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Farm Context and Farmers' Perceptions of the Compatibility, Complexity and Relative Advantage of Innovations

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Abstract

Agriculture is under increasing pressure to change practices and technologies due to climate change, market forces and community pressures. The strongest influences on farmers' adoption of practices and technologies are their perceptions of the relevant benefits and costs. Differences in the fine-grained characteristics of farm systems can lead to diversity in farmers' perceptions. Where this is the case, the rate of adoption is best increased through product development rather than promotion. The extent to which differences in the characteristics of farm systems translate into diversity in farmers' perceptions of innovations has rarely been explored. Our purpose was to investigate whether the diversity in farmers' perceptions of practices correlated with fine-grained differences in the characteristics of their farm systems using survey data on four management practices used by livestock farmers in New Zealand. We found that the diversity in farmers' perceptions did correlate with subtle differences in a variety of characteristics of farm systems. This result has important implications for research, extension and policy.

Keywords: adaptation; adoption; farm systems; agricultural policy; agricultural extension; natural resource policy; agricultural innovation

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1. Introduction

The literature on the adoption of new technologies and management practices in agriculture is replete with studies motivated by a desire to understand why farmers do not adopt technologies and practices that would seem to benefit them in relation to improving productivity [1–10] and adapting to climate change [11,12]. There is a consensus in this literature that the strongest influence on farmers' adoption of practices and technologies is, to put it as simply as possible, their perception of the relevant benefits and costs. There is also a consensus that these perceptions are diverse. This leads, almost inevitably, to the conclusion that the penetration and rate of adoption of practices and technologies may be modified by changing farmers' perceptions.

This conclusion implies any of the following:

- That farmers are unaware of a practice or technology;
- That they are aware of a practice or technology but are misinformed about it;
- That they are aware and informed but misunderstand a practice or technology.

Awareness may be raised through promotion, while misinformation may be corrected through promotion and extension activities. Whether the adoption of practices and technologies is hampered because misunderstanding is widespread is unclear. For

misunderstanding to hamper the adoption of a practice or technology requires that farmers, despite possessing the appropriate information, err in the inferences they draw about any of the following [13]:

- The relative advantage a practice or technology offers;
- The compatibility of a practice or technology with their needs;
- The complexity of a practice or technology.

It is apposite to bear in mind that relative advantage, compatibility and complexity are inter-related.

Cowan et al. [14] argued that farmers are managers of open, complex systems and that these systems are subject to random, erratic perturbations because of unpredictable variable seasonal conditions and product prices, which can threaten the livelihood of farmers and their families. These circumstances are a powerful motivation for farmers to regularly scan for practices and technologies that offer the promise of contributing to the achievement of their objectives, and to engage in extensive information searches about those practices and technologies that do seem promising. This means that farmers' decisions about adopting practices and technologies are subjectively rational, a view that is consistent with, though often implicit in, the literature (Sneddon et al. [15] is a rare exception).

It also means that, to the degree that relative advantage, compatibility and complexity are influenced by the observable characteristics of farm systems, farmers' perceptions of them should correlate with those characteristics. Consequently, the differences in the characteristics of farm systems that influence perceptions of the benefits and costs associated with adopting a practice or technology may provide, in part, an explanation for the variation that is observed in farmers' perceptions of the benefits and costs of practices and technologies.

The greater the degree to which the variation in farmers' perceptions of a practice or technology can be ascribed to differences in the relevant characteristics of farm systems, the smaller the potential will be for promotion and extension activities to promote their adoption, and the potential for product development (tailoring the features of practices and technologies to better fit diverse farm systems) to promote their adoption will be correspondingly greater. Relatedly, to the degree that farmers' perceptions are influenced by characteristics of farm systems that are not obvious to subject experts (e.g., the extant mix of technologies), the greater the potential for farmers' perceptions to differ from those of experts (see Halbrendt et al. [16], for example).

The extent to which the variation in farmers' perceptions is attributable to differences in relevant characteristics of their farm systems is, then, of fundamental importance when it comes to formulating strategies to promote the adoption of new practices or technologies. Yet, for the most part, the uniform, objective nature of farmers' perceptions of relative advantage, compatibility and complexity of new practices and technologies has largely been taken as a given. The extent to which these perceptions correlate with the variety in the status of relevant characteristics of farm systems has only occasionally been systematically investigated (for example, see [16–18]).

Relatedly, an increasing number of studies have identified associations between the perceived complexity of practices and technologies and their adoption [19]. Rarely, it seems, have these studies sought to identify the extent to which the variations in these perceptions are rooted in the characteristics of farm systems. Often the explanation for the variation in perceptions is thought to lie in differences in farmers' demographic or psychographic characteristics; access to extension services; or differences in coarse farm characteristics, such as scale, region or production system [13,16,19].

In this paper we investigate the extent to which variability in farmers' perceptions of relative advantage, compatibility and complexity of practices and technologies correlate with differences in the characteristics of their farm systems.

