Logistical estimation of the probability of mainstream market participation among small-scale livestock farmers: a case study of the Northern Cape province

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Abstract

Livestock farming significantly contributes to income generation and the improvement of the livelihoods of the rural poor in the Northern Cape. However, profitability and sustainability in the sector are constrained by low returns to investment due to a number of factors. The study investigates the factors influencing mainstream market participation among small-scale farmers in the five districts of the province. The main aim is to calculate the probability of small-scale farmers selling their livestock to more profitable mainstream markets, for example auction pens, against the odds of selling to informal speculators. A binary logistic regression model is applied to primary data collected from 60 sampled households in the districts of Kgalagadi, Pixley ka Seme, Frances Baard, Siyanda and Namakua. The partial effects of the conditional probability of selling livestock to mainstream markets and the impact of changes to the variables on the probability of selling to formal markets are estimated. The results show that farming experience, extension visits and infrastructure have a profoundly positive effect on the probability of small-scale farmers marketing their animals to the mainstream markets. On the other hand, household size, distance to the nearest market, and whether or not farmers have outstanding debts have a negative impact on the probability of them selling their animals to the formal markets. A unit increase in the farmer's debts, household size and distance to nearest market decreases the probability of profitable operation by 69.84%, 9.04% and 2.79% respectively. This result implies that an intervention policy is needed to alleviate these constraints that are impeding participation in the mainstream markets.

Keywords: speculators; partial effects; conditional probability; market participation; mainstream market

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1. Background

The livestock sub-sector is an important agricultural stronghold that contributes immensely to improving the livelihoods of the rural poor in the Northern Cape. The reason for this is that the small-scale farming of livestock, for example cattle, sheep and goats, plays an important role in income generation and job creation. It is one of the main policy targets for poverty alleviation, especially in the livestock stronghold districts of the Northern Cape, where the majority of the rural communities are poor and depend on subsistence livestock agriculture for survival.

In this regard, changing the landscape of subsistence farming has been on the development agenda at both national and provincial level, with the focus on the transformation of the agricultural sector for increased productivity and profitability. Engaging in profitable agriculture means generating maximum returns from the resources expended. In the small-scale livestock industry, returns have been a far cry from optimal, because the sector is characterised by low economic returns due to a host of factors, including lack of access to the mainstream markets, as well as inadequate and inaccessible market infrastructure. The term "mainstream markets" implies competitive and formally established market institutions such as auction markets, abattoirs and feedlots. These markets offer reasonably competitive market prices based on market forces of demand and supply whereby farmers get good returns on their investments.

In contrast to these markets are the informal speculative markets that cash in on the arbitrage opportunities created by the farmers' inability to exploit the formal markets, thus necessitating the sale of animals at exploitative and unprofitable prices. According to Northern Cape Premier Dipuo Peters (2008), the changing agrarian landscape of the Northern Cape commits the will to transform yesterday's mere herders of livestock into active participants in the local and global market economies.

It is from this that the study draws its motivation to investigate the factors that influence mainstream market participation among small-scale farmers in the five districts of the province. The main aim of the study is to calculate the probability of small-scale farmers selling their livestock to the mainstream markets. Understanding the dynamics in market participation and the factors driving it will inform appropriate policy formulation towards improving the livestock sector, thus achieving the objectives of the Provincial Growth and Development Strategy of the Northern Cape and the Accelerated Shared Growth Initiative of South Africa (ASGISA).

2. Factors influencing mainstream market participation

Many factors are considered to have a major influence on the farmer's decision to sell to the mainstream markets. Information about markets and market prices guide the farmer in making informed decisions (Nkosi & Kirsten, 1993). Making uninformed decisions may result in the farmer accessing the market when it is not profitable to do so. This is a common situation where livestock farmers approach saturated markets with the wrong price signals. On the other hand, cognisance should be taken of the fact that certain factors are beyond the scope of the farmers. For example, most livestock farms are constrained by high transaction costs due to great distances to markets, lack of adequate marketing infrastructure, lack of adequate access to finance, and in some cases socio-cultural factors (Doran *et al*., 1979; Fafchamps & Gavian, 1996).

