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Determinants of Market Choice and Strategies Adopted by Small-Scale Pig Producers in Redline Areas of Mpumalanga Province, South Africa: A Fractional Outcome-Tobit Model Approach

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Abstract: Different studies indicate that accessing a market is one of the frustrating challenges encountered in small-scale pig farming. The market within the pig farming sector is regarded as competitive, with small-scale farmers having to confront many constraints, which impede their bargaining position within the market. Although several studies on market channels have been carried out, there has not been any on piggery farming in South Africa. Thus, this study was carried out among small-scale pig farmers located in a redlined area in Mpumalanga province, where the government prohibits the unauthorized movements of animals. The research aims to explore the existing market channels and factors that influence the decision and choice of the market channels used by small-scale pig farmers. Cross-sectional data were collected, descriptive statistics, the Tobit and fractional outcome response models were adopted to identify the determinants of the choice of marketing channel used by the farmers. The descriptive statistics show that about 38% of the pig farmers engaged in the local market, 21% used abattoir, and 33% adopted auction as a market channel. Furthermore, the results from the two models showed similar significant factors, indicating that there is little or no variation in the two models. The study recommends that access to veterinary services and having the right breed to avoid market discrimination, among others, should be considered to overcome the challenges related to market channel choice among small-scale pig farmers.

Keywords: market channel choices, pig farmers, Tobit, fractional outcome response, South Africa.

南非普馬蘭加省紅線地區小規模養豬生產者採用的市場選擇和策略的決定因素: 分數結果-托比特模型方法

摘要: 不同的研究表明，進入市場是小型養豬業遇到的令人沮喪的挑戰之一。養豬業的市場被認為是具有競爭力的，小規模養殖戶必鬚麵臨許多限制，這阻礙了他們在市場中的議價地位。雖然已經對市場渠道進行了多項研究，但還沒有關於南非養豬場的研究。因此，這項研究是在位於普馬蘭加省紅線區的小型養豬戶中進行的，該地區政府禁止未經授權的動物移

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動。研究的目的是探索現有的市場渠道和影響小規模養豬戶使用的市場渠道的決策和選擇的因素。收集橫斷面數據，採用描述性統計、托比特和分數結果響應模型來確定農民使用的營銷渠道選擇的決定因素。描述性統計結果顯示，約 38%的養豬戶從事當地市場，21%使用屠宰場，33%採用拍賣作為市場渠道。此外，兩個模型的結果顯示出相似的重要因素，這表明兩個模型幾乎沒有變化或沒有變化。該研究建議應考慮獲得獸醫服務和擁有正確的品種以避免市場歧視等，以克服與小規模養豬戶的市場渠道選擇相關的挑戰。

关键词： 市場渠道選擇，養豬戶，托比特，部分結果響應，南非。

1. Introduction

Pig production is considered a high-valued income-generating business within agricultural development. Pigs are known for their prolificacy, massive reproduction capacity, and associated products, which sustain livelihoods and provide employment and income while at the same time promoting food security. Apart from contributing to human nutrition and food security, the pig provides less expensive sources of animal protein when compared with beef and lamb and sustains rural livelihood along the pig products' value chain. Commercial farmers dominate pig production in South Africa, and small-scale farmers are often deprived of participating in the high-value competitive market. The constraints impede the small-scale farmers from benefiting in this high-valued agricultural sector and weaken their bargaining position within the market.

In South Africa, this lack of access to markets is one of the most frustrating challenges experienced by small-scale pig farmers [5]. The smallholder farms are often characterized by linkages to local markets where they sell live animals or slaughter locally. In addition to the existing challenges in accessing the market, farmers in the veterinary redline area (demarcated area (infected zone for selected animal diseases – FMD and ASF) in South Africa are typically classified for veterinary inspections and usually bordering the Kruger National Park, Mozambique, Swaziland, Zimbabwe, and Botswana) in Mpumalanga, also have to deal with the restrictions regarding animal movement, because the government prohibits the unauthorized movement of animals in such areas. The area is known for its history of foot and mouth disease (FMD); thus, farmers are required to obtain permits from state veterinarians to authorize animal movements. This challenge is coupled with a lack of knowledge and resources to achieve the required market grades and standards [7] and negotiation skills [6, 9]. Furthermore, this lack of market access prevents absorption of local production, attracts low prices for the products [10, 14] is associated with poor product handling and packaging and lack of transparency of the market information system, mainly in the export market [4].

