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 that 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 2011/12 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.

Keywords: Karoo, risk perceptions, climate change, predation, principal components analysis, 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 is 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 (Pannell et al., 2006; Sattler and Nagel, 2010; Størdal et al., 2007; Marra et al., 2003; Beal, 1996). 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 the 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) argued that owner characteristics and environmental factors combine to shape risk perceptions, which in turn determine first 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 the motivation aspects. Two principal component analyses identified the main components of each, which was 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 specifically chosen 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) argued 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 now uses few inputs besides land and labour (Conradie and Landman, 2015; Conradie and 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 was 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 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, namely to investigate how farmers prioritise the environment compared to other sources of risk and to be 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 is an Afrikaans-speaking male, who was 54 years old in 2012. The majority are married with children. Education varies from incomplete high school to university degrees, with a two-year agricultural diploma reported most frequently. The average farm is 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 derives from the farm while 20% comes 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 regulation, 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 but are the first attempt to address all of these risk factors in a single study.

2.3 Analytical approach

The empirical analysis includes 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. From these data only four components could be extracted, 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 are 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 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 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. This identified four underlying components of risk perception by 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 originally identified 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 with 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 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; Cousins et al., 2013). Changes in environmental legislation included a new Water Act and the introduction of an environmental impact assessment that was required for all new land developments. However, neither Act had much impact on the Karoo.

Two post-apartheid laws affect 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

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

included agriculture. Although the Employment Conditions 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. The Tenure Act caused significant unemployment because farmers believed it would award permanent tenure rights to disgruntled former workers. To avoid having their land expropriated in this way, farmers resorted to increased mechanization 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 femail 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 underway, a series of violent strikes erupted in the fruit sector, where workers demanded a doubling of the statutory minimum 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 8-12% 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			
Individual risk factors	Component 1 Institutional	Component 2 Price	Component 3 Security	Component 4 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

In the Karoo sample, the three labour legislation factors and the environmental laws factor are all strongly (≥0.70) associated with component 1, which was consequently 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 over 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, whose 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 will 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 and 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 it. Estimates of the degree of transformation vary from half of all sales that take place in the Central Karoo (Reed and Kleynhans, 2006) to about 90% of sales that occur in the Willowmore and Steytlerville districts in the southeast of the Karoo (Wessels and Willemse, 2013).

High input prices, low output prices, output price variability and market access strongly loaded on 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, whose factor loading was 0.5749 on this component, was

linked to both types of crime, as it often the case in South Africa (Kamper and 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 of unemployment to risk resulted in this having a third lower weight in the index than stock theft and farm attacks. Large farm size and the resulting low population density make the area vulnerable to crime and this is exacerbated by every farm sale to a largely non-resident lifestyle farmer. Stock theft has been reported in the area, although farmers do not always know if losses of older lambs and breeding ewes are due to stock theft or predation by baboons. Farmer attacks are not common in the area, but one has occurred since the beginning of the panel survey.

With respect to the environment, Lumsden et al. (2009) predicted the following climate change in South Africa: 1) higher temperatures, 2) higher rainfall intensity, 3) less precipitation in the west coast and western escarpment, perhaps with greater rainfall variability, and 4) more severe weather events. Obviously, 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, which could result in permanently bare patches. Temperatures will rise in these areas and the chance of future recruitment will be even lower (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 over 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 remerged in the study area in the late 1990s after being locally extirpated in the 1950s. The behavioural ecology of this species' 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 hunt clubs. As the problem was brought under control, even this was considered unnecessary. Subsidies for hunt 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's 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, whose 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 on 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 believe that their children will continue to farm sheep when they inherit, 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 that 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 recognise that it is 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, ZAR 100 was equally 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 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 2011/12 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 keep rainfall records. Finally, awareness of environmental concerns was expected to vary with the amount of time the farmer spends 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 ≤0.05, which is an acceptable level of significance. Non-significant coefficients were retained to minimize 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 1.4-1.7% 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 do 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.

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

Dependent variable	Institutional risk Coef [RSE]	Price risk Coef [SE]	Security risk Coef [RSE]	Environment risk 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≤ 0.001, **signifies p ≤0.05, * signifies p ≤0.10 and † signifies p ≤0.1

The proxy for the severity of the 2011/12 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 ≤ 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.

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 in 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 is 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 on the future of agriculture, which is consistent with Barnes et al. (2013).

In summary, the importance of these individual models is that they show the formation of risk perceptions is complex and 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 in the analysis that clustered the cases on the four risk indices, plus two original factors: labour availability and predator control regulation.

The result was two similar-sized groups whose members more or less agreed about the most serious threats to farm survival but scored these threats very differently (see Table 3). The mean of means for the first cluster was 3.75 compared to 2.82 for the second. Therefore, it was appropriate to label the risk perceptions of the first group "heightened" and that of the second group "moderate".