Other factors that exert an influence include the socio-economic characteristics of the farmer, for example training, farming experience, age, level of education, and household size. In investigating the market performance among small-scale farmers in South Africa, many studies imply that these factors, amongst others, restrain farmers from making the decision to participate in the market (Makhura, 2001; Montshwe *et al*., 2006; Bahta & Bauer, 2007). According to Doran *et al.* (1979) socio-cultural values attached to the animals, for example the storing of wealth, inhibit market participation. Previous studies have failed to take into consideration the constraints faced by farmers in terms of the target market and the impact on the profitability and economic welfare of farmers. This study differs in that the emphasis is not on whether the farmers will participate, but rather on determining the probability of the farmers selling to a likely target market (mainstream or informal speculative market). Moreover, most of the forgoing studies based their analyses on a single livestock enterprise, for example cattle (Schmidt, 1992; Montshwe, 2005; Bahta & Bauer, 2007). In reality, it is rare to encounter a small-scale farmer with only a single livestock enterprise. The dynamics of a combined enterprise affect the farmer's decision to participate in a particular market. In this study the probability of marketing livestock (cattle, sheep and goats) is modelled.

3. Data and methodology

The study makes use of primary data collected by means of an appropriately structured questionnaire in all five districts of the Northern Cape Province, namely Kgalagadi, Pixley ka Seme, Frances Baard, Siyanda and Namakua. As a result of constraints to data collection, only sixty households were sampled,

comprising households owning one or more cattle, sheep and/or goat enterprises. The independent variables (both categorical and continuous) considered as factors and included in the model are farm size, household size, farming experience, market information, extension visits, training, access to transport facilities, infrastructure, non-farm income, membership of a farm organisation, distance to the market, and the availability of credit. In determining the response variable, farmers were asked whether they preferred selling their animals to speculators or to auction markets. Therefore, the response variable takes the value of one if a farmer was selling to the mainstream market (auction) and zero if the farmer was selling to speculators.

A binary logistic regression technique was used to analyse the data. The choice of analytical technique was based on the following reasons: (a) It can be used to analyse the relationship between a categorical response variable and a set of both categorical and continuous independent variables; and (b) It is best suited to modelling non-linear distribution, which is not plausible with ordinary least square (OLS) regression. By using a logistic regression technique, the probability of a result falling in one of the two response groups (binary response) is modelled as a function of the level of one or more explanatory variables. After estimating the conditional probability for mainstream marketing, the partial effects of statistically significant variables on the conditional probabilities were determined, followed by a simulation of the impact of changes in these variables on livestock sales.

4. Model specifications

The model specifications for logistic regression are as follows (Gujarati, 2003):

$$P_i = E(Y_i = 1/X_i) = \frac{1}{1+e^{-\left(\alpha_0 + \sum_{i=1}^{K} \alpha_i X_i\right)}} \quad (1)$$

Where P_i represents the probability of household i selling their livestock to a mainstream market, Y_i is the level of participation by household i, X_i represents a set of explanatory variables that influence the participation of household i in the mainstream market, and α_i represents the parameters to be estimated.

The symbol $\alpha_0 + \sum_{i=1}^{k} \alpha_i X_i$ can be denoted as Z; therefore equation (1) can be written to give the probability of household i participating in the mainstream market as:

$$P_i = \frac{1}{1+e^{-Z_i}} \tag{2}$$

If P_i – the probability of selling to the mainstream market – is given as equation (2), then $(1-P_i)$ – the probability of selling to speculators – is given as:

$$(1-P_i) = \frac{1}{1+e^{Z_i}} \tag{3}$$

The odd ratio $P_i/(1-P_i)$ is given as:

$$\left(\frac{P_i}{1-P_i}\right) = \frac{1+e^{Z_i}}{1+e^{-Z_i}} e^{Z_i} \tag{4}$$

Taking the natural logarithm of equation 4 gives rise to the logarithm of the odd ratio as:

$$L_i = \ln\left(\frac{P_i}{1-P_i}\right) = \alpha_0 + \sum_{i=1}^{k} \alpha_i + \varepsilon_i \tag{5}$$

