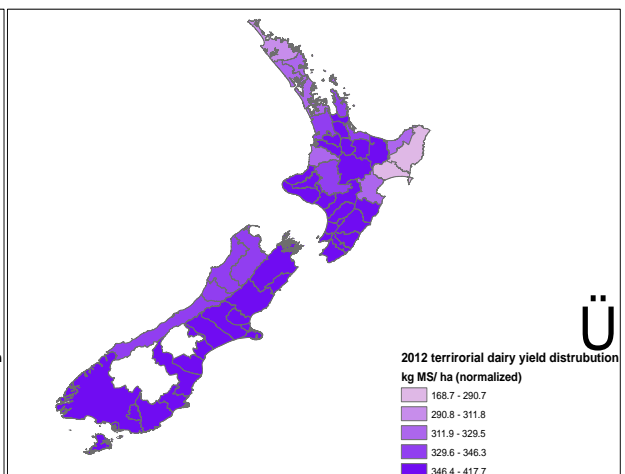


Figure 1f Normalized distribution in 2012



# Spatial Diagnosis-Moran's I test

- We use Moran's I test to diagnose the existence of spatial autocorrelation.
- The test is developed to explore the spatial interaction for cross-sectional data, we calculate it for the years of 2002, 2007 and 2012 respectively. In this test, the null hypothesis is specified to be no spatial autocorrelation.
- The relationship between two spatial units through the expression of contiguity weights: Queen contiguity and rook contiguity.

# Spatial Panel Model Selection

The dairy yield response equation with main-effects considered:

$$\begin{aligned} \ln Y_{it} &= \beta_0 + \beta_1 \ln N_{it} + \beta_2 \ln P_{it} + \beta_3 \ln LIM_{it} + \beta_4 \ln PO_{it} + \beta_5 \ln EFF_{it} \\ &+ \beta_6 \ln SR_{it} + \beta_7 RE + \beta_8 TI + \mu_i + \varepsilon_{it} \quad (1) \end{aligned}$$

- RE and TI are dummy variables representing the region effects (of South Island, using North Island as the base region) and the year effects (of year 2007 and 2012, taking 2002 as the base year).
- $\varepsilon_{it}$  is an independently and identically distributed error term;
- $\mu_i$  denotes a spatial specific effect.

# Spatial Panel Model Selection

The dairy yield response equation with interaction-effects considered:

$$\begin{aligned}
 \ln Y_{it} &= \beta_0 + \beta_1 \ln N_{it} + \beta_2 \ln P_{it} + \beta_3 \ln LIM_{it} + \beta_4 \ln PO_{it} + \beta_5 \ln EFF_{it} \\
 &+ \beta_6 \ln N_{it} \ln EFF_{it} + \beta_7 \ln P_{it} \ln EFF_{it} + \beta_8 \ln LIM_{it} \ln EFF_{it} \\
 &+ \beta_9 \ln PO_{it} \ln EFF_{it} + \beta_{10} \ln SR_{it} + \beta_{11} RE \\
 &+ \beta_{12} TI + \mu_i + \varepsilon_{it}
 \end{aligned}
 \tag{2}$$

Centered the variables about their means. See the dairy yield response to fertilizer use given different levels of effluent irrigation areas.

# The Lagrange Multiplier (LM) Test

Test the random effects and spatial autocorrelation. We consider a spatial autoregressive model with spatially autocorrelated disturbances of order (1, 1) (SARAR (1, 1) model) and can be described by equation 3.

$$Y_{it} = \lambda WY_{it} + X_{it}\beta + \mu_i + U_{it};$$

$$U_{it} = \rho WU_{it} + V_{it}, \quad (i = 1, 2, \dots, n; t = 1, 2, \dots, T) \quad (3)$$

- $Y_{it} = (y_{1,t}, y_{2,t}, \dots, y_{n,t})$  is the  $n \times 1$  vector of the dependent variable (dairy yield) for all individuals in period  $t$ ;
- $X_{it}$  is the  $n \times k$  matrix of independent variables;
- $V_{it} = (v_{1,t}, v_{2,t}, \dots, v_{n,t})$  is the innovation term;
- $\mu_i$  is the  $n \times 1$  vector of individual fixed effects.
- $\rho$  and  $\lambda$  are the unknown spatial parameters to be estimated.

# Spatial Panel Model Selection---Summary

- The spatial autocorrelation exists in our data (territorial dairy yields in regard to intensive farming);
- We choose rook contiguity weights matrix.
- We choose spatial autoregressive (lagged) fix effects model;

$$Y_{it} = \lambda WY_{it} + X_{it}\beta + \mu_i + \varepsilon_{it}; \varepsilon_{it} \sim N(0, \sigma^2), (i=1,2,\dots,n; t=1,2,\dots,T)$$

# Results

## ---Part 1

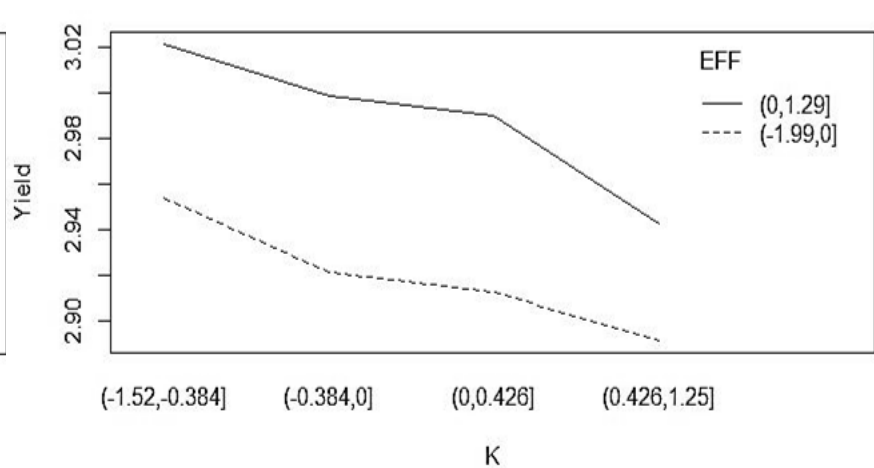
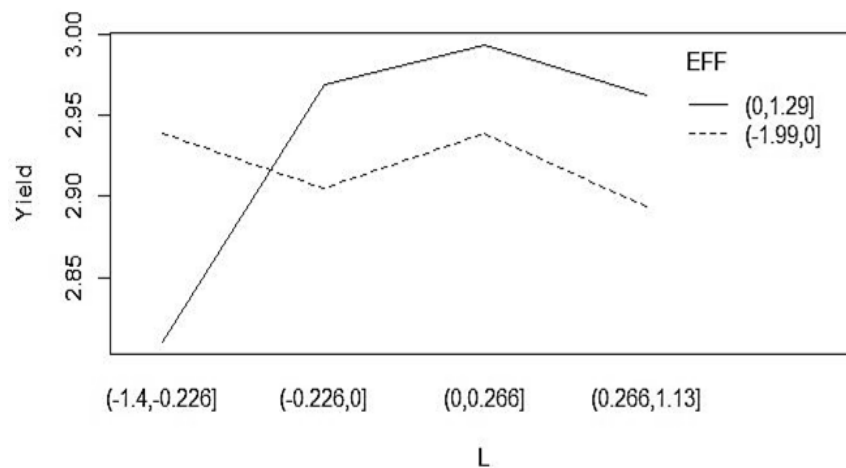
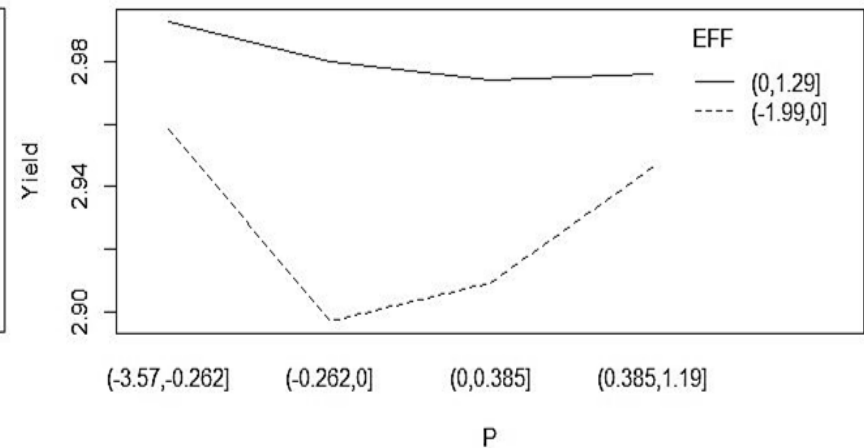
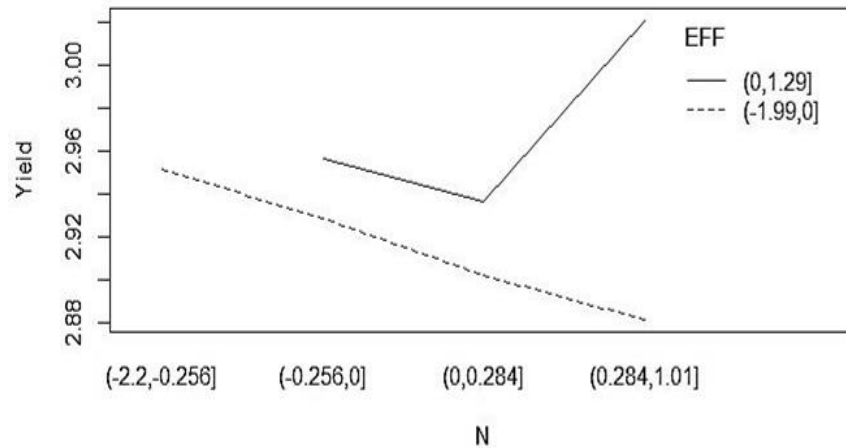
Variables	Models			
	Basic Model 1	Basic Model 2	S-Model 1	S-Model 2
Intercept	2.41*** (3.89e-02)	2.44*** (2.91e-02)	2.09*** (3.72e-02)	2.13*** (2.75e-02)
N	-5.94e-02** (1.79e-02)	-6.00e-02*** (1.57e-02)	-6.83e-02*** (1.76e-02)	-6.96e-02*** (1.54e-02)
P	3.91e-02** (1.37e-02)	4.86e-02*** (1.22e-02)	4.23e-02** (1.35e-02)	5.33e-02*** (1.21e-02)
L	-2.33e-02 (1.58e-02)	-2.83e-02* (1.40e-02)	-2.21e-02 (1.56e-02)	-2.75e-02* (1.37e-02)
K	-1.71e-02. (1.04e-02)	-1.43e-01 (9.16e-03)	-1.40e-02 (1.02e-02)	-1.16e-02 (8.99e-03)
EFF	6.83e-02*** (1.17e-02)	5.57e-02*** (1.05e-02)	6.87e-02*** (1.15e-02)	5.76e-02*** (1.03e-02)
SR	1.18*** (7.58e-02)	1.13*** (6.69e-02)	1.20*** (7.47e-02)	1.15*** (6.59e-02)
Lambda ( $\lambda$ )			1.10e-01* (5.48e-02)	1.03e-01* (4.69e-02)
R <sup>2</sup>	0.841	0.875	0.891	0.899
Log-likelihood	326.36	351.33	329.01	355.62

# Results

## ---Part 2

NEFF		1.04e-01*** (1.95e-02)		1.05e-01*** (1.94e-02)
PEFF		2.97e-02* (1.39e-02)		3.03e-02* (1.37e-02)
LEFF		-9.66e-02*** (1.84e-02)		-9.33e-02*** (1.81e-02)
KEFF		-3.93e-02** (1.22e-02)		-3.99e-02*** (1.21e-02)
Group dummy SOUTH	4.17e-02*** (6.82e-03)	3.79e-02*** (6.21e-03)	4.05e-02*** (6.71e-03)	3.67e-02*** (6.10e-03)
Yeardummy2007	9.57e-03 (1.29e-02)	2.13e-02. (1.16e-02)	6.65e-03 (1.27e-02)	1.99e-02. (1.14e-02)
Yeardummy2012	2.31e-02** (7.95e-03)	3.47e-02*** (7.13e-03)	1.72e-02* (7.81e-03)	2.95e-02*** (7.01e-03)

# Dairy yield response to fertilizer given the areas of irrigated effluent





# Conclusions---Model results

- The results clearly show that the spatial panel model with interaction-effects fits our data better than the other models;
- Most of the intensive farming variables are statistic significant;
- There are significant spillovers in territorial dairy yield data.

# Conclusions---Policy Implication

- From a national perspective, policy makers should take into account of the neighbouring impact between territories. Consequently, political decisions do not only affect the district which they are targeted but also the neighbouring districts. This fact would motivate political cooperation between different territorial authorities.
- The more sensitive response to intensive inputs of South Island encourage the regional governments of the South Island to make the best use of intensive inputs, which could significantly increase the dairy production.

# Conclusions---Policy Implication

- The positive coefficients of intensive inputs as well as the positive time effect prove the increasing trend of intensive dairy farming over the past decade and highlight its positive impact on dairy yields.
- Because the rational utilization of effluent can complement chemical fertilizer use, encouraging effluent use might help the dairy industry not only meet the needs of economic growth but also protect the environment.

# THANK YOU !



Questions and  
comments are  
welcome!