Similarly, small-scale pig farmers in the red line area experience bacterial, viral, and parasitic diseases and conditions, among others, that jeopardize livestock's market value [3]. Consequently, Antwi and Seahlodi [1] have explained the dual market structure of the South African pig value chain composed of both formal and informal markets. The formal market includes processors and abattoirs, which are dominated by commercial pig farmers, while the latter includes local auctions and pork meat from home slaughter, mostly utilized by small-scale pig farmers. Because the small-scale pig farmers find it difficult to penetrate the market, they adopt several channels to sell their livestock.

The choice of the market channel remains a complex and challenging decision among small-scale pig farmers in South Africa. Comparatively, pig farming in South Africa is not as big as for other livestock, primarily cattle and sheep, and there is limited or no research about what informs their market choice, especially in the redlined area. Therefore, the current study aims to fill the research gap by identifying various market channels available to small-scale pig farmers and to point out the factors influencing the choice which limit their participation in the existing market. The study should further help stakeholders, government, and policymakers to have a better understanding of the challenges that small-scale pig farmers deal with and enable them to package matching assistance that informs policy formulation, which promotes and incorporates small-scale pig farmers.

2. Methodology

2.1. Study Area and Research Design

The study was conducted in the redline area of Mpumalanga, which includes Nkomazi, Mbombela, and Bushbuckridge. These three areas (local municipalities) fall under the Ehlanzeni District

Municipality. The district is situated in the northeast of the province, which covers a third of the province's geographical area (27 896 km²) and is the most vibrant economic hub within the province. The district is next to the Swaziland and Mozambique borders, allowing people from neighboring countries to enter the district. These local municipalities were purposely selected because of 1) The history of FMD; 2) As a result of being close to the border entry points; 3) As a center of attraction and business hub which attracts a lot of people's patronages with the potential of coming in with foreign pests and diseases.

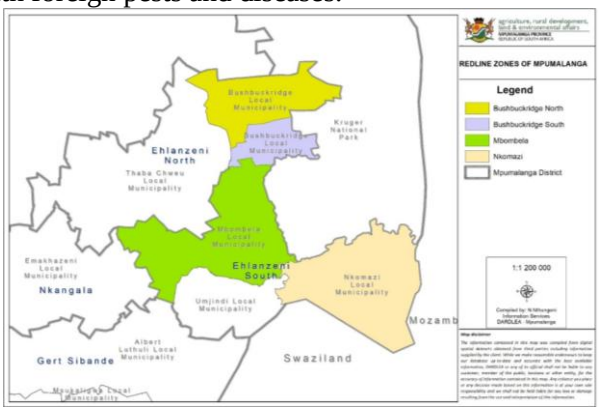

Fig. 1 DARDLEA Information Services

2.2. Data Collection and Procedure

Primary data was collected from small-scale pig farmers in the redline area, using a questionnaire containing semi-structured questions. The questionnaire was pretested and validated to avoid ambiguities and misinterpretation, which ensured easy comprehension of all the questions by the respondents. A total of 121 small-scale pig farmers (sample size) across the areas mentioned above, was selected to participate in the interviews through a multistage random sampling technique. These farmers, therefore, constituted the unit of analysis for this study.

2.3. Data Analytical Techniques

The data collected was edited, coded, and sorted to ensure accuracy, consistency, and uniformity. The data were entered into Microsoft Excel, then coded and transferred into STATA v15 computer software (Stata Corporation, College Station, Texas, USA). Descriptive statistics such as means, median, minimum and maximum values, frequencies, percentages, and standard deviations were used to describe the data. Similarly, the study applied two different models (The Tobit model and the fractional response model) to identify the factors that influence the market channel choice and compare the outputs of the models to guide future use by other researchers.