L_i is called the logit – hence the term "logit model". If equation 5 is rearranged, with the dependent variable in log odds, the logistic regression can be manipulated to calculate the conditional probabilities as:

$$P_i = \frac{e^{\left(\alpha_0 + \sum_{i=1}^{k} \alpha_i X_i\right)}}{1+e^{\left(\alpha_0 + \sum_{i=1}^{k} \alpha_i X_i\right)}} \tag{6}$$

After calculating the conditional probabilities for each sampled household, the partial (marginal) effects of the discrete (categorical) variables on the probability of the household selling their livestock to the mainstream market are determined from the expression:

$$\frac{\partial P_i}{\partial X_i} = P_i(1-P_i)\alpha_i \tag{7}$$

Finally, the partial effects are calculated by taking the differences of the mean probabilities estimated for the respective discrete variables, i.e. when $X_i = 0$ and $X_i = 1$.

The partial effects of the continuous variables on the probability of the household selling their livestock to the mainstream market are determined by rescaling the parameter estimate from the logistic regression with a scale factor by simply subtracting the coefficient from the scale factor.

5. Results and discussion

The results of the logistic regression show that six out of the fourteen variables considered in the study have a significant influence on the probability of the small-scale livestock farmers selling their animals to the mainstream markets (Table 1). The results conform to *a priori* expectation and to the results obtained elsewhere (see Bahta & Bauer, 2007). Farming experience, extension visits to farmers, and the availability of adequate road infrastructures have a positive influence and enhance the probability of the farmers selling their animals to the mainstream markets. On the other hand, distance to the nearest market, household size and financial indebtedness of the farmers reduces the probability of them selling their livestock to the mainstream markets. The greater the distance to market, the more difficult it becomes for farmers to access such a market due to increased transaction costs. In that case, speculators cash in and procure animals at the farm gate at an unprofitable give-away price. The negative influence of household size is not surprising. Cognisance should be taken of the fact that most of the farms are projects with many beneficiaries, with group dynamics having a major effect on efficiency in the decision-making process.

An important and influential factor in market participation among small-scale farmers is the problem of debt, although this fact has nevertheless been widely ignored by many researchers. In this study, farmer indebtedness was found to have a negative influence on the probability of small-scale farmers participating in profitable marketing. Farmers who are under obligation to repay their debts may be more willing to sell their livestock to the speculators who are always ready and willing buyers.

Table 1 Parameter estimates of logistic regression a

Regressor	Coefficient	Standard Error	T-ratio	p-value
Constant	2.5492	2.6014	0.97995	0.332
Land tenure	1.2356	1.6950	0.72895	0.470
Farm size	-0.0002	0.0003	-0.5200	0.606
Household size	-0.9685**	0.5218	-1.8562	0.070
Farming experience	0.2103**	0.0947	2.2195	0.032
Market information	1.6011	1.5035	1.0649	0.293
Training	-1.7713	1.4223	-1.2454	0.219
Extension visits	0.8591*	0.3481	2.4681	0.017
Access to transport	1.0618	1.4844	0.7153	0.478
Infrastructure	4.6456**	2.0499	2.2663	0.028
Non-farm income	-2.0254	1.4093	-1.4372	0.158
Co-op membership	-1.1677	1.2746	-0.9162	0.364
Distance to market	-0.0387**	0.0209	-1.8512	0.071
Credit available	-1.6828	1.3651	-1.2327	0.224
Debt	-3.6662**	1.6952	-2.1628	0.036

[a] *Estimation is by the logit maximum likelihood procedure; the estimation converged after 8 iterations. The asterisks [*, **, and ***] represent statistical significance at 1%, 5% and 10% levels respectively.*

5.1 Robustness of the estimation

As a result of the problem of multicollinearity caused by the large number of regressors, the appropriate technique would be to first reduce the dimensionality of the data to improve the orthogonality of residuals. The analysis was carried out in two phases: The principal component regression (PCR) procedure was firstly used to analyse the data and address the problem of multicollinearity by transforming the explanatory variables into component estimators. The results obtained were then compared using the binary logistic regression estimation technique. The results obtained with the binary logistic regression estimation technique were more plausible, with appropriate signs that made more economic sense compared to the results of the PCR estimation technique.[4]

With regard to the predictive efficacy of the logistic model, 52 out of the 60 households sampled were correctly predicted, which is an accuracy rating of 87%. The predictive performance of the model was also demonstrated by means of the Pesaran-Timmermann non-parametric test, which is based on the proportion of times that the direction of change of the response variable is correctly predicted by the sets of regressors. The null hypothesis of predictive failure is rejected at the 1% level of statistical significance (Table 2).

