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Ranking perceived risk to farmers: How important is the environment?

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Abstract

This study investigates the structure of farmers' risk perceptions in an arid area where agriculture faces many difficulties. Principal component analysis identified four components of risk from amongst twenty Likert scale items, including aspects of the natural and institutional environments. Index scores were created for each of the four components of risk, which were then explained using OLS regression. The intensity of perceived risk was inversely correlated with profitability of the farm enterprise. Management experience, time spent in nature and more education corresponded to perceptions of less risk, while risk increased with farm size, the presence of heirs, the severity of the 2011/2012 drought and the threat of jackal predation. More educated and experienced farmers, who are more profitable, were found to be more likely to be moderates, while those with heirs to succeed them and those with more intense jackal problems were more likely to be in the group with greater concerns. Four important results were found: 1) risk perceptions vary even within an apparently homogenous community, 2) economic factors dominate risk perceptions, 3) climate change concerns are crowded out by more immediate issues, and 4) coming to terms with predator management is a major concern.

Key words: Karoo; risk perceptions; climate change; predation; PCA; k-means cluster analysis

1. Introduction

Farmers have to contend with many sources of risk, which makes them naturally risk averse. Yield and price variability are arguably the most important areas of concern, but there are also climate risk, natural disasters, financial risk, regulatory constraints and the uncertainties around new technology (Barry *et al*. 1995; Martin 1996; Baquet *et al*. 1997). Patrick *et al*. (1985) reported on how some of these risks were ranked by American farmers, but did not explain the ranking. We now know that farmers' behaviour is affected by their risk perceptions (Beal 1996; Marra *et al*. 2003; Pannell *et al*. 2006; Størdal *et al*. 2007; Sattler & Nagel 2010). Multiple dimensions of perceived environmental risk are routinely examined in climate change studies, which sometimes even include prices (Weber 1997; Greiner *et al*. 2009; Barnes *et al*. 2013), but so far it seems that farmers have not yet been asked to rate climate risk relative to other risk factors.

Thus, the contribution of this paper is to re-examine the relative importance of the longer list of risk factors in Patrick *et al*. (1985) with updated empirical methods borrowed mostly from the climate change literature. The common approach in this literature is to summarise risk perceptions with

principal component analysis and then either to model the risk index scores directly or to model cluster membership based on the scores. Størdal *et al*. (2007) argue that owner characteristics and environmental factors combine to shape risk perceptions, which in turn first determine management strategies, and then actions. The main aim was to see how off-farm employment mediates risk perceptions and choices. Two sets of factor analyses extracted six risk components and four management strategies. A number of OLS and tobit models were used to model first risk perceptions, then management strategies and then actions. These started with farm and farmer characteristics, but then at each stage also included the main elements from the previous stage. Some components of risk were significant in the adoption models, but the explanatory power of the risk perception models themselves was virtually nil. Greiner *et al*. (2009) approached the adoption of best management practice in Australian dairy farming from the risk perception and motivation aspects. Two principal component analyses identified the main components of each, which were then correlated with adoption. While environmental motivation was found to correlate with the adoption of best management practice, it was not possible to demonstrate that risk perceptions and other (e.g. social or economic) motivations affected management actions. Barnes *et al*. (2013) examined risk perceptions in Scottish dairying with more success. Latent class cluster analysis identified three homogenous groups of farmers with measurably different profiles. Three logit models explained group membership with farm and farmer characteristics.

Our study was located in a small, tightly knit farming community in the Karoo region of South Africa, where the major threats are drought and predators. This region was chosen specifically to demonstrate that different risk perceptions exist even where views are expected to be homogenous. The Karoo is an area in decline, a circumstance that tends to make farmers more fearful. During the eighteenth and nineteenth centuries, wool exports from the Karoo contributed a large part of South Africa's early economic growth. Since the 1950s, however, the region's agricultural progress has fallen behind the rest of South Africa because its climate does not favour agricultural intensification (Thirtle *et al*., 1993; Conradie *et al*., 2009). Archer (2000) argues that early attempts to improve the system led to overgrazing, a claim supported by Hoffman's (2014) longitudinal studies of declining vegetation cover and carrying capacity. The result is an unprofitable and unproductive farming system, which uses few inputs besides land and labour (Conradie & Landman 2015; Conradie & Piesse 2015) and is vulnerable to climate change (Archer *et al*. 2008; Blignaut *et al*. 2009). These difficulties are made worse by rising energy costs in a weak economy, and by predation, which has been estimated to reduce output by 30% (Van Niekerk 2010). Our dataset also identified predation as the most important perceived threat to prosperity in the Karoo. The factors representing predation problems and predator control regulations scored 4.29 ± 0.96 and 4.03 ± 1.20 out of five respectively. On the other hand, the factors the farmers were least concerned about were the adequacy of support provided by the local cooperative, which scored 1.64 ± 0.97, and market access, which scored 2.01 ± 1.13 out of five.