2.4. Tobit Regression

The Tobit model, also called the censored regression model, was employed to estimate linear relationships among variables that influence the choice of market channels. Firstly, the farmers' available choices generated a market choice strategies index (MCSI). Yi = market choice strategies index (MCSI) was determined by dividing the number of choices used by the individual farmers by all the choice strategies available in the study area. Thus, the value of MCSI ranges between zero (0) and one (1). According to Oduniyi [12], the dependent variable is censored between 0 and 1, and conventional regression methods fail to consider the qualitative difference between zero and continuous observations; hence, the Tobit model was preferred.

The model is specified as:

$$Yi = \beta Xiifi^* = \beta Xi + ui > Ti \quad (1)$$

$$Yi = \beta 0 + \beta iXi + ui \quad (2)$$

where:

uí - normally distributed with zero mean and constant variance;

Xi - vector of explanatory variables;

βi - vector of the parameter estimate.

The model is fully estimated as follows:

$$yi^* = \beta 0 + \beta 1xi + \varepsilon i = xi'\beta + \varepsilon i,\ \varepsilon i \sim N(0,\sigma 2) \quad (3)$$

$$\text{If } yi^* > 0 \Rightarrow yi = \text{climate change} = yi^* = xi'\beta + \varepsilon i. \quad (4)$$

$$\text{If } yi^* \leq 0 \Rightarrow yi = 0 (y^* \text{ can be negative, but if it is, } y = 0) \quad (5)$$

$$\text{Probability model --} \varepsilon i \sim N(0, \sigma 2) \quad (6)$$

$$Prob(y=0|x) = Prob(y^* \leq 0|x) = Prob\left[(y^* - X\beta)/\sigma \leq (0 - X\beta)/\sigma|x\right] \quad (7)$$

$$Prob[z \leq -X\beta/\sigma|x] = \Phi(-X\beta/\sigma) = 1 - \Phi(X\beta/\sigma) \quad (8)$$

$$Prob(y>0|x) = Prob(y^* > 0|x) = 1 - \Phi(-X\beta/\sigma) = \Phi(X\beta/\sigma) \quad (9)$$

2.5. Fractional Outcome Model

Fractional responses concern outcomes between zero and one. It captures nonlinear relationships, especially when the outcome variable is near 0 (zero) or 1 (one). Fractional response estimators fit continuous zero to one data models using probit, logit, heteroskedastic probit, and beta regression. Since the response variable, the MCSI, is a proportion that is naturally a fraction bounded between 0 and 1 thus, this model is deemed fit. Following Oduniyi [12], fractional probit outcome was used to estimate the factors that influence the choice of market channels. The model is expressed as:

The proportion of choice of channels used by a farmer E(y | x) is given by

$$E\ Y|X = G(X\theta) \quad (10)$$

where:

y represents the dependent variable, which is bounded between 0 and 1;

x is the explanatory variables;

θ is a vector of parameters;

G(.) is a cumulative distribution function of the standard normal distribution, which takes several forms

such as the probit—$G(x\theta) \equiv \Phi(x\theta)$ or loglog—$G(x\theta) \equiv e-ex\theta$.

3. Results and Discussion

The results in Table 1 show the descriptive statistics in which the explanatory variables' percentages, mean, variance, and standard error were displayed. Similarly, Table 1 indicates the following results: the mean choice of market channels is 2.107, while the variance and standard deviation are 1.047 and 1.023, respectively. Table 1 reveals that the most popular choice of the market channel used by the farmers in the local market (38%) involves selling live livestock locally and slaughtering at home, whereby the pork is sold. Similar results have been reported previously [8] where approximately 64% of all respondents slaughter at home without proper inspection from approved authorities or sell live pigs at home. About 33% of the farmers engaged in an auction as a market channel. This result is not surprising, as most small-scale farmers do not have a formal market. This is in line with the study findings by Nxumalo *et al.* [11], who reported that 65% of the emerging sunflowers farmers in the North West province of South Africa were utilizing informal markets due to lack of access to formal market.