The Wald test of linear/non-linear restriction was used to test for overall model fit. The null hypothesis is that the joint coefficients of the parameter

[4] *See the work of Magingxa* et al. *(2006). Here the problem of unexpected results from the PCR procedure is evident. Nevertheless, the results of PCR for this study will be available on request.*

estimate are equal to zero. The null hypothesis is rejected at 10% level of significance. The results show that at least one of the regressors is different from zero and contributes to the prediction of the outcome. Wald test statistics are shown in Table 2. The results of the Wald test show that the logistic regression model is appropriate and is a good fit for the data. The correlation matrix of the logistic regression is given in the Appendix.

Table 2 Goodness of fit

Percentage of correct prediction	Pesaran-Timmermann test statistics	Number of observations	Wald test of coefficient restriction
87%	4.4693 [0000]	60	3.1319[0.077]

Figures in parenthesis are p value

5.2 Partial effects of conditional probability of selling livestock to mainstream markets

5.2.1 Partial effects of discrete (categorical) variables

The aim of this section is to determine the partial effects of the statistically significant variables on the conditional probability of selling livestock to formal markets. The impact of changes in the level of farmers' indebtedness was calculated. The results show that all things being equal, a unit increase in the level of debt owed by farmers defined by a change from $(X_i = 0)$ to $(X_i = 1)$ results in a decrease in the probability of selling to formal markets from -0.5359 to -0.8147, thus resulting in a net decrease of -0.2788.

5.2.2 Partial effects of significant continuous variables

The partial effect of a unit increase in farming experience on the conditional probability of selling livestock to mainstream markets is 0.1846 (Table 3). This implies that a unit increase in farming experience will increase the probability of selling to formal markets by 0.1846. Also, there is a probability increase of 0.8334 for a unit increase in extension visits to farmers.

However, there is a decrease in probability for a unit increase in the number of household members and the distance to market by about -0.9943 and -0.0644 respectively (Table 3).

Table 3 Partial effects of significant continuous variables

Variable	Coefficient	Probability change
Household size	-0.9685	-0.9943
Farming experience	0.2103	0.1846
Extension visits	0.8591	0.8334
Distance to market	-0.0387	-0.0644

Factor for the calculation of marginal effects = 0.025728

6. Simulating the impact of changes in the variables on the probability of selling to formal markets

In this section, a sensitivity analysis is performed. The aim is to simulate the impact of changes in the statistically significant variables on the probability of the farmers selling their animals to formal markets. The simulation is performed against a base case, which represents households that sell to speculators. The value of the base case for these households for dichotomous variables is set to zero. For the dichotomous variable "infrastructure", this implies that farmers have no access to market infrastructure, while for the variable "debts", it is assumed that farmers have no debts. On the other hand, the initial condition for the continuous variables is set to the sample mean.

Table 4 Simulated impact of variables on the probability of selling to mainstream markets[a]

Variable	Base	Unit change	Increase (%)	Probability	Probability change (%)
Household size	4.40	5.40	22.73	0.8543	9.0360[b]
Farming experience	13.23	14.23	7.56	0.9502	1.1663
Extension visits	4.15	5.15	24.10	0.9733	3.6316
Infrastructure	0.00	1.00	1.00	0.9994	6.4063
Distance to market	49.08	59.08	20.37	0.9130	2.7900[b]
Debts	0.00	1.00	1.00	0.2832	69.8457[b]

[a] *Probability of base scenario = 0.9392.* [b] *Only absolute values of the probability changes are reported.*

The results of the simulation show that an increase in farming experience by one unit, i.e. 7.56%, and an increase in extension visits by one unit, i.e. 24.10%, will increase the probability of the farmer selling his animals to the mainstream markets from the base case 0.9392 to 0.9502 and 0.9733 respectively (Table 4). If market infrastructure is increased by one unit, the probability of selling to mainstream markets will increase from 0.9392 to 0.9994. At the same time, if household size and distance to market are increased by one unit, i.e. 22.73% and 20.37% respectively, the probability of selling to mainstream markets will decrease from 0.9392 to 0.8543 and 0.9130 respectively. Also, the farmer's indebtedness reduces the probability of selling to formal markets from 0.9392 to 0.2832.

