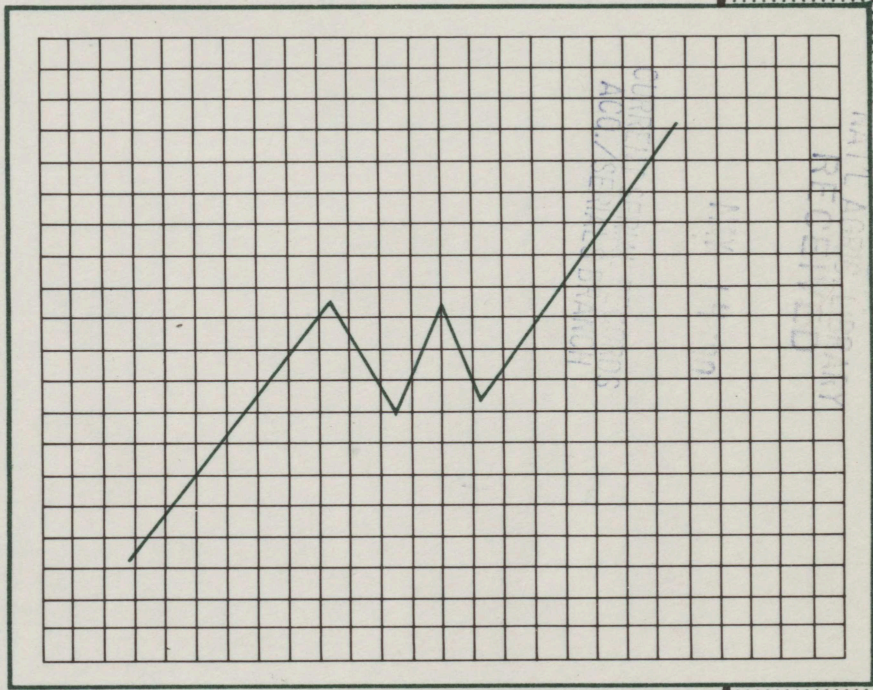

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FACTORS INFLUENCING CROP INSURANCE PARTICIPATION IN MAIZE FARMING

by E.M. JARVIE and W.L. NIEUWOUDT*

ABSTRACT

Crop insurance has been divided into comprehensive (all-risk) and hail insurance and these have been analysed separately. A discriminant analysis of 82 farmers surveyed in the Highveld Region during July and August 1987 indicates that it is the farmer more exposed to risk, with lower liquidity, greater experience and more debt, who insures comprehensively. The latter producer also tends to have an unfavourable return on assets with a small or non-existent livestock enterprise.

With respect to hail insurance, results indicate that it is the older farmer with low gross farm and off-farm income that tends to insure.

Further insight into economic forces influencing farmer participation is important as it may aid policy-makers in the adjustment of present and the formation of future policies regarding such risk management strategies as crop insurance.

INTRODUCTION

The bulk of maize production in South Africa occurs in the so-called maize triangle. (*Abstract of Agricultural Statistics,* 1988, p.9). The area has a high potential for the cultivation of maize, but is subject to adverse climatic conditions from time to time. First, the average yearly rainfall is marginal in comparison with maize cropping areas in the main producing countries and, secondly, the inconsistency of the rainfall has a profound impact on yields and farm income. Examples of this are the crippling droughts experienced in 1983 and 1984. It is imperative that risk management should be given more attention by farmers.

The importance of crop insurance in agricultural development is widely recognised and its potential usefulness has been emphasised by many researchers (Halcrow, 1949; Jones & Larson, 1965; Ray, 1981; Staniforth, 1954) as regards offsetting some of the instability prevalent in agriculture.

For crop insurance to be effective and self-sustaining a high degree of participation is necessary, otherwise farmers will ask for Government assistance in adverse years. In South Africa a large majority of crop insurance policies have been offered by privately funded organisations. According to Van Rooyen (1987) these organisations are at present experiencing severe problems as regards lack of farmer participation, coupled with the problem of adverse selection (i.e. only high-risk farmers buy insurance) (Zering, 1984, p.29).

The main purpose of this study is to separate maize farmers into two groups, depending on whether they insured their crops or not, on the basis of certain discriminating variables. These results may assist policy-makers in their understanding of factors influencing crop insurance and ultimately in the successful promotion of risk management strategies.