Correspondingly, respondents were from the three local municipalities with the following proportions; Bushbuckridge (45), Mbombela (50), and Nkomazi (26). Farmers were involved in the different kinds of projects (with the mean, variance, and standard deviation to be: 2.298, 0.677, and 0.823) such as Masibuyele Esibayeni Programme (MESP), private, individual, and community projects with 14.87%, 48.76%, 28.09%, 8.26% respectively. The number of individuals in a project is 1.537, with the variance and standard deviation of 0.817 and 0.904, respectively. Also, about 66.94% of the farmers prefer to be alone in their projects. The farming area is mostly rural and peri-urban areas, in which the mean, variance, and standard deviation are; 2.033, 0.032, and 0.180, respectively, whereby 58.67% reported that they did not know what it means by redline area. It was reported that most of the farmers (about 71.07%) did not castrate their pigs, in which about 52.066 of the farmers did not know if the price of the castrated pigs differs from that of uncastrated pigs. A previous study revealed that castrated pigs grow faster and have better carcass characteristics when compared with uncastrated ones [2]. Likewise, castration improves the meat quality as male pigs develop boar taint when they become sexually active.

The predominant breed used by the farmers is Landrace (46.28%), followed by various crossbreeds of the Large White, Landrace & Indigenous (21.48%). However, in terms of feeding, the majority of the farmers used a free-range scavenging feed system which accounted for 54.54%, followed by the use of Restaurant/school swills (22.31%) to feed the pigs. In the same line of thought, approximately 61.15% of the farmers did not have access to their transportation, and the majority of the farmers (84.29%) hired transport for the farming operations. Furthermore, most farmers (about 70.24%) have movement permits to move the animals from one place to another. However, the majority (55.37%) had no access to veterinary services, with 81.81% reporting having never vaccinated their animals.

Table 1 Descriptive statistics (Authors' computation)

Variables	Categories	Frequency per category	Rel. frequency per category (%)	Mean	Variance	Standard deviation	Expected Sign
Municipality				1.843	0.567	0.753	+
	Bushbuckridge	45	37.190				
	Mbombela	50	41.322				
	Nkomazi	26	21.488				
Kind of project				2.298	0.677	0.823	+
	MESP (Masibuyele Esibayeni Programme)	18	14.876				
	Private	59	48.760				
	Individual	34	28.099				
	community	10	8.264				
No of the individuals in the project							+
				1.537	0.817	0.904	
	1	81	66.942				
	2-5	23	19.008				
	6-10	10	8.264				
	11-15	6	4.959				
	16-20	1	0.826				
Farming area				2.033	0.032	0.180	+
	Rural	117	96.694				
	Semi-Urban	4	3.306				
Castrate				0.711	0.207	0.455	+
	Yes	35	28.926				
	No	86	71.074				
Price differ castrated				1.934	0.479	0.692	+

	Yes	33	27.273				
	No	63	52.066				
	Do not know	25	20.661				
Discriminated pigs				2.124	0.443	0.665	+
	1	9	7.438				
	2	99	81.818				
	3	2	1.653				
	4	11	9.091				
Vaccinate				1.289	0.424	0.651	+
	Never	99	81.818				
	Sometimes	9	7.438				
	Always	13	10.744				
Type of breed				4.215	7.487	2.736	
	Cross of Large White, Landrace & Indigenous	26	21.488				+
	Indigenous	3	2.479				
	Landrace	56	46.281				
	Cross of Large White & Landrace	16	13.223				
	Cross of Large White, Landrace & Duroc	20	16.529				
Feeds				4.562	3.498	1.870	+
	Concentrate feeds	69	57.03				
	Vegetable swills	82	67.77				
	Restaurant / school swills	23	19.01				
	Home Leftovers	54	44.63				
	Free-range	15	12.40				
	Others	4	3.31				
Own transport				0.388	0.240	0.489	+
	No	74	61.157				
	Yes	47	38.843				
Hire transport				0.157	0.133	0.365	+
	No	102	84.298				
	Yes	19	15.702				
movement permit				0.702	0.211	0.459	+
	No	36	29.752				
	Yes	85	70.248				
Certificate source				0.124	0.110	0.331	+
	No	106	87.603				
	Yes	15	12.397				
Veterinary accessible				1.562	0.482	0.694	+
	No	67	55.372				
	Sometimes	40	33.058				
	Always	14	11.570				
Redline Area				0.413	0.244	0.494	+
	No	71	58.678				
	Yes	50	41.322				

