Article

Adoption of ICT-based Information Sources and Market Participation among Smallholder Livestock Farmers in South Africa

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Abstract: The study explored the contribution of ICT-based information sources to market participation among smallholder livestock farmers. Use of ICTs is considered paramount for providing smallholder farmers with required market information, in order to reduce market asymmetries. A Double Hurdle regression was utilized to analyze data collected from 150 smallholder livestock farmers in the study area. The results show that while use of ICT-based market information sources significantly influenced market participation, the effect of using ICT-based information sources on intensity of market participation was not significant. Other variables shown to influence both market participation and the intensity of market participation were age, additional income and membership of farmer cooperatives. This suggests the need to also consider other associated factors in the application of interventions which utilize ICT-based information sources in achieving planned market interventions.

Keywords: double hurdle, ICTs, information source, market participation, probit, regression, smallholder, livestock farmer

1. Introduction

The significant contribution of Information and Communication Technologies (ICTs) in the disseminating information to farmers has been widely reported, indicating that smallholder farmer's need for relevant and timely market information can be met through ICT-based information sources [1, 2]. This has resulted in the development of different platforms that use ICTs for disseminating market information to farmers in many countries, aimed at addressing the perceived lack of market information among rural smallholder farmers. Proponents of ICT-enabled market information sources envisage ubiquitous information systems, capable of widespread distribution of market information and resulting in increased accessibility and the participation of smallholder farmers in markets. The use of ICT-enabled market information sources is associated with an increased market transparency, through the provision of current market information, while simultaneously improving incomes and leading to other welfare outcomes. However, available studies have mostly examined how ICTs contribute to improving farmers access to market information [3, 4], adoption of production technologies [5, 6], or livelihoods effects [7]. Though, some studies have explored the link between market information and commercialization, such as [8], there is a dearth of studies which examine the effect of adopting ICT-based information sources on market participation among this group of farmers.

Access to market information is considered a key institutional factor that affects participation of smallholders in markets. The information enables producers to make economic decisions regarding market interactions, either to purchase or sell, and hence enhances their comparative advantages. A lack of market information contributes to increased transaction costs, while reducing market efficiency. Farmers therefore require accurate and timely market information to improve their

knowledge of the market, as a balanced knowledge provides a fairer spread of anticipated receipts accruable from a better organized market price formation for all market actors.

In the literature regarding transaction costs, commentators have observed that better market information reduces transaction costs, and also stimulates market participation among smallholder farmers [9-11]. A common opinion suggests that a lack of market information hinders participation in the market among smallholder farmers, through raising their search, screening and bargaining costs. Other costs associated with transactions include the cost of monitoring and ensuring adherence to the terms of agreements, and the costs of adapting to changes in the market environment. These costs are significant for smallholder farmers, and occur irrespective of whether a sale or purchase is finalized.

The Transaction Cost concept has been utilized in explaining many economic phenomena, and regarded as central in highlighting and mitigating market failures in agriculture. Transaction costs encompass various definitions and meanings, including the cost of searching for information, the cost of using the price mechanism, and the cost of exchange, among others. It is a catch-all phrase applied for explaining the variety of costs involved in the transfer of ownership, or the running of an economic system [12]; considered as a direct cost incurred when engaging in any market transaction. Due to the effect of transaction costs on smallholder farmers, market advocates have called for interventions that reduce transaction costs [13]. These interventions include provision of adequate market information which in their view, encourage increased farmer participation in markets.

Affirming the importance of market information for farmers, [14] submitted that the provision of basic market information increases agricultural market efficiency, and also contributed significantly towards market participation. Conversely, poor access to market information increased both personal disadvantages and inimical choices, leading to increased transaction costs among smallholder farmers, and is acclaimed as a discouraging factor to market participation among this group of farmers [15, 16].

The lack of market information is considered a big challenge in the livestock sector, especially among rural smallholder farmers, as it has been noted by [17] to be positively and significantly related to their probability of selling livestock. Hence, the increased use of ICTs has potential for fostering improved business opportunities or market activities [18].

According to [19], the cost of obtaining relevant information affects the decision to enter markets and exacerbates existing disparities. Furthermore, the information source also has a significant effect on market participation. Informal information sources such as relatives, friends and fellow farmers are a major information source among farmers, and considered effective in provision of relevant information that contributes to market participation. Although the availability of information generally affects market participation, [8] posits that the directional effect of the market information variable differs with the type of information source. This study therefore casts the spotlight on the link between utilization of ICT-based information sources and participation in markets. It is tasking to find studies which have focused on how the usage of ICT-based market information sources influence market participation in specific sectors or among explicit groups, such as smallholder livestock farmers. Many available studies focused on factors influencing market participation among farmers, but with little emphasis on the role of market information sources in determining participation. In addition, there is little categorization of the market information received by farmers according to the source, and [20] highlights the importance of an information source while outlining the different values that farmers ascribe to various communication methods and channels. All of which lends urgency to investigate whether ICT-based information sources contribute towards market participation among targeted smallholder livestock farmers.