Attention was focused on two policies which exist for maize production in South Africa, i.e. comprehensive and hail insurance. Comprehensive, or all-risk, insurance covers damage to crops caused by natural phenomena such as drought, floods, diseases, pests, hail, etc. Hail insurance covers damage to crops caused by the mechanical action of the hailstones and the associated wind damage.

Discriminant and principal component analyses were the multivariate techniques employed in the data analyses. The data were collected in the form of a survey covering 82 maize farmers in the Highveld Region during July and August of 1987.

THEORY

Alfred Manes (cited by Ray, 1981, p.20), defines insurance as "... the elimination of the uncertain risk of loss for the individual through the combination of a large number of similarly exposed individuals who each contribute... premium payments sufficient to make good the loss caused to any one individual". Crop insurance is a contingent contract, an agreement in which a farmer pays a price, the premium, after which his crop yield determines a payout or indemnity. The contingency is that only certain low yields result in indemnities and yield is a random variable, the value of which is unknown when the insurance contract is purchased (Gardner & Kramer, 1982). Owing to lack of information on expected risks the insurer cannot separate farmers into risk classes leading to adverse selection. The lower risk members in each group will always opt out, raising the loss ratio (Binswanger, 1982) and effectively moving the insurance market into disequilibrium (Rothschild & Stiglitz, 1976).

The demand for crop insurance depends on (a) the farmer's utility function of income, (b) his current income, (c) his subjective frequency distribution of income, (d) the change in the frequency distribution of future income generated by the contract and (e) the premium of the contract. Regarding (a), Friedman & Savage (1948) show that if marginal utility of income decreases as income increases, then the maximum insurance premium an individual will pay depends upon the extent to

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which the utility of expected income exceeds expected utility. Regarding (b), Arrow (1971) suggests that the cost an individual attaches to risk is a declining function of profit (wealth) i.e.: decreasing absolute risk aversion. Items (c) and (d) determine returns from insurance and item (e) determines its cost.

Risk aversion varies from producer to producer and generates a downward sloping aggregate demand for insurance. A "highly risk averse producer" will purchase insurance even at a high price (premium cost) because the marginal utility of insurance is high for such an individual (Friedman & Savage, 1948). A "slightly less risk averse producer" will purchase insurance if the price is lower, since the marginal utility of insurance is lower for the second individual. A "risk neutral producer" will purchase no insurance even if the premium cost is actuarially fair as the marginal utility of insurance is zero for him.

Although diversity in risk aversion determines slope of the demand function, the level of the function can be shifted by variables such as the wealth effect and the risk actually experienced by the individual.

It is expected that, with increased wealth, the demand function will shift to the left, assuming decreasing absolute risk aversion (Arrow, 1971). The percentage of the acreage insured can be stated as a function of variables such as price of insurance, wealth, risk expectations and disaster payments (Nieuwoudt & Bullock, 1986, p.661).

If the producers are risk averse, it may be expected that more insurance will be purchased under conditions of greater risk. Risky conditions in the environment will be expected to shift the demand for insurance to the right. Such conditions may be reflected in terms of variability of yields owing to weather-related effects and the extent to which risk is reduced through diversification. In diversified areas producers experience less risk than in areas where one crop is clearly more profitable than alternative enterprises.

If farmers expect disaster assistance in the event of a crop failure, they would be less inclined to insure (Nieuwoudt, 1984).

DATA CONSIDERATIONS

Data were obtained from a sample survey in the three primary maize producing areas, i.e. the Transvaal Highveld, the North-western Orange Free State (NWOFS) and the Western Transvaal (WTVL), during July and August 1987.

Financial and time constraints precluded interviewing all maize farmers in these areas. Multi-stage sampling was therefore used to collect a representative sample. Although this technique may lead to less efficient sample estimates than other sampling methods, it is far less costly. Nevertheless, stratification and selection of primary stage units (PSUs) with probability proportional to size reduces the potential loss in efficiency (Barnett, 1984, p. 77).

The study area was first stratified into two rainfall zones. The "low" rainfall zone lies to the west of an imaginary line from Ventersdorp in the Western Transvaal, southward through Potchefstroom, Vredefort, Koppies and Lindley, to Fouriesburg in the OFS. To the east of this line lies the "high" rainfall zone. The imaginary zoning line is similar to the one used by a major crop insurance firm in South Africa (de Wet, 1987).