Market channel choice	No of categories	Frequency per category %	Frequency per category
	Local market (1)	38	46
	Abattoir (2)	21	26
	Auction (3)	33	40
	Combination of local market and abattoir (4)	7	8
	Combination of local market and auction (5)	1	1

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	Combination of local market and abattoir (4)	7	8
	Combination of local market and auction (5)	1	1

Statistic	Market channel choice
No. of observations	121
Mean	2.107
Variance (n-1)	1.047
Standard deviation (n-1)	1.023

Note: The total for 'Feed*' above is higher than 121 because multiple responses were allowed wherein farmers utilized more than one feed source.

3.1. Inferential Statistics Result

The study compares the two models as explained above based on the fractional outcome and Tobit model (Table 2); however, the respective models generated the same results. In other words, the same variables were significant in both models with a slight variation. This indicates some similarity between the two models; however, the fractional outcome model is preferred when there are more outcomes or incidences of zero. The results in the two tables show that *the number of individuals in a project*, "*breed discrimination*," and *access to veterinary services* were greatly significant ($p>0.05$) and influenced their choice of market channel.

The higher the number of individual farmers engaged in various farming projects, the lower the choice of market channel opportunities. This is because if people are many, the tendency to consume most of the outputs is high, making them less desire and volume of outputs to compete in the market. Because the needs of diverse group members also vary, commitment and patience to seek a high-value market may be inconsistent within the group as some members may need returns quicker, thus a push to concentrate on the informal market. It is also likely that a bigger group could have group dynamic problems, like shifting responsibilities, delayed contributions, and partial commitment, which hamper productivity and less output volume to participate in a formal market.

Similarly, the choice of market channel is affected by a preference for certain breeds and discrimination against some pig breeds. For instance, the indigenous breed is considered unhygienic and dirty. Hence, some schools of thought considered the meat from this breed as not good for consumption or may carry zoonotic pathogens causing human illnesses. In addition, the indigenous breed has small carcass output compared to breeds such as Landrace, Large White, and Duroc, which attracts a comparably better market. However, from this study, the more discriminated pigs produced due to better management, the more the choices of the market channel the farmers explore to sell the pigs. However, not all the channels are acceptable to date. Furthermore, access to veterinary services affects the market channel choices of small-scale pig farmers since access to veterinary service tends to promote healthy pigs and distribution of the movement permits, which would allow farmers to sell their livestock at a formal abattoir and the other official channels.