The contribution of this paper is twofold: it investigates how farmers prioritise the environment compared to other sources of risk, and it is methodologically explicit about the ranking process. Section 2 gives a brief description of the data and methods, while Section 3 reports the results, identifies and explains the underlying dimensions of these farmers' risk perceptions, and profiles each case. This is an essential first step for understanding how to engage a vulnerable community about climate change and resource degradation.

2. Data and methods

2.1 Data collection

The data used in this study are from the farm management survey of an interdisciplinary study of predation on farmland in the Laingsburg district of the Central Karoo region of South Africa. The management survey was conceived as a four-wave panel study, which has been collecting data on various aspects of the farming system annually for the last four years. Wave 1, on the 2012 season, approached 66 farmers, of whom 60 agreed to be interviewed (91%) and 58 (88%) gave useable answers to most questions. The 37 000 sheep and goats on which this group reported amount to 78% of the small stock recorded for the district in the 2002 farm census (Statistics South Africa 2006). The average farmer in the sample was an Afrikaans-speaking male, who was 54 years old in 2012. The majority were married with children. Education varied from incomplete high school to university degrees, with a two-year agricultural diploma reported most frequently. The average farm was 7 374 hectares of Nama-Karoo vegetation, supporting 620 breeding ewes in 2012. Livestock contributed 80% of farm income and crops 20%. About 80% of household income derived from the farm, while 20% came from off-farm employment, including salaries and self-employment.

Wave 1 of the panel survey included a set of twenty questions that asked farmers to rate, on a five-point Likert scale, the seriousness of the threat posed by each factor to the survival of their farms. The labels used for the five categories were 1 = no threat, 2 = slight threat, 3 = threat, 4 = serious threat and 5 = severe threat, which is similar to the scale used in Patrick *et al*. (1985). The items concerned with regulation were labour laws in general, environmental laws in general, predator control regulation, statutory minimum wage regulations, the Extension of the Security of Tenure Act (Act 62 of 1997) and land reform. Perceptions of labour market risk were proxied by questions on labour availability and unemployment. Market access, rising input prices, falling output prices, unpredictable exchange rates and the variability of output prices captured different dimensions of price risk. Crime was reflected by measures of stock theft and farm attacks, and environmental issues were represented by problems with predation, drought and climate change. Finally, perceptions of support for the sector were measured by views on the performance of the local cooperative and drought relief assistance. Martin (1996) and Musser and Patrick (2002) have used the same scale to rate a similar list of potential threats. Only 52 people completed all twenty items in the survey, which makes the conclusions presented here somewhat preliminary, although they are the first attempt to address all of these risk factors in a single study.

2.2 Analytical approach

The empirical analysis included factor analysis, econometric modelling and cluster analysis. Principal component factor analysis identified elements of risk perception with Eigen values of ≥ 1 according to Kaiser's criterion. A Kaiser-Meyer-Olkin test confirmed sampling adequacy (0.5924, barely adequate), while a scree plot revealed that four to six components should be retained. Akaike and Schwartz Bayesian information criteria compared factor analyses with different numbers of factors. Only four components could be extracted from these data, as the rest were Heywood cases.[1] The four retained components explained slightly less than 55% of the variance in the sample. Orthogonal (Kaiser's varimax) rotation was then applied to distinguish between relevant factors (with maximised loadings) and irrelevant factors (of which the rotated loadings were minimised after rotation). A cut-off value of 0.5 discriminated between relevant and irrelevant factors better than the customary cut-off value of 0.4, as several irrelevant factors presented with factor loadings

[1] A Heywood case occurs when the communalities, or squared correlations, approach one. In this study they were the result of trying to extract too many components with too little data.

of around 0.39. Each risk index was computed from the retained factors using rotated scores. The component scores were standardised to unity so that index values could be compared directly.[2] Missing observations were interpolated to maximise the sample size for the indices, which were then explained by a set of farm and farmer characteristics in regression models. Huber-White estimators produced robust standard errors. K-means cluster analysis clustered cases on the four risk indices plus two other important factors. This approach identified two groups of farmers whose risk perceptions differed significantly. Finally, a logit model was used to identify the intensity of risk perceptions.