Relatively homogeneous farming areas (RHFAs) were selected in each zone with probability proportional to size (number of farmers). Within these RHFAs, study groups of farmers (secondary stage units (SSUs) were randomly selected and the whole study group was sampled. Most of the study groups were of a similar size and approximately 50% of the sample members responded. The final sampling unit was the farmer himself, which made it possible for the variability between individual farmers to be captured. Previous studies completed by Gardner & Kramer (1982) and Nieuwoudt (1984) in the USA were based on aggregated data. In both studies the authors acknowledged the aggregation as a weakness in their approach.

A total of 82 farmers were interviewed personally and over 400 time series and cross-sectional observations were recorded for possible use in ensuing analyses.

METHODOLOGY

A combination of principal component and discriminant techniques was employed to determine:

- The characteristics of producers who tend to insure their maize crops comprehensively against natural phenomena such as drought, floods, pests and diseases, etc.
- What type of producer would insure his/her crop against hail and associated wind damage.

Discriminant analysis is simply a technique to distinguish statistically between two groups or categories of cases, for example, to differentiate between maize producers who tend to take out crop insurance and those who do not.

The method aims to maximise the separation of these groups by forming weighted linear combinations of predictor variables that measure the characteristics as to which the groups are expected to differ. The variables discriminate between groups of cases and predict into which category or group a case falls, based upon its values of these variables.

The discriminant functions are of the form:

$$D_i = d_{i1} Z_1 + d_{i2} Z_2 + \dots + d_{ip} Z_p$$

where D_i = discriminant function score (Klecka 1975, p. 435)

d_{ij} = weighting coefficients

Z_j = standardised values of discriminating variables

Since there were a large number of predictor variables a stepwise procedure was used to aid the selection of the best discriminating variables. The criterion employed for the stepwise procedure was that of minimising Wilk's Lambda, which is merely an inverse measure of the discriminatory power of the function.

Other methods of judging the importance of the derived function are the canonical correlation and eigenvalue statistics. As a further check of adequacy, the original set of cases in known groups is reclassified in order to determine the percentage correctly classified (Tabachnick & Fidel, 1983, p.292 - 318).

Principal component analysis is a multivariate method that has as its aim the explanation of relationships between several correlated variables in terms of a few conceptually meaningful and independent factors (Steffens, 1983). Three objectives are accomplished using this method, these being:

- To identify inter-relationships between variables
- To reduce the number of variables being studied
- To rewrite a number of variables in an alternative form in order to overcome collinearity

The latter two objectives form the primary reasons for employing principal components in this study, thereby facilitating an improved discriminant analysis.

The logic behind component analysis is to extract a common dimension which is a weighted representation of the original variables.

The component is of the form:

$$PC_1 = A_{11} X_1 + A_{12} X_2 + \dots\dots + A_{1p} X_p$$

Where $X_1, X_2, \dots\dots, X_p$ = original variables
$A_{11}, A_{12}, \dots , A_{1p}$ = variable loadings

The variable loadings are chosen such that PC_1, the first principal component, accounts for the greatest share of the total variation (or correlation) in the original p variables (Nieuwoudt, 1977, p. 77).

Use was made of the correlation matrix and standardised variables since variables were measured in different units (Steffens, 1983, p. 12). The percentage of correlation accounted for by the component is represented by the eigenvalue (Stevens, 1986, p. 341).

DISCUSSION OF VARIABLES

A number of variables were used in the discriminant analyses, of which the most important are discussed below. Some were used in their raw state and others were combined to form indices.

Liquidity index (LIQ)

The ability of a maize producer to carry his own risk could be gauged by his liquidity position. This would indicate the extent to which a farmer could respond to a crisis situation. An index of three variables has been formulated to measure liquidity. Selected variables include gross farm income (GFI), credit reserve (CR) and the ratio of current assets to current liabilities (CACL).

The GFI variable included income from all "on-farm" enterprises in that year. The credit reserve variable was a composite of "own reserves", which included cash savings and investments, and "other reserves" that were obtainable from the Land Bank, commercial banks and agricultural co-operatives in the form of credit.

In the CACL ratio, current assets include cash on hand and in the bank, co-operative invoices, debtors, marketable livestock, etc., and the current liabilities overdraft bank accounts, co-operative production loans, etc.