Both groups ranked the environmental index first amongst the risk indices. The group with the heighted risk perceptions ranked institutional risk second, followed by price and security risk, while the moderates ranked price risk second, followed by security risk, with institutional risk in fourth place. This suggests that these two groups did not only differ in terms of the severity of the risks they faced, but prioritised the components of risk differently. Since any form of aggregation tends to smooth out differences between groups, between-group differences in the underlying components were also investigated. Here there was more overlap. The top five sources of risk as perceived by the group with the heightened risk perceptions were first rising input prices (4.76), second predation problems (4.57), joint third predator control regulation and labour availability (4.48) and finally drought (4.40). The moderates ranked predation problems first (4.15), predator control regulation second (3.77), drought (3.66) third, rising input costs (3.60) fourth, and stagnating output prices (3.17) in fifth place.

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≤ 0.001, **signifies p ≤0.05, * signifies p ≤0.10

A series of two-tailed t-tests showed that most of the differences were significant at p ≤ 0.000. The exceptions were support from the local cooperative, where the difference was not significant and stagnating output prices, predators and unemployment, whose differences were only significant at p ≤ 0.15. The factor rated most similarly by these two groups was predator problems where the two mean scores differed by less than 10%. The two groups' risk assessments were also quite close on low output prices where mean scores differed by approximately 15% and unemployment, drought and predator control regulation, each of which produced mean scores that differed by less than 20% from the other group's score. The factors on which the two groups were furthest apart were the environment, minimum wage regulation and the Tenure Act, which produced mean scores that were approximately 50% apart. This meant that regulation was the index on which there was least agreement, while the price index produced the greatest consensus. Apart from the regulation index, labour availability was the only factor on which group mean scores were more than 40% apart.

Table 4 shows the results of the logit estimation that investigated cluster membership. The dependent variable is binary with the value of one classified as having heightened risk perceptions and 0 otherwise. Positive coefficients identified factors that increase perceived risk in general. As in the component models that explained the scores obtained for the indices that capture particular dimensions of risk, a more profitable sheep enterprise and more management experience both reduced perceived risk. More educated farmers were also less fearful, although this variable did not have a significant coefficient in the logit model. Knowledge that the next generation is willing (and able) to continue working the farm increased risk perceptions, as one might expect for anyone that takes a longer-term view. However, this result was the opposite of what was expected, since it was thought that farmers that have higher perceptions of risk would encourage their successors to move out of agriculture. Environmental difficulties in terms of the number of jackals culled also increased perceived risk, although the proxy for the severity of the 2011/12 drought was not statistically significant.

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≤ 0.001, **signifies p ≤0.05, * signifies p ≤0.10 and † signifies p ≤0.15

The marginal effect of 0.378 on the "heirs" dummy variable meant that farmers that have heirs identified were 38% more likely to be in the more concerned group than those that do not. 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. In addition, a ZAR 100 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.

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 between these farmers as they face the same multiple threats, ranging from a tough price environment to security and institutional risks, to multiple environmental threats. Principal component analysis identified four main components to 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 formally extracted 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 take over the farm in the future, as well as two indicators of the environmental quality. The cluster analysis yielded just two groups whose priorities were somewhat similar but who scored almost all perceived threats very differently. Those with a moderate degree of risk perception were found to be better educated, more experienced and profitable and less likely to have heirs or intense jackal problems than those with heightened risk perceptions.

The importance of these results is that they confirm the heterogeneity of the risk perceptions of farmers, even if just in terms of intensity. The environmental component was ranked the most important of the four elements of risk, followed by institutional risk for farmers with heightened risk perceptions and market risk for the moderates. This means that although climate change as a separate risk factor is not amongst the top three on the list of priorities for the farmer, this community is concerned about environmental health and therefore could be engaged successfully on climate change issues, if the government and NGO sector need to do so. Either party is likely to find more openness from progressive, successful farmers than from those that are struggling. Furthermore, 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,

followed by structured questionnaires based on the insights that emerged from these conversations. In addition, these results showed while farmers are primarily motivated by profit, there is a major concern for conservation and neither individually determine how risk is perceived. Finally, the rankings obtained for each group provides some support for the idea that climate change is crowded out by more pressing concerns, which in this case happened to be environmental too.

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 generalise to other communities.

A number of policy implications arise from these results. Information on environmental risk is lacking in a number of cases, as here the less educated farmers and those that do not have employment off the farm are frequently poorly informed. Predator control is still mismanaged in a number of cases and the responsibilities 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 farmer does not have any special policy implications. The management interventions undertaken to maximise expected profits frequently also reduce risk. Rather, the public good aspects of information on climate change and predator management can contribute to lowering uncertainty in the sector.

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