3. Results

3.1 Dimensions of Karoo farmers' risk perceptions

The results of the principal component analysis are in Table 1. The results identified four underlying components of risk perception in this Karoo community. The figures in bold indicate risk factors that correlate strongly with a particular component of risk. The cases (rows) were those factors that the farmers identified originally, while the components (columns) were identified as a result of the co-variation in the dataset. As described above, a factor was considered relevant to a particular component if it presented with a loading of 0.5 or more. Once the relevant components were known, it was possible to construct scores from the underlying factor values for each observation in the sample. These scores were then explained by farm and farmer characteristics to uncover possible reasons for the attitudes that people hold. The results of this exercise are in Table 2.

The first underlying element of perceived risk was labelled institutional risk. In the period between 1948 and 1994, South Africa had a minority white rule. As soon as the first democratically elected government came to power, reforms to outdated and offensive apartheid laws were introduced. The agriculture sector was affected mainly by changes in the regulation of farm labour markets and the use of natural resources, including land. A land reform target of 30% black ownership was set, which was pursued by means of a willing buyer/willing seller policy of limited effectiveness (Lahiff 2007; O'Laughlin *et al*. 2013). Changes in environmental legislation included a reform of the process of water allocation and new environmental impact procedures for all changes in land use. None of this had much impact on the Karoo.

Two post-apartheid laws affected farm labour, namely the Extension of the Security of Tenure Act (Act 62 of 1997) and the Basic Conditions of Employment Act (Act 75 of 1997), which were expanded to included agriculture. Although the Conditions of Employment Act raised the cost of labour by introducing benefits such as paid leave, the impact on employment was small compared to that of the Tenure Act, which caused harm by creating the impression that it awarded permanent tenure rights to disgruntled former workers. To avoid having their land expropriated in this way, farmers resorted to increased mechanisation and outsourcing, which left Ewert and Du Toit (2005) to conclude that the legislation undermined instead of strengthened tenure security. The next major development in the regulation of farm labour markets was in March 2003, when a statutory minimum wage was introduced (Department of Labour 2002). Levels were initially set so that they did not affect the remuneration of regular male workers, although the wages of female farm workers went up by as much as 25% in certain cases (Conradie 2003), causing unemployment amongst women. For the next ten years, the statutory minimum wage remained virtually unchanged in real terms. However, in November 2012, when this Karoo survey was under way, a series of violent strikes erupted in the fruit sector, with workers demanding a doubling of the statutory minimum

[2] See the results section for details of index construction.

wage for agriculture. A 50% increase was eventually awarded in March 2013. Although the use of hired labour in the Karoo was already at a minimum, this increase caused total labour costs to farmers to increase by between 8% and 12% in the short term.

Table 1: Rotated factor loadings of selected principal components of the risk covariance matrix (n = 52)

	Latent components of risk perceptions			
	Component 1	**Component 2**	**Component 3**	**Component 4**
Individual risk factors	**Institutional**	**Price**	**Security**	**Environment**
Labour laws	**0.7256**	0.1605	0.0990	-0.0720
Tenure act	**0.7519**	0.3508	0.1649	-0.1035
Minimum wage regulations	**0.8410**	-0.0536	0.1736	0.1353
Environmental laws	**0.7599**	0.2831	0.0101	0.1322
Market access	0.0098	**0.6214**	0.3753	-0.1307
High input costs	0.1444	**0.6632**	0.1377	0.2985
Low output prices	0.0995	**0.8362**	-0.1269	-0.2129
Output price risk	0.3682	**0.7612**	-0.1197	0.1433
Land reform	0.3936	0.2933	0.4926	-0.2931
Farm attacks	0.0321	0.0077	**0.7992**	-0.0823
Unemployment	0.1849	-0.0266	**0.5749**	0.1606
Stock theft	0.1262	-0.1508	**0.7829**	0.1525
Climate change	0.1690	-0.1146	0.3852	**0.5259**
Drought	0.0919	-0.0317	-0.0445	**0.8427**
Predation problems	-0.2460	0.1013	0.0835	**0.5360**
Predator control regulations	0.2822	0.1156	0.0432	-0.0199
Labour availability	0.3036	0.0863	0.1061	0.0010
Weak cooperative	0.1625	0.3920	0.1395	-0.2249
Exchange rate risk	0.3186	0.2207	0.5314	-0.1218
Drought relief subs	0.3842	0.3940	-0.1515	0.3623
Eigen values	5.0377	2.5162	1.9492	1.4553
Cumulative variance explained	0.2519	0.3777	0.4752	0.5479