As expected, selected variables were significantly correlated (Table 1).

TABLE 1. Matrix of correlation coefficients of selected financial variables obtained in survey of the Highveld Region, 1987

Variable	GFI	CR	CACL
GFI	1,00	0,33**	0,23**
CR		1,00	0,30**
CACL			1,00

**Correlations significant at 1 % level

A common factor was extracted from these variables using principal components. Of the total variation in the data, 52 % is explained by the liquidity index, which has an eigenvalue of 1,587.

$$LIQ = 0{,}7229^{*} (GFI^{A}) + 0{,}7633^{*} (CR^{A}) + 0{,}6768^{*} (CACL^{A})$$

Where A = standardised variate
* = significant at the 5 % level. Harman (1976) estimated the standard errors of factor coefficients using the following relationship:

$$\sigma = \frac{\frac{1}{2}\sqrt{(^{3}/r - 2\text{-}5r + 4r^{2})}}{N}$$

Where σ = standard error of factor coefficient a
r = *mean* correlation of the set of variables
N = numbers of observations

It should be noted that all latent vector loadings show a positive relationship with one another and are of similar magnitude, thereby implying a common association between the variables.

Experience index

The experience of a producer can be measured either by his age (AGE) or by years of farming (YRS).

These two variables were significantly related (Table 2).

TABLE 2. Matrix of correlation coefficients of two selected experience variables from a survey in the Highveld Region

Variable	AGE	YRS
Age	1,00	0,566**
Yrs		1,00

**Correlation significant at 1 % level

A common factor (EXP) was extracted using principal components. A total of 78 % of the variance in the data is explained by this index, which had an eigenvalue of 1,567.

$$EXP = 0{,}8850^{**} (AGE^{A}) + 0{,}8850^{**} (YRS^{A})$$

Where A = standardised variate
** = significant at 1 %-level (Harman, 1976, p. 441)

Latent vector loadings have the same sign and magnitude because the correlation matrix is of an equicorrelation type (Morrison, 1982, p.289).

Perceived risk index

Owing to the variation in climatic conditions across the sample area, the fluctuation in the number of crops and the area per crop, it is obvious that an index should account for these differences.

A risk index was calculated that took cognisance of the variation in individual producer yields over five years for all the crops that were planted by a specific producer. The extent of specialisation or diversification was also included in the computation by considering land area for each crop in Equation 1.

$$\text{Risk} = \sum_{i=1}^{N} (CV_i * LAND_i)/LAND_i \quad .... (1)$$

Where N = number of crops

CV_i = coefficient of variation in yield for $crop_i$ $(SE_i/MEAN_i)$

$LAND_i$ = area in ha under $crop_i$

A risk index, calculated for each producer, was included in the data base as a separate variable to be used in the discriminant analysis.

Off farm income (OFI)

A number of producers earned income from "outside" investments. This could have some bearing on the decision to insure or not to insure. A dummy variable was used to capture the effects:

If dummy = 0, then less than 5 % of total income was accrued from off-farm investments.

If dummy = 1, then at least 5 % of total income was accrued from off-farm investments.

Gross farm income (GFI)

Farmers approximated their total GFI per year (i.e. gross income from all farm enterprises) for the five years preceding the survey.

Long-term debt (DEBT)

Respondents reported the approximate value of all their debt repayable over a period greater than one year, e.g. Land Bank loans, mortgages and carry-over schemes of five to 10 years, etc. This factor may influence the producer's decision on whether to insure or not.

Gross farm income from livestock (LS)

The reliance on income from livestock is an important factor as far as diversification of on-farm enterprises is concerned and is expected to affect the demand for insurance adversely. Producers submitted estimates of the percentage contribution of income from livestock to GFI.

G-A Ratio (GA)

This ratio is calculated to obtain the relationship between the GFI per annum and total farm assets, i.e. it is an indication of the returns on investment.

RESULTS

Discrimination of comprehensive policy-holders/non-policy holders

All maize producers in the surveyed area had the opportunity to apply for comprehensive cover from one or more of the crop insurance companies. The phenomenon studied is why some producers insured their maize crops while others did not.

A discriminant analysis was undertaken on a number of quantitative and qualitative variables. These variables were collected and explored using a stepwise selection criterion in order to select the "best" function, i.e. the function that would explain the greatest portion of total differences in the data.

