Assessing the Farmers Perception of Environmental Regulations and their Impact on Farm Profitability in New Zealand

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Abstract

This study investigates the impact of environmental regulations on the profitability of agricultural farms in New Zealand, utilizing the 2023 Survey of Rural Decision Makers conducted by Landcare Research. Discrete dependent variable models and an instrumental variable approach were employed. The results indicate that improved environmental regulation significantly enhance farm profitability, while input cost volatility negatively affect it. Although compliance with environmental regulations presents financial challenges, the overall regulatory burden yielded mixed results. Additionally, CEO experience was positively associated with profitability. These findings highlight the potential for sustainable practices to improve both environmental and economic outcomes in New Zealand.

Key Words: Farm profitability, environmental regulation, New Zealand, survey data.

Rationale of the Research

The agricultural sector significantly influences New Zealand's economy, predominately comprising dairy, sheep and beef farming, forestry and horticulture. Farming is an important source of income and employment, contributing significantly to the country's gross domestic product (GDP) and vibrant rural communities. It generated $54 billion in export revenue and contributed 11 per cent to the total GDP in 2023 (Ministry for the Primary Industries, 2022). Additionally, it plays a crucial role in mitigating the country's climate impact (Ministry of the Environment, 2022). The New Zealand government has recently introduced more than 20 new regulations that directly affect agriculture (Hannah, et al., 2023). These regulations mainly focus on managing the impact of farms on the natural environment, with an emphasis on biodiversity, freshwater health, and greenhouse gas emissions.[1] In 2019, the New Zealand government introduced new regulations aimed at addressing the environmental impacts of intensive winter grazing practices. This system involves grazing livestock on paddocks of forage crops specifically grown for winter feed, which can lead to soil erosion, nutrient runoff, and animal welfare concerns (Ministry for the Environment, 2020a). These proposed regulations are part of the National Environmental Standards for Freshwater 2020 (NES-FW) and include specific rules for intensive winter grazing practices. These rules impose restrictions on the area of land used, the slope of the land, and the management of pugging (Ministry for the Environment,2020b).

The New Zealand Institute of Economic Research (NZIER) conducted a farmers' workshop that focused on how farmers cope with environmental regulations (NZIER, 2024). The workshop revealed that many farmers found impractical environmental rules, lacking in local context, and developed without adequate consultation with the farming community. Hannah et al. (2023) conducted a study on the farm-level financial impact of government policies on four selected sheep and beef farms and indicated that these policies have significantly negatively affected the financial performance of thefarms.

Chen and Liu (2023) explored the influence of environmental regulations on Chinese rural household income and found that environmental regulation has a significant positive effect on farmers' agricultural production income. The rise in agricultural green total factor productivity serves as a pathway through which environmental regulations enhance agricultural production income.

However, environmental regulations and performance could significantly affect the costs and profitability of agricultural farms in New Zealand. These regulations often require farmers to adopt sustainable practices, which can lead to increased costs in the short term. While these regulations introduce additional costs and operational challenges, they also present opportunities for innovation, market differentiation, and long-term sustainability. Farms that can successfully navigate these challenges and find opportunities to achieve long-term profitability while contributing to environmental protection. In the long term, these practices can improve soil health, water quality, and biodiversity, resulting in more resilient farming systems. Improved

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[1] National environmental standards for freshwater, Ministry for the Environment. https://environment.govt.nz/acts-and-regulations/freshwater-implementation-guidance/agriculture-and-horticulture/

environmental performance can also open up new market opportunities, as consumers and international markets increasingly demand sustainably produced products. Therefore, while there may be initial financial challenges, the overall effect of environmental regulations and performance on farm profitability can be positive. Against this background, the main research question is how environmental regulations and performance affect New Zealand's agricultural farm profitability. There is no study analyzing the impact of this environmental regulation on agricultural farm profitability in New Zealand in literature. Against this background, this study aims to provide a comprehensive analysis of the impact of environmental regulations and performance on New Zealand's agriculture. By using advanced econometric techniques and leveraging recent survey farm-level survey data, the research will offer valuable insights into the dynamics of environmental regulation adaptation and its economic implications.