2. Materials and Methods

2.1. Analytical framework

Numerous studies on factors influencing market participation consider it a two-stage decision process, and utilize variants of two main approaches including a selectivity model introduced by [21],

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and the hurdle model pioneered by [22]. The literature provides varied analytical methods for determining cause-effect relationships, with views indicating a heavy dependence on the two step selectivity models for discrete and continuous decisions reported by [23]. A two-stage econometric method outlined in [24] is based on the ordered Probit and Tobit models, and current methods for analysing the effect of identified variables on market participation have been incorporated using the truncated, binary and multinomial regression models [25-28].

2.2. Specification of model

Following the assumptions in the Double Hurdle model, market participation is generally analysed using a two-step approach. The farmer firstly needs to decide whether to, or not to, participate in the market, before deciding on continued participation. Therefore, market participation is commonly assumed to involve two independent problems, the initial problem is a personal decision made by the farmer whether to participate or not (considered as the first hurdle); and the second problem is the clearly obvious intensity of participation, measured by quantity sold in, or purchased from, the market (seen as the second hurdle).

The Double Hurdle model is a form of parametric generalization of the P-Tobit model in which, market participation and the intensity of participation are determined by separate stochastic processes. First, a Probit model of market participation (MKTPAT) for the selection equation is obtained using a function of the explanatory variables which also determines market participation intensity, using one or more exclusion variables. A truncated least squares regression equation of the MKTPAT intensity, which closely resembles the Tobit model is employed in a second step. An Inverse Mills Ratio (IMR) predicted from the Probit regression is then included as a regressor to account for the selectivity bias.

The regression equation thus defines the latent variable $MKTPAT_i^*$:

$$MKTPAT_i^* = Z_i\beta + e_i \qquad e_i \approx N(0,1) \qquad \text{(First hurdle)} \qquad (1)$$

$$MKTPAT_i = 1 \text{ if } MKTPAT_i^* > 0 \text{ , and } MKTPAT_i = 0 \text{ if } MKTPAT_i^* \le 0$$

Where $MKTPAT_i$ is a categorical variable that takes the value of 1 if a smallholder livestock farmer participates in the market, and 0 if otherwise.

According to [29], a Probit model of $MKTPAT_i$ which follows random utility is expressed as:

$$\Pr\left(MKTPAT_i = 1 \mid Z_i, \alpha\right) = \Phi\left(h(Z_i, \alpha)\right) + e_i \quad \text{..... (2)}$$

Where; $MKTPAT_i$ equals 1 for households that participates and 0 otherwise. Z_i represents the vector of ICT-based information sources; α, is vector of parameters to be estimated; Φ is a standard

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normal cumulative distribution function; *ei* is a random error term hypothesized to be distributed normally with unit variance σ^2 and zero mean.

In the second step (hurdle), the generated sample selection term IMR from the Probit model (first hurdle) which accounts for potential selectivity bias is then utilized as an exogenous variable in the truncated model regarding $MKTPAT$ intensity, as described by [30].

The second stage ($MKTPAT$ intensity) equation is expressed as:

$$E(Q_i / MKTPAT = 1) = f(Z_i, \beta) + \omega\lambda \quad \text{(Second hurdle)} \quad \ldots\ldots\ldots\ldots (3)$$

Where; Q is the quantity sold in the market and is the observed response on intensity; E is the expectation operator; Z is a vector of the ICT-based information source; β is a vector of parameters to be estimated; λ is the IMR which accounts for sample selection bias in the probit model; and ω is the associated parameter to be estimated.

The IMR can hence be calculated as $\lambda = \dfrac{\varphi(h(Z_i, \beta))}{\Phi(Z_i\beta)}$ ..... (4)

Where, $\varphi(.)$ is the normal distribution and Φ is the cumulative density function. Therefore, Q can be expressed as follows:

$$Q_i^* = \beta' Z_i + \omega\lambda_i + \mu_i,\ \mu_i \approx N(0, \ell^2) \quad \ldots\ldots\ldots\ldots (5)$$

Where, μ_i is a random error term with zero mean and variance ℓ^2; and Q_i^* is the observed response on quantity sold $(MKTPAT = 1)$, in which case $Q = Q_i^*$. The truncated estimation of Equation (2), with the inclusion of λ, gives consistent estimates, accounting for selectivity bias [30].