The three labour legislation factors affecting the farms and the item labelled "environmental laws" were strongly (≥ 0.70) associated with component 1, which therefore was labelled institutional risk. A factor loading of only 0.2822 on "predator control regulation" indicated that this issue was not part of a general concern about the regulatory powers of the state. On the other hand, one could argue that the regulations governing drought relief subsidies and the South African land reform programme, for which the factor loadings were about 0.39, belonged here, although these associations were not considered quite strong enough to warrant inclusion in the index. Rotated factor scores according to the regression model were used as weights to calculate the institutional risk index, as follows:

$$Institutional\ risk\ index_i = 0.2202 \cdot labour\ laws_i + 0.2514 \cdot environmental\ laws_i + 0.2135 \cdot ESTA_i + 0.3149 \cdot minimum\ wage_i \quad (1)$$

The larger weight on minimum wage regulation simply says that, while farmers have adjusted to some extent to the other aspects of legal reform, the farm strikes of November 2012 revived fears that the government would not hesitate to use its legislative powers to discriminate against white farmers. Eventually, this concern would result in insufficient agricultural investment and the deterioration of farm infrastructure, which could undermine food security in South Africa.

The Abstract of Agricultural Statistics shows that, over the period 1965 to 2012, there was no growth in the real mutton price, while the real wool price declined at a rate of 0.5% per year (DAFF 2015). In comparison, the real prices of fuel, fertiliser and farm feed each increased by more than 7% per year over the same period. This means that these Karoo farmers are no better off than their

great-grandfathers were at the turn of the twentieth century (Nattrass & Conradie 2015). Since they are too poor to buy more land, their communities have been fractured by sales to lifestyle farmers who have no intension of making productive use of the land. Estimates of the degree of transformation vary from half of all sales that take place in the Central Karoo (Reed & Kleynhans 2006) to about 90% of sales that occur in the Willowmore and Steytlerville districts in the southeast of the Karoo (Wessels & Willemse 2013). High input prices, low output prices, output price variability and market access strongly loaded onto component 2 (≥ 0.60), which was labelled price risk. Of the four, output prices had the strongest association, with a factor loading of 0.8362. While the performance of the local cooperative and fodder subsidies for drought relief were also associated to some degree with price risk, their factor loadings of about 0.39 did not justify their inclusion in the price index. The price risk index was calculated as follows:

$$Price\ risk\ index_i = 0.2345 \cdot market\ access_i + 0.2425 \cdot input\ cost_i + 0.2939 \cdot output\ price_i + 0.2291 \cdot price\ vaiability_i \quad (2)$$

According to the factor scores in equation 2, risk perceptions were more sensitive to output prices, although the scores indicate that input prices were considered a greater source of risk than output prices.

Component 3 was labelled security risk because of strong associations with farm attacks (0.7992) and stock theft (0.7829). Unemployment, for which the factor loading was 0.5749 on this component, was linked to both types of crime, as it often the case in South Africa (Kamper & Steyn, 2007). The security risk index was calculated as follows:

$$Security\ risk\ index_i = 0.3905 \cdot farm\ attacks_i + 0.2549 \cdot unemployment_i + 0.3546 \cdot stock\ theft_i \quad (3)$$

Equation 3 shows that the indirect link between unemployment and risk resulted in this having a third lower weight in the index than stock theft and farm attacks. Low population density due to large farm size and many absent landlords make the Karoo vulnerable to crime, including stock theft, although this is easily confused with predation. Farm attacks are not common.

With respect to the environment, Lumsden *et al*. (2009) predicted the following climate changes in South Africa: 1) higher temperatures, 2) higher rainfall intensity, 3) less precipitation on the west coast and western escarpment, perhaps with greater rainfall variability, and 4) more severe weather events. Higher rainfall intensity with the same total rainfall implies longer dry spells and, of the four predicted changes, this has the most serious potential to disrupt productivity. As the length of dry spells increases, fewer seedlings will recruit and this will cause permanently bare patches (Milton *et al*. 1994). Strong factor loadings, of 0.8427 on drought and 0.5259 on climate change, indicated that these factors formed part of component 4. In addition, component 4 associated relatively strongly with predator problems (0.5360), which suggests that it captured a common concern about the environment. The environmental risk index was calculated as follows:

$$Environment\ risk\ index_i = 0.4639 \cdot drought_i + 0.2848 \cdot climate\ change_i + 0.2516 \cdot predator\ problems_i \quad (4)$$