Data and Research Methodology

Data preparation

This research uses the 2023 Survey of Rural Decision Makers (SRDM) data collected by Manaaki Whenua - Landcare Research. The SRDM is the leading source of information on New Zealand's agricultural sector. Conducted by Landcare Research every two years, thousands of farmers, foresters, growers, and lifestyle block owners from Cape Reinga to Oban complete this online survey. The sixth biennial SRDM was conducted in 2023 which we have used for this research. The SRDM 2023 gathers extensive qualitative data including land use and changes in land use, farming, management practices, personal values, well-being, and future climate. The survey contains only quantitative categorical data. Questionnaire[2], of 2023 Survey of Rural Decision Makes is attached in the footnote. To analyze how environmental regulations affect the profitability of agricultural farms in New Zealand, the survey asked respondents several key questions relevant to this study. The responses to the survey questions were scaled from zero to six, aggregated, and converted into dummy variables for analysis. Table 1 displays all the data and its conversion. Socio-economic factors such as gender, education, farm size, and regional farm distribution were also included in the analysis to provide a comprehensive understanding of the impact of environmental regulations and performance on farm profitability. Dorner et al. (2024), Brown and Roper (2017), and William and Brown (2018) utilised a similar research design to create variables from a survey of rural decision-makers conducted in different years. We converted the missing values to zero dummy as required. Table 1 indicates that approximately 2-3 percent of the data contains missing values.

[2] 2023 Survey of Rural Decision Makers, We thank the Manaaki Whenua- Land Research New Zealand for providing their SRDM 2023 survey data.

Table 1: Variables and Dummy Variables Conversion Mechanism

Question No (As Survey)	Response	No of Respondents	New Variable	Dummy
Q.78 How profitable has your operation been in the past 2 years	1. Unprofitable 2. Break-even 3. Profitable 4. Prefer not to answer	554 out of 566	profit	1 = 2|3 0 = 1
Q.73 How would you describe your properties' overall environmental performance?	1. Very bad 2. Bad 3. Adequate 4. Good 5. Very Good 6. Don't know	559 out of 559	EnvPer	1 = 3|4|5 0 = 2
Q.80_2 What about the (input) price volatility over the past 2 years?	1. Much lower 2. Lower 3. About same 4. Higher 5. Much higher 6. Prefer not to answer	541 out of 562	IPVol	1 = 3|4|5 0 = 1|2
Q.81_2 What about the (output) price volatility over the past 2 years?	1. Much lower 2. Lower 3. About same 4. Higher 5. Much higher 6. Prefer not to answer	546 out of 563	OPVol	1 = 3|4|5 0 = 1|2
Q.83 How would you assess the overall financial situation of your operation	1. Very good 2. Good 3. Neutral 4. Bad 5. Very bad 6. Prefer not to answer	501 out of 562	FinC	1 = 1|2|3 0 = 4|5
Q.106 How do you feel about the regulations facing your property?	1. S Disagree 2. Disagree 3. Neutral 4. Reasonable 5. V Reas.	565 out of 565	Reg	1 = 3|4|5 0 = 1|2
Q.126 Gender	1. Male 2. Female 3. Others 4. Prefer not to answer	562 out of 565	Gen	1 = Male 0 = Female
Q.27 Firm Size	One option	583	FST	1 = >300 0 = <300
Another Option		581	F Size	1 = >200 0 = <200

Region	North / South	586	N	1 = N 0 = Not N/S
Q.127 Age	One option	578	Eld	1 = Age < 50 0 = Age > 50
Q.128 Experience on farms, forests, etc. after age 18	1. <1 Y 2. 1-2 3. 3-5 4. 6-10 5. 11-15 6. 16-20 7. 21-30 8. 31-40 9. 41-50 10. 51-60 11. 60+ 12. Prefer not to answer	585	ExpP	1 = Exp > 7 0 = Exp < 7

Empirical Methodology

A series of discrete dependent variable models,[3] particularly the Logistics, Probit[4] and Tobit has been employed to investigate the research question concerning the impact of environmental regulations on farm profitability depending on the distribution of the outcome variable. Logit and Probit models assume a non-linear relationship between the independent variables and the probability of the event occurring (i.e., the probability of the dependent variable being 1). They transform the output using a logistic function (Logit) or a cumulative normal distribution (Probit) to ensure that predicted probabilities lie between 0 and 1. The choice between these models often depends on convenience, as both produce similar results. The Logit model assumes a logistic distribution for the error terms, while the Probit assumes a normal distribution. The Tobit model is used when the dependent variable is censored, meaning that there is a portion of the observations for which the dependent variable is not fully observed, usually because it is limited or truncated at a certain threshold (e.g., non-negative values). As our survey data are mostly dummy variables, therefore we have used discrete dependent variable models for this analysis.