2.3. Description of variables

The independent variables and their hypothesized relationship with the dependent variable (market participation) including expected sign is described in Table 1.

Table 1. Variables in the model and their hypothesized relationship

Variable	**Type**	**Measure**	**Relationship with dependent variable**	**Expected sign**
Gender	Dummy	0= female 1= male	Males more likely to participate in markets.	Positive (+)

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Age	Continuous	Years	Older farmers likely to be market inclined and experienced	Positive (+)
Level of education	Continuous	Number of years in school	Increases the ability to seek out markets and partake	Positive (+)
Marital status	Dummy	0= single 1= Other	Maybe positive or negative	+ / -
Herd size	Continuous	Number of animals	Indication of wealth status, more likely to sell or purchase.	Positive (+)
Household size	Continuous	Number of persons	Maybe positive or negative	+/-
Membership of farmer coop	Dummy	0= no 1= yes	Members have access to information and maybe more inclined to market.	Positive (+)
Other income source	Dummy	0= no 1= yes	Additional income may result to more market interaction	Positive (+)
Use of ICT-based sources	Dummy	0 = no 1 = yes	Adequate market information results in more market interaction.	Positive (+)

2.4. Study area

The Eastern Cape Province as shown in Figure 1 is located in the south-eastern part of South Africa, and is the second largest province by surface area in the country. It covers approximately 170,000 square kilometres which comprise about fourteen percent (14%) of the total land mass in South Africa [31].

Figure 1. Map of South Africa showing the various provinces.

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2.5. Data types, sources and ethics

Following an extensive review of the literature on market participation, the use of ICTs among farmers and related topics, a draft questionnaire was developed. This schedule was pre-tested and amended as necessary, before field data collection. The questionnaire was utilized to capture primary data from smallholder livestock farmer-respondents. The data collected comprised the socio-economic characteristics of the respondents, use of identified ICT sources, livestock numbers owned, market information channels utilized and engagement with markets. A total of 150 livestock farmers were selected and interviewed for the study. The interviewed farmers were informed of the academic purpose of the data collection, and their consent requested using a signed agreement form before the interview.

2.6. Sampling, sample size and analysis

The Eastern Cape Province was purposively selected due to its leading status as the province with the largest number of livestock in South Africa. From the province, Alfred Nzo District was identified for convenience non-random sampling. A multi-stage procedure was utilized in identifying samples from the study population and the collection of data. In the first stage, three local municipalities in the Alfred Nzo District were purposively selected, based on the availability of information from the Department of Agriculture, and their proximity. In the second stage, one Ward from each local municipality shown in Table 2 was randomly selected from a list of Wards available from the local municipal offices. In the third stage, 150 livestock farmers were selected after determining the required sample size, as outlined in [32].

Table 2. Number of farmers sampled from each local municipality.

Municipality	Listed livestock farmers	No of farmer respondents	% of total farmers surveyed
Umzimvubu	380	37	25
Ntabankulu	470	47	31
Mbizana	650	65	44
Total	1500	150	100

Source: Researchers Fieldwork 2017

Utilizing a snowball selection approach, 150 smallholder livestock farmers were identified and interviewed using a structured pre-tested questionnaire which was administered by trained field enumerators.

3. Results / Discussion

3.1. Demographic characteristics of respondents

The personal features of the survey respondents is presented in Table 3, it shows that male respondents constituted 64% of the total number, while 36% of the respondents were female.

Respondents aged less than thirty-six years made up only 7% of respondents; those between thirty-six and fifty-five years represent 33% of respondents, while respondents fifty-six years and older comprise 50% of the study population.

Table 3. Demographic characteristics of survey respondents

	Category	Total (n=129)	Percentage (%)
Gender	Female	47	36
	Male	82	64
Age	<36 years	9	7
	36 -55 years	43	33
	56+ years	77	60
Marital status	Single	35	27
	Married	59	46
	Other	35	27
Education	None	22	17
	Primary	47	36
	High School	25	20
	Post High	35	27
Coop member	No	112	87
	Yes	17	13
Herd size	50 or less	43	33
	51 - 100	46	36
	More than 100	40	31

Source: Questionnaire survey 2017.

The data suggest that persons aged fifty-six and older constitute the majority of smallholder livestock farmers in the study area. This finding is in agreement with another reported by [33], as generally reflective of the age bracket among the majority of smallholder farmers in rural areas of South Africa.

Among the survey respondents, 27% were single with 46% married and 27% comprised those either widowed or divorced. The number of persons in respondent's households were also analysed, and show that 29% of the respondents had between two and four persons in the household. The majority of survey respondents, about 53%, had between five and seven persons in the household, while 18% of respondents had between eight and ten persons in the household. Large household sizes are common in rural areas, especially in the Eastern Cape Province, as extended families live within the same compound.

Education levels varied among the respondents, with 17% having no formal education, 36% attended schooling for six years or less, while 20% attended schooling for a period of between 6 and 12 years. Respondents who had more than 12 years of formal schooling comprised 27% of the study population. The data shows that among 53% of survey respondents, approximately 36% had only a primary education, with 17% of these respondents having no formal education. Most of the respondents, approximately 87%, did not belong to any farmer cooperative, and only 13% were members of a farmer cooperative.

The herd sizes among respondents varied widely, the data was compressed as a result to narrow the range with a mean value of 83 animals. Herd size was determined by the total number of livestock owned by the respondents, and the analysis show that 33% of respondents had less than 50 animals in total, 36% of respondents owned between 51-100 animals, while 31% of respondents had more than

100 animals in their herd. Livestock ownership within the study area is considered as a status symbol, with many households keeping different types of livestock.

3.2. Effect of identified variables on market participation

The Probit model result for market participation (MRKPAT) is used together with the truncated model estimates for the Double Hurdle regression. As shown in Table 4 the significant variables are age, additional or off-farm income, including membership of farmer's cooperative and the use of ICT-based source.

Table 4. Effect of variables including ICT-based information source on market participation

Market participation	**Coef.**	**Std. Err.**	**P-value**	**dy/dx**	**Std. Err.**	**P-value**
Age	-0.072	0.033	**0.027****	-0.008	0.003	**0.014****
Gender	2.141	1.253	0.412	-0.337	0.120	0.335
Marital status	0.824	0.684	0.228	0.088	0.071	0.212
Household size	0.702	0.462	0.128	0.075	0.047	0.110
Education	-0.305	0.558	0.585	-0.033	0.059	0.582
Off-farm income	2.556	1.270	**0.044***	0.274	0.128	**0.033****
Membership in Coop	2.741	0.972	**0.005*****	0.294	0.084	**0.000*****
ICT-based source	3.844	0.825	**0.000*****	0.413	0.052	**0.000*****
Log of Herd size	3.327	1.452	0.326	0.357	0.143	0.612
Constant	-8.048	4.292	**0.061***			
Prob >Chi²			**0.000*****			
LR Chi2 (9)	**104.99**					

***,**&* represent level of significance at 1%,5% & 10%, respectively

The farmer's age was found to be significant, though negatively correlated to market participation. This finding is supported by other studies such as [34-35], where significant negative relationships between age and market participation were reported, and contrasts with the view of [36], which considers age as an enabler of market participation. These sources allude to risk aversion and conservative attitudes among older farmers, against the market-enthusiasm exhibited by younger farmers, to elucidate the negative correlation between age and market participation among some farmers.

An additional or off-farm income is significant and positively correlated to market participation from this study. Though [37] also emphasized the usefulness of an additional income source in overcoming market entry costs, a number of studies [38-40] have reported a significant but negative effect of additional income on the farmer's market participation. However, this study corroborates the findings by [41], suggesting that an additional income from off-farm activity positively influenced market participation; as well as [42] who inferred that investing additional off-farm income stimulated farm productivity which translates into increased market participation.

The coefficient of membership of farmer's cooperative had a positive and statistically significant impact on livestock market participation. Cooperative membership increased the farmer's probability of participating in markets by approximately 29%. Cooperatives have been noted by [43] to provide farmers with requisite platforms for exchanging information, and serves as a link to buyers at a lower cost. These led to improvements in their collective bargaining power and production capabilities [44, 45], while invariably lowering the transaction costs due to market participation. A

similar finding of the positive influence exerted by membership of farmer's cooperative or association has also been reported by [46, 47].

ICT-sources are considered indispensable for providing information related to livestock marketing and market prices. The coefficient of access among livestock farmers to ICT-based information source had a positive and statistically significant impact on market participation. Though there is agreement regarding the importance of ICTs for market information, some studies such as [48] have reported insufficient evidence to indicate the influence of an ICT market information source on farmer's market participation decisions. Nonetheless, other findings have shown the benefits of using ICTs, and how they constitute a viable approach for linking smallholders to markets [49-51]. The finding of a significant positive influence of ICTs on market participation among farmers corroborate other studies, where its additional welfare benefits [52], effect on marketing decisions [53], and a significant positive coefficient on the quantity produced and price received [54) was reported.

The results from the truncated regression of market participation is reported in Table 5, and the coefficient of the inverse-Mills-ratio (IMR) was not found to be statistically significant in this model, implying that any bias due to self-selection could be discounted. The variables influencing intensity of market participation among the smallholder livestock farmers are highlighted.

Table 5. Truncated model estimates: Intensity of market participation.

Log of Quantity Sold	Coefficient	Std. Err.	P-value
Gender	-0.457	0.217	**0.035****
Age	0.013	0.010	**0.004*****
Marital status	-0.624	0.232	**0.007*****
Household size	-0.660	0.170	0.277
Education	1.006	0.226	0.165
Off-farm income	0.679	0.195	**0.000*****
Membership in Coop	0.038	0.240	**0.013*****
ICT-based source	-0.184	0.311	0.553
Log of Herd size	-0.167	0.133	0.208
IMR	0.615	0.523	0.239
Constant	7.945	0.876	**0.000*****
Sigma	0.720	0.051	**0.000*****
Wald Chi^2 (10)	102.78		
Prob > Chi^2			**0.000*****

*** & ** represent level of significance at 1% & 5% respectively

The variables driving intensity of market participation were gender, age, additional income and cooperative membership. Others include marital status and off-farm income. Respondents' education, use of ICT-based sources, household size and the herd size were not found significant in influencing the intensity of market participation (proxy as amount received from sale) among the smallholder livestock farmers. The independent variables on their own did not strongly affect the direction of the dependent variable, and as such the result confirms the noted effect of a combination of variables in producing different outcomes. As reported by [55], the interaction of variables such as gender, membership of cooperatives and use of ICT source, led to positive commercialization outcomes. This position is also supported by [8], where the explanatory variables jointly influenced the extent of market commercialization. Other relevant studies where combinations of variables were identified

as influencing market participation decisions, either positively or negatively, among surveyed smallholder farmers include [23, 35, 40] and also in [56].

While the use of ICT-based market information sources did not significantly affect the intensity of market participation, its combination with other independent variables such as gender, marital status, and membership of a cooperative led to more significant market participation outcomes among smallholder farmers. This finding corroborates the inference by [57], among many others, that different sets of factors significantly influence market participation and the intensity of participation decisions among farmers; which ultimately supports the position enunciated by [58] suggesting that information systems, akin to market-participation decisions in this instance, are clearly entrenched within a specific context or local reality, and hence are affected by different factors along various points in the farmers decision making processes.

4. Conclusion

Key personal characteristics of farmers found to be significantly associated with market participation include age, an additional income, the membership of cooperative, as well as use of ICT-based sources. However, among those participating in markets, the membership of a cooperative, having an additional income, marital status, gender and age were found to be significant in driving the intensity of market participation. Use of ICT-based source was not found to significantly influence the intensity of market participation. This confirms that various variables are at play during different stages of the farmer's decision-making process. It is worth noting, nonetheless, that variables such as age, additional income and cooperative membership, significantly influenced both the participation of farmers in markets as well as the intensity of market participation, in this study.

The result from this study highlights pertinent issues that are relevant in improving market participation among smallholder livestock farmers. These issues have important implications for interventions aiming to progress smallholder livestock farmers on the commercialization pathway.

Some recommendations that are put forward include; the roll out of livestock intervention programs targeted at young farmers that provides improved livestock breeds and increased access to relevant input and infrastructure; increased extension support services utilizing existing community platforms to provide livestock health and management education, as well as provision of adequate market information to farmers; the establishment of alternative off-farm income generating activities such as fresh produce gardens, local craft-making, supporting community eco-tourism developments; all aimed at increasing the potential of smallholder farmers in the area to earn an additional income. Furthermore, the formation of farmer cooperatives should be facilitated and these groups provided with access to ICT-based market information sources.

Author Contributions: For this article, the conceptualization, C.U.N.; methodology, C.U.N. and A.A.O; writing—original draft preparation, C. U. N.; writing—review and editing, C.U.N. and A.A.O.; supervision, A. A. O.; C.W.

Funding: This research received no external funding

Acknowledgments: The authors wish to acknowledge the research support provided by the Central University of Technology, South Africa through the post-graduate CUT-URIC Grant, which enabled the completion of this study. Initial assistance during project conceptualization by Prof. Muthoni Masinde (Department of Information Technology, Central University of Technology) is acknowledged.

Conflicts of Interest: The authors declare no conflict of interest.

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