Of all variables used a combination of six was significant and may be ranked in importance according to the magnitude of their standardised discriminant function coefficients. The function is as follows:

$$\text{FUNCTION 1} = -0{,}5932\ (LS)^{**} - 0{,}5325\ (LIQ)^{**} + 0{,}4954\ (DEBT)^{**} - 0{,}4913\ (GA)^{**} + 0{,}2987\ (RISK)^{**} + 0{,}2943\ (EXP)^{**} \ldots (2)$$

** = variables significant at the 1 % level

From equation (2) it can be seen that the livestock variable LS is most important in explaining the separation between the two groups (i.e. the comprehensive insurers and the non-insurers) because it has the highest standardised coefficient (0,5932). Similarly, the experience index EXP is the least important of the six variables in explaining the separation as it has the lowest standardised coefficient (0,2943).

Signs of all variables are in accordance with expectations. It follows that the LS, LIQ and GA variables have a negative association, indicating that the greater the values of these variables, the *less* the tendency for the farmer to insure. The variables DEBT, RISK and EXP have a positive association, which indicates that the greater their values, the *greater* is the tendency for the farmer to insure his maize crop comprehensively.

The discriminant function shows fairly good discriminatory power, as indicated in Table 3. The function is capable of correctly classifying 92 % of the sample producers who did not insure and 64 % of the farmers who did insure their crops comprehensively. Of all the original farmers, 86 % can be correctly classified into the two groups.

TABLE 3. Measures of the discriminatory power of the discriminant function 1 (Equation 2)

Eigenvalue	0,57
Canonical correlation	0,60
Wilk's Lambda	0,64
Percentage of farmers in known groups correctly classified	
Farmers not insured (%)	92,30
Farmers insured (%)	64,20
All farmers (%)	85,68

The group means of the discriminant variable are based on 400 cases (Table 4). Results indicate that those producers who tend to insure their crops comprehensively have a low percentage of gross farm income from livestock, a relatively unfavourable "liquidity" position, substantial long-term debt and a low gross farm income to assets ratio. These farmers also have a high risk index and tend to be older and more experienced.

Those farmers who did not insure had a reasonably high percentage of gross farm income coming from livestock enterprises, a relatively favourable "liquidity" position, little long-term debt and a high gross farm income to assets ratio. These producers also have a low risk index and tend to fall into the younger and less experienced group.

TABLE 4. Mean values of the discriminating variables for both producers who do and those who do not insure their crops comprehensively. Variables collected in survey of Highveld Region during 1987.

Discriminating variable	Farmers *not* insuring	Farmers insuring	Difference %
LS	0,261	0,092	184
LIQ	0,277	-0,852	133
DEBT	182,328	352,790	93
GA	0,505	0,293	72
RISK	32,369	48,200	49
EXP	-0,046	0,036	22
No. of cases	305	95	**Total 400**

Note: Percentage differences are calculated as the difference in the means divided by the smaller group mean expressed as a percentage

Results indicate that the greater the risk experienced, the more insurance will be purchased by risk-averse producers. The risk index measured the variability of yields from all crops and the degree of crop specialisation, which is a dimension of risk, as shown in the portfolio theory (Markowitz, 1952). It is expected that in areas where yields vary substantially from year to year and/or where farmers tend to specialise, for instance where a crop has a clear comparative advantage, producers will insure more.

The percentage contribution of livestock enterprises to gross farm income and thereby to diversification of farm portfolios has positive and highly significant effects on the ability of producers to reduce overall risk, i.e. the larger the livestock enterprise the less the producer will insure.

The larger liquidity index group mean for non-insurers suggests that those farmers with high gross farm income, favourable CACL ratios and appreciable credit reserves are financially stable and have a certain degree of wealth. It is expected that with increased wealth and decreasing absolute risk aversion farmers may have less incentive to insure their crops, i.e. the cost an individual attaches to risk is a declining function of wealth (profit).

This agreement largely reinforces results obtained by the GA ratio, which can be used as a proxy for returns on investment. They suggest that as this ratio improves, so the risk aversion and associated cost attached to risk decline.

Average long-term debt is significantly higher in cases where farmers insure comprehensively. This implies that as debt levels rise and associated debt servicing commitments increase, there is a change in risk perception and farmers become more risk averse. The marginal utility of insurance is high for such individuals and they will purchase insurance even at a high price (premium cost).