However, the logistic function may be appropriate for this analysis as it helps us with the optimal scaling of the categorical variable (Casacci and Pareto, 2015). The model helps estimate the likelihood and intensity of environmental adoption across different farms, considering the factors that influence environmental regulations adaptation, farm size, type of production, education level of the farmer, and access to relevant other information.

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[3] The general logistic function that is $p(y=1) = \frac{1}{[(1+\exp[-(\alpha+\beta_x x_1 + \ldots\ldots \beta_k x_k)]]}$ that generates probabilities range from 0 to 1 as the regression equations value from –∞ to +∞.

[4] The probit model follows a similar estimation approach as the logistic model but uses cumulative distribution function (CDF) from the standard normal distribution rather than the logistic distribution.

The logistic model can be specified as follows:

$C_{ij} = p(y_{i\leq j)}$=$\sum_{k=1}^{i} p(y_i = k)$ (1)

Where C_{ij} is a cumulative probability in the *j*th category, y_i is the latent variable representing the farm profitability.

This can be transformed into a cumulative logit as follows

$logit(C_{ij}) = \ln\left(\left(C_{ij}/(1 - C_{ij})\right)\right)$ (2)

The logistic model then estimates the cumulative logit as a linear function of the explanatory variables as represented by

$logit\left(C_{ij}\right) = \alpha_j - \beta x$ (3)

Where:

X_{1i}, X_{2i}, X_{ki} are the explanatory variables (e.g., regulatory environment and performance, farm size, type of farming, farmer's education level, experience, and access to information).

Results Discussions

Descriptive Statistics

Table 2 and Appendix Table A1 provide insights into various factors related to farm profitability, environmental performance, input price volatility, demographics, and education of the farmers. Below is a brief analysis of the descriptive statistics of the main variables:

Profitability

- The majority of farms (59.66 percent) are reported as profitable, while 27.86 percent break even, and 12.48 percent are unprofitable. This indicates that over half of the farms are financially viable, but there is a significant proportion (40.34 percent) facing financial strain.

Environmental Performance

- A large proportion of farms (53.5 percent) are rated as having a "Very good" environmental performance, with 37.26 percent being rated as "Good."
- Only 8.89 percent are categorized as "Adequate," and very few (0.34 percent) are considered "Bad" performers.
- Overall, farms seem to have strong environmental performance, with more than 90 percent of them receiving good to very good ratings.

Input Price Volatility

- Most farms (68.72 percent) have experienced "Much higher" input prices, and 25.81 percent report "Higher" prices. Only a small percentage (4.79 percent) report input prices staying "About the same."
- Very few farms have experienced "Lower" or "Much lower" input prices (both at 0.34 percent). The data suggests widespread concern about rising input costs.

Demographics

- **Gender**: The majority (79.83 percent) of respondents are male, indicating a gender imbalance in farm management.
- **Age**: The average age of respondents is 64.2 years, with a range from 24 to 88 years. This suggests that farm management is predominantly undertaken by older individuals, potentially raising concerns about succession planning.
- **Farm Size**: The average farm size is 431.37 hectares, but there is significant variability, with a maximum size of 19,017.8 hectares. A farm size dummy variable shows that 32.57 per cent of farms are larger than 300 hectares.

Education

- Education levels are spread across different categories. The most common education level is a Bachelor's degree (25.22 percent), followed by secondary schooling (19.44 percent) and diplomas (19.09 percent). A smaller percentage of farmers have Postgraduate qualifications (13.66percent), Master's degrees (4.73percent), and Doctorate (2.45percent).

The data suggests that the majority of farms are profitable and environmentally sound, though rising input prices are a significant issue for most farmers. Farms are predominantly managed by older, male farmers, with a wide range of farm sizes.

Table 2: Descriptive Statistics

	Variable	Obs	Mean	Std. dev.	Min	Max
Farm profitability	Profit	585	0.8256	0.3797	0	1
Environmental Performance	EnvPer	585	0.9521	0.2137	0	1
Input cost volatility	IPVol	585	0.9214	0.2694	0	1
Output Price Volatility	OPVol	585	0.8889	0.3145	0	1
Regulatory Burden	Reg	585	0.3949	0.4892	0	1
Gender	Gen	585	0.7675	0.4228	0	1
Age	eld	585	0.6598	0.4742	0	1
Region	N	585	0.6103	0.4881	0	1
CEO Experience	ExpP	585	0.7453	0.4361	0	1
Farm Size	FST	585	0.3402	0.4742	0	1
Financial Situation	FinC	585	0.8564	0.3510	0	1

Source: Author’s calculation

Simulations Results

Table 3 displays results from Logit, Tobit, and Probit models, analyzing the impact of different factors (including environmental performance) on farm profitability. The average marginal effect is shown in the Appendix Tables A2, A3 and A4. The coefficient for environmental performance is consistently positive and significant in all three models (Logit, Tobit, and Probit). This indicates that improved environmental performance significantly raises the probability or degree of higher profits across the three models. Consistency across the models emphasizes the significance of environmental performance in influencing farm profitability.