The main predator in the region is the black-backed jackal (*Canis masomelas*), which re-emerged in the study area in the late 1990s after being locally extirpated in the 1950s. The behavioural ecology of this specie's close cousin, the coyote (*Canis latrans*), suggests that culling could cause demographic compensation (Knowlton *et al*., 1999: Mitchell *et al*. 2004). Conradie and Piesse (2013) found that demographic compensation also applies to the culling of a predator complex dominated by caracals (*Caracal caracal*). A century ago the South African government supported

lethal control of a variety of predator species by poisoning. Later, poison subsidies were replaced by support for dog packs and dedicated hunters that functioned within divisional council hunting clubs. As the problem was brought under control, even this was considered unnecessary. Subsidies for hunting clubs were phased out in the period between 1988 and 1993, although farmers were still allowed to trap, shoot and poison black-backed jackals and caracals, as well as vagrant dogs. To farmers' great consternation, the Western Cape wildlife authority, Cape Nature, announced that, effective from January 2009, a bag limit of five animals per night would be imposed, even on predators, and that gin trapping would be outlawed. Thus, unsurprisingly, the regulation component was the most heavily weighted in the predation risk index. While component 4 strongly associates with predator ecology, there was no association with predator control regulation, of which the factor loading on this component was -0.01999.

With fourteen risk factors reduced to four components, there were still six factors unaccounted for. Of these, the two perceived to be most important were predator control regulation, which scored 4.03 ± 1.20, and labour availability, which scored 3.51 ± 1.39. The factor predator control regulation was strongly associated with component 5 (0.7638), but despite an Eigen value of ≥ 1 it could not be extracted, as it was a Heywood case. The same applied to labour availability, which loaded strongly onto component 6 (0.8215). Therefore, these two factors were also incorporated in the cluster analysis (see section 3.3). To maximise sample size for the subsequent analysis, missing item values were inferred from the respondents' views on the other factors in a given index or, where that was not obvious, the index was calculated from a subset of factors for which scores were available.

3.2 Explaining the different dimensions of risk perceptions

Due to the chosen survey method, there were almost as many potential explanatory variables as cases to explain. The usual farmer characteristics of age, education and management experience were available and the assumption was that more experience or better education equated to being better informed. However, it was unclear if being better informed would increase or decrease perceived risk. In addition to the level of education of the farmer, the data also included information on that of his wife, which varied more. Data on the farm's contribution to household income made it possible to test the hypothesis that the heads of households with more diversified sources of income would perceive fewer risks (Størdal *et al*. 2007). The variable "heirs" was constructed as a dummy variable equal to 1 if the farmer believed that their children would continue to farm sheep when they inherited, and 0 otherwise. Barnes *et al*. (2013) reported that farmers who intend to pass on the farm to family members rated climate risk more highly than those who did not expect the family to continue farming. However, since Karoo farmers already face serious difficulties, it was assumed that those who were still willing to burden their children with the expectation of running the farm would rate the various threats less strongly than those who recognised that it was time to leave the sector.

Farm characteristics included farm size, measured in breeding ewes rather than hectares of land, and the profitability of the sheep enterprise, measured in ZAR100 per ewe in the flock. At the time of the survey, ZAR100 was equal to approximately US$10. It was assumed that the financial buffer implied by greater profitability and/or a larger operation would reduce risk perceptions, although it was also recognised that a larger farm could make the operation more vulnerable to crime or labour availability risk. In addition, three farm characteristics were believed to affect environmental risk perceptions. Since wildlife densities increase in rugged terrain (Sappington *et al*. 2007), it was thought that farms with a larger percentage of high ground would experience more predator problems and that this would fuel environmental risk perceptions. The number of jackals culled during the preceding twelve-month period served as an alternative for terrain ruggedness, although

it was recognised that causality could run in either direction. The severity of the 2011/2012 drought, proxied by the number of months of survival feeding required during the previous twelve months, was expected to increase concerns over drought and climate change. Unfortunately, the severity of the drought could not be measured in terms of actual rainfall, as only 35% of farmers kept rainfall records. Finally, awareness of environmental concerns was expected to vary with the amount of time the farmer spent out in nature (Nguyen *et al*. 2016). In South Africa, the distinction between black hired labour and white farm management means that not all farmers are equally involved in the day-to-day farming activities. The closest we could come to how much time the farmer spends in nature was a livestock handling interval that counts in days how frequently the farmer is out working with the sheep. The interpretation of this variable is as follows: the longer the interval, the less frequently the farmer is out in nature, and the lower the perceived environmental risk.