The net probability changes are shown in Table 4. Debt has the highest probability change, implying that a unit increase in the amount of money owed by the farmer decreases the probability of operating profitably by 69.84%. For household size, there is a net probability decrease of 9.04%, while for distance to market the net probability decrease is 2.79%, for infrastructure 6.41%, and for extension visits 3.63%.

7. Conclusions and recommendations

Small-scale farming of livestock, for example cattle, sheep and goats, plays an important role in income generation and job creation in the Northern Cape. It is one of the main policy targets for poverty alleviation, especially in the livestock stronghold districts where the majority of the rural communities are poor and depend on subsistence livestock agriculture for survival. To improve the profitability of livestock farming and raise the standard of living of the rural poor, the participation of small-scale farmers in the mainstream markets is important.

The study investigates the probability of farmers selling their livestock to more profitable formal markets, for example auction pens and abattoirs, against the odds of selling to speculators (shrewd merchants who do not give farmers their money's worth). The study uses primary data collected by means of an appropriately structured questionnaire in all five districts of the Northern Cape, namely Kgalagadi, Pixley ka Seme, Frances Baard, Siyanda and Namakua.

In determining the response variable, farmers were asked whether they preferred to sell their animals to speculators or to formal markets such as auction pens and abattoirs. The response variable therefore takes the value of one (1) if the farmer was selling to a mainstream market (auction) and zero (0) if the farmer was selling to speculators. The logistic regression technique was used to analyse the data. After estimating the conditional probability of mainstream marketing, the partial effects of statistically significant variables on the conditional probabilities were determined. This was followed by simulating the impact of changes in these variables on the sales of livestock.

The results of the analysis show that farming experience, extension visits and infrastructure have a profoundly positive influence on the probability of the small-scale farmers marketing their animals to mainstream markets (auctions). On the other hand, household size, distance to the nearest market, and whether or not farmers have outstanding debt have a negative impact on the probability of the small-scale farmers marketing their animals to formal markets (auctions). It is recommended that attention be paid to formulating and improving policies that target the marketing infrastructure. The results show that group dynamics may have a negative impact on the sustainability and profitability of any project. The number of farm beneficiaries should be limited to ensure profitable economic returns to projects. Farmers should be encouraged to form commodity groups and cooperatives so that they can market in groups and reduce transaction costs.

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Appendix
Correlation matrix

	LandT	FarmSize	HHsize	Fexp	MktInfo	Train	ExtVisit	Transacc	Infras	Nfinc	Memcop	Distmkt	Creditav	Debts
LandT	1.00	**1.94*** **	0.45	0.66	1.17	0.51	0.11	0.83	0.55	1.39	1.06	0.05	0.33	0.87
FarmSize		1.00	1.74***	0.47	0.70	0.87	1.51	0.07	1.52	0.04	1.48	1.54	0.16	0.15
HHsize			1.00	0.64	1.85***	0.86	0.97	1.46	1.59	0.07	0.60	0.43	1.86***	1.80***
Fexp				1.00	1.44	1.82***	1.59	0.14	2.50**	1.58	0.71	1.58	0.88	0.08
MktInfo					1.00	2.06**	1.76***	3.85*	1.11	0.84	0.21	0.83	1.89***	0.89
Train						1.00	2.02**	2.96*	1.40	0.53	0.53	2.46**	0.58	0.45
ExtVisit							1.00	1.85***	0.78	0.15	0.27	0.66	1.49	1.08
Transacc								1.00	1.77***	1.20	0.14	0.50	0.24	0.30
Infras									1.00	1.16	1.10	1.11	0.46	1.19
Nfinc										1.00	1.90***	0.64	1.41	0.60
Memcop											1.00	0.55	0.89	1.15
Distmkt												1.00	0.54	0.13
Creditav													1.00	1.19
Debts														1.00

Source: Own calculations
Critical values for 1%, 5% and 10% levels of significance are [2.66, 2.00, and 1.67] respectively. The asterisks [, **and ***] represent statistical significance at [1%, 5% and 10%] levels.*