However, the results show that input cost volatility and output price volatility positively correlate with profitability. This could indicate that under certain conditions or with certain assumptions, farms might be able to manage volatility which needs to be investigated further. The results also show that there is no regulatory burden in any of the models, with small negative coefficients for Tobit and Probit. This is an inconsistency with the farm profitability mechanism. While CEO experience is associated with higher profits, consistent across all estimation techniques.

Table 3: Simulations results: Farm Profitability dependent variable

	Logit	Tobit	Probit
Environmental Performance	5.159	0.26	0.994
	(2.80)**	(3.35)**	(2.83)**
Input cost volatility	7.311	0.373	1.176
	(4.50)**	(5.71)**	(4.49)**
Output Price Volatility	3.865	0.221	0.777
	(3.82)**	(4.27)**	(3.71)**
Regulatory Burden	0.876	-0.017	-0.066
	-0.52	-0.6	-0.48
Gender	0.729	-0.029	-0.162
	-0.96	-0.84	-0.92
Age	0.715	-0.037	-0.19
	-1.15	-1.16	-1.21
Region	1.1	0.007	0.042
	-0.37	-0.25	-0.3
CEO Experience	1.933	0.076	0.364
	(2.20)*	(2.20)*	(2.22)*
Farm Size	1.472	0.041	0.207
	-1.4	-1.41	-1.41
_cons		0.016	-1.781
		-0.21	(4.38)**
var(e.profit)		0.11	
		(17.10)**	
N	585	585	585

Source: Author's calculation, Note: * $p<0.05$; ** $p<0.01$

Dealing with Endogeneity

The Logit, Probit, and Tobit estimates indicate that adequate environmental performance significantly influences farm profitability. To investigate whether environmental performance is an endogenous variable, we conducted an instrumental variable (IV) analysis using the financial situation of the firm as an instrument.[5]

We run 2SLS regression using the financial situation as an instrument. We conducted a first-stage performance test, which revealed a low partial R-squared value (0.041), indicating a low correlation between the environmental performance and the financial situation (Appendix Table A5). The F-statistic was high (24.5) compared to the critical value, suggesting that the instrumental variable is strong, and we rejected the null hypothesis (Ho: Instruments are weak).

We then run an endogeneity test where the null hypothesis of environmental performance is exogenous. The Durbin and Wu-Hausman p-value (p=0.000) is quite low, so we reject the null hypothesis (Appendix Table A5). This indicates that environmental performance is endogenous therefore a linear model is not enough for an efficient estimate.

Table 4: IV where financial situation is an instrumental variable

	Estimates
Environmental Performance	3.814
	(4.63)**
Input cost volatility	-0.601
	(2.30)*
Output Price Volatility	-0.231
	-1.53
Regulatory Burden	-0.142
	(2.10)*
Gender	-0.203
	(2.41)*
Age	0.024
	-0.35
Region	-0.147
	(2.06)*
CEO Experience	0.191
	(2.44)*
Farm Size	-0.002
	-0.03
_cons	-1.902
	(4.09)**
R^2	0.021
N	585

Source: Author's calculation,

[5] Endogeneity can arise from omitted variables, measurement errors, or simultaneity.

Table 4 shows the IV regression results. The positive and significant coefficient of environmental performance (3.8) suggests that better environmental performance leads to higher profitability. The strong significance implies that when farms improve their environmental performance, possibly through sustainable practices or meeting regulatory standards, they experience higher profitability.

Interestingly, input cost volatility is now negative and significant. The negative and significant input cost volatility coefficient (-0.6) indicates that higher volatility in input costs reduces profits. Farms facing fluctuating input prices may struggle with cost management, adversely impacting their profitability. However, the coefficient of output price volatility is not statistically significant. However, the regulatory burden coefficient is also a negative coefficient (-0.14) and significance at the 5 percent level suggests that higher regulatory burdens reduce profits. Compliance costs or restrictive regulations likely hinder profitability.

Concluding Remarks

To examine the framers perception of environmental regulations and its impact on farm profitability of agricultural farms in New Zealand, this study utilizes the 2023 SRDM data gathered by Manaaki Whenua - Landcare Research. A range of discrete dependent variable models have been utilized to explore the research question regarding the influence of environmental regulations on farm profitability.