In a normality test of the dependent variables, the probability of skewness according to Royston (1991) varied between 0.16 for the environment index and 0.62 for the price index. This indicates that ordinary least squares is the appropriate estimator. The F-statistics for the four models in Table 2 corresponded to $p \leq 0.05$, which is an acceptable level of significance. Non-significant coefficients were retained to minimise information criteria statistics. Of the results in Table 2, the price risk model performed best and the institutional risk model the worst.

Greater profitability reduced perceived risk in all four models. An increase of ZAR100 in net farm income per breeding ewe reduced risk scores by 1.4% to 1.7%, depending on the type of risk under review. But the next result was perplexing. This showed that the more the household relied on farm income, the lower the perceived institutional and price risk, which means that these farmers did not find income diversification reassuring. This may be because there are limited off-farm opportunities in their area. The other explanation is that people whose livelihoods depend entirely on the farm are myopic and less aware of institutional and price risk because they never leave the farm and are thus uninformed about the wider environment. Greater farm size increased perceptions of institutional, security and environmental risk, with the coefficient on size significant in both the security and environmental risk models, although it was 50% higher in the latter. This shows that, although the owners of larger properties are concerned about expropriation and worry about controlling predators on their land, rural safety becomes a real issue when farms are large and homesteads far apart.

The proxy for the severity of the 2011/2012 drought did not affect environmental risk perceptions, as hypothesised, but instead increased perceived price risk, with each extra month of feeding required leading to a 0.6% increase in the price risk score. This makes sense, since feeding livestock is a major financial commitment and therefore climate risk perception is subsumed into price risk perception. The sign on the stock-handling interval was negative in the environmental risk model, which means that people who see their stock more frequently and thus spend more time in nature observe changes in the environment and are more aware of the degree of environmental risk. This is supported by Nguyen *et al*. (2016). The terrain ruggedness variable was not significant in any of the models, but the number of jackals culled during the previous twelve-month period increased risk perceptions, as expected, although this factor was not in the environmental risk model where the impact was expected. Instead, Table 2 shows that the coefficient on jackals culled was positive and significant at $p \leq 0.10$ in the price index model, where predation is clearly bound up with other perceived threats to profitability. In addition, there was a positive although insignificant coefficient on jackals culled in the security risk model. Since this model captures concerns about crime and unemployment, this means that farmers are unsure whether to attribute stock losses to theft or to predation.

Table 2: The determinants of the main components of Karoo farmers' risk perceptions

Dependent variable	Institutional risk	Price risk	Security risk	Environment risk
	Coef [RSE]	Coef [SE]	Coef [RSE]	Coef [RSE]
Profitability (ZAR/ewe)	-0.00093** [0.00044]	-0.00079** [0.00029]	-0.00078 ** [0.00037]	-0.00084** [0.00027]
Income from farming (%)	-0.00510 [0.00363]	-0.01109*** [0.00301]		
Farm size (# breeding ewes)	0.00045 [0.00045]		0.00067** [0.00033]	0.00046 ** [0.00023]
Severity of drought (months fed)		0.03288 † [0.02216]		
Stock-handling interval (days)				-0.00462*** [0.00091]
Jackals culled (number)		0.01678 * [0.00926]	0.01350 [0.01687]	
Farmer's age (years)		-0.02592** [0.00827]		
Management experience (years)	-0.03017** [0.01340]		-0.03965*** [0.01134]	
Farmer's education (years)			-0.12686 * [0.07395]	
Wife's education (years)	-0.15480 † [0.09311]	-0.24314*** [0.06812]		
D heirs (1 = children will continue)	0.58020 † [0.38177]			
Constant	5.92341*** [1.27372]	8.56488*** [1.07589]	5.04776*** [1.10194]	4.03465*** [0.22705]
Observations	51	48	51	54
F-stat	2.74**	7.63***	6.76***	12.17***
Adjusted R^2	0.2090	0.4585	0.3106	0.2460
Akaike's IC	156.08	97.52	152.55	123.77
Bayesian IC	169.60	110.62	164.44	131.73