Table 2 Factors influencing the choice of market channel

Result of Fractional Outcome Response						**Result of Tobit Regression**				
Variables	**Coef.**	**Robust Std. Err.**	**z**	**P>|z|**	**dy/dx**	**Variables**	**Coef.**	**Std. Err.**	**t**	**P>|t**
Kind of project	0.040	0.047	0.84	0.402	0.016	Kind of project	0.016	0.020	0.77	0.444
No of the individuals in the project	-0.123	0.040	-3.08	0.002***	-0.050	No of the individuals in the project	-0.049	0.018	-2.69	0.008***
Farming area	-0.162	0.204	-0.80	0.427	-0.065	Farming area	-0.064	0.085	-0.76	0.451
Castrated pigs	-0.036	0.098	-0.37	0.711	-0.014	Castrated pigs	-0.015	0.039	-0.38	0.702
Price of castrated	0.042	0.062	0.68	0.494	0.017	Price of castrated	0.016	0.024	0.68	0.499
Discriminated pigs	0.152	0.056	2.73	0.006***	0.061	Discriminated pigs	0.060	0.023	2.62	0.010***
Vaccinate	0.029	0.060	0.48	0.630	0.012	Vaccinate	0.0106	0.023	0.43	0.669
Type of breed	0.014	0.017	0.81	0.421	0.005	Type of breed	0.005	0.006	0.93	0.354
Own transport	-0.009	0.085	-0.10	0.920	-0.003	Own transport	-0.003	0.032	-0.11	0.915
Feeds	-0.012	0.018	-0.69	0.493	-0.005	Feeds	-0.005	0.008	-0.60	0.548
Hire transport	0.038	0.112	0.34	0.735	0.015	Hire transport	0.015	0.043	0.35	0.727
Movement permit	0.126	0.082	1.53	0.127	0.050	Movement permit	0.049	0.036	1.35	0.181
Certificate source	-0.063	0.122	-0.52	0.602	-0.025	Certificate source	-0.025	0.047	-0.54	0.590
Vets accessible	0.258	0.065	3.98	0.000***	0.103	Vets accessible	0.101	0.027	3.75	0.000***
Redline	0.051	0.082	0.63	0.530	0.020	Redline	0.020	0.031	0.65	0.520
constant	-0.518	0.552	-0.94	0.348		Constant	0.300	0.220	1.36	0.176
						var (e. market choice channel)	0.023	0.003		
Number of obs = 121						Number of obs = 121				
Wald chi2(15) = 80.55						LR chi2(15) = 30.26				
Prob > chi2 = 0.0000						Prob > chi2 = 0.0110				
Pseudo R2 = 0.0188						Pseudo R2 = -0.3576				
Log pseudo-likelihood = -82.274375						Log likelihood = 57.447649				

Table 3 Predictive margins for fractional outcome response (Authors' computation)

	Margin	Delta-method Std. Err.	z	P>|z|
Constant	0.491	0.014	35.76	0.000

Notes: The number of obs = 121, Model VCE: Robust, Expression: Pr (Choice of the market channel), predict ().

The Model fit information in Tables 2 and 3 appropriately explain that the two models fit well.

4. Conclusion

Using a quantitative approach, the study identifies the determinants of market choices among small-scale pig farmers in the red line area of Mpumalanga, South Africa. Several studies on market channels have been explored, but none has been done on pig farmers. Similarly, the model adopted in this study is relatively uncommon. The small-scale farmers in the redline areas cannot move the livestock from the redline zone to the free zone to reduce the risk of animal diseases. As indicated on the result, few respondents confirmed auction sales, while in reality, there is no auction facility in the redline zones of Mpumalanga province.

Further probing indicated that they sometimes obtain movement permits from unauthorized sources. According to Animal Movement Act No. 35 of 1984, animals in the redline zone should be inspected before moving from one area to another, and such movement must be accompanied by an accreditation certificate of freedom from diseases. The establishment of dedicated auctions and markets, including the processing facilities in the redline areas of Mpumalanga province, will reduce the tendency to move animals out of the region, positively impacting the risk of disease transmission.

Adequacy in terms of the number and training of animal health professionals and paraprofessionals will facilitate disease surveillance and control activities in the redline areas of Mpumalanga province. Since access to veterinary services influences market access, the professionals should be involved in community and stakeholders' engagements and teaching good farming practices to these farmers. Similarly, because certain pig breeds are discriminated against, overall improvement of the genetic stock can be a target of the pig genetic centers, and scaling up of smallholder piggery can be planned through programmed crossbreeding activities to reduce the volume of undesirable breeds while scaling up those that are preferred by the market. Finally, the organization of farmer groups, coordination, and set rules of engagement should address the challenges associated with a larger group as limitations to choosing markets. It is believed that the implementation of the above recommendations will positively impact incomes and rural livelihoods of smallholder pig farms in Mpumalanga, South Africa.

The study is limited to the red line area of Mpumalanga Province. Further research can be carried out in the other provinces of South Africa to inform a general policy to solve the problem of market channel choices among small-scale piggery farmers.

5. Ethics Approval and Consent to Participate

The study received ethical clearance, and each participant signed a consent form.

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