Crouch [20] observed that the decision to change a practice or technology is often a matter of practical sense, as the potential to modify practices is restricted by resource constraints, management strategies and the portfolio of technologies and practices that have already been adopted. These combine to create path dependencies, which strongly restrict the choices for change when it comes to systems as complicated as farm systems [21]. Often the presence of path dependencies means that the decision to change is often a simple matter of elimination rather than optimisation based on finely balanced criteria [17]. This implies that differences in farmers' perceptions of the relative advantage, compatibility and complexity of practices or technologies are not due to fine-grained differences in their interpretation of information about the practices or technologies, nor to marginal differences in their personal traits, such as innovativeness or risk aversion. Rather, it implies that differences in farmers' perceptions should be associated with qualitative differences in either their aspirations and objectives or the characteristics of their farm systems.

As an aside, the presence of path dependencies means that farmers can safely employ heuristics, such as elimination-by-aspects [22], when deciding if a practice or technology is a candidate for adoption. Consequently, practices and technologies may be appropriately and efficiently eliminated from consideration based on limited information about them.

Path dependence in farm systems [20,21] also suggests that, in addition to being conceptually connected, assessments of the relative advantage, compatibility and complexity of practices are likely to be influenced by overlapping sets of farm system characteristics. Consequently, we propose that actual and perceived variations in the relative advantage, compatibility and complexity associated with a proposed practice or technology should be associated with differences in a relatively small set of system characteristics. We term this subset of system characteristics the 'farm context' for adopting the practice or technology.

This reasoning suggests that farmers whose farm contexts are alike should be similar in their assessments of complexity, compatibility and relative advantage of practices or technologies, and that farmers whose farm contexts are different should be dissimilar in their assessments of these. Consequently, we expect the following:

1. Consistency in a farmer's assessments of complexity, compatibility and relative advantage of practices or technologies. This implies that, for each practice, a farmer's assessment of its complexity, compatibility and relative advantage should be correlated.
2. Consistency among farmers' assessments of complexity, compatibility and relative advantage of different practices and the relevant characteristics of their farm systems (i.e., inter-farmer consistency). That is, farmers' assessments of complexity, compatibility and relative advantage are correlated with the relevant characteristics of their farm systems.
3. Consistency in a farmer's assessment of the complexity, compatibility and relative advantage of different practices and adoption of them (i.e., intra-farmer consistency).

2. Materials and Methods

We tested our hypotheses using data from a survey of New Zealand farmers carried out by Kaine & Wright [17]. They elicited data on livestock farmers' perceptions and adoption of four widely adopted practices: fencing of wet areas, fencing of streams, planting cover crops and installing ungrazed buffers alongside laneways. These fencing practices apply to both dairy and drystock farmers, while cover cropping and laneway buffers are mostly relevant to dairy farmers. As these practices have been widely promoted and have been

adopted by a substantial proportion of farmers across New Zealand [17], we assumed that most farmers who have not adopted them are aware and have some knowledge of them.

Kaine & Wright [17] elicited farmers' perceptions about the relative advantage and complexity of each practice. They also elicited data on farmers' perceptions of the effect of adopting each practice on the availability of critical inputs. They interpreted this measure as an indicator of the compatibility of the practice with the farm system. They also collected data on the impacts of each practice on the architecture of the farm system, which was thought to influence perceptions of complexity and compatibility (see Kaine & Wright [17], for more detail).

In addition, they elicited farmers' perceptions about the nature of any tactical or strategic changes they made, or would have to make, to incorporate the practices into their farm systems. Tactical changes are adjustments to farm inputs to compensate for changes in access to critical inputs, such as pastures [14]. Strategic changes are modifications to the farm system to compensate for changes in access to critical inputs; they involve either completely reconfiguring the system (e.g., moving from conventional to organic production methods) or producing an entirely new output [17]. Note that the implementation of several or more tactical changes may mean that a farm system is, effectively, reconfigured. The scales for the relative advantage, complexity, compatibility and effects on the farm system architecture, tactical change and strategic change are reproduced in Tables S1 and S2 in the Supplementary Materials.

Respondents indicated their agreement with the statements in the scales measuring relative advantage, complexity, compatibility and effect on critical inputs using a five-point rating, from strongly disagree (1) to strongly agree (5). Scale scores were then computed for each respondent as the average of their ratings for the statements in each scale, following reverse coding of negatively phrased statements. The internal consistency of the scales was tested using Cronbach's alpha [23].

The respondents answered a series of questions, based on consultation with agricultural scientists and extension advisors, concerning the contextual characteristics of farm systems relevant to each practice (e.g., number of rivers and streams, nature and location of wet areas, accessibility of paddocks for cultivation in winter, etc.) (see Tables S3–S6 in the Supplementary Materials). They were also asked to provide information on their property area, numbers of livestock, regional location and the topography (e.g., flat, rolling, steep) of their property. The questionnaire received ethics approval through the Manaaki Whenua–Landcare Research human ethics committee process (social ethics approval number 2223/21).