*** signifies $p \leq 0.001$, ** signifies $p \leq 0.05$, * signifies $p \leq 0.10$ and † signifies $p \leq 0.1$

The coefficient on farmer age was negative and significant in the price risk model. This is easily explained in terms of life cycle accumulation models: younger farmers are more concerned about price risk because they are paying for children's education and accumulating pensions. The years of management experience was negative and significant in the regulation and security risk models, which suggests that the costs of regulatory compliance and the difficulty of securing property are more of a challenge to inexperienced managers. More education, for either the farmer or his wife, reduced risk perceptions in the institutional, price and security risk models. An extra year of schooling reduced perceived price risk by 60% more than perceptions of risk on the other two factors, presumably because wives with more years of education can play a more active role in the strategic and financial management of the farm. Finally, the dummy variable indicating the presence of likely heirs only featured in the regulation model, where it had a positive sign, contrary to expectations. This can be interpreted as an increase in fears over institutional risk for farmers who take a longer-term view of the future of agriculture, which is consistent with Barnes *et al*. (2013).

In summary, the importance of these individual models is that they show that the formation of risk perceptions is complex. One cannot simply assume that the same farm and farmer characteristics influence risk perceptions in the same way for different issues.

3.3 Cluster membership

With n = 56 it was not possible to specify more than k = 2 groups in the cluster analysis of cases on items and sub-indices. In addition to the four sub-indices, we also clustered on the labour availability and predator regulation items. The two sets of views that emerged differed both in terms of intensity and the ranking of the individual elements of risk (see Table 3), although both rated the environment as the most important source of risk that faces agriculture. For the first cluster – the more concerned group, the environment was followed by institutional risk, market risk and security. For the second cluster – the not so scared group, the environment was followed by the market, security and then the risk of institutional collapse. The two groups were the furthest apart on the items that formed part of the institutional risk component, namely environmental legislation, and the risk embodied in minimum wage legislation and the Tenure Act. In each of these cases the mean score for the more concerned group was at least 60% higher than the mean score of the moderate group. The individual item rated most similarly by these two groups was predator problems, for which the two mean scores differed by less than 10%. They were also quite close on stagnating output prices, drought, and the risks represented by unfavourable predator control regulations and unemployment.

Table 3: Risk perceptions by cluster

	Heightened risk perceptions (n = 21)	**Moderate risk perceptions (n = 35)**	
	Mean ± SD	**Mean ± SD**	**Spearman's ρ**
Labour laws	4.33 ± 1.20	3.08 ± 1.20	0.5140 ***
Tenure act	4.43 ± 0.81	2.77 ± 1.50	0.5419 ***
Minimum wage regulations	3.67 ± 1.28	2.17 ± 1.01	0.5278 ***
Environmental laws	3.60 ± 1.23	2.20 ± 1.11	0.5165 ***
Institutional risk index	**3.94 ± 0.81**	**2.51 ± 0.88**	**0.6278 *****
Market access	2.38 ± 1.07	1.83 ± 1.15	0.2804 **
Rising input prices	4.76 ± 0.54	3.60 ± 1.09	0.5650 ***
Falling output prices	3.67 ± 1.32	3.17 ± 1.12	0.2251 *
Price variability	3.67 ± 1.35	2.71 ± 1.20	0.3636 **
Price risk index	**3.63 ± 0.76**	**2.86 ± 0.88**	**0.4406 *****
Unemployment	3.62 ± 1.50	2.97 ± 1.36	0.2374 *
Farm attacks	3.48 ± 1.72	2.60 ± 1.31	0.2730 **
Stock theft	3.57 ± 1.29	2.49 ± 1.40	0.3662 **
Security risk index	**3.55 ± 1.22**	**2.65 ± 0.97**	**0.3449 ** **
Drought	4.40 ± 0.88	3.66 ± 1.16	0.3282 **
Climate change	3.76 ± 1.34	2.80 ± 1.08	0.3777 **
Predator problems	4.57 ± 0.75	4.15 ± 1.05	0.2148
Environmental risk index	**4.23 ± 0.66**	**3.52 ± 0.84**	**0.4250 ** **
Predator control regulations	4.48 ± 0.93	3.77 ± 1.29	0.3087 **
Labour availability	4.48 ± 0.93	2.92 ± 1.28	0.5619 ***
Availability of drought relief subsidies	3.29 ± 1.23	2.66 ± 1.08	0.2533 *
Support from cooperative	1.90 ± 1.22	1.54 ± 0.82	0.1499
Exchange rate variability	3.25 ± 1.37	2.51 ± 1.27	0.2690 **
Land reform	3.52 ± 1.44	2.74 ± 1.54	0.2483 *