The experience index was found to be significantly useful in distinguishing those who insure from those who do not. As opposed to the young, inexperienced income-seeking farmer with few dependants and obligations, the older, more experienced farmer is more interested in consolidation and security and is therefore more averse to risk. He will attempt to reduce risk by buying insurance.

A discriminant analysis of the characteristics of producers who are hail policy holders/non-policy holders

The logical *a priori* reason why a producer would seek hail insurance is when his farm lies in a belt which continually experiences hail. To obtain the frequency and severity of hail one need only calculate the indemnity to premium ratios of claims in the area. Although this procedure is simple, it obviously applies only to those farmers who have taken out hail cover in the five years preceding the survey and is therefore insufficient as a proxy for both groups of producers.

Other variables that did apply to both policy holders and non-holders were included in the analysis in an attempt to explain the discrimination. A stepwise criterion was again used in order to select the "best" or most powerful discriminant function.

Of all the combinations of variables that were analysed, only three were significant at the minimum 5% level. The following function was the most successful in explaining the separation between the two groups of farmers (i.e. the hail insurers and non-insurers):

FUNCTION 2 = -0,7400 (GFI)** - 0,5821 (OFI)** + 0,2426 (AGE)** ... (3)

Where** = variables significant at 1% level.

From the magnitudes of the standardised discriminant function coefficient in equation (3) it is clear that the GFI variable explains the greatest variation in the data (0,7400). It is followed by the variables OFI (0,5821) and AGE (0,2426)

The negative signs attached to GFI and OFI and the positive sign attached to AGE indicate their respective associations to the function. It follows that the lower are GFI and OFI and greater AGE the greater is the tendency for a farmer to insure his crops against hail.

The discriminant function has an eigenvalue of 0,22, a canonical correlation of 0,43 and a Wilk's Lambda of 0,82. It is capable of correctly classifying 40% of sample farmers not insured and 96% of sample farmers insured and of making an overall correct classification of 78%.

Group means of the discriminating variables were based on 400 cases with twice as many policy holders as non-holders (Table 5).

These results fit theoretical expectations. As

TABLE 5. Mean values of the discriminating variables for producers who did/did not take out hail insurance for their maize crops

Discriminating variable	Not insured	Insured	Difference
	Group means		%
Gross farm income (GFI)	1,385	0,352	293
Off-farm income (OFI)	4,223	3,093	37
Age (AGE)	0,077	0,167	117
Number of cases	270	130	Total 400

total income (GFI and OFI) increases, so the actual profit share (wealth) should increase, with a resultant downward pressure on risk aversion and insurance participation.

With AGE however, group means indicate that as the farmer gets older so his perception of risk changes. This is due to his seeking to achieve security for dependants and meet other obligations and responsibilities. The tendency will therefore be to insure his maize against hail.

CONCLUSION

A discriminant analysis of farmers who insure their crops in contrast to those who do not insure their crops shows the following variables to be significant in explaining the different characteristics between the two groups: percentage of gross income from livestock, liquidity position of the farmer measured by the component liquidity index, long-term debt, ratio of gross farm income to total assets, variation in yields of given crops and the extent of specialisation given by the risk index, and, lastly, age and years of farming measured by the experience index.

All these variables were significant at the 1 % level. The most important variables according to the magnitude of the standardised discriminant function coefficients were percentage GFI from livestock and the liquidity index.

Concerning hail insurance, of the many variables that were attempted in the analysis, only the following three were significant in discriminating between insurers and non-insurers: gross farm income, off-farm income and age in years. As a producer's total income (OFI + GFI) increases, so he will be less inclined to insure, but as he gets older, the tendency will be to insure against hail. Although these variables were also significant at the 1 % level, the function itself was not as good at discrimination as was the comprehensive function for comprehensive crop insurance. The results could contribute to a better understanding of why many farmers do not insure crops.

The results suggest that crop insurers might direct their efforts at cropping areas known to be specialised in their enterprise portfolio and that have relatively small herds of livestock, variable yields and a fair amount of debt. Although this should improve overall participation, cognisance must be taken of the possibility of increased adverse selection.

Further insight into the economic forces influencing farmer participation is important as these forces may affect the adjustment of present and the formation of future policies regarding risk management strategies.

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