The questionnaire was distributed, after pilot testing, by a commercial market research company to the farmer members of a commercial internet panel. The practices were presented to the panellists in random order and the panellists had the option of completing the questionnaire for one or two practices in return for rewards, in the form of a small gift card and a monetary donation to a charity of their choice [17]. Respondents were screened for having waterways and wet areas on their properties prior to being randomly allocated a practice. The questionnaires were distributed until 100 completed responses for each practice were obtained [17]. The survey commenced at the beginning of June 2024 and closed mid-July 2024, after 425 fully completed questionnaires had been received from 331 panellists [17]. Hence, 237 respondents completed the survey for one practice, and 94 respondents completed the survey for two practices.

The first and second hypotheses were tested by using linear regression analysis to estimate the parameters of the following regressions:

1. Architecture (dependent variable), with the farm context characteristics for each practice and regional dummy variables as the independent variables.

2. Complexity (dependent variable), with the architecture, the farm context characteristics for each practice and regional dummy variables as the independent variables.
3. Compatibility (dependent variable), with the architecture, the farm context characteristics for each practice and regional dummy variables as the independent variables.
4. Relative advantage (dependent variable), with the complexity, compatibility and the farm context variables for each practice and regional dummy variables as the independent variables.

The regional dummy variables were interpreted as capturing the effect of regional differences in climate, soils, production systems and regulatory controls. We originally included a dummy variable for farm type (dairy or drystock) but removed it from the analysis as it was not significant in any of the regressions.

To identify the smallest set of statistically significant explanatory variables, we used the Backwards regression procedure in SPSS Version 29 [24]. This procedure commences with the full set of explanatory variables and progressively eliminates all variables that are not statistically significant. Note that the procedure automatically eliminates variables that have a suppressor effect [25].

Regarding the third hypothesis, as there were six possible two-way combinations of the four practices, only a small number of respondents completed the questionnaire for each possible two-way combination. Consequently, we were forced to aggregate perceptions of relative advantage, complexity, compatibility and effect on architecture across the four practices. If farmers were consistent in their adoption behaviour, then we could expect that that respondents would have similar perceptions of both practices where both had been adopted. We could also expect that the respondents would have similar perceptions of both practices where neither practice had been adopted. Conversely, we could expect that the respondents' perceptions of the relative advantage, complexity, compatibility and effect on architecture of the practices would be dissimilar where only one of the practices had been adopted. These expectations were tested using paired samples *t*-tests available in SPSS Version 29 [24].

3. Results

Kaine and Wright [17] reported that the dairy farms in the sample were larger than the industry average, while the beef and sheep farms were smaller than the industry average. Although dairy farms were over-represented and drystock farms were under-represented in the sample, the overall distribution of farms was regionally representative (see Tables S7–S9 in the Supplementary Materials). The reliability of the scales was judged to be satisfactory [17]. See Tables S10 and S11 in the Supplementary Materials for a statistical summary of the key data.

3.1. Hypothesis One

The parameter estimates for the regressions for each of the practices are reported in Tables 1–4. Overall, the results are satisfactory, with all the regressions being statistically significant and explaining a substantial proportion of the variance in respondents' perceptions of complexity, compatibility and relative advantage. An inspection of residual plots indicated they were normally distributed.

The influence of architecture on complexity, architecture on compatibility and the influence of complexity and compatibility on relative advantage are as expected, they are statistically significant and substantial for each practice. Hence, the results support the first hypothesis.

Table 1. Regression results for fencing wet areas.

	Dependent Variable			
	Architecture (n = 104)	**Complexity (n = 104)**	**Compatibility (n = 104)**	**Relative Advantage (n = 104)**
Architecture		0.613 ***	−0.713 ***	
Complexity				−0.434 ***
Compatibility				0.606 ***
Farm topography		0.299 ***		
Wet areas are scrubby		−0.230 **		
Wet areas are peatlands	0.307 ***		−0.135 *	0.173 **
Wet areas have poor soils			−0.149 *	
Wet areas are productive			−0.192 **	
Northland		−0.293 ***		
Auckland	0.376 ***	−0.285 ***		
Gisborne	0.238 **			
Otago	0.307 ***			
Adjusted R^2	0.31	0.44	0.62	0.67
F-Test significance	<0.001	<0.001	<0.001	<0.001

Notes: Values are standardised beta coefficients. * Denotes $p < 0.05$. ** Denotes $p < 0.01$. *** Denotes $p < 0.001$.

Table 2. Regression results for fencing streams.

	Dependent Variable			
	Architecture (n = 113)	**Complexity (n = 113)**	**Compatibility (n = 113)**	**Effect on Performance (n = 113)**
Architecture		0.709 ***	−0.852 ***	
Complexity				−0.470 ***
Compatibility				0.495 ***
Farm topography	0.359 ***		0.139 *	
Streams are low-lying		−0.122 *	-	
Streams are productive flats	0.202 *	−0.269 ***	0.113 *	
Streams are scrubby		−0.275 ***		
Streams dry out in summer	0.450 ***			0.219 **
Streams are flood-prone		0.146 *		
Streams never dry out	0.288 *			0.229 **
Northland	−0.221 **			
Bay of Plenty	−0.221 **			
Auckland		−0.177 **		
Hawkes Bay	−0.174 *			
Waikato	−0.271 ***			
Taranaki	−0.184 *	−0.194 **		
Wairarapa	−0.182 *			
Adjusted R^2	0.37	0.64	0.66	0.68
F-Test significance	<0.001	<0.001	<0.001	<0.001

Notes: Values are standardised beta coefficients. * Denotes $p < 0.05$. ** Denotes $p < 0.01$. *** Denotes $p < 0.001$.

Table 3. Regression results for cover crops.

	Dependent Variable			
	Architecture (n = 100)	**Complexity (n = 100)**	**Compatibility (n = 100)**	**Effect on Performance (n = 100)**
Architecture		0.316 ***	−0.622 ***	
Complexity				−0.506 ***
Compatibility				0.474 ***
Too cold to germinate before September		0.494 ***		
Only plant on flat land		−0.188 *	−0.228 ***	
Have sediment traps to catch runoff		0.217 **		0.267 ***
Too wet to plant before August	0.362 ***	0.223 *	−0.248 ***	

Table 3. *Cont.*

	Dependent Variable			
	Architecture (n = 100)	**Complexity (n = 100)**	**Compatibility (n = 100)**	**Effect on Performance (n = 100)**
Plant different paddocks in successive years	−0.190 *			
Paddocks for winter forage crops are bordered by grass buffer strips			−0.154 *	
Northland	0.316 ***	−0.170 *		
Auckland	0.366 ***	−0.183 *	0.221 **	
Hawkes Bay	−0.215 **			
Taranaki		−0.194 **		
Wellington	0.218 **	−0.188 **		
Tasman	0.203 *			
Adjusted R^2	0.40	0.46	0.59	0.58
F-Test significance	<0.001	<0.001	<0.001	<0.001

Notes: Values are standardised beta coefficients. * Denotes $p < 0.05$. ** Denotes $p < 0.01$. *** Denotes $p < 0.001$.

Table 4. Regression results for laneway buffers.

	Dependent Variable			
	Architecture (n = 108)	**Complexity (n = 108)**	**Compatibility (n = 108)**	**Effect on Performance (n = 108)**
Architecture		0.491 ***	−0.808 ***	
Complexity				−0.382 ***
Compatibility				0.609 ***
Races in low-lying areas		−0.187 *	0.190 ***	0.120 *
Races prone to pugging or flooding		−0.212 *		
Good productive soils along some races	0.225 **			
Some races have a steep drop down to a waterway	0.329 ***		−0.149 **	
Some races that run alongside drains			−0.126 *	
Northland		0.316 **		0.092 *
Auckland	0.336 ***			0.220 ***
Waikato		0.208 *		
Hawkes Bay				0.091 *
Tasman			−0.121 *	
Canterbury				0.092 *
Southland				0.094 *
Adjusted R^2	0.34	0.27	0.75	0.80
F-Test significance	<0.001	<0.001	<0.001	<0.001

Notes: Values are standardised beta coefficients. * Denotes $p < 0.05$. ** Denotes $p < 0.01$. *** Denotes $p < 0.001$.

3.2. Hypothesis Two

An inspection of Tables 1–4 reveals that, for each practice, a mix of farm context and regional variables contributes to explaining the differences in respondents' perceptions of the effect of fencing wet areas on farm system architecture and relative advantage, the complexity of the practice and its compatibility with their farm system.

The farm context variables at play with respect to fencing wet areas were respondents' judgements about the topography of their properties and whether the wet areas on their properties were scrubby, were productive or had poor soils or were peatlands (Table 1).

The relevant variables in the farm context for fencing streams were respondents' judgements about the topography of their properties and whether the streams on their properties were scrubby, low lying, flood prone, were productive flats, never dried out or only dried out in summer (Table 2).

The farm context variables relevant to planting cover crops after winter grazing were respondents' judgements about whether it was too wet to plant crops before August; too cold for crops to germinate before September; and whether they only planted winter forage crops on flat land, planted different paddocks to winter forage crops in successive years, had sediment traps to catch runoff or their winter forage crops were bordered by grass buffer strips (Table 3).

The relevant variables in the farm context for installing ungrazed buffers alongside laneways were whether the races were in low-lying areas, prone to pugging or flooding, had a steep drop down to a waterway and whether there were good productive soils along some races or if they were bordered by drains (Table 4).

For the most part, the direction of influence the farm context variables had on the architecture, complexity, compatibility and relative advantage are plausible (see Section 4 for detail). Hence, we concluded the results support the second hypothesis.

3.3. Hypothesis Three

An inspection of Tables 5–8 reveals that, where respondents had adopted two practices, they had similar perceptions of the complexity, compatibility and relative advantage of each practice and the effect of each practice on their farm system architecture. The same was the case where respondents had not adopted either practice. In contrast, where respondents had adopted one practice but not the other, they had significantly different perceptions of the complexity, compatibility and relative advantage of each practice and the effect of each practice on farm system architecture. These results are consistent with the hypothesis that farmers are consistent in their assessment of the complexity, compatibility and relative advantage of different practices and their adoption of them.

Table 5. Summary of paired samples *t*-tests for effect of practice on farm architecture.

	Adopted Both Practices (n = 36)	**Adopted One Practice (n = 40)**	**No Practice Adopted (n = 18)**
Paired correlations	0.88 ***	0.51 ***	0.80 ***
Mean difference	0.03	−0.49 ***	−0.16
Effect size [a]	0.07	−0.57	−0.29
	(−0.10, 0.15)	(−0.90, −0.23)	(−0.76, 0.19)

Notes: *** Denotes $p < 0.001$. [a] The values in parentheses are the lower and upper estimates of the 95% confidence interval for the effect size. Note that only 94 respondents completed the survey for two practices.

Table 6. Summary of paired samples *t*-tests for complexity of practices.

	Adopted Both Practices (n = 36)	**Adopted One Practice (n = 40)**	**No Practice Adopted (n = 18)**
Paired correlations	0.78 ***	0.21	0.70 ***
Mean difference	0.06	−0.92 ***	0.20
Effect size [a]	0.13	−0.90	0.24
	(−0.19, 0.46)	(−1.27, −0.53)	(−0.23, 0.70)

Notes: *** Denotes $p < 0.001$. [a] The values in parentheses are the lower and upper estimates of the 95% confidence interval for the effect size. Note that only 94 respondents completed the survey for two practices.

Table 7. Summary of paired samples *t*-tests for compatibility of practices.

	Adopted Both Practices (n = 36)	**Adopted One Practice (n = 40)**	**No Practice Adopted (n = 18)**
Paired correlations	0.88 ***	0.34 *	0.75 ***
Mean difference [a]	0.13	0.59 ***	0.31 *
Effect size [a]	0.33	0.55	0.51
	(−0.01, 0.66)	(0.21, 0.88)	(0.01, 0.99)

Notes: * Denotes $p < 0.05$. *** Denotes $p < 0.001$. [a] The values in parentheses are the lower and upper estimates of the 95% confidence interval for the effect size. Note that only 94 respondents completed the survey for two practices.

Table 8. Summary of paired samples *t*-tests for relative advantage of practices.

	Adopted Both Practices (n = 36)	Adopted One Practice (n = 40)	No Practice Adopted (n = 18)
Paired correlations	0.83 ***	0.37 *	0.87 ***
Mean difference [a]	0.02	0.68 ***	0.06
Effect size [a]	0.05 (−0.28, 0.38)	0.81 (0.45, 1.16)	0.16 (−0.31, 0.62)

Notes: * Denotes $p < 0.05$. *** Denotes $p < 0.001$. [a] The values in parentheses are the lower and upper estimates of the 95% confidence interval for the effect size. Note that only 94 respondents completed the survey for two practices.

4. Discussion

The results support the proposition that farmers' judgements about the complexity and compatibility of technologies and practices, and the relative advantage they offer, are based on understanding how well a technology or practice will integrate into their individual farm system. This understanding is based, strongly, on farmers' observations of the presence or absence of relevant characteristics in their farm system. We use 'strongly' because of the good explanatory power of the regressions, bearing in mind that the set of farm system characteristics in the analyses are unlikely to be comprehensive, and that the analyses did not include factors that might delay adoption.

The results indicate that a mix of several system characteristics may influence the perceived complexity, compatibility and relative performance of practices and technologies. This means that the task of tracing the network of consequences arising from adopting a practice or technology, and subsequently assessing the complexity, compatibility and relative performance of practices and technologies, can be quite complicated. This is illustrated in the following.

4.1. Fencing Wet Areas

With respect to a practice that appears superficially simple, like fencing wet areas, we found that the characteristics of wet areas, together with farm topography, directly or indirectly influenced respondents' perceptions of the following:

- The effect fencing would have on managing the various farm subsystems (architecture);
- The complexity and compatibility of fencing wet areas;
- The relative advantage offered by fencing wet areas.

To begin with, the respondents judged the effect of fencing wet areas on the management of farm subsystems (architecture) to be greater if the wet areas on their farms were peatlands. Where this was the case, respondents' assessments of the complexity of the practice were raised and their assessments of its compatibility and relative advantage were lowered.

Respondents' assessments of the complexity of fencing wet areas increased the more their properties consisted of rolling or steep country. Where this was the case, respondents' assessments of the relative advantage offered by the practice were lowered. By contrast, respondents' assessments of the complexity of fencing wet areas were reduced if wet areas were scrubby or unproductive. Where this was the case, respondents' assessments of the relative advantage offered by the practice were raised.

Respondents' perceptions of the compatibility of fencing wet areas were lowered if the wet areas on their farms were peatlands, were productive or had poor soils. The latter result may be due to the possibility that wet areas may often be incorporated into laneways. The Pearson correlation between wetlands having poor soils and the belief that fencing would severely restrict movement around the property was 0.27 ($p < 0.05$). Where this

was the case, respondents' assessments of the relative advantage offered by the practice were lowered.

Lastly, while respondents thought that fencing wet areas would be more complex and less compatible if wet areas were peatlands, they also thought that fencing them would increase the relative advantage of the practice. This may be partly because fencing wet areas on peatlands was strongly correlated with improving environmental performance. The Pearson correlation between wetlands being peatlands and the belief that fencing would generate a substantial improvement in environmental performance was 0.20 ($p < 0.05$).

4.2. Fencing Streams

The respondents judged the effect of fencing streams on the management of farm subsystems (architecture) to be greater if the streams were on productive flats, never dried out or only dried out in summer. Respondents also judged the effect of fencing streams on the management of farm subsystems (architecture) to be greater if properties consisted of rolling or steep country. In these circumstances, respondents' assessments of the complexity of the practice were raised and their assessments of its compatibility and relative advantage were lowered.

Respondents' assessments of the complexity of fencing streams increased if their streams were flood prone. Where this was the case, respondents' assessments of the relative advantage offered by the practice were lowered. By contrast, respondents' assessments of the complexity of fencing wet areas were reduced if the streams were on low-lying land, on productive flats or on scrubby or unproductive land. In these circumstances, respondents' assessments of the relative advantage offered by the practice were raised.

Respondents' perceptions of the compatibility of fencing streams were raised if the streams were on productive flats and increased if their properties consisted of rolling or steep country. Where this was the case, respondents' assessments of the relative advantage offered by the practice were raised. The result with respect to farm topography appears to be an artefact of the strong correlation between farm topography and the effect of fencing streams on farm architecture. The Pearson correlation between the farm topography and effect on architecture was 0.33 ($p < 0.01$). The implication here is that the effect of changes to farm architecture on compatibility is smaller when fencing streams on properties that consist of steeper country compared to properties consisting of flatter country.

The result regarding streams on productive flats may be due to an interaction between system characteristics and farm topography. The Pearson correlation between farm topography and streams on productive flats was -0.25 ($p < 0.01$). The implication here is that the effect of changes to farm architecture on compatibility is smaller when fencing streams on productive flats compared to properties consisting of rolling country.

Put another way, these results suggest that the effect of changes to farm architecture on compatibility is greatest when fencing streams in rolling country and somewhat less for streams on productive flats or streams on steeper country.

Lastly, while respondents thought that fencing streams would have a greater effect on the management of farm subsystems, if the streams never dried out or dried out in summer, the resulting depressing effect on the relative advantage (of the associated increased complexity and reduced compatibility) of the practice was offset to a degree, because they also thought that fencing these streams would directly increase the relative advantage of the practice. Regarding streams that never dry out, this may be partly because fencing these streams may improve livestock management and would not affect feed management. The Pearson correlation between having streams that never dry out and the statements that fencing streams would severely restrict livestock management and

not needing to make any changes to feed management was −0.19 ($p < 0.05$) and 0.30 ($p < 0.01$), respectively.

The result with respect to streams that dry out in summer appears to be an artefact of the strong correlation between having streams that dry out in summer and architecture, complexity and compatibility. The Pearson correlation between having streams that dry out in summer and farm architecture, complexity and compatibility was 0.32 ($p < 0.01$), 0.20 ($p < 0.05$) and −0.35 ($p < 0.01$), respectively. The implication here is that the effect of complexity and compatibility on relative advantage is smaller when fencing streams that dry out in summer compared to fencing streams that do not dry out.

4.3. Cover Crops

On one hand, respondents judged the effect of planting cover crops after winter grazing on the management of farm subsystems (architecture) to be greater if they believed their farms were too wet to plant a cover crop in August. Where this was the case, respondents' assessments of the complexity of the practice were raised and their assessments of its compatibility and relative advantage were lowered. On the other hand, respondents judged the effect of planting cover crops after winter grazing on the management of farm subsystems (architecture) to be smaller if they planted different paddocks to winter forages in successive years. Where this was the case, respondents' assessments of the complexity of the practice were lowered and their assessments of its compatibility and relative advantage were raised.

Respondents' assessments of the complexity of planting cover crops after winter grazing were increased if they believed that their farms were too wet to plant a cover crop in August, the climate was too cold for germination to occur before September, or they had sediment traps to catch runoff. Where this was the case, respondents' assessments of the relative advantage offered by the practice were lowered. In contrast, respondents' assessments of the complexity of planting cover crops after winter grazing were reduced if they would be planting flat land. Where this was the case, respondents' assessments of the relative advantage offered by the practice were raised.

Respondents' perceptions of the compatibility of planting cover crops after winter grazing were lowered if they believed that their farms were too wet to plant a cover crop in August, or they planted winter forage crops on flat land or paddocks bordered by grass buffer strips. Where this was the case, respondents' assessments of the relative advantage offered by the practice were lowered.

While respondents thought that having sediment traps to catch runoff increased the complexity of planting cover crops after winter grazing, they also thought having sediment traps would increase the relative advantage of the practice. This was, presumably, because planting a cover crop would reduce the magnitude and frequency of sediment losses, thereby improving the effectiveness of the traps.

4.4. Laneway Buffers

Respondents judged the effect of installing ungrazed laneways on the management of farm subsystems (architecture) to be greater if their laneways were bordered by good soils or steep drops to waterways. Where this was the case, respondents' assessments of the complexity of the practice were raised and their assessments of its compatibility and relative advantage were lowered.

In contrast, respondents' assessments of the complexity of installing ungrazed laneways were reduced if laneways were in low-lying areas or prone to pugging or flooding. Where this was the case, respondents' assessments of the relative advantage offered by the practice were raised. Respondents' perceptions of the compatibility of installing ungrazed

laneways were raised if the laneways were in low-lying areas. This also raised assessments of the relative advantage the practice offered.

Kaine and Wright [17] pointed out that tactical (input-related) or strategic (output-related) modifications to a farm system may be necessary to enable the integration of a new practice or technology into the farm system. The nature of such modifications will, inevitably, be influenced by the farm context, which further compounds the challenge of evaluating the consequences arising from adopting a practice or technology (see Tables S12–S15 in the Supplementary Materials).

4.5. Implications for Farm Extension

Our findings have several implications for farm extension in the fields of agriculture and natural resource management. First, given that farmers' judgements about the complexity and compatibility of technologies and practices, and the relative advantage they offer, are based on understanding how well a technology or practice will integrate into their farm system and, given the potential complexity of the reasoning underpinning farmers' perceptions, extension professionals must be exceedingly cautious in questioning the validity of those perceptions [26]. There is every possibility that less experienced extension professionals themselves are making judgements about the suitability of practices and technologies based on an inadequate appreciation of the consequences of their adoption [27].

By the same token, less experienced extension professionals must be exceptionally careful in attributing any differences of opinion they may have with farmers about the suitability of a practice or technology to a lack of awareness, an acceptance of partial or incorrect information or errors in processing information on the part of farmers. The same applies when there are differences of opinion between researchers and farmers [16].

That the suitability of practices and technologies is influenced by several, if not more, idiosyncratic characteristics of farm systems means that farmers' perceptions of the suitability of practices and technologies are likely to be better grounded than the perceptions of researchers and extension professionals. By 'idiosyncratic', we mean that the relevant characteristics are peculiar to a particular practice or technology. This means that differences in perceptions should stimulate researchers and extension professionals to examine their beliefs and to seek to discover what they may be missing rather than presuming the validity of their perceptions and moving immediately to trying to persuade farmers to change their opinions [27,28].

The results indicate that, when practices or technologies offer some promise, farmers engage in sophisticated, in-depth reasoning when tracing the network of consequences arising from adopting a practice or technology and, subsequently, assessing the complexity, compatibility and relative performance of practices and technologies (and the potential need for tactical or strategic changes to the farm system). This implies that farmers' perceptions about the suitability of a complex practice or technology should (appropriately) be exceptionally difficult to change (see [27,29], and contrast these with [30]).

Relatedly, these results indicate that farmers must be considered and careful in drawing inferences about the suitability of practices and technologies for their farm systems from the experiences of other farmers [31,32]. The lessons that can be learned from the experiences of other farmers will depend on the similarity in the relevant characteristics of farm systems. This sounds a note of caution in attempting to draw inferences about the potential for social norms to influence the adoption of practices and technologies by farmers [33]. The same might be said for making comparisons between commercial farms and demonstration or research farms about the suitability of practices and technologies [34,35].

Given that the usefulness of the experiences of other farmers in evaluating practices and technologies is contingent on their farm systems having similar relevant characteristics,

the effectiveness of group learning and group collaboration in promoting the adoption of practices and technologies will be influenced by the number of system characteristics that are relevant. The greater the number, the greater the variety in farm contexts will be and the narrower the scope for group learning and group collaboration to promote adoption; unless there is a process to clearly articulate the system characteristics that are relevant, and the ways in which they combine to influence complexity, compatibility and relative advantage [36].

4.6. Implications for Agricultural Research

The points made above regarding differences of opinion between extension professionals and farmers also apply to differences of opinion between researchers and farmers about the suitability of practices and technologies [12,16,37].

The sophisticated, in-depth reasoning required to trace the network of consequences arising from adopting a practice or technology and making assessments about the complexity, compatibility and relative performance of it, and the need for tactical or strategic changes to a farm system, means the task of improving the suitability of a practice or technology may be quite challenging; in fact, the exercise may be intrinsically problematic. The greater the number of system characteristics that influence the suitability of a practice or technology, the greater the diversity in farm contexts and, correspondingly, the greater the need to customise the practice or technology. The subtlety and tacit character of knowledge owned by the manager of each idiosyncratic farm system places increasing demands for informed, purposeful probing and clear communication between farmers, extension professionals and researchers (for example, see Wilson et al. [38] and Findlater et al. [39]).

The fact that several characteristics of farm systems may influence the complexity, compatibility and relative advantage of practices and technologies means that tracing these influences may require quite sophisticated reasoning about the causal pathways in these complicated systems. Given this context, and that these characteristics of interest are idiosyncratic and may not be obvious to observers, it should not be surprising that farmers are hesitant, or fail, to adopt practices and technologies that appear to others to be beneficial, and that the reasons for this failure are not readily apparent or understood [34]. This may help explain the apparently variable or low rates of adoption of seemingly important complex technologies, such as precision agriculture and practices related to climate adaptation [40–44]. It may also help explain the inconsistent, and often conflicting, results of adoption studies [45,46] and sounds a note of caution in attempting to draw inferences about the adoption of practices and technologies based on coarse characteristics of farm systems and broad characterisations of farmers' motivations [33,47].

4.7. Implications for Agricultural and Natural Resource Management Policy

An important implication of our results is that they help explain why some, but not all, farmers may strongly resist the imposition of regulations compelling the adoption of certain practices or technologies. Given that differences in relevant characteristics of farm systems give rise to considerable differences in the complexity, compatibility and relative advantage of practices and technologies, regulations compelling the adoption of a practice or technology will have differential implications for farmers. This means that the motivation to challenge such regulations will vary among farmers, and the reasoning underpinning such challenges will be varied and nuanced (and may not be well understood by policy advisors, be they public servants or industry representatives).

Another implication of our results is that they help explain why most, if not all, farmers value autonomy in decision making and prefer performance-based regulation to practice-based regulation. The former allows farmers the flexibility to exercise autonomy in

deciding the most suitable means of complying with a regulation, whereas the latter does not [48,49]. Given that farmers themselves are in the best position to judge the suitability of practices and technologies, they are more likely than researchers, extension professionals or policy advisors to identify least-cost solutions to meeting performance standards.

Our results show that farmers' perceptions of the complexity, compatibility and relative advantage of farming practices and technologies depend, appropriately, on pertinent characteristics of their farm systems. Our results also indicate how tracing the effects of these characteristics can require sophisticated reasoning about the complicated, causal pathways within farm systems. Hence, the framework for describing and classifying change proposed by Kaine & Wright [17] offers a window into the subtle, tacit world of changing farming practices and technologies. Consequently, it could be a tool that researchers, extension professionals and policy advisors might usefully employ to interact with, and so learn from, farmers about the value of practices and technologies.

4.8. Limitations and Future Research

Our results are subject to some qualifications. One is that the lists of system characteristics that might influence the suitability of the practices we investigated are unlikely to be comprehensive as they were based on reviews of the literature and discussions with experts. The statistical significance of the regional dummy variables in the regressions suggests that there are geographically related characteristics of farm systems that influence farmers' perceptions that we have not explicitly identified. This qualification does not change the central findings but will affect the details. Relatedly, there may be factors (such as personality traits) that influence farmers' perceptions that are not farm system characteristics but may be correlated with them. If this is the case, then the influence of farm system characteristics on farmer perceptions may be over-estimated. Determining whether there are such factors deserves study.

Another qualification is that we could not compare farmers' perceptions with observations obtained, for example, by detailed analyses of individual farms or farm trials [3]. Such comparisons would assist in testing our contention that farmers' perceptions of the suitability of practices and technologies are appropriately grounded in relevant characteristics of their farm systems. This is an area that merits future research.

A third qualification is that our reliance on regression analyses of survey data means that we could not explicitly illustrate the actual diversity in farm contexts associated with the practices we investigated. In this regard, market segmentation studies linking relevant characteristics of farm systems with farmers' perceptions and behaviours, such as adoption [50,51], would be valuable. Such studies would assist in validating our findings and providing a useful means, from product development and promotion perspectives, of identifying and describing diversity in farm contexts associated with practices and technologies.

5. Conclusions

We found that variability in farmers' perceptions of relative advantage, compatibility and complexity of different practices and technologies correlated with differences in the characteristics of their farm systems. Our results indicate that a mix of system characteristics appropriately influences these perceptions. This means the task of tracing the network of likely consequences arising from adopting a practice or technology, and subsequently assessing their resulting complexity, compatibility and relative performance, can be quite complicated and challenging. It also means that the consequences arising from adopting a practice or technology cannot be inferred from the coarse characteristics of farm systems, and that farmers' perceptions of the suitability of practices and technologies are likely to be better grounded than the perceptions of researchers and extension professionals.

This has important implications for research, extension, agricultural policy and natural resource policy.

Two limitations of our study are that the sets of farm system characteristics we investigated were unlikely to be comprehensive and that our analysis was based on farmers' self-reported perceptions. Testing our hypotheses with more comprehensive sets of farm system characteristics and comparing self-reports with data from farm trials are both areas for future research. Market segmentation studies linking the relevant characteristics of farm systems with farmers' perceptions and behaviours would also be valuable for validating our findings.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agriculture15171841/s1. Table S1: Examples of items in the architecture, complexity and compatibility scales; Table S2: Examples of items in the relative advantage, tactical change and strategic change scales; Table S3: Items in the farm context for fencing wet areas; Table S4: Items in the farm context for fencing streams; Table S5: Items in the farm context for cover crops; Table S6: Items in the farm context for ungrazed laneway buffers; Table S7: Sample statistics farm type; Table S8: Sample statistics region; Table S9: Sample statistics area and livestock numbers; Table S10: Summary statistics for key variables; Table S11: Adoption of farm practices; Table S12: Regression results for fencing wet areas; Table S13: Regression results for fencing streams; Table S14: Regression results for cover crops; Table S15: Regression results for laneway buffers.

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