*** signifies $p \leq 0.001$, ** signifies $p \leq 0.05$, * signifies $p \leq 0.10$

A logit model was used to explain when a person would perceive agriculture to be facing a lot of risk (see Table 4). The explanatory variables included the profitability of the sheep enterprise, years of management experience, years of formal education and a dummy variable that captured a farmer's long-term commitment to the sector (children will inherit) and a proxy for environmental pressure (number of jackals culled). Four of the five variables – all except education – were significant at $p \leq 0.10$ at least. Greater profitability and more experience reduced fears, as expected,

while the presence of heirs and the proxy for environmental pressure both increased fears. The only surprise was heirs, a factor that is probably not fully exogenous to how risk perceptions are formed.

Table 4: Logit model explaining being classified as having heightened risk perceptions

Independent variable	Coefficient	SE	Marginal effect	SE
Profitability (ZAR100 / ewe)	-0.22176 *	0.11623	-0.05158 *	0.02673
Management experience	-0.07801 **	0.03462	-0.01814 **	0.00798
Farmer's education	-0.23374	0.21373	-0.05437	0.04963
D heirs – children will continue	1.71877 **	0.83982	0.37824 **	0.16771
Jackals culled	0.06644 *	0.03753	0.01545 *	0.00879
Constant	3.34038	2.95989		
Observations	50			
Likelihood ratio test	15.05 **			
McFadden's R^2	0.2237			
Predicted membership	36.8%			
Actual membership	37.5%			
Akaike's IC	64.25			
Bayesian IC	75.72			

*** signifies $p \leq 0.001$, ** signifies $p \leq 0.05$, * signifies $p \leq 0.10$ and † signifies $p \leq 0.15$

The marginal effect of 0.378 on the "heirs" dummy variable meant that farmers who had identified heirs were 38% more likely to be in the more concerned group than those without heirs. The marginal effect of an extra year of formal education was a 5% reduction in the likelihood of being classified as very concerned. The effect of additional management experience was smaller; in this case, an extra year corresponded to a less than 2% decrease in the probability of being classified as very concerned. A ZAR100 or 30% increase in the profitability of the sheep enterprise was predicted to reduce the probability of being classified as very concerned by 5%. Finally, the chance of being classified as very concerned increased by about 1.5% for every additional jackal culled on that farm during the previous twelve-month period.

4. Conclusions and implications

This study investigated the structure, origins and degree of homogeneity of risk perceptions in a small agricultural community in the arid interior of South Africa. It was expected that there would be a level of commonality amongst these farmers as they faced the same multiple threats. Principal component analysis identified four main components of this risk: institutional, price, security and environmental risk. Two other important components of perceived risk, namely concerns over labour availability and predator control regulation, could not be extracted formally due to the limited sample size, but were included in the risk profiling that followed. Profitability provided an important explanation for the degree of perceived risk. Other explanations included farm size, education and experience, time spent in nature and the existence of heirs to continue working on the farm, as well as two indicators of environmental quality. The cluster analysis yielded just two groups, which ranked items and rated the intensity of the various elements of risk differently. More moderate views were associated with greater profitability, more experience, less environmental pressure and fewer concerns about the next generation having to make a living off the farm.

A number of policy implications arise from these results. Predator pressures were a serious concern. Predation could certainly be better managed, even just by distributing more accurate information, as the management interventions undertaken to maximise output also frequently reduce risk. The role of lifestyle farmers should be clarified and monitored. Thus, this study does not support the argument presented by Musser and Patrick (2002) that the risk aversion of farmers does not have any special policy implications. Environmental managers and extension officers should not assume that the views of farmers who participate in a stakeholder process necessarily represent those of the

broader community. A better approach would be to conduct a series of in-depth open-ended conversations with focus groups as part of the process of co-designing interventions. This should then be followed up with structured questionnaires based on the insights that emerge from these conversations. The results in this paper show that, while farmers are primarily motivated by profit, they also care about the environment, and neither of these two aspects individually determines how risk is perceived.

It was encouraging for conservation to see that the environment ranked so highly amongst farmers' priorities. While climate change itself was not that important, the importance assigned to weather/ drought could create opportunities to talk about climate change mitigation.

Further work on this group should extend to qualitative confirmation of the quantitative findings presented here. The risk indices developed in this paper should be correlated with the adoption of various best management practices to get a better understanding of how risk perceptions affect management practices, in particular predator management choices, which are still poorly documented and not well understood. The study should also be replicated elsewhere to see if the components of risk presented here can be generalised to other communities.

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