An instrumental variable approach was employed to address potential endogeneity concerns regarding environmental performance. The analysis indicates that improved environmental performance significantly raises the likelihood of farm profitability. However, input cost volatility showed a negative and significant effect, indicating that rising input costs reduce profitability. Regulatory burden was found to negatively affect profitability, implying that compliance with environmental regulations imposes financial challenges.

The findings suggest that improved environmental practices are positively correlated with higher farm profitability, supporting the view that sustainable practices can benefit both the environment and economic outcomes. While input cost volatility negatively affects profitability, the regulatory burden showed mixed results. CEO experience also played a role in enhancing profitability. Overall, the research underscores the importance of balancing environmental regulations with economic sustainability to ensure long-term farm profitability. These results provide valuable insights for policymakers aiming to design regulations that support both environmental and economic goals in New Zealand's agricultural sector.

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Appendix Table A1. Frequency distribution of main variables

Profitability	Frequency	Percent
Break-even	163	27.86
Profitable	349	59.66
Unprofitable	73	12.48
Total	585	100

Environmental performance	Frequency	Percent
Adequate	52	8.89
Bad	2	0.34
Good	218	37.26
Very good	313	53.5
Total	585	100

Input price volatility	Frequency	Percent
About the same	28	4.79
Higher	151	25.81
Lower	2	0.34
Much higher	402	68.72
Much lower	2	0.34
Total	585	100

Appendix Table A2: Average marginal effects (logistic regression)

dy/dx	Delta-method Std.err	z	P>|z|	95 percent conf. interval	
0.181	0.064	2.830	0.005	0.056	0.306
0.219	0.047	4.710	0.000	0.128	0.310
0.149	0.038	3.910	0.000	0.074	0.224
-0.015	0.028	-0.520	0.604	-0.070	0.040
-0.035	0.036	-0.960	0.339	-0.106	0.036
-0.037	0.032	-1.150	0.251	-0.100	0.026
0.010	0.029	0.370	0.714	-0.046	0.066
0.073	0.033	2.200	0.028	0.008	0.137
0.043	0.030	1.400	0.162	-0.017	0.102

Source: Author's calculation

Appendix Table A3: Average marginal effects (Tobit regression)

dy/dx	Delta-method Std.err	t	P>|t|	95 percent conf. interval	
0.260	0.078	3.350	0.001	0.108	0.413
0.373	0.065	5.710	0.000	0.245	0.501
0.221	0.052	4.270	0.000	0.119	0.323
-0.017	0.029	-0.600	0.550	-0.073	0.039
-0.029	0.035	-0.840	0.399	-0.098	0.039
-0.037	0.032	-1.160	0.246	-0.100	0.026

0.007	0.029	0.250	0.807	-0.050	0.064
0.076	0.035	2.200	0.028	0.008	0.144
0.041	0.029	1.410	0.159	-0.016	0.098

Source: Author’s calculation

Appendix Table A4: Average marginal effects (Probit regression)

dy/dx	Delta-method Std.err	z	P>|z|	95percent conf. interval	
0.202	0.070	2.880	0.004	0.064	0.340
0.239	0.051	4.660	0.000	0.139	0.340
0.158	0.042	3.780	0.000	0.076	0.240
-0.013	0.028	-0.480	0.632	-0.068	0.042
-0.033	0.036	-0.920	0.356	-0.103	0.037
-0.039	0.032	-1.210	0.227	-0.101	0.024
0.009	0.029	0.300	0.762	-0.047	0.065
0.074	0.033	2.220	0.026	0.009	0.139
0.042	0.030	1.410	0.158	-0.016	0.101

Source: Author’s calculation

Appendix Table A5: Endogeneity Test

Tests of endogeneity H0: Variables are exogenous	
Durbin (score) chi2(1)	88.8966 (p=0.0000)
Wu-Hausman F(1,574)	102.855 (p=0.0000)

Minimum eigenvalue statistic = 24.3995

Critical Values # of endogenous regressors: 1

H0: Instruments are weak # of excluded instruments: 1

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--------------------------------------------------------------------
|  5%   10%   20%   30%
2SLS relative bias                 |      (not available)
----------------------------------- +--------------------------------
|  10%   15%   20%   25%
2SLS size of nominal 5% Wald test |  16.38   8.96   6.66   5.53
LIML size of nominal 5% Wald test |  16.38   8.96   6